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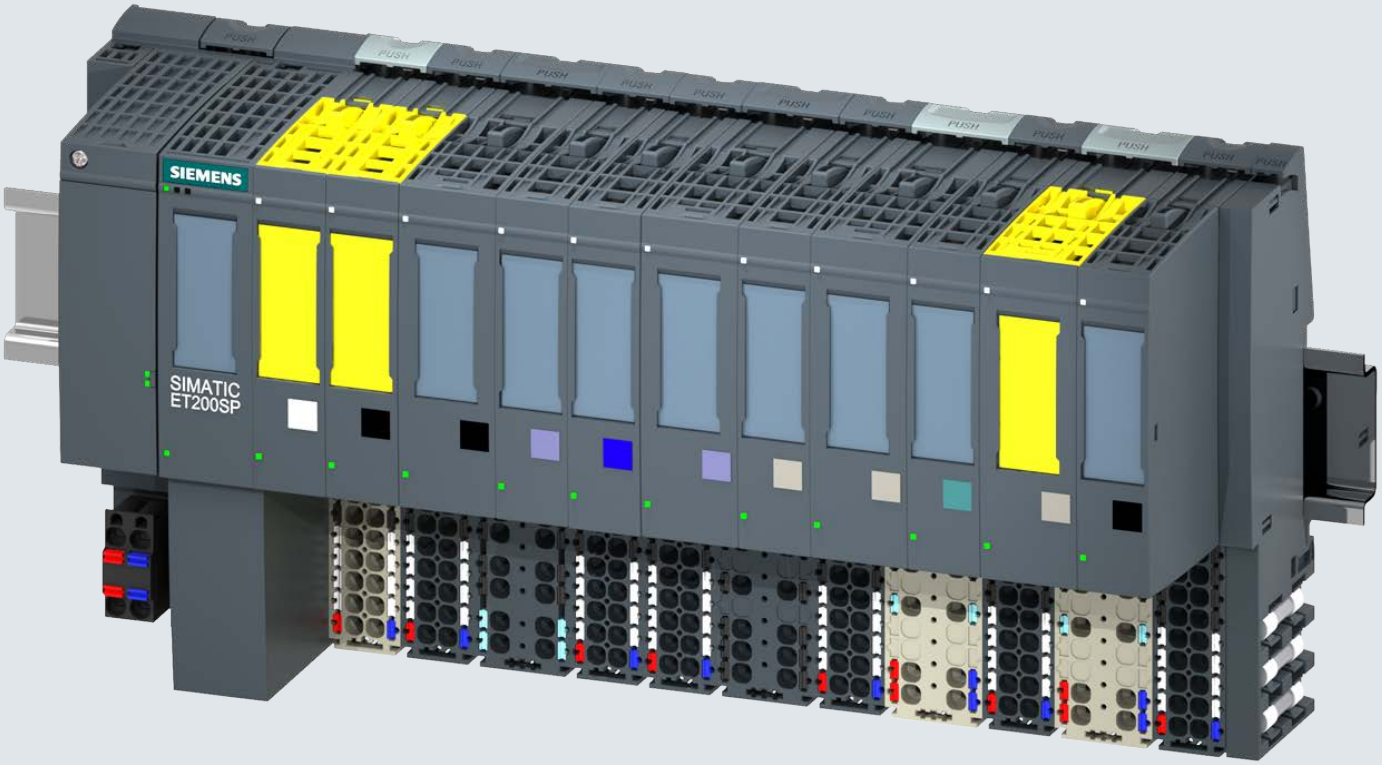

Manual Collection

SIMATIC

ET 200SP

ET 200SP distributed I/O system

This document contains a compilation of all manuals for the ET 200SP system family. Use the bookmarks on the left edge of the screen to navigate.

Edition 06/2017

support.industry.siemens.com

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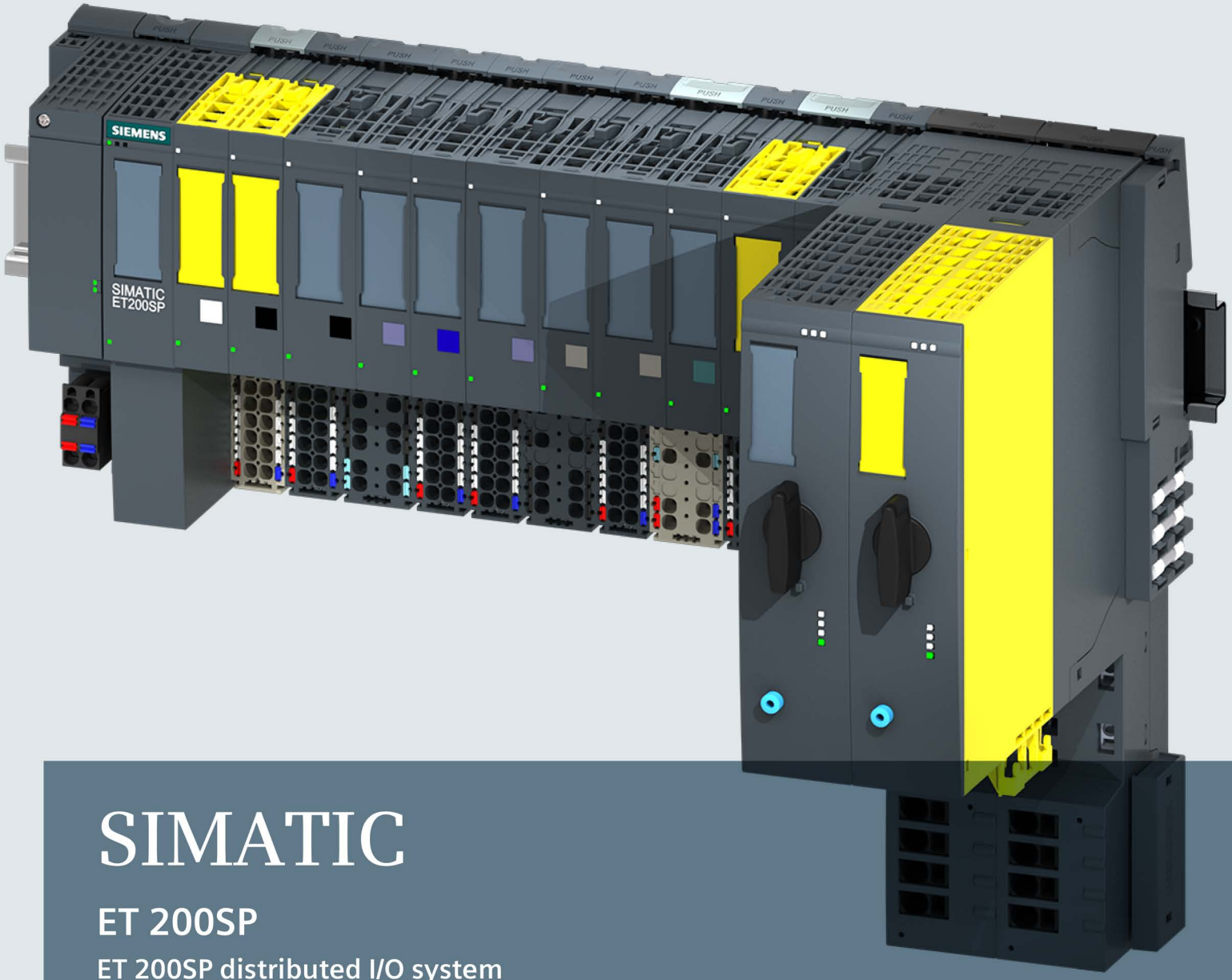

SIMATIC

ET 200SP

ET 200SP distributed I/O system

System manual

Edition 12/2016

siemens.com

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SIMATIC

ET 200SP
Distributed I/O system

System Manual

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Legal information

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This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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GERMANY

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℗ 03/2017 Subject to change

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Preface

Preface

Purpose of the documentation

This documentation provides important information on configuring, installing, wiring and commissioning the ET 200SP distributed I/O system.

Basic knowledge required

A basic knowledge of automation technology is required to understand the documentation.

Validity of the documentation

This documentation applies to the distributed I/O system, ET 200SP.

Definition

In this document, " motor starter" always refers to all variants of the ET 200SP motor starters.

Conventions

Please pay particular attention to notes highlighted as follows:

Note

Notes contain important information on the product, handling the product or on part of the documentation to which you should pay particular attention.

Special information

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

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This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

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Note

Important note for maintaining operational safety of your plant

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. Even suppliers are required to observe special measures during product monitoring. For this reason, we inform you in the form of personal notifications about product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

By subscribing to the appropriate notifications, you will ensure that you are always up-to-date and able to make changes to your system, when necessary.

Log onto Industry Online Support. Go to the following links and, on the side, right click on "email on update":

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

Note

When using F-CPUs in safety mode and fail-safe modules, observe the description of the SIMATIC Industrial Software SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) fail-safe system.

Recycling and disposal

The products are low in pollutants and can be recycled. For environmentally compliant recycling and disposal of your electronic waste, please contact a company certified for the disposal of electronic waste.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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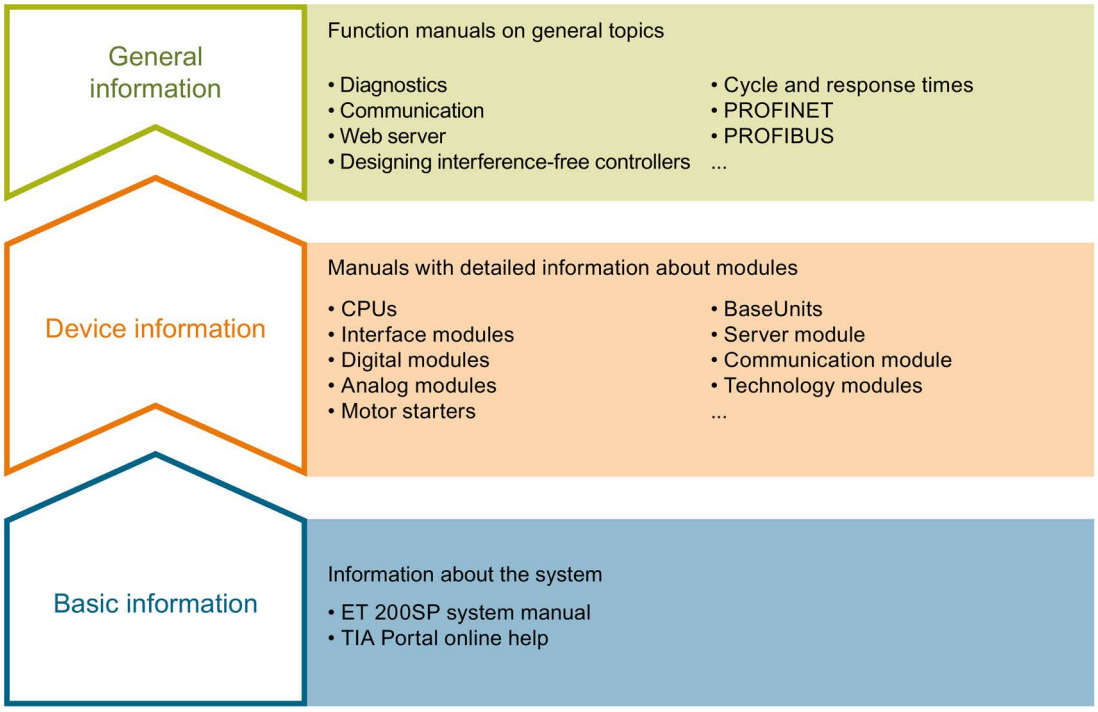
Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

System overview

2

2.1 What is the SIMATIC ET 200SP distributed I/O system?

SIMATIC ET 200SP

SIMATIC ET 200SP is a scalable and highly flexible distributed I/O system for connecting process signals to a higher-level controller via a fieldbus.

Customer benefits of the system

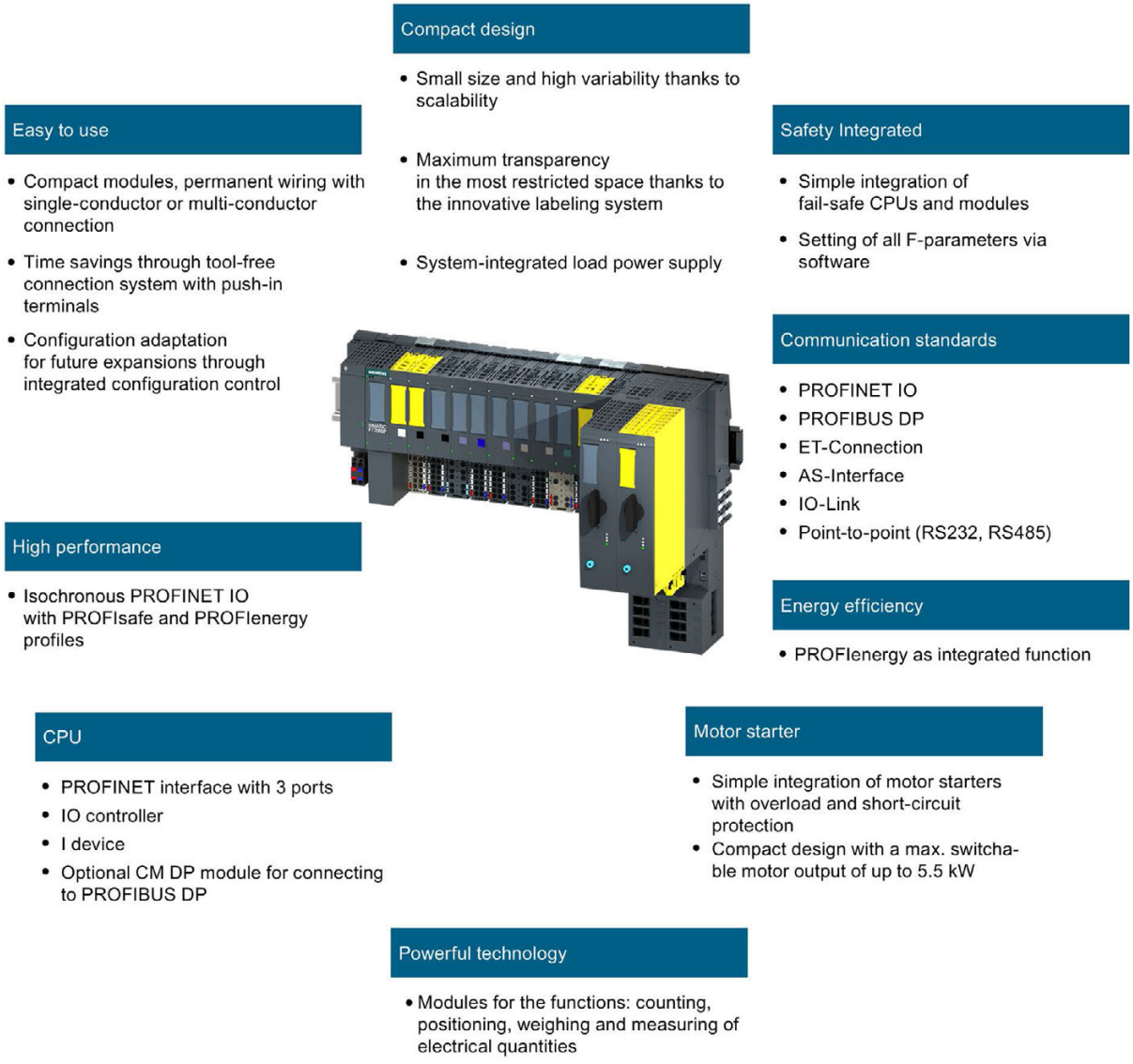


Figure 2-1 SIMATIC ET 200SP distributed I/O system - Customer benefits

Area of application

Thanks to its multifunctionality, the SIMATIC ET 200SP distributed I/O system is suitable for a wide range of applications. Its scalable design allows you to tailor your configuration to local requirements. Different CPUs/interface modules are available for connection to PROFINET IO or PROFIBUS DP.

SIMATIC ET 200SP with CPU allows intelligent pre-processing to relieve the higher-level controller. The CPU can also be used as standalone device.

By using fail-safe CPUs, you can implement applications for safety engineering. Configuration and programming of your safety program takes place the same way as for standard CPUs.

A wide range of I/O modules rounds off the product range.

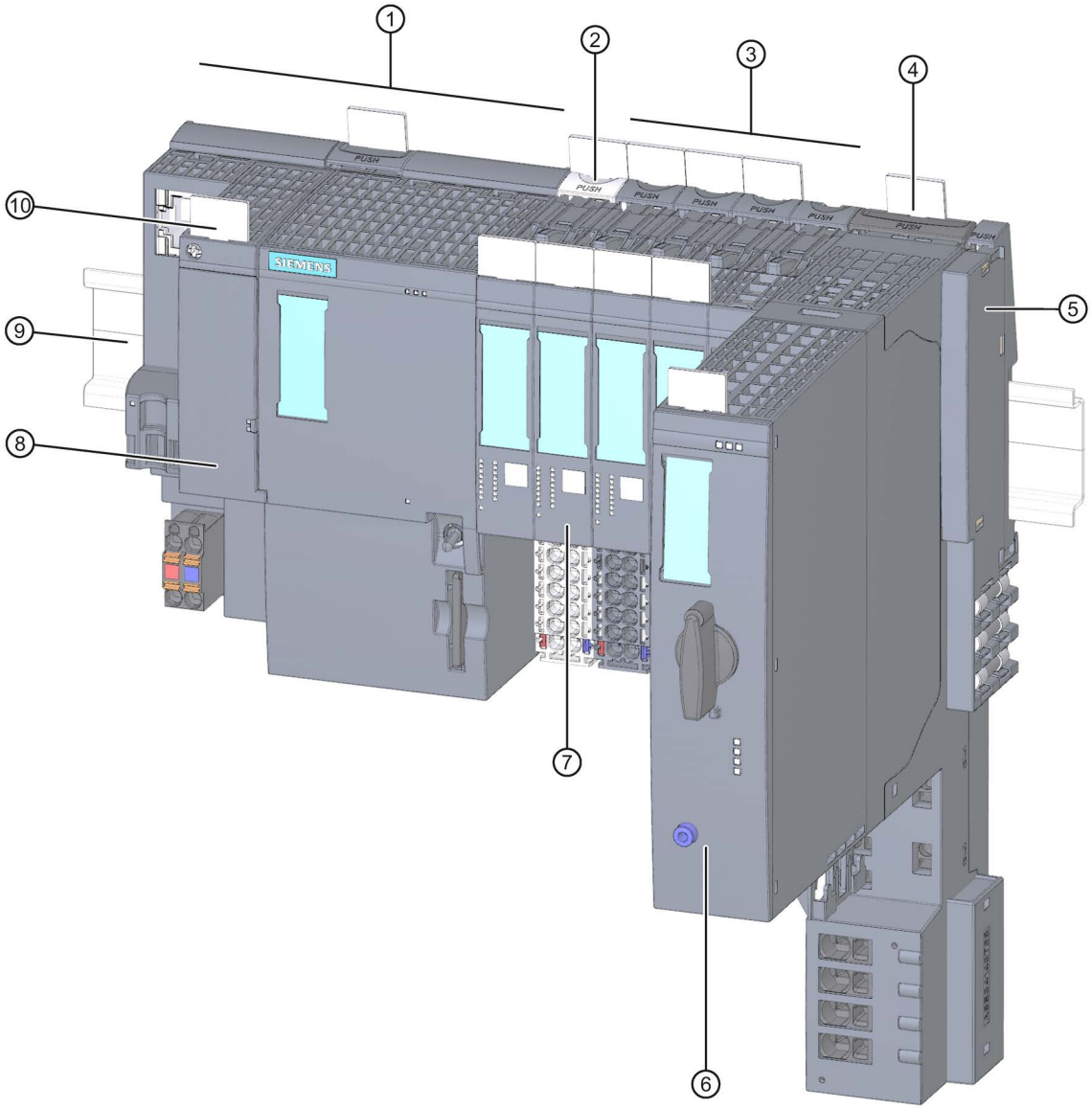
SIMATIC ET 200SP is designed with degree of protection IP20 and is intended for installation in a control cabinet.

Configuration

The SIMATIC ET 200SP distributed I/O system is installed on a mounting rail. It consists of:

- CPU/interface module
- Up to 64 I/O modules, which can be plugged into BaseUnits in any combination
- Up to 31 motor starters
- A server module that completes the configuration of the ET 200SP.

Configuration example



① CPU/interface module
② Light-colored BaseUnit BU..D with infeed of supply voltage
③ Dark-colored BaseUnits BU..B for extending the potential group
④ BaseUnit for motor starter
⑤ Server module (included in the scope of delivery of the CPU/interface module)
⑥ ET 200SP motor starter
⑦ I/O module
⑧ BusAdapter
⑨ Mounting rail
⑩ Reference identification label

Figure 2-2 Configuration example of the ET 200SP

2.2 What are fail-safe automation systems and fail-safe modules?

Fail-safe automation systems

Fail-safe automation systems (F-systems) are used in systems with higher safety requirements. F-systems control processes and ensure that they are in a safe state immediately after shutdown. In other words, F-systems control processes in which an immediate shutdown does not endanger persons or the environment.

Safety Integrated

Safety Integrated is the integrated safety concept for automation and drive technology from Siemens.

Proven technologies and systems from automation technology are used for safety systems. Safety Integrated includes the complete safety sequence, ranging from sensor, actuator and fail-safe modules right through to the controller, including safety-related communication via standard fieldbuses. Drives and controllers handle safety tasks in addition to their actual functions.

Fail-safe modules

The key difference between fail-safe modules (F-modules) and standard modules is that they have an internal two-channel design. This means the two integrated processors monitor each other, automatically test the input and output circuits, and switch the fail-safe module to a safe state in the event of a fault.

The F-CPU communicates with a fail-safe module via the safety-related PROFIsafe bus profile.

Fail-safe motor starters

Fail-safe motor starters enable safety-related tripping of motor loads. Fail-safe motor starters are not PROFIsafe nodes. Motor starters operate together with the fail-safe modules of the ET 200SP system.

Area of application of ET 200SP with fail-safe I/O modules

By using the ET 200SP distributed I/O system with fail-safe I/O modules, you are replacing conventional safety engineering configurations. This includes the replacement of switching devices for emergency STOP, protective door monitors, two-hand operation, etc.

2.3 How are SIMATIC Safety F-systems structured with ET 200SP?

SIMATIC Safety F-system with ET 200SP

The figure below shows an example of a configuration for a SIMATIC Safety F-system with ET 200SP distributed I/O system and PROFINET IO. The PROFINET IO lines can be set up with copper cable, fiber-optic cable or WLAN.

Fail-safe I/O modules and non-fail-safe I/O modules can be combined in an ET 200SP configuration.

The fail-safe IO controller (F-CPU) exchanges safety-related and non-safety-related data with fail-safe and non-fail-safe ET 200SP modules.

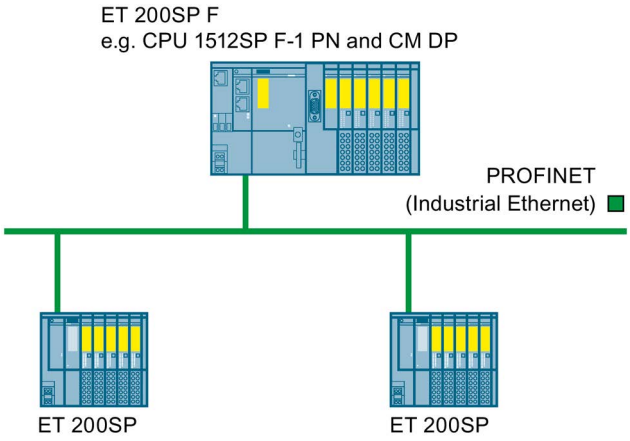


Figure 2-3 Fail-safe SIMATIC Safety automation system (sample configuration)

Fail-safe ET 200SP I/O modules

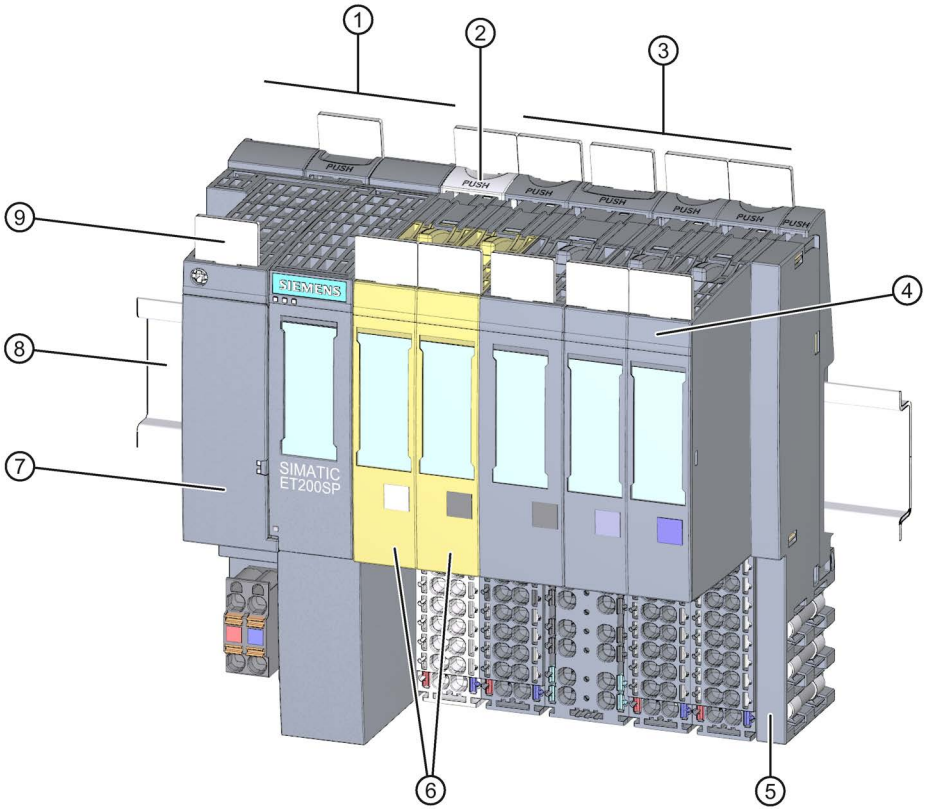
The following fail-safe I/O modules are available for the ET 200SP distributed I/O system:

- Fail-safe power modules are used to supply the potential group load voltage and for the safety-related tripping of the load voltage for non-fail-safe output modules.
- Fail-safe digital input modules detect the signal states of safety-related sensors and send the relevant safety frames to the F-CPU.
- Fail-safe digital output modules are suitable for safety-related shutdown procedures with short circuit and cross-circuit protection up to the actuator.

ET 200SP fail-safe motor starters

Fail-safe motor starters are suitable for safety-related tripping of motor loads.

Example of a configuration with fail-safe I/O modules



① Interface module
② Light-colored BaseUnitBU..D with infeed of supply voltage
③ Dark-colored BaseUnitsBU..B for conducting the potential group further
④ I/O module
⑤ Server module (ships with the interface module)
⑥ Fail-safe I/O modules
⑦ BusAdapter
⑧ Mounting rail
⑨ Reference identification label

Figure 2-4 Example of a configuration of the ET 200SP with fail-safe I/O modules

Hardware and software requirements

ET 200SP fail-safe modules are supported by interface modules IM155-6PN BA, firmware V3.2 or higher, IM155-6PN ST, firmware V1.1.1 or higher, IM155-6PN HF, firmware V2.0 or higher, IM155-6PN HS firmware V4.0 or higher and IM155-6DP HF, firmware V1.0 or higher.

You require the STEP 7 Safety Advanced option package, V12 or higher including HSP 54, for configuration and programming of the ET 200SP fail-safe modules with the SIMATIC Safety fail-safe system.

You require the F-Configuration Pack V5.5 SP10 for configuration and programming of the ET 200SP fail-safe modules with the Distributed Safety fail-safe system.

You require the F-Configuration Pack V5.5 SP12 for configuration and programming of the ET 200SP fail-safe modules with the F/FH Systems fail-safe system.

ET 200SP fail-safe motor starters are supported by interface modules IM155-6PN BA, firmware V3.2 or higher, IM155-6PN ST, firmware V3.1 or higher, IM155-6PN HF, firmware V3.1 or higher and IM155-6DP HF firmware V3.0 or higher.

You require SIMATIC Step 7 V14 or higher for configuration and programming of ET 200SP fail-safe motor starters. The F-Configuration Pack is not needed for configuration and programming of the ET 200SP fail-safe motor starter.

Note

Configuration of ET 200SP motor starters, SIMATIC Step 7 V13 or higher, is possible with a GSD file (GSDML).

Use in safety mode only

Safety mode is the F-I/O operating mode that allows safety-related communication using safety frames.

Safety mode of motor starters is characterized by the fail-safe digital input (F-DI) and availability of the 24 V power supply.

You can only use the ET 200SP fail-safe I/O modules in safety mode. They cannot be used in non-fail-safe mode.

Achievable safety classes

The fail-safe modules are equipped with integrated safety functions for safety mode.

You can achieve the safety classes of the table below:

- With the appropriate parameter assignment of the safety functions in STEP 7
- With a specific combination of fail-safe and non-fail-safe I/O modules
- With a special arrangement and wiring of the sensors and actuators

Table 2- 1 Safety classes that can be achieved with ET 200SP in safety mode

Safety class in safety mode		
According to IEC 61508	According to ISO 13849-1:2006	
SIL2	Category 3	(PL) Performance Level d
SIL3	Category 3	(PL) Performance Level e
SIL3	Category 4	(PL) Performance Level e

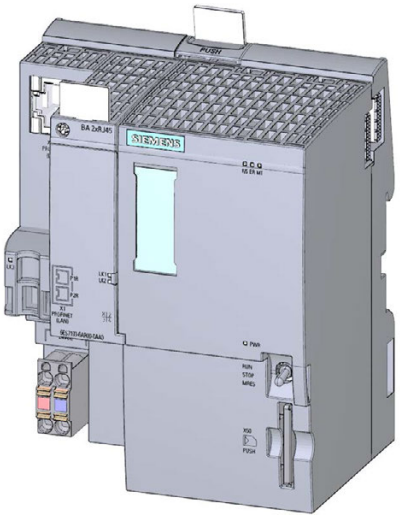
Additional information

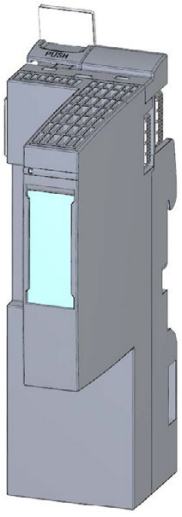
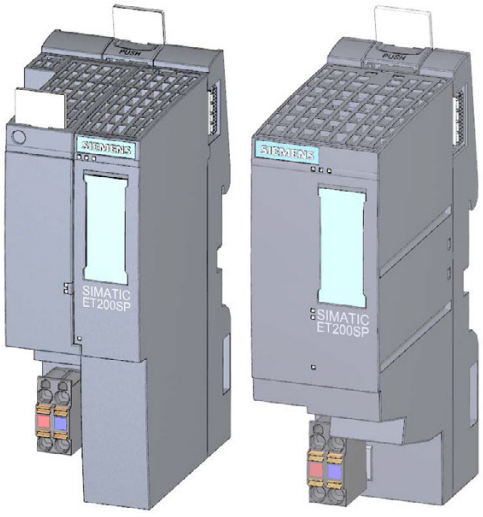
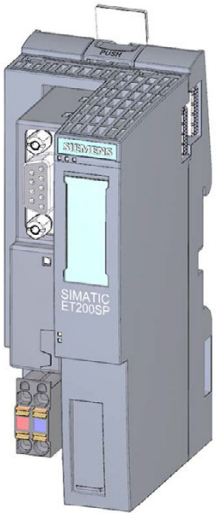
You will find the use cases and wiring for the relevant safety class in the manuals of the fail-safe I/Os and the fail-safe motor starters.

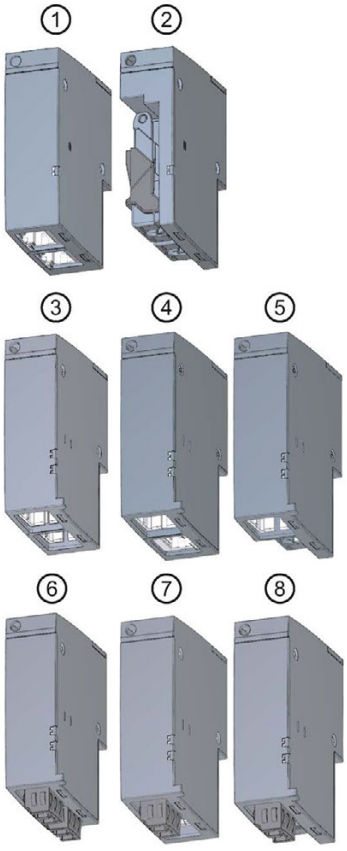
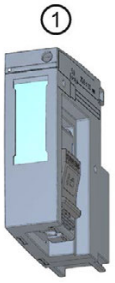
2.4 Components

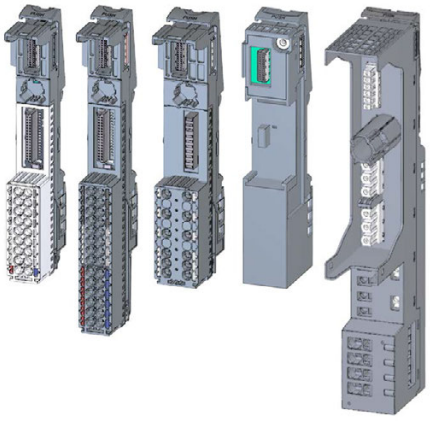
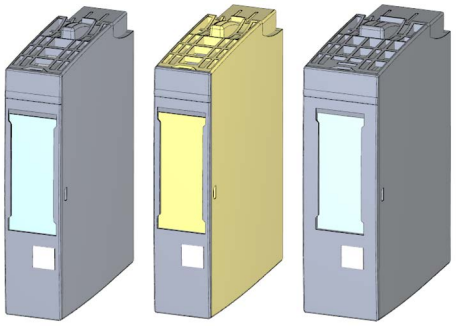
Basic components of the ET 200SP distributed I/O system

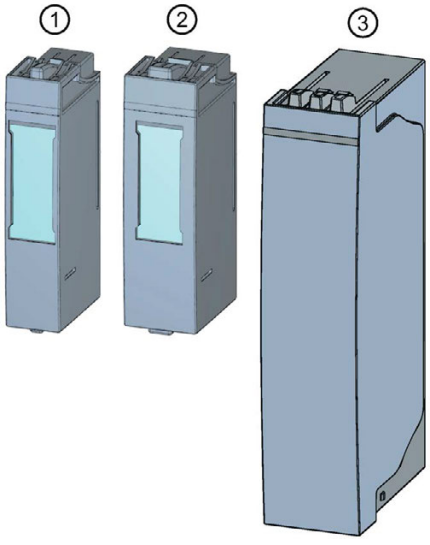
Table 2- 2 Basic components of the ET 200SP

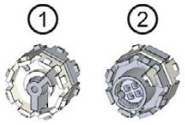
Basic component	Function	Figure
Mounting rail in accordance with EN 60715	The mounting rail is the rack of the ET 200SP. The ET 200SP is installed on the mounting rail. The mounting rail is 35 mm high.	
CPU/Fail-safe CPU	The (F) CPU: • Runs the user program. The F-CPU also runs the safety program. • Can be used as an IO controller or I-Device on PROFINET IO or as a standalone CPU • Links the ET 200SP to the IO devices or the IO controller • Exchanges data with the I/O modules via the backplane bus. Additional CPU functions: • Communication via PROFIBUS DP (the CPU can be used as a DP master or DP slave in combination with the CM DP communication module) • Integrated Web server • Integrated technology • Integrated trace functionality • Integrated system diagnostics • Integrated safety • Safety mode (when using fail-safe CPUs)	

Basic component	Function	Figure
Communication module CM DP	The communication module CM DP • Connects the CPU with PROFIBUS DP • The bus connection is an RS485 interface	
Interface module for PROFINET IO	The interface module: • Can be used as IO device on PROFINET IO • Links the ET 200SP with the IO controller • Exchanges data with the I/O modules via the backplane bus.	
Interface module for PROFIBUS DP	The interface module: • Can be used as DP slave on PROFIBUS DP • Links the ET 200SP with the DP master • Exchanges data with the I/O modules via the backplane bus.	

Basic component	Function	Figure
BusAdapter	The BusAdapters allow free selection of the connection technology for PROFINET IO. The following versions are available for PROFINET CPU/interface modules: • For standard RJ45 connector (BA 2×RJ45) ① • For direct connection of the bus cable (BA 2×FC) ② • For POF/PCF fiber-optic cable (BA 2xSCRJ) ③ • As media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 plug (BA SCRJ/RJ45) ④ • As media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable (BA SCRJ/FC) ⑤ • For glass fiber-optic cable (BA 2xLC) ⑥ • As media converter for glass fiber-optic cable ⇔ standard RJ45 plug (BA LC/RJ45) ⑦ • As media converter for glass fiber-optic cable ⇔ direct connection of the bus cable (BA LC/FC) ⑧	
	For mixed ET 200SP/ET 200AL configuration, you require the BusAdapter BA-Send 1xFC ① (plugged into the BaseUnit BU-Send). Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1xFC.	

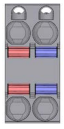
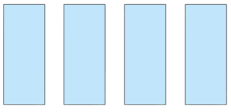
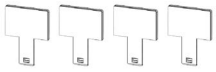
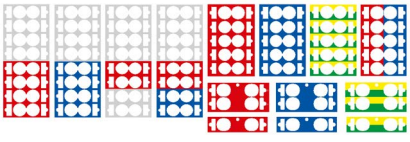
Basic component	Function	Figure
BaseUnit	The BaseUnits provide the electrical and mechanical connection of the ET 200SP modules. Place the I/O modules or the motor starter onto the BaseUnits. Suitable BaseUnits are available for each of the different requirements (see Selecting the BaseUnit for I/O modules (Page 36)).	
Fail-safe power module	The fail-safe power module allows the safety-related shutdown of digital output modules / fail-safe digital output modules.	
I/O module / fail-safe I/O module	The I/O module determines the function at the terminals. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions. I/O modules are divided into the following module types: • Digital input (DI, F-DI) • Digital output (DQ, F-DQ, F-RQ) • Analog input (AI) • Analog output (AQ) • Technology module (TM) • Communication module (CM)	

Basic component	Function	Figure
Motor starter/fail-safe motor starter	The motor starter is a switching and protection device for 1-phase and 3-phase loads. The motor starter is available as a direct-on-line and reversing starter.	
BU cover	Insert the BU cover on the BaseUnits: • Whose slots are not occupied by I/O modules /motor starters • Whose slots have been reserved for future expansion (as empty slots). You can keep a reference identification label for the planned I/O module inside the BU cover. There are three versions: • For BaseUnits with a width of 15 mm ① • For BaseUnits with a width of 20 mm ② • For BaseUnits of motor starters with a width of 30 mm ③	
Server module	The server module completes the configuration of the ET 200SP. The server module includes holders for 3 spare fuses (5 × 20 mm). The server module ships with the CPU/interface module.	

Basic component	Function	Figure
Coding element	The coding element codes the I/O module with the BaseUnit. There are two versions: • Mechanical coding element ①: Ensures the coding • Electronic coding element ②: This version also has an electronic, rewritable memory for module-specific configuration data (such as the F-destination address for fail-safe modules, parameter data for the IO link master).	

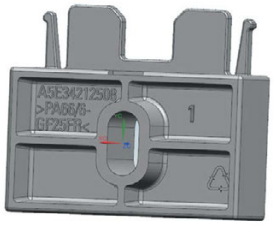
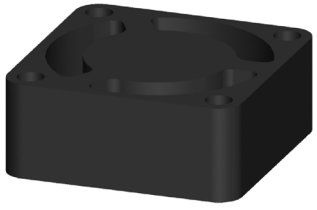
Accessories of the ET 200SP distributed I/O system

Table 2- 3 Accessories of the ET 200SP

Accessories	Function	Figure
24 V DC connector	Applying the 24 V DC supply at the connector and connection with the IM.	
Shield connection	The shield connection allows the low-impedance contacting of cable shields with minimum installation times.	
Labeling strips	Attach the labeling strips to the modules for system-specific labeling of the ET 200SP. The labeling strips can be printed. The labeling strips can be ordered as accessories (Page 286) on a roll for thermal transfer printers or as DIN A4 format sheets for laser printers.	
Reference identification labels	The labels enable the reference identification labeling of the ET 200SP components. The labels can be ordered on a mat for thermal transfer and inkjet printers as accessories (Page 286).	
Color identification labels	The color identification labels are module-specific and can be ordered for the process terminals, AUX terminals and additional terminals as accessories (Page 286).	

Accessories of the SIMATIC ET 200SP motor starters

Table 2- 4 SIMATIC ET 200SP motor starter accessories

Accessories	Function	Figure
3DI/LC module	The optional 3DI/LC module has three digital inputs and one LC input. For reasons of operational safety, input LC is permanently set to manual local mode. By parameterizing the inputs DI1 - DI3 with motor CLOCKWISE or motor COUNTER-CLOCKWISE, you can control the motor in manual local mode. The functions of the 3DI/LC module are not relevant to functional safety. Detailed information on the functions when using a 3DI/LC module can be found in the Manual (https://support.industry.siemens.com/cs/ww/en/view/109479973).	
Mechanical bracket for BaseUnit	Use the mechanical bracket for additional fixing of the motor starter. You can use the mechanical bracket on 7.5 mm and 15 mm mounting rails.	
Infeed bus cover	For finger-safe termination of the infeed bus, use the cover.	
Fan	You can use the motor starter at higher ambient temperatures if a fan is installed.	

Application planning

3

Overview

The BaseUnits (BU) are classified according to different types. Every BaseUnit type is distinguished by characteristics that match certain I/O modules and motor starters (see the following table and graphics).

You recognize the BU type for an I/O module by the last two digits of an I/O module's article number.

Note

You will find a complete overview of the possibilities of combining BaseUnits and I/O modules /motor starters in the Product information for documentation of the ET 200SP I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

Table 3- 1 Selecting a suitable BaseUnit for I/O modules

Selecting a BaseUnit	I/O module (example)	Examples of suitable I/O modules for BU types	
		I/O module (example)	BaseUnit
BU type **A0** See Digital, fail-safe, communication, technology or analog modules without temperature measurement (Page 36)	Digital, fail-safe, technology or communication module • 6ES7...**A0** • 24 V DC • 15 mm wide	DI 16×24VDC ST (6ES7131-6BH00-0B**A0**)	BU15-P16+A0+2D (6ES7193-6BP00-0D**A0**)
	Analog module **without** temperature measurement** • 6ES7...**A1** • 24 V DC • 15 mm wide	AI 4xU/I 2-wire ST (6ES7134-6HD00-0B**A1**)	
BU type **A1** See Analog modules with temperature measurement (Page 37)	Analog module **with** temperature measurement* • 6ES7...**A1** • 24 V DC • 15 mm wide	AI 4×RTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0C**A1**)	BU15-P16+A0+2D/T(6ES7193-6BP00-0D**A1**)

Selecting a BaseUnit	I/O module (example)	Examples of suitable I/O modules for BU types	
		I/O module (example)	BaseUnit
BU type **B0** (BU..B, dark-colored BaseUnit)	Digital output module with relay • 6ES7...**B0** • Up to 230 V AC • 20 mm wide	RQ 4×120VDC-230VAC/5A NO ST (6ES7132-6HD00-0B**B0**)	BU20-P12+A4+0B (6ES7193-6BP20-0B**B0**)
BU type **B1** (BU..B, dark-colored BaseUnit)	Digital modules • 6ES7...**B1** • up to 230 V AC • 20 mm wide	DI 4×120..230VAC ST (6ES7131-6FD00-0B**B1**)	BU20-P12+A0+4B (6ES7193-6BP20-0B**B1**)
BU type **C0** (BU..D, light-colored BaseUnit)	Fail-safe power module • 6ES7...**C0** • 24 V DC • 20 mm wide CM AS-i Master ST/F-CM AS-i Safety ST • 6ES7...**C1** • Up to 30 V DC • 20 mm wide	CM AS-i Master ST (3RK7137-6SA00-0B**C1**)	BU20-P6+A2+4D (6ES7193-6BP20-0D**C0**)
BU type **C1** (BU..B, dark-colored BaseUnit)	F-CM AS-i Safety ST • 6ES7...**C1** • Up to 30 V DC • 20 mm wide	F-CM AS-i Safety ST (3RK7136-6SC00-0B**C1**)	BU20-P6+A2+4B (6ES7193-6BP20-0B**C1**)
BU type **D0**	AI Energy Meter • 6ES7...**D0** • Up to 400 V AC/ 480 V AC • 20 mm wide	AI Energy Meter 480VAC ST (6ES7134-6PA20-0B**D0**)	BU20-P12+A0+0B (6ES7193-6BP00-0B**D0**)
BU type **F0**	F-RQ 1×24VDC/24..230 VAC/5A • 6ES7...**F0** • Up to 230 V AC • 20 mm wide	F-RQ 1×24VDC/24..230VAC/5A (6ES7136-6RA00-0B**F0**)	BU20-P8+A4+0B (6E7193-6BP20-0B**F0**)

* For compensation of the reference junction temperature for thermocouples. The BU type A1 is required if measuring the reference junction temperature with an internal temperature sensor or if you need the 2×5 additional terminals.

** Analog modules with temperature measurement can be plugged on BU type A0.

Table 3- 2 BaseUnit for motor starters

		Selecting the BaseUnit					
		BU-30-MS1	BU-30-MS2	BU-30-MS3	BU-30-MS4	BU-30-MS5	BU-30-MS6
24 V infeed		x		x			
500 V infeed		x	x			x	
F-DI terminals						x	x
Motor starters							
DS 0.3 - 1A HF	3RK1308-0AB00-0CP0	x	x	x	x	x*	x*
DS 0.9 - 3A HF	3RK1308-0AC00-0CP0	x	x	x	x	x*	x*
DS 2.8 - 9A HF	3RK1308-0AD00-0CP0	x	x	x	x	x*	x*
DS 4.0 - 12A HF	3RK1308-0AE00-0CP0	x	x	x	x	x*	x*
RS 0.3 - 1A HF	3RK1308-0BB00-0CP0	x	x	x	x	x*	x*
RS 0.9 - 3A HF	3RK1308-0BC00-0CP0	x	x	x	x	x*	x*
RS 2.8 - 9A HF	3RK1308-0BD00-0CP0	x	x	x	x	x*	x*
RS 4.0 - 12A HF	3RK1308-0BE00-0CP0	x	x	x	x	x*	x*
F-DS 0.3 - 1A HF	3RK1308-0CB00-0CP0	x	x	x	x	x	x
F-DS 0.9 - 3A HF	3RK1308-0CC00-0CP0	x	x	x	x	x	x
F-DS 2.8 - 9A HF	3RK1308-0CD00-0CP0	x	x	x	x	x	x
F-DS 4.0 - 12A HF	3RK1308-0CE00-0CP0	x	x	x	x	x	x
F-RS 0.3 - 1A HF	3RK1308-0DB00-0CP0	x	x	x	x	x	x
F-RS 0.9 - 3A HF	3RK1308-0DC00-0CP0	x	x	x	x	x	x
F-RS 2.8 - 9A HF	3RK1308-0DD00-0CP0	x	x	x	x	x	x
F-RS 4.0 - 12A HF	3RK1308-0DE00-0CP0	x	x	x	x	x	x

* The F-DI terminals have no function with this combination.

Additional information

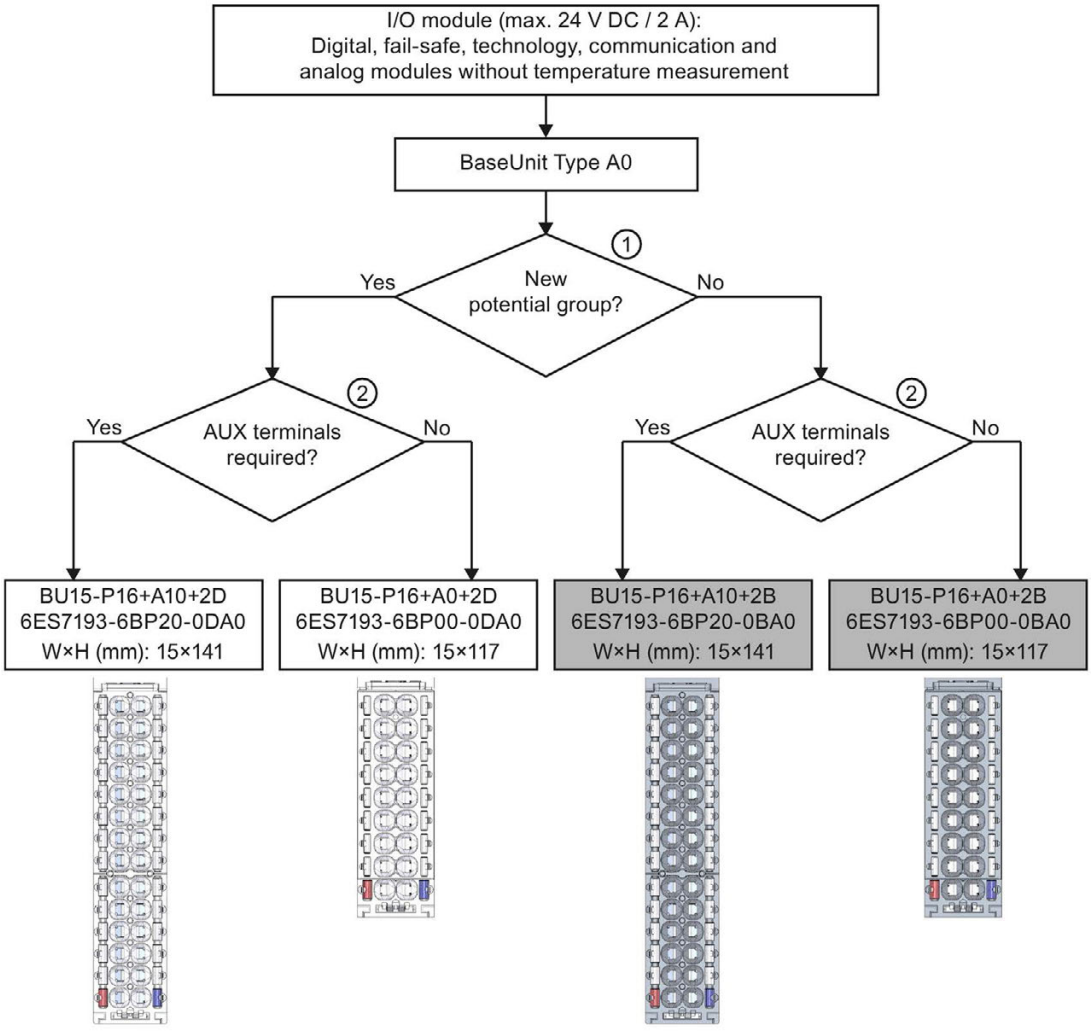
Additional information on the functional assignment of the terminals and on the associated BaseUnits can be found in one of the following manuals:

- Manual for the relevant I/O module (http://support.automation.siemens.com/WW/view/en/55679691/133300)
- Manual BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)
- Motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual

3.1 Selecting the BaseUnit for I/O modules

3.1.1 Digital, fail-safe, communication, technology or analog modules without temperature measurement

Selection of a suitable BaseUnit



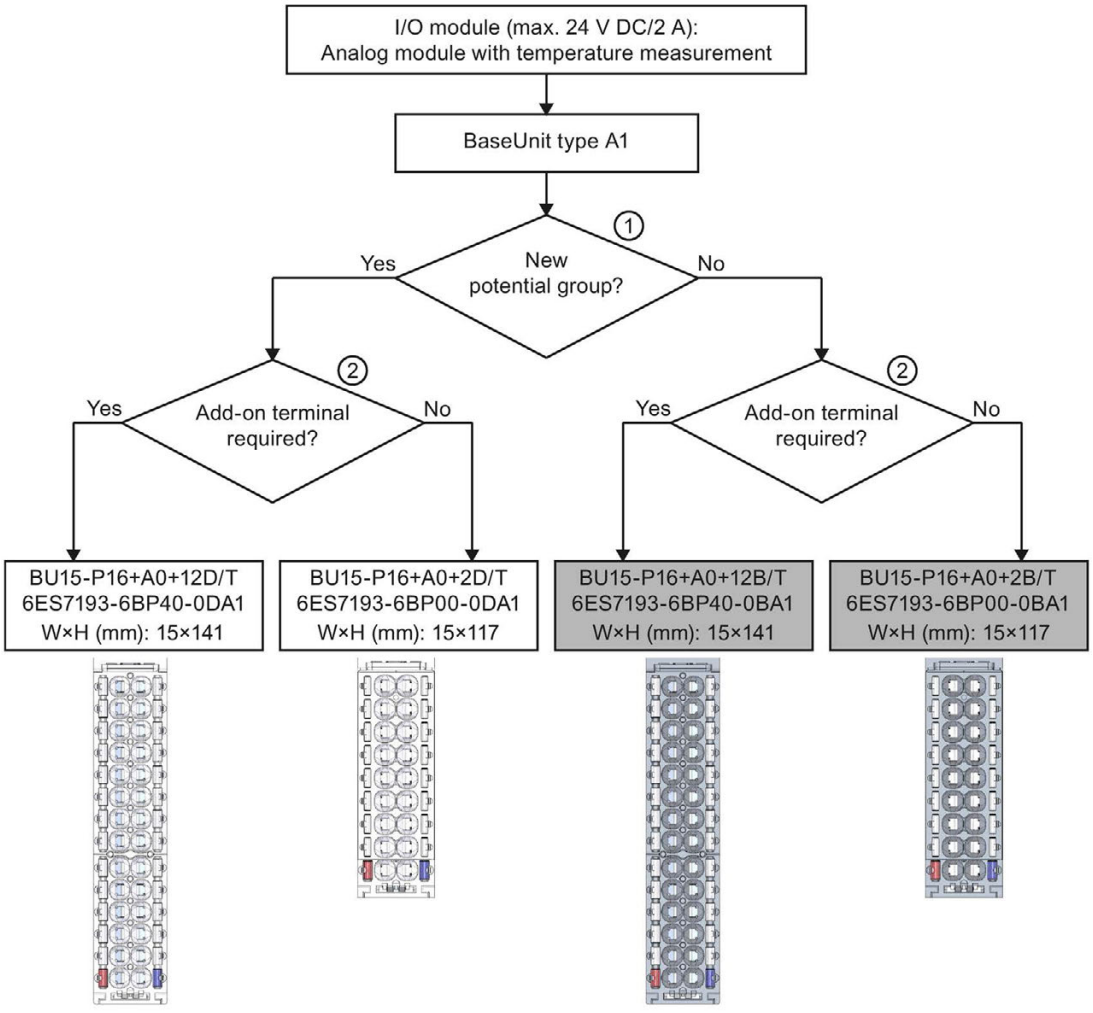
① Light-colored BaseUnit: Configuration of a new potential group, electrical isolation from adjacent module on the left. The first BaseUnit of the ET 200SP is usually a light-colored BaseUnit for feeding the supply voltage L+.
Exception: If you insert an AC I/O module or an AI Energy Meter as the first I/O module, the first BaseUnit in the ET 200SP configuration can be a dark-colored BaseUnit. The requirement is that you use a CPU or IM 155-6 (as of V3.0).
Dark-colored BaseUnit: Conduction of the internal power and AUX buses from the adjacent module on the left.

② AUX terminal: 10 internally bridged terminals for individual use up to 24 V DC/10 A or as protective conductors.
Example: Multiple cable connection for DI 8×24VDC ST

Figure 3-1 Digital, fail-safe, communication, technology or analog modules without temperature measurement

3.1.2 Analog modules with temperature measurement

Selection of a suitable BaseUnit



① Light-colored BaseUnit: Configuration of a new potential group, electrical isolation from adjacent module on the left. The first BaseUnit of the ET 200SP is usually a light -colored BaseUnit for feeding the supply voltage L+.
Dark-coloredBaseUnit: Continuation of the internal power and AUX buses from the adjacent module on the left.

② Additional terminals: 2×5 internally bridged terminals for individual use up to 24 V DC/2 A
Example: Sensor supply for AI 4×U/I 2-wire ST

Figure 3-2 Analog modules with temperature measurement

3.2 Selecting motor starters with a suitable BaseUnit

3.2.1 Selecting a BaseUnit for motor starters

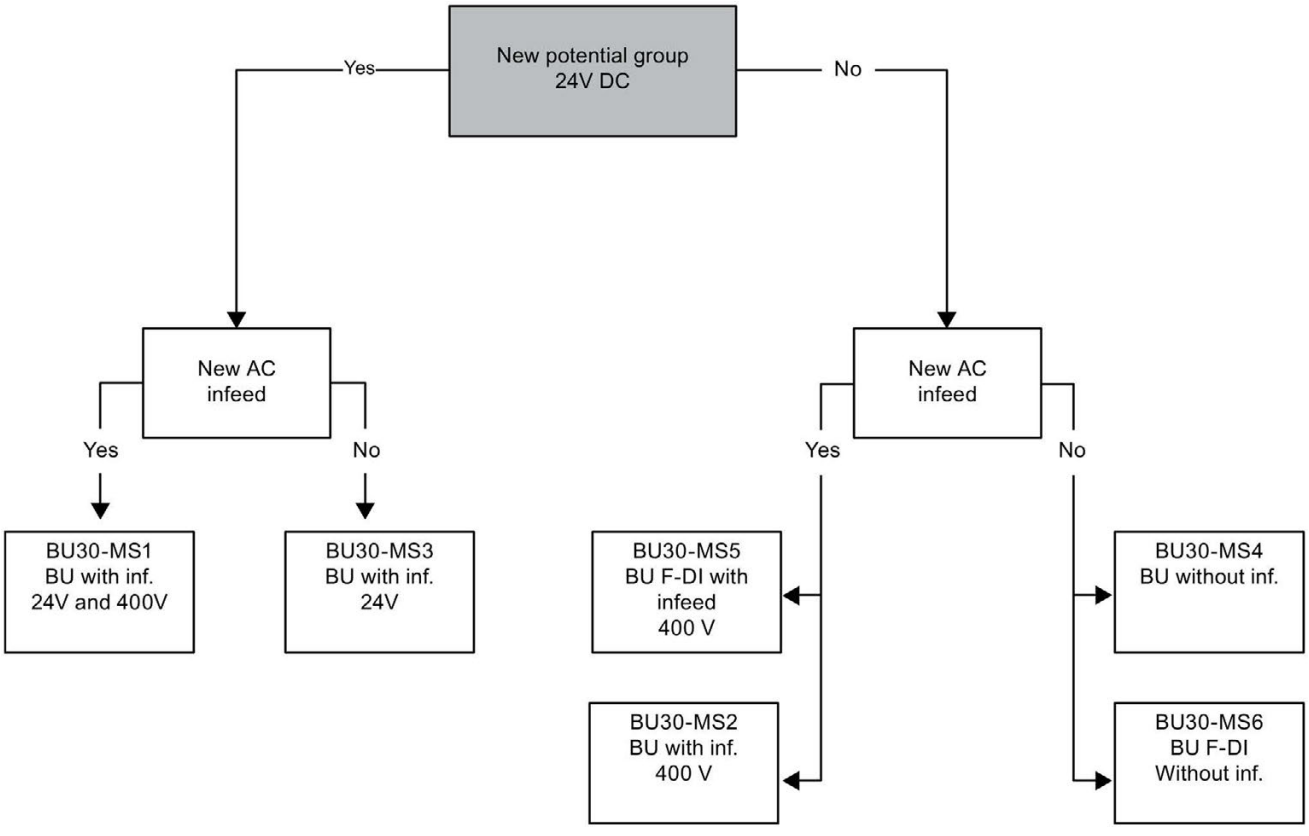
The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3" and "BU30-MS4" are compatible with all non-fail-safe motor starters. The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3", "BU30-MS4", "BU30-MS5" and "BU30-MS6" are compatible with all fail-safe motor starters. You will find an overview of available BaseUnits for motor starters here (Page 32). With the different BaseUnits, you can form different potential groups for the 24 V DC electronics supply (L+/M) and for the AC infeed.

Voltage range

The voltage range of the AC infeed is between 48 V AC and 500 V AC.

Selection criteria for the BaseUnit

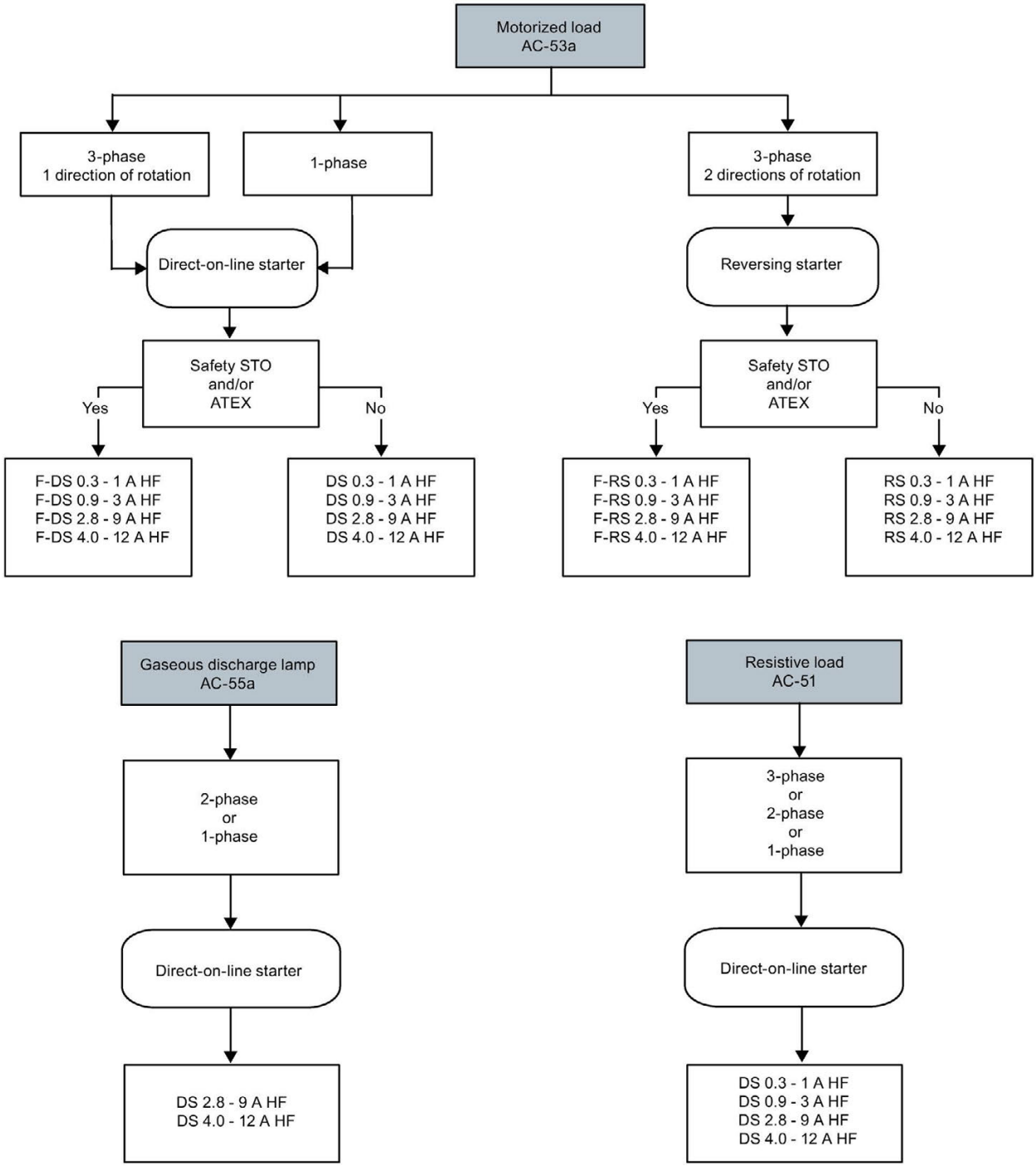
The figure below shows the criteria you use to select the appropriate BaseUnit:



Form separate potential groups on the infeed bus for single-phase (L, N, PE) and three-phase (L1, L2, L3, PE) operation.

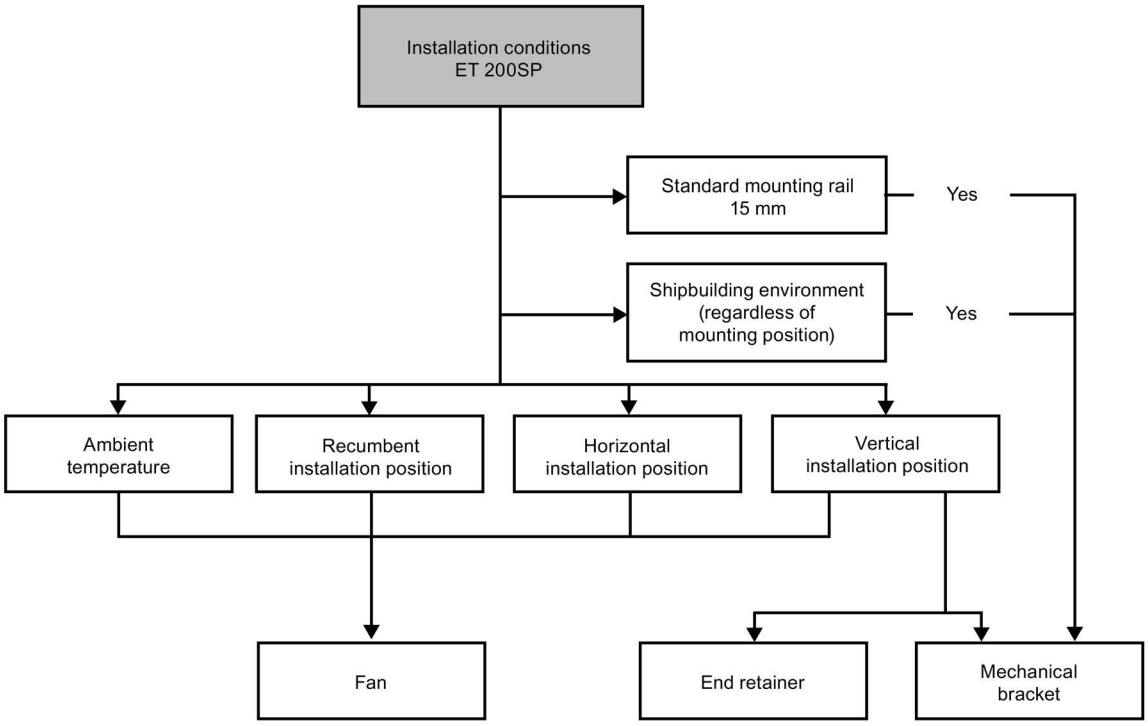
3.2.2 Selecting the motor starter

You select the suitable motor starter using the load type according to the following scheme:



3.2.3 Selecting accessories for motor starters

Observe the installation conditions of the station with ET 200SP motor starters. The figure below shows the criteria the station must meet:



3.3 Hardware configuration

Maximum mechanical configuration

As soon as **one** of the following rules applies, the maximum configuration of the ET 200SP has been reached:

Table 3- 3 Maximum mechanical configuration

Properties	Rule
Number of modules	Maximum of 12/30/32/64 I/O modules (depending on the CPU used/the interface module used; see CPU (http://support.automation.siemens.com/WW/view/en/90466439/133300) and interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) manuals)
	For every 6 F-modules F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0), the maximum configuration is reduced by 1 module.
Number of motor starters	Maximum of 31 motor starters
Backplane bus length of the ET 200SP	maximum 1 m mounting width (without CPU/interface module, including server module)

Electrical maximum configuration for I/O modules

The number of operable I/O modules of a potential group is limited by the following factors:

- Power consumption of the I/O modules
- Power consumption of the components supplied via these I/O modules

The maximum current carrying capacity of the terminals on the BaseUnit L+/M is 10 A. Current carrying capacity refers to the current load via the power bus and the infeed bus of the ET 200SP station. Consider the current carrying capacity when using a motor starter.

Maximum electrical configuration for motor starter power bus (24 V DC)

To determine the current requirement of an individual motor starter via the power bus, take account of the following parameters:

- Current consumption via DC infeed in the ON state
- Current consumption via DC infeed when switching on (40 ms peak load)
- Increased power consumption through fan operation
- Current requirement via encoder supply of the connected DI module

The maximum current carrying capacity of the 24 V potential group is 7 A across the entire permissible temperature range.

Maximum electrical configuration for motor starter infeed bus (500 V AC)

To determine the current requirement of an individual motor starter via the infeed bus, proceed as follows:

Calculate the current requirement via the main current paths of the individual motor starter. In doing so, take into account the parameter I_e (set rated operational current of the motor starter). The permissible overload characteristics of the motor feeder for motors are determined with the thermal motor model. You calculate the current value ($I_{infeed\ bus}$) for the infeed bus of the ET 200SP system according to the following formula:

$I_{infeed\ bus} = \sum_n(I_e * 1.125)$
n = number of motor starters of a potential group on the infeed bus

Refer to the Manual (https://support.industry.siemens.com/cs/ww/en/view/109479973) for details of how to assign the basic rated operational current I_e parameter.

The following values apply for the potential group of the AC infeed:

- The maximum current carrying capacity is 32 A at an ambient temperature of up to 50 °C.
- The maximum current carrying capacity is 27 A at an ambient temperature of up to 60 °C.
- The maximum current carrying capacity for applications according to UL requirements is 24 A at an ambient temperature of up to 60 °C.

Address space

The address space depends on the CPU/interface module (see CPU (http://support.automation.siemens.com/WW/view/en/90466439/133300) Manual) and the interface module used (see Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual):

- For PROFINET IO: Dependent on the IO controller/IO device used
- For PROFIBUS DP: Dependent on the DP master used

3.4 Forming potential groups

3.4.1 Basics

Introduction

Potential groups for the ET 200SP distributed I/O system are formed by systematically arranging the BaseUnits.

Requirements

For formation of potential groups, the ET 200SP distinguishes between the following BaseUnits:

- BaseUnits BU...D (recognizable by the light-colored terminal box and the light-colored mounting rail release button):
  - Opening of a new potential group (power and AUX bus interrupted to the left)
  - Infeed of the supply voltage L+ up to an infeed current of 10 A
- BaseUnits BU...B (recognizable by the dark-colored terminal box and the dark-colored mounting rail release button):
  - Conduction of the potential group (power and AUX bus continued)
  - Pick up of the supply voltage L+ for external components or loop-through with a maximum total current of 10 A
- BaseUnits BU30-MSx (BaseUnit for the motor starter only)

  Depending on the version, the BaseUnits in the "BU30-MSx" model series possess the following properties:
  - Opening a new potential group or continuing an existing one
  - Feeding in the supply voltage L+ up to an infeed current of 7 A DC
  - Opening a new load group or continuing an existing one by means of 500 V AC infeed bus
  - Feeding in the line voltage up to an infeed current of 32 A AC

Placement and grouping of I/O modules

Each BaseUnit BU...D that you install in the ET 200SP configuration opens a new potential group and supplies all subsequent I/O modules (on BaseUnits BU...B) with the necessary supply voltage. The first 24 V DC I/O module to the right of the CPU/interface module must be installed on a light-colored BaseUnit BU...D. Exception: If you insert an AC I/O module or an AI Energy Meter as the first I/O module, the first BaseUnit in the ET 200SP configuration can be a dark-colored BaseUnit. The requirement is that you use a CPU or IM 155-6 (as of V3.0).

If you want to place another BaseUnit BU...B after a BaseUnit BU...D, disconnect the power and AUX buses and open a new potential group at the same time. This allows individual grouping of the supply voltages.

Do not connect any BaseUnit of the "BU...B" type on the right of a motor starter's BaseUnit (BU30-MSxx).

Placement and grouping of I/O modules and motor starters

For the potential group (L+/M), the following slot rules apply within the motor starter modules and other I/O modules of the ET 200SP:

- An unassembled BaseUnit (BaseUnit with BU cover) must be inserted between the CPU, an interface module or an I/O module and the motor starter. This is not necessary between the motor starters.
- The empty slot can take on the potential (24 V DC) of the potential group on the left of it (L+, M), i.e. I/O modules and motor starters can be operated in the same potential group.
- If you would like to insert an I/O module on the right of a motor starter, then use only one BaseUnit of the BU...D Typ A0 type (light terminal box).
- The BaseUnits BU30-MS2, BU30-MS4, BU30-MS5 and BU30-MS6 can take on the potential groups of other BaseUnit types.
  However, pay attention to the following exceptions:
  - Only a BaseUnit of type BU30-MS1 or BU30-MS3 may follow an AS-i module (AS-i potential group).
  - Only BaseUnits with fail-safe motor starters can be connected together in the same potential group of an F-PM-E.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

AUX bus (AUX(iliary) bus)

BaseUnits with additional AUX terminals (e.g. BU15-P16+**A10**+2D) enable the additional connection of a potential (up to the maximum supply voltage of the module), which is applied via the AUX bus.

In the case of BaseUnits of motor starters, the AUX bus is interrupted to the left. An internal 24 V DC signal is output to the right.

The AUX bus can be used individually:

- As a protective conductor bar (the requirements of EN 60998-1 apply). To comply with this standard, a maximum of 8 I/O modules may be plugged into the corresponding potential group.
- For additionally required voltage

NOTICE
AUX bus as PE bar If you use an AUX bus as a protective conductor bar, attach the yellow-green color identification labels to the AUX terminals, and establish a functional connection to the central protective conductor connection. If you stop using the AUX bus as a protective conductor bar, make sure you remove the yellow-green color identification labels and remove the connection to the central protective conductor connection again.

The AUX bus is designed as follows:

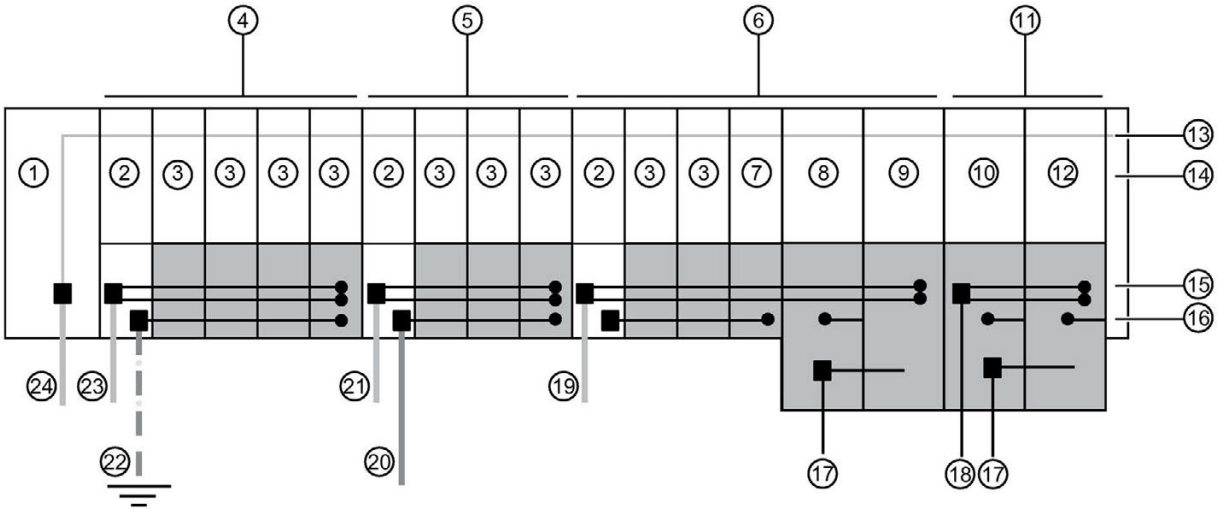
- Maximum current carrying capacity (at 60 °C ambient air temperature): 10 A
- Permissible voltage: Depending on the BaseUnit type (see BaseUnit manual (http://support.automation.siemens.com/WW/view/en/59753521))

Self-assembling voltage buses

You must feed in the supply voltage L+ via the BaseUnit BU...D, BU30-MS1 or BU30-MS3 .

Each BaseUnit BU...B allows access to the supply voltage L+ via terminals (red/blue). The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3", "BU30-MS4", "BU30-MS5" and "BU30-MS6" do not have this access.

Operating principle



1	CPU/interface module	14	Server module
2	BaseUnit BU...D	15	Self-assembling voltage buses P1/P2
3	BaseUnit BU...B	16	AUX bus
4	Potential group 1	17	Infeed bus 500 V AC (L1, L2(N), L3, PE)
5	Potential group 2	18	Supply voltage L+
6	Potential group 3	19	Supply voltage L+ (3)
7	BaseUnit BU...B with dummy module	20	Additionally required voltage
8	BaseUnit BU30-MS2	21	Supply voltage L+ (2)
9	BaseUnit BU30-MS4	22	Protective conductor
10	BaseUnit BU30-MS1	23	Supply voltage L+ (1)
11	Potential group 4	24	Supply voltage 1L+
12	BaseUnit BU30-MS4		
13	Backplane bus		

Figure 3-3 Placing the BaseUnits

Connecting different potentials to the AUX bus

Note

If you apply different potentials to the power or AUX bus within an ET 200SP station, you need to separate the potential groups with a BaseUnit BU...D.

3.4.2 Forming potential groups with AC I/O modules

Introduction

The AC I/O modules of the ET 200SP are required to connect sensors/actuators with alternating voltage 24 to 230 V AC.

Requirements

BaseUnits BU20-P12+A0+4B (BU type B1) and

- DI 4x120..230VAC ST digital input module
- DQ 4x24..230VAC/2A ST digital output module

Operating principle

Connect the required alternating voltage for the AC I/O modules directly at the BaseUnits BU20-P12+A0+4B (terminals 1L, 2L/1N, 2N). Insert the AC I/O modules on the BaseUnits.

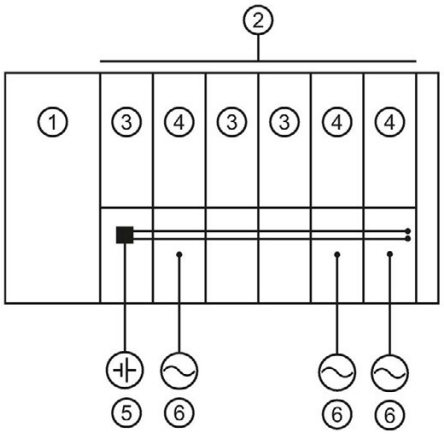
Note

Placing the BaseUnits for AC I/O modules

If you insert an AC I/O module as the first I/O module, a BaseUnit BU20-P12+A0+4B can be the first BaseUnit to the right of the CPU/interface module in the ET 200SP configuration.

The requirement is that you use a CPU as of V3.0 or IM 155-6 (as of V3.0).

- The BaseUnits BU20-P12+A0+4B do not monitor the connected alternating voltage. Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.
- Remember to take the BaseUnit type into account during configuration.



① CPU/interface module
② 24 V DC potential group
③ BaseUnits with DC I/O modules
④ BaseUnits BU 20-P12+A0+4B with AC I/O modules
⑤ Direct voltage
⑥ Alternating voltage

Figure 3-4 Placing the BaseUnits for the AC I/O modules

3.4.3 Forming potential groups with fail-safe modules

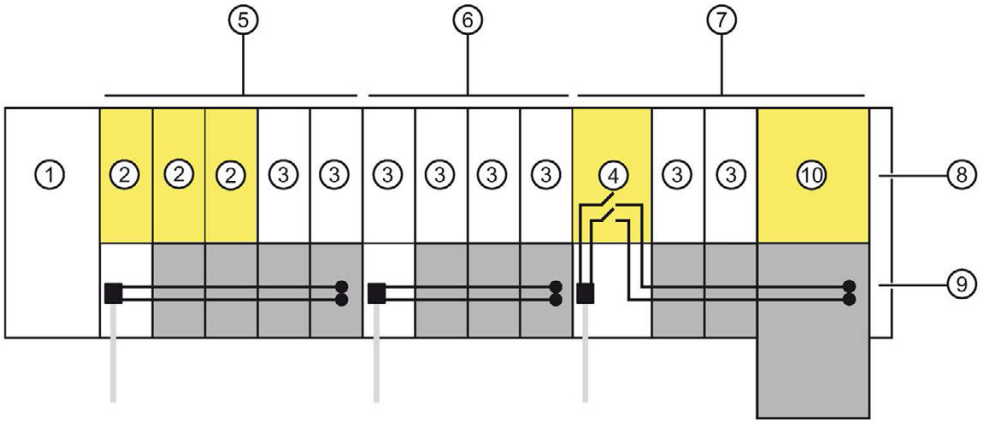
Introduction

ET 200SP distributed I/O systems can be configured using fail-safe and non-fail-safe modules. This chapter provides an example of a mixed configuration comprising fail-safe and non-fail-safe modules.

Example of an ET 200SP configuration with fail-safe and non-fail-safe modules

In principle, it is not necessary to operate fail-safe and non-fail-safe modules in separate potential groups. You can divide the modules into fail-safe and non-fail-safe potential groups and install them.

The figure below shows an example of a configuration with fail-safe and non-fail-safe modules within a single ET 200SP distributed I/O system.



① IM 155-6 PN HF interface module
② F-module
③ Non-fail-safe module
④ Power module F-PM-E 24VDC/8A PPM ST
⑤ Mixed fail-safe and non-fail-safe potential group with BaseUnits BU15..D and BU15..B.
You achieve SIL3/Cat. 4/PLe for the fail-safe modules. No safety category can be achieved with the non-fail-safe motor starter.
⑥ Non-fail-safe potential group with BaseUnits BU15..D and BU15..B
⑦ Fail-safe potential group with BaseUnits BU20..D, BU15..B and BU30-MSx.
Through disconnection of the self-assembling voltage bus, and thus of the non-fail-safe modules, up to SIL2/Cat. 3/PLe is possible.
⑧ Server module
⑨ Self-assembling voltage buses P1/P2
⑩ Fail-safe motor starter F-DS HF

Figure 3-5 ET 200SP - example of a configuration with fail-safe modules

3.4.4 Forming potential groups with motor starters

Properties of the 500 V AC infeed bus

The infeed bus has the following properties:

- The infeed bus is assembled by lining up the motor starter BaseUnits "BU30-MSx".
- The infeed bus distributes the energy to the SIMATIC ET 200SP motor starter within one load group.
- You can open load groups by inserting a 500 V infeed BaseUnit (BU30-MS1, BU30-MS2 or BU30-MS5). With the BaseUnits BU30-MS3, BU30-MS4 or BU30-MS6, you can take over the infeed bus from the left-hand BaseUnit.
- Via the infeed bus, you have the option of supplying three-phase load groups via L1, L2 and L3 or with single-phase load groups via L and N.
- The permissible voltage range is between 48 and 500 V AC.
- The maximum current carrying capacity is up 32 A (3-phase) at 50 °C and 500 V. Pay attention to the derating values depending on the configuration.

Properties of the self-assembling voltage bus (L+)

Self-assembling voltage buses have the following properties:

- Maximum current: 7 A
- Rated voltage: 24 V

Pay attention to the derating values depending on the configuration.

The AUX1 bus is not supported in the BaseUnits of the SIMATIC ET 200SP motor starters.

WARNING

Electric shock when operating the infeed bus without touch protection cover

There is a risk of electric shock when touching the infeed bus if you have not fitted a touch protection cover on the infeed bus on the right.

Always fit a touch protection cover on the infeed bus on the right (article number: 3RK1908-1DA00-2BP0).

WARNING

Electric shock when operating a BaseUnit without an inserted motor starter

If you fit a BaseUnit for motor starters without cover (e.g. option handling), there is a risk of an electric shock when touching the BaseUnit.

Always fit a cover on the BaseUnit (article number: 3RK1908-1CA00-0BP0).

Requirements

Use the following devices to form potential groups with motor starters:

- BaseUnits BU30-MSx
- 3RK1308-0xx00-0CP0 motor starters

Operating principle

Feed in the supply voltage L+ via the BaseUnit BU30-MS1 and BU30-MS3 at the 24V DC and M terminals.

You can operate the motor starter on a single-phase (L1, N, PE) or a three-phase (L1, L2, L3, PE) AC voltage system. You connect the required AC voltage directly to the BaseUnits BU30-MSx (terminals L1, L2(N), L3, PE). You plug the motor starter onto the BaseUnits.

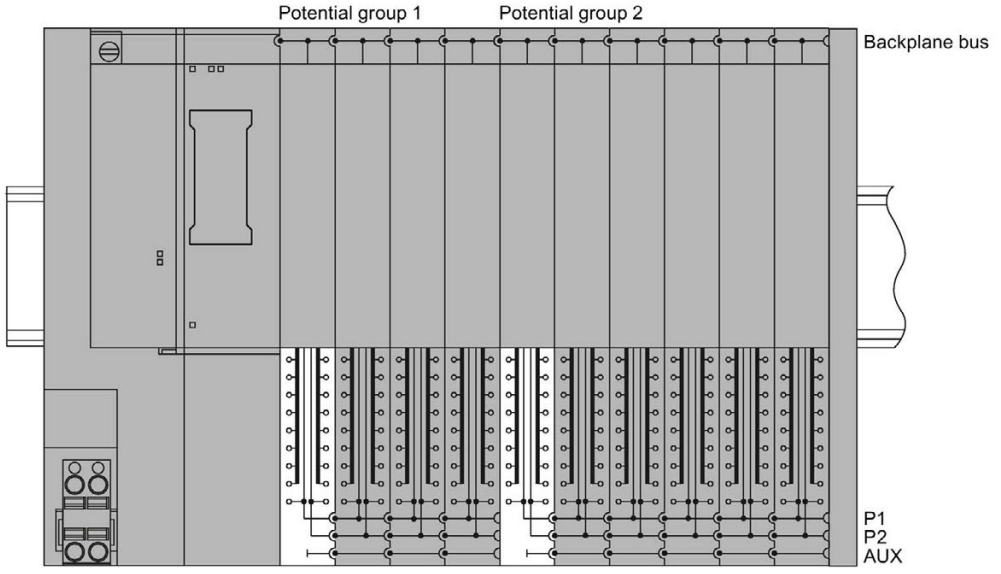
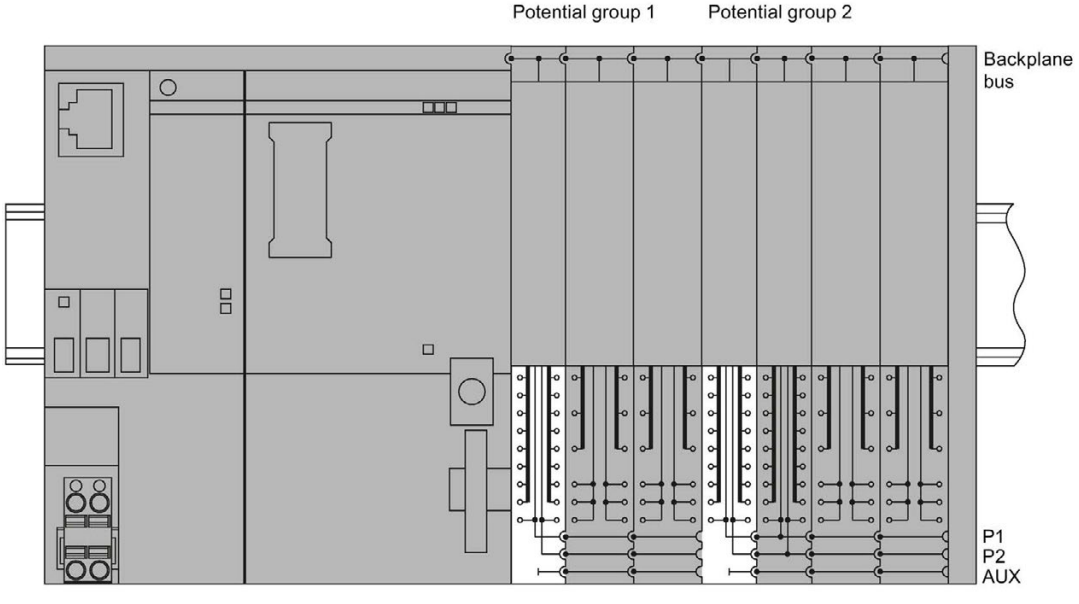
Note

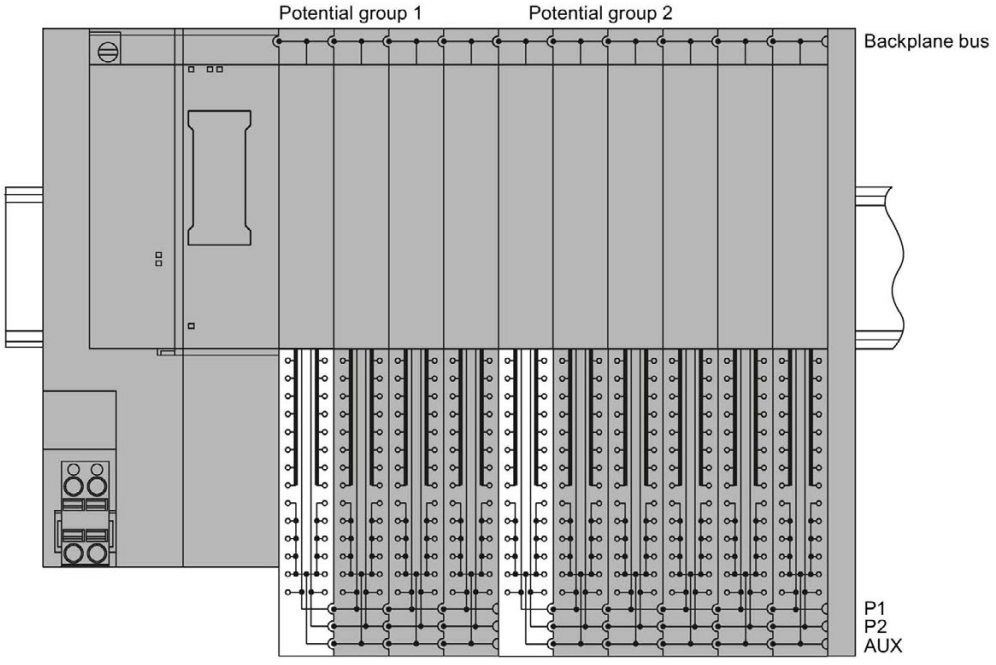
The motor starters' AC power supply is not connected to the AC power supply for the AC I/O modules (see Chapter "Forming potential groups with AC I/O modules (Page 47)").

3.5 Configuration examples for potential groups

Configuration examples with BaseUnits

Table 3- 4 Configuration examples with BaseUnits

BaseUnits	Configuration
BU15-P16+A0+2D BU15-P16+A0+2B	
BU15-P16+A0+2D BU15-P16+A0+2B BU20-P12+A0+0B	

BaseUnits	Configuration
BU15-P16+A10+2D BU15-P16+A10+2B	

Installation

4

4.1 Basics

Introduction

All modules of the ET 200SP distributed I/O system are open equipment. This means you may only set up the distributed I/O system ET 200SP in enclosures, cabinets or electrical equipment rooms and in a dry environment (IP20 degree of protection). These enclosures, cabinets or electrical equipment rooms must only be accessible with a key or tool. Access must only be possible for personnel instructed or authorized to work with such equipment.

Installation location

Install the ET 200SP distributed I/O system into a suitable housing/control cabinet with sufficient mechanical strength, fire protection and at least IP54 degree of protection according to EN 60529, and take into consideration the ambient conditions for operating the devices.

Installation position

You can mount the ET 200SP distributed I/O system in any position. The preferred mounting position is horizontal mounting on a vertical wall. The ambient temperature may be restricted in certain installation positions. You will find more information in the section Mechanical and climatic environmental conditions (Page 279).

You can only install motor starters vertically, horizontally or on their backs. Pay attention to chapter "Installation conditions for motor starters (Page 58)" when using motor starters.

Mounting rail

Mount the ET 200SP distributed I/O system on a mounting rail in accordance with EN 60715 (35 × 7.5 mm or 35 × 15 mm).

You need to ground the mounting rail separately in the control cabinet. Exception: If you install the rail on grounded, zinc-plated mounting plates, there is no need to ground the rail separately.

Note

If the ET 200SP distributed I/O system is exposed to vibration and shock loads, both ends of the ET 200SP system assembly must be mechanically fixed to the mounting rail (e.g using 8WA1010-1PH01 ground terminals). This measure prevents the ET 200SP distributed I/O system from shifting to the side.

Note

If the ET 200SP distributed IO system is exposed to increased vibrations and shock, we recommend that you screw the mounting rail to the mounting surface at intervals of approx. 200 mm.

The following are suitable surfaces for the mounting rails:

- Steel strip in accordance with Appendix A of EN 60715 or
- Tinned steel strip. We recommend these in conjunction with the mounting rails in the section Accessories/spare parts (Page 286).

  Note

  If you use mounting rails from other manufacturers, make sure that they have the required properties for your ambient climatic conditions.

Minimum clearances

The figure below shows the minimum clearances you must observe when installing or dismantling the ET 200SP distributed I/O system.

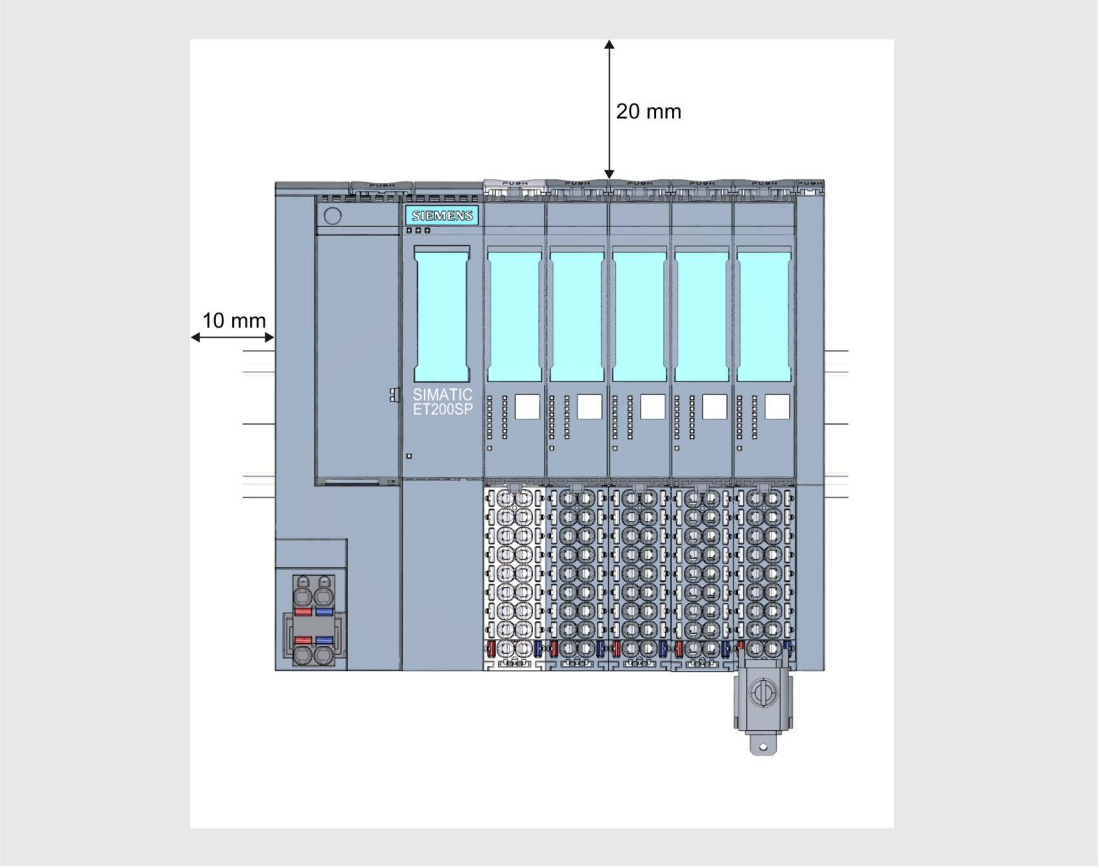


Figure 4-1 Minimum clearances

General rules for installation

⚠WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

Observe the following rules:

- Installation starts on the left-hand side with the CPU/interface module.
- A light-colored BaseUnit BU..D0, BU30-MS1 or BU30-MS3 with infeed of the supply voltage L+ follows the CPU/the interface module or is placed at the start of each potential group.
  If you fit an AC I/O module or an AI Energy Meter as the first I/O module, then the first BaseUnit in the structure of the distributed I/O system ET 200SP may be a dark-colored BaseUnit. The requirement is that you use a CPU or IM 155-6 (as of V3.0).
- This is followed by BaseUnits BU..B, BU30-MS2 or BU30-MS4 (with a dark-colored terminal box).
- The matching I/O modules / motor starters can be plugged onto the BaseUnits. You will find matching combinations of BaseUnits and I/O modules / motor starters in Application planning (Page 32).
- The server module completes the configuration of the ET 200SP distributed I/O system.

Note

Mount the ET 200SP distributed I/O system only with disconnected supply voltage.

For fail-safe ET 200SP modules:

⚠WARNING

Protection from conductive contamination

Taking into account the environmental conditions, the devices must be protected from conductive contamination.
This can be achieved, for example, by installing the devices in a control cabinet with the appropriate degree of protection.

4.2 Installation conditions for motor starters

Observe the following installation conditions when using an ET 200SP motor starter:

- Mounting position
  You can install the motor starter vertically, horizontally or on its back. The mounting position refers to the alignment of the mounting rail The maximum permissible ambient temperature range depends on the mounting position:
  - Up to 60° C: Horizontal mounting position
  - Up to 50° C: Vertical and recumbent mounting position

  Also take into account the current carrying capacity of the ET 200SP components.

  In the case of a vertical mounting position, use end retainers "8WA1808" at both ends of the ET 200SP station:
- Mounting rail

  Use one of the following mounting rails:
  - 35x15 mm DIN rail in accordance with DIN EN 60715
  - 35x7.5 mm DIN rail in accordance with DIN EN 60715
  - SIMATIC S7 mounting rail
- Current carrying capacity of the ET 200SP station
  Current carrying capacity refers to the current load via the power bus and the infeed bus of the ET 200SP station.

Depending on the ambient conditions and mounting position, you have to take account of the fan unit or additional mechanical fixings.

Mechanical brackets

Use the mechanical brackets in the following situations:

- When using a 15 mm mounting rail
- With a vertical mounting position
- For applications according to shipbuilding standards in all mounting positions with 7.5 mm and 15 mm mounting rails

Designing interference-free motor starters

For interference-free operation of the ET 200SP station in accordance with standard IEC 60947-4-2, use a dummy module before the first motor starter.

Note the following mounting rules:

Use the following dummy module on the standard mounting rail between the previous module and the SIMATIC ET 200SP motor starter:

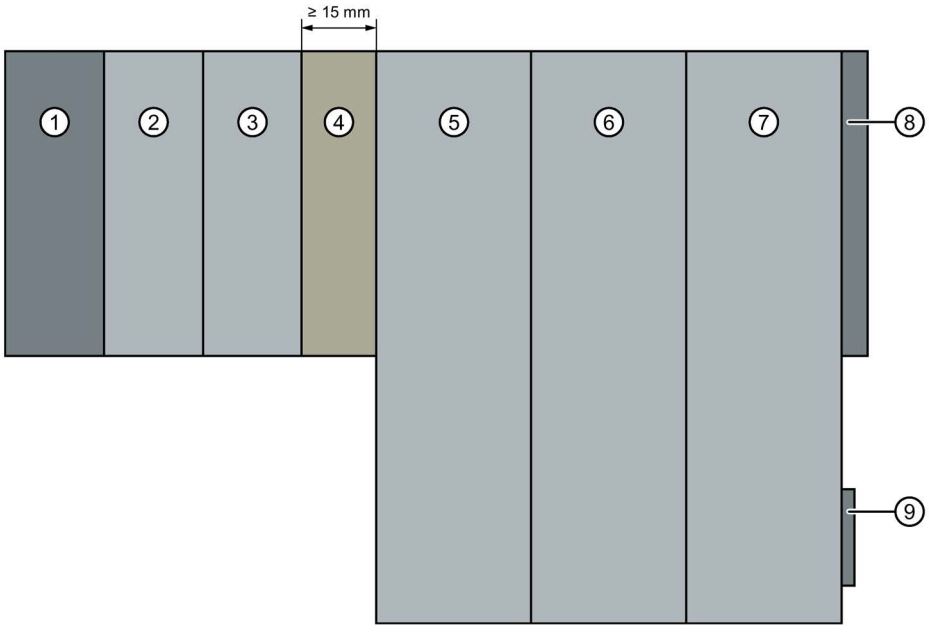
BU cover 15 mm: 6ES7133-6CV15-1AM0 with BaseUnit 6ES7193-6BP00-0BA0

For operation of the ET 200SP station with an unused BaseUnit, a cover must be provided for the open BaseUnit plug contacts (power connector, power bus connector, and backplane bus connector).

The cover protects the plug contacts against dirt. The BU cover can be ordered as an accessory.

Mount the dummy module

The figure below provides a schematic representation of how to implement measures for improving interference immunity.



① Interface module
② Digital input module
③ Digital output module
④ Dummy module
⑤ Motor starter
⑥ Motor starter
⑦ Motor starter
⑧ Server module
⑨ Infeed bus cover

NOTICE
Ensure interference immunity You must not plug any other module into the BaseUnit of the dummy module, otherwise interference immunity is no longer ensured.

4.3 Mounting the CPU/interface module

Introduction

The CPU/the interface module connects the ET 200SP distributed I/O system to the fieldbus and exchanges the data between the higher-level control system and the I/O modules / motor starters.

Requirement

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only for mounting and removing the BusAdapter)

Mounting the CPU/interface module

Watch the video sequence (http://support.automation.siemens.com/WW/view/en/95886218)

To install a CPU/interface module, follow these steps:

1. Install the CPU/interface module on the mounting rail.
2. Swivel the CPU/interface module towards the back until you hear the mounting rail release button click into place.

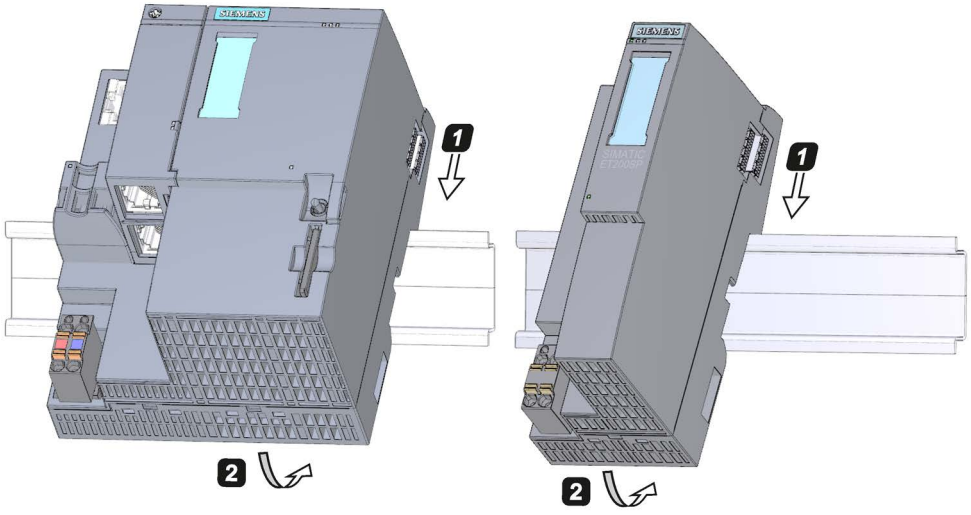


Figure 4-2 Mounting the CPU/interface module

Dismantling the CPU/interface module

The CPU/interface module is wired and BaseUnits are located to its right.

To remove the CPU/interface module, follow these steps:

1. Switch off the supply voltage on the CPU/interface module. Remove the 24 V DC connector from the CPU/interface module.
2. Press the mounting rail release button on the first BaseUnit. At the same time, shift the CPU/interface module parallel to the left until it detaches from the rest of the module group.

   Note: The mounting rail release button is located above the CPU/interface module or BaseUnit.
3. While pressing the mounting rail release button on the CPU/interface module, swivel the CPU/interface module off of the mounting rail.

Note

It is not necessary to remove the BusAdapter from the CPU/interface module.

4.4 Installing the CM DP communication module

Introduction

You need the CM DP communication module to use the CPU with a DP master or DP slave.

Requirements

- The mounting rail is fitted.
- The CPU is installed.

Installing CM DP

To install the CM DP communication module, follow these steps:

1. Install the CM DP to the right of the CPU.
2. Swivel the CM DP towards the back until you hear the mounting rail release button click into place.
3. Slide the CM DP to the left until you hear it click into the CPU.

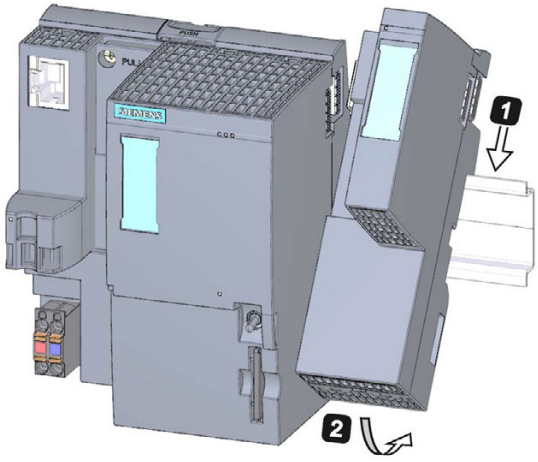


Figure 4-3 Installing CM DP

Removing a CM DP

The CPU and the CM DP are wired and BaseUnits are located to its right.

To remove the CM DP communication module, follow these steps:

1. Switch off the supply voltage on the CPU.
2. Press the mounting rail release button on the first BaseUnit and, at the same time, move the CPU and the CM DP parallel to the left until they detach from the rest of the module group (clearance about 16 mm).
3. Press the mounting rail release button on the CM DP and move it to the right until it detaches from the CPU (clearance about 8 mm).
4. While pressing the mounting rail release button on the CM DP, swivel the CM DP off of the mounting rail.

Note

It is not necessary to remove the bus connector from the CM DP unless you have to replace the CM DP.

4.5 Mounting BaseUnits for I/O modules

Introduction

The BaseUnits are used for electromechanical connection between the individual ET 200SP components. They also provide terminals for connecting external sensors, actuators and other devices.

Requirements

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only for dismantling the terminal box and the encoding element)

Installing a BaseUnit

Watch "Install configuration" video sequence (http://support.automation.siemens.com/WW/view/en/95886218)

To install a BaseUnit, follow these steps:

1. Install the BaseUnit on the mounting rail.
2. Swivel the BaseUnit backwards until you hear it click into the mounting rail.
3. Slide the BaseUnit parallel to the left until you hear it click into the preceding CPU/interface module or BaseUnit.

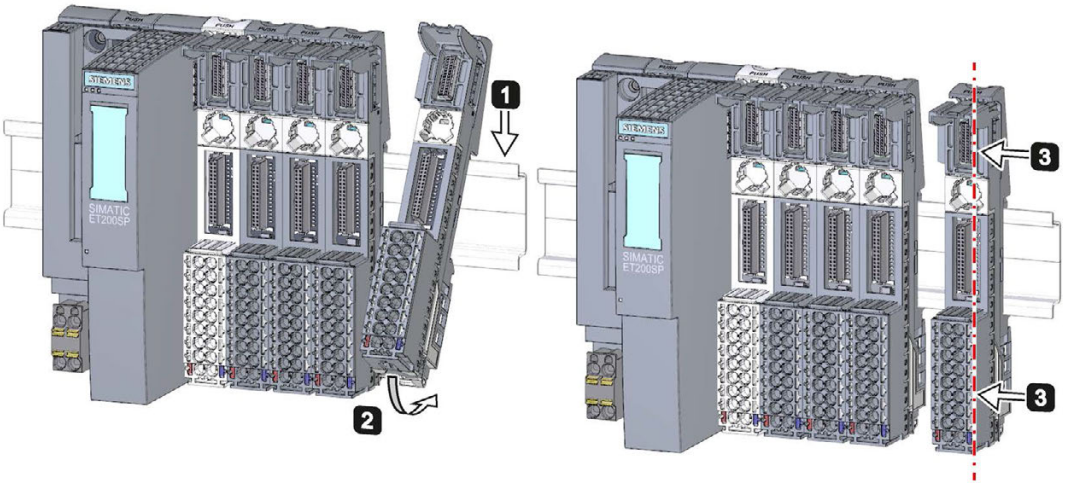


Figure 4-4 Installing a BaseUnit

Removing a BaseUnit

⚠ WARNING

Hazardous Voltage

Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

To remove a BaseUnit, follow these steps:

The BaseUnit is wired and there are other BaseUnits to its right and left.

To remove a specific BaseUnit, move the neighboring modules. As soon as you have created a clearance of about 8 mm from the neighboring BaseUnits, you can remove the BaseUnit.

Note

The terminal box can be replaced without removing the BaseUnit. Refer to section Replacing the terminal box on the BaseUnit (Page 243).

To remove a BaseUnit, follow these steps:

1. If present, turn off the supply voltage on the BaseUnit.
2. Loosen the wiring on the BaseUnit (with a 3 to 3.5 mm screwdriver).
3. **Removing (from the right):**

   Press the mounting rail release button on the corresponding BaseUnit. Move the BaseUnit parallel to the right and swivel the BaseUnit off of the mounting rail while pressing the mounting rail release button.

   Removing (from the left):

   Press the mounting rail release button on the corresponding BaseUnit and on the BaseUnit to the right of this. Move the BaseUnit parallel to the left and swivel it out of the mounting rail while pressing the mounting rail release button.

   Note: The mounting rail release button is located above the BaseUnit.

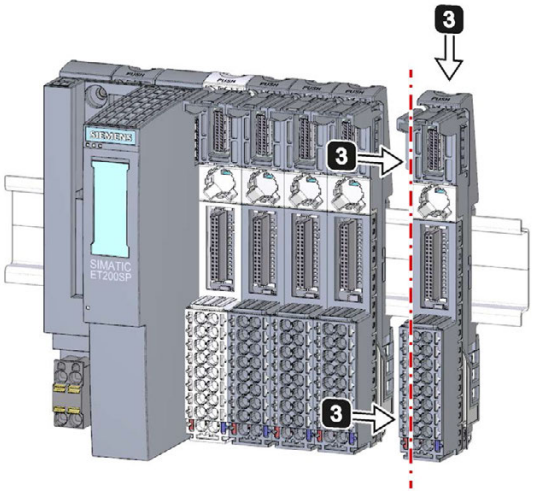


Figure 4-5 Removing the BaseUnit (removing from the right)

4.6 Mounting and dismantling BaseUnits for motor starters

Requirements

- The mounting rail is fitted.
- When using a 15 mm mounting rail, the mechanical bracket (3RK1908-1EA00-1BP0) must be mounted.

Note
Mechanical bracket for BaseUnit
You will find out how to mount the mechanical bracket for the BaseUnit in chapter "Mounting the mechanical bracket for the BaseUnit (Page 71)".

CAUTION

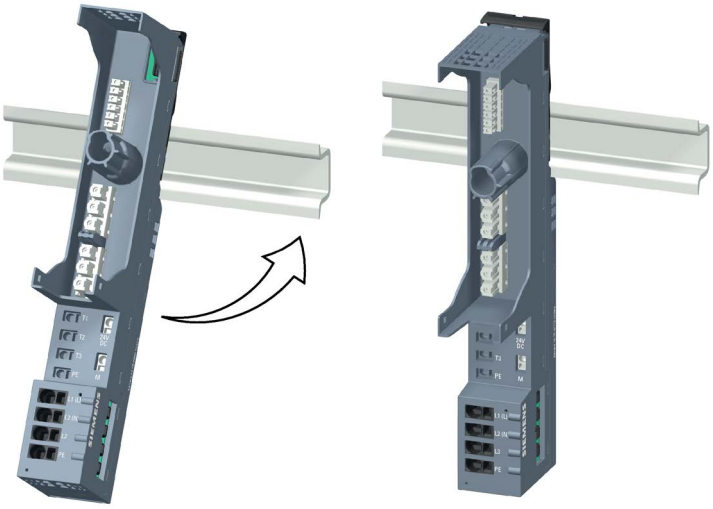
Protection against electrostatic charge

When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

Mounting a BaseUnit

Proceed as follows to mount a BaseUnit for motor starters:

1. Hook the BaseUnit into the DIN rail from above.
2. Swing the BaseUnit to the rear until the BaseUnit audibly engages.



3. Slide the individual BaseUnits to the left to the previous BaseUnit until they audibly engage.

   Assemble the BaseUnits only on the DIN rail.

Note

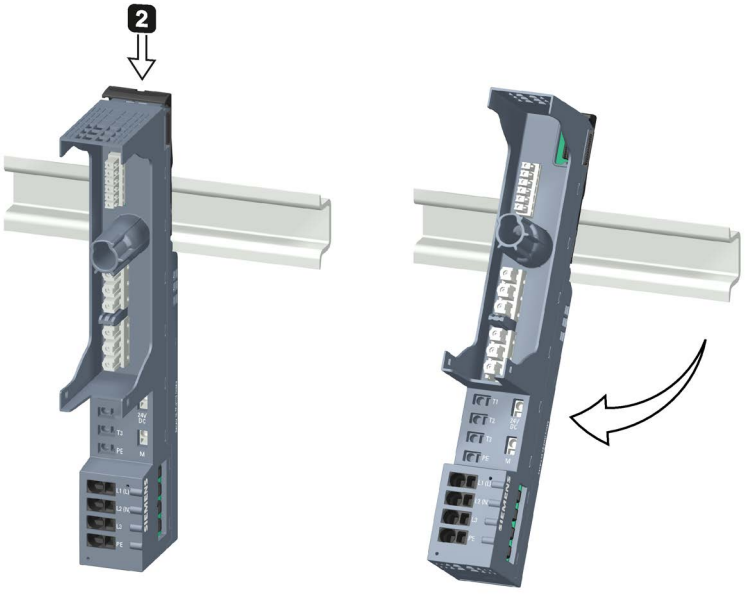
The BaseUnits for motor starters can be plugged together with the BaseUnits for I/O modules.

Disassembling the BaseUnit

WARNING
Hazardous Voltage Hazardous electrical voltage can cause electric shock, burns and property damage. Disconnect your system and devices from the power supply before starting any assembly tasks.

To disassemble the BaseUnit, proceed as follows:

1. Disconnect the main power supply and the control current supply of the SIMATIC ET 200SP motor starter.
2. Actuate the DIN rail release on the BaseUnit of the motor starter.
3. Move the BaseUnit to the left. As soon as there is a clearance of approximately 8 mm to the neighboring BaseUnits, you can disassemble the BaseUnit of the motor starter.
4. Swing the BaseUnit away from the DIN rail while pressing the DIN rail release.



4.7 Installing the server module

Introduction

The server module on the far right of the assembly/line completes the ET 200SP distributed I/O system.

Requirement

The last BaseUnit is mounted.

Installing the server module

Watch "Install configuration" video sequence (http://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a server module:

1. Install the server module on the mounting rail on the right next to the last BaseUnit.
2. Swivel the server module backwards on the mounting rail.
3. Move the server module parallel to the left until you hear it click into the last preceding BaseUnit.

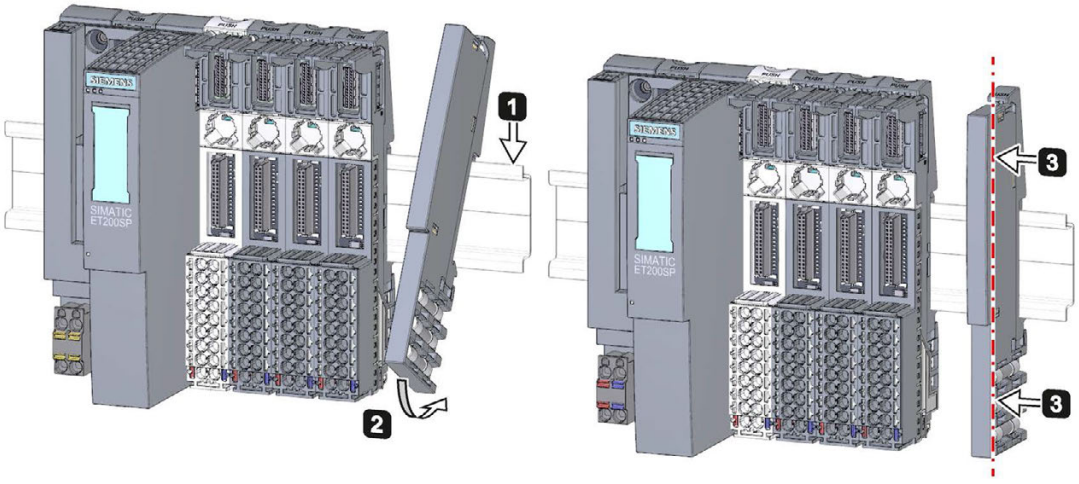


Figure 4-6 Installing the server module

Removing the server module

Proceed as follows to remove a server module:

1. Press the mounting rail release button on the server module.
2. Move the server module parallel to the right.
3. While pressing the mounting rail release button, swivel the server module off the mounting rail.

4.8 Mounting further accessories for motor starters

4.8.1 Mounting the cover for the 500 V AC infeed bus

Introduction

The 500 V infeed bus connects all SIMATIC ET 200SP motor starters. For finger-safe termination of the infeed bus, you must use the cover.

DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage causes electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

DANGER

Infeed bus - electric shock

You must provide the infeed bus with a touch protection cover on the right (Article No.: 3RK1308-1DA00-2BP0).

Failure to do so will result in the danger of electric shock.

WARNING

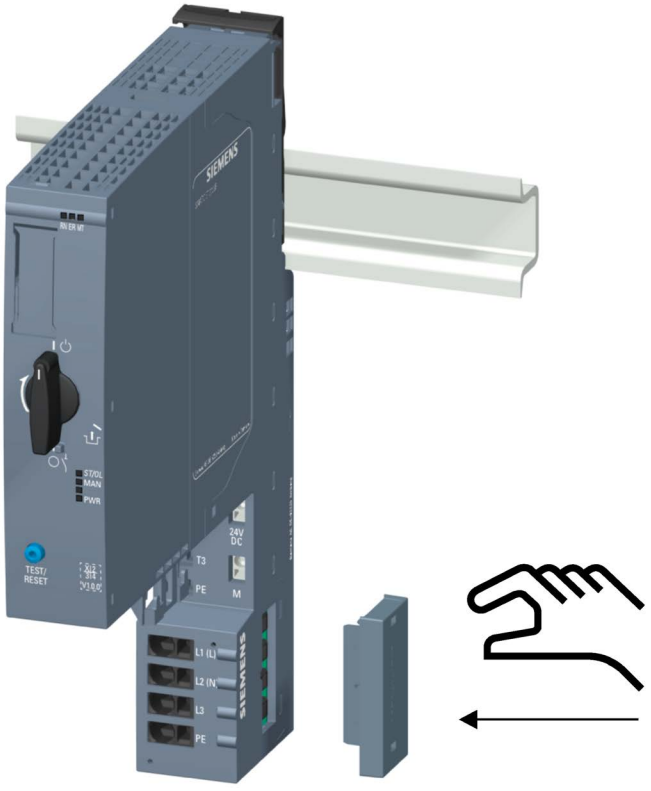
Personal injury may occur

On the last plugged-in BaseUnit of a motor starter, place a cover on the opening of the contacts of the infeed bus.

Procedure

Proceed as follows to mount the infeed bus cover on a SIMATIC ET 200SP motor starter:

1. Press the cover onto the opening of the BaseUnit on the right until it audibly engages.

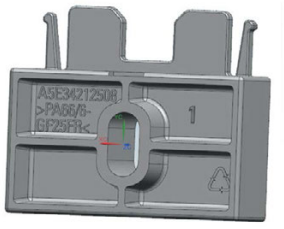


The cover can be removed again using 2 fingers and without tools.

4.8.2 Mounting the mechanical bracket for the BaseUnit

Introduction

To achieve higher stability, you can use a mechanical bracket on 7.5 mm and 15 mm mounting rails.



You must use the mechanical bracket in the following situations:

- When using a 15 mm mounting rail
- With a vertical mounting position
- For applications according to shipbuilding standards in all mounting positions with 7.5 mm and 15 mm mounting rails

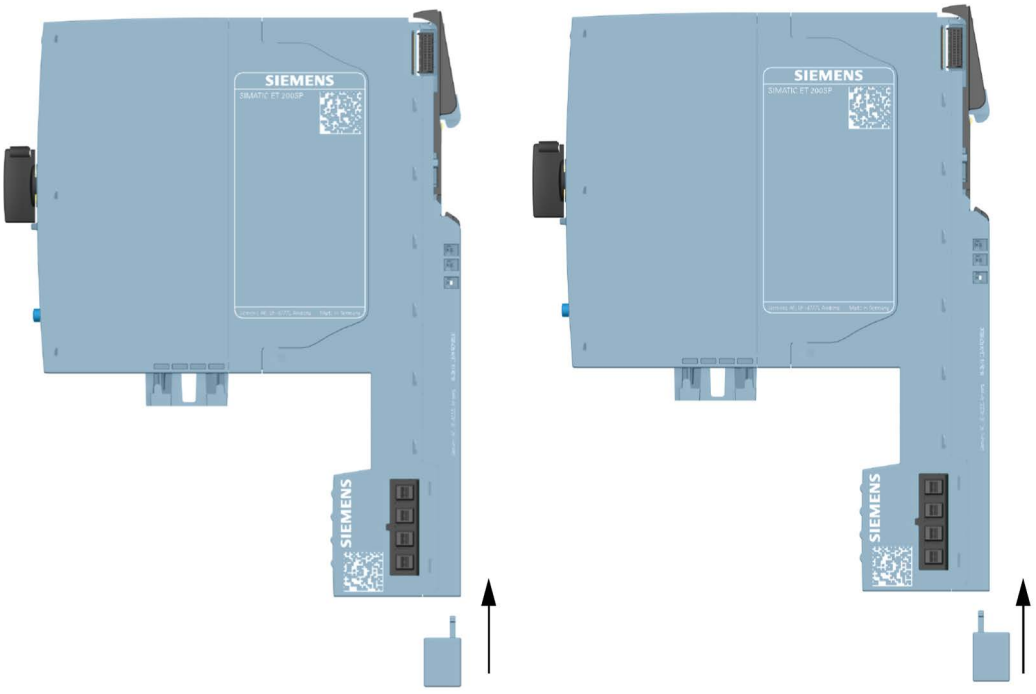
You can find further information on the mechanical bracket in chapter "Installation conditions for motor starters (Page 58)".

Procedure

To mount the mechanical bracket, proceed as follows:

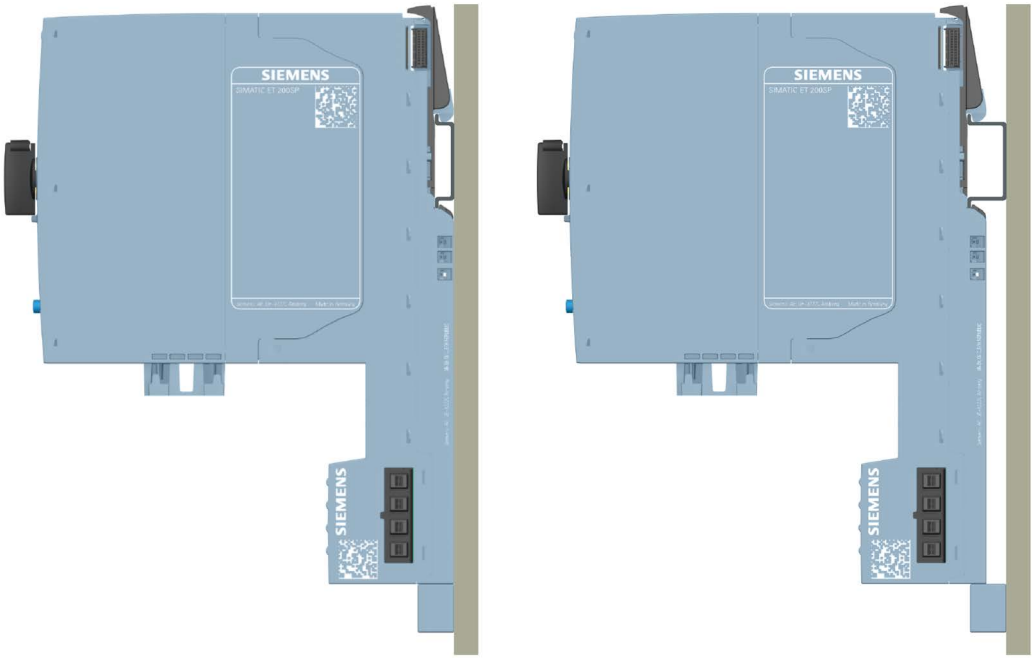
1. Insert the mechanical bracket into the opening at the bottom of the BaseUnit.

   You use the same mechanical bracket for both mounting rails, rotated through 180° respectively.



2. Hook the BaseUnit into the mounting rail.
3. Insert the mechanical bracket into the BaseUnit.
4. Screw the mechanical bracket securely onto the mounting panel. Use an M4 screw and a suitable washer.

The figures below show the mechanical bracket after installation on a 7.5 mm or 15 mm mounting rail.



4.8.3 Mounting the BU cover

Introduction

BU covers are plugged onto BaseUnits whose slots have been reserved for future expansion (as empty slots). The BU covers for motor starters serve as touch protection covers for unoccupied slots.

DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage causes electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

DANGER

BaseUnit without motor starter - electric shock

If you install a BaseUnit without motor starter in the ET 200SP system (e.g. options handling), you must provide the BaseUnit with a BU cover (Article No: 3RK1908-1CA00-0BP0).

Failure to do so will result in the danger of electric shock.

Procedure

To mount the BU cover onto a SIMATIC ET 200SP motor starter, insert the BU cover in the BaseUnit in parallel until both interlocks audibly engage.

Wiring

5

5.1 Rules and regulations for operation

Introduction

When installing the ET 200SP distributed I/O system as part of a plant or system, special rules and regulations need to be adhered to depending on the area of application.

This section provides an overview of the most important rules that must be observed for the integration of the ET 200SP distributed I/O system in a plant or system.

Specific application

Adhere to the safety and accident prevention regulations applying to specific applications, for example machine protection guidelines.

EMERGENCY STOP devices

EMERGENCY STOP devices in accordance with IEC 60204 (corresponds to DIN VDE 0113) must remain effective in all operating modes of the plant or system.

Excluding hazardous plant states

Hazardous operating states must not occur when

- the plant restarts after a voltage dip or power failure.
- Bus communication is reestablished following a fault.

If necessary, EMERGENCY STOP must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY STOP is unlocked.

Line voltage

Below, everything you need to consider in terms of line voltage is described (refer to section Insulation, protection class, degree of protection and rated voltage (Page 281)):

- For fixed plants or systems without an all-pole mains disconnection switch, a mains disconnection device (all-pole) must be available in the building installation.
- For load power supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the ET 200SP distributed I/O system, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

24 V DC supply

Below you will find a description of what you need to pay attention to with 24 V DC supply:

- For buildings: In the event of danger through overload, you must provide lightning protection measures for external lightning protection (e.g. lightning protection elements).
- For 24 V DC supply lines and signal lines: If there is a risk of overvoltages, you need to take precautions to ensure internal lightning protection (e.g. lightning protection elements, refer to section Accessories/spare parts (Page 286)).
- For 24 V DC supply: Ensure safe (electrical) isolation and separate cable laying or increased insulation of the extra-low voltage (SELV/PELV) to circuits with hazardous potentials in accordance with IEC 60364-4-41.

Protection against outside electrical influences

Below is a description of what you must pay attention to in terms of protection against electrical impacts and/or faults:

- Make sure that the system for discharging electromagnetic interference is connected to a protective conductor with sufficient cross-section for all plants with an ET 200SP distributed I/O system.
- For supply, signal and bus lines, you must ensure that the laying of the lines and the installation is correct.
- For signal and bus lines, you must ensure that a wire/cable break or a cross-circuit does not lead to undefined states of the plant or system.

Reference

You can find more information in the Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

5.2 Additional rules and regulations for the operation of the ET 200SP with fail-safe modules

5.2.1 Safety extra low voltage for fail-safe modules and fail-safe motor starters

⚠ WARNING

The fail-safe modules must be operated with safety extra low voltage (SELV, PELV).

You can find more information on safety extra-low voltage in the data sheets, for example, of the applicable power supplies.

The fail-safe modules operate with the 24 V DC rated voltage. The tolerance range is 19.2 V DC to 28.8 V DC.

The fail-safe motor starters operate with the 24 V DC rated voltage. The tolerance range is 20.4 V DC to 28.8 V DC.

Within the overvoltage range from 32 V DC to 36 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages greater than 36 V DC, the F-modules are permanently de-energized.

Use a power supply unit that does not exceed U_m = 36 V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g. use of an overvoltage protector.

All system components that can supply electrical energy in any form whatsoever must fulfill this condition.

Each additional circuit (24 V DC) used in the system must have a safety extra low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.

Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safety extra-low voltage as well. The process signal of a 24 V DC digital module may not exceed a fault voltage U_m in the event of a fault.

⚠ WARNING

Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.

An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which would cause the fault voltage U_m to be exceeded.

Power supply requirements for compliance with NAMUR recommendations

Note

To ensure adherence to the NAMUR recommendation NE 21, IEC 61131-2 and EN 298, only use power packs/power supply units (230 V AC → 24 V DC) with a mains buffering time of at least **20 ms**. The latest up-to-date information on PS components is available on the Internet (https://mall.industry.siemens.com).

These requirements, of course, also apply to power packs/power supply units not constructed using ET 200SP / S7-300-/400-/1500 technology.

5.2.2 Requirements for sensors and actuators for fail-safe modules and fail-safe motor starters

General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:

WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Also bear in mind that sensors and actuators generally do not have proof-test intervals of 20 years as defined in IEC 61508:2010 without considerable loss of safety.

The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. A listing of values achieved by F-modules in the technical specifications of the F-modules is available under "Fail-safe performance characteristics".

To achieve the required safety class, suitably qualified sensors and actuators are necessary.

Additional sensor requirements

General rule: To achieve SIL3/Cat. 3/PLe, a single-channel sensor is adequate. However, to achieve SIL3/Cat. 3/PLe with a single-channel sensor, the sensor itself must be SIL3/Cat. 3/PLe-capable; otherwise the sensor must be connected by two channels to achieve this safety level.

To achieve SIL3/Cat. 4/PLe, sensors must be connected by two channels.

WARNING

In the case of fail-safe input modules, the value "0" is output to the F-CPU after detection of faults. You therefore need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.

Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the relevant actuator when it is in the "0" state (EMERGENCY-STOP button pressed).

Additional requirements for sensors for fail-safe motor starters

Only single-channel sensors that fulfill the required safety category themselves may be connected to the fail-safe motor starter's F-DI. Fail-safe laying must be observed in accordance with the required safety category.

Duration requirements for sensor signals

WARNING

Observe the following requirements for sensor signals:

- To ensure the correct detection of the sensor signals via fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
- For pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

Reliable detection by F-modules with inputs

The minimum duration of sensor signals for F-modules with inputs depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in the section "Response times" of the relevant F-module.

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period) with parameters.

Fast reacting actuators may briefly drop out or be activated during the test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

WARNING

If the actuators switch voltages higher than 24 V DC (e.g. 230 V DC), safe galvanic isolation must be ensured between the outputs of a fail-safe output module and the parts carrying a higher voltage (in compliance with the IEC 60664-1 standard).

This is generally the case for relays and contactors. Particular attention must be paid to this with semiconductor switching devices.

Technical specifications of sensors and actuators

Refer to the manuals of the fail-safe modules for technical specifications to assist you in selecting sensors and actuators.

5.2.3 Crosstalk of digital input/output signals

When fail-safe digital output and input signals are in a single cable, F-DQ modules and F-PM-E modules may experience readback errors.

Cause: capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply of the inputs, the steep switching edge of the output drivers caused by the coupling capacitance of the line may result in crosstalk to other non-activated output or input channels. This may then lead to a response of the readback circuit in these channels. A cross circuit/short-circuit is detected, which leads to safety-related tripping.

Remedy:

- Separate cables for F-DI modules, F-DQ modules, and F-PM-E modules or non-fail-safe DQ modules
- Separate cables for F-DQ channel and F-DI channels for the F-PM-E module
- Coupling relay or diodes in the outputs
- Disable the sensor supply test if safety class requirements allow it.

Cause: magnetic crosstalk

Note that an inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

Remedy:

- Separate the inductive loads spatially or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

5.3 Additional rules and instructions for operation with motor starters

5.3.1 Protection against short circuit

The motor starter complies with type of coordination 1. Secure the feeder cable for the infeed bus according to current, country-specific rules for conductor protection.

⚠ WARNING
Hazardous Voltage at the Motor **Can Cause Death, Serious Injury, or Property Damage.** Following a short-circuit, the SIMATIC ET 200SP motor starter is defective. Replace the motor starter following a short-circuit.

5.4 Operating the ET 200SP on grounded incoming supply

Introduction

Below you will find information on the overall configuration of an ET 200SP distributed I/O system on a grounded incoming supply (e.g. TN-S network). The specific subjects discussed are:

- Disconnecting devices and short-circuit and overload protection according to IEC 60364 (corresponds to DIN VDE 0100) and IEC 60204 (corresponds to DIN VDE 0113)
- Load power supplies and load circuits.

Grounded incoming supply

In the case of grounded incoming supplies (TN-S system) the neutral conductor (N) and the protective conductor (PE) are each grounded. Both conductors form a part of the overvoltage concept. When a plant is in operation, the current flows across the neutral conductor. When a fault occurs, for example, a single ground fault between a live conductor and ground, the current flows through the protective conductor.

Safe electrical isolation (SELV/PELV in accordance with IEC 60364-4-41)

Load current / power supply modules with safe electrical isolation are required for the operation of the ET 200SP distributed I/O system. According to IEC 60364-4-41, this protection is referred to as SELV (Safety Extra Low Voltage)/PELV (Protective Extra Low Voltage).

The wiring of SELV/PELV circuits must either be isolated from the wiring of other circuits that are not SELV/PELV or the insulation of all conductors must be dimensioned for the higher voltage.

Configuration of ET 200SP with ungrounded reference potential

To conduct interference currents, the reference potential of the CPU/interface module and the BaseUnits BU15...D is connected internally via an RC combination (IM/CPU: R = 10 MΩ / C = 100 nF, BU15...D: R = 10 MΩ / C = 4 nF) with the mounting rail (protective conductor).

- This configuration conducts high-frequency interference currents and prevents static charges.
- It is always possible to configure an ungrounded setup of the ET 200SP distributed I/O system as the ET 200SP distributed I/O system has no fixed ground connection. The power pack/power supply module for 24 V DC must also be ungrounded and electrically isolated.

If you want to configure the ET 200SP distributed I/O system with grounded reference potential, connect the 1M connection of the CPU/interface module electrically with the protective conductor.

Short-circuit / overload protection

Various measures as protection against short-circuits and overloads are required for setting up a full installation. The type of components and the binding protective measures depend on which IEC (DIN VDE) regulation applies to your system configuration. The table refers to the figure below and compares the IEC (DIN VDE) regulations.

Table 5- 1 Components and protective measures

	Refer to figure	IEC 60364 (DIN VDE 0100)	IEC 60204 (DIN VDE 0113)
Disconnecting device for controller, sensors, and actuators	①	Main switch	Disconnector
Short-circuit / overload protection: In groups for sensors and actuators	② ③	Single-pole protection of circuits	With grounded secondary circuit: **single-pole** protection otherwise: **all-pole** protection
Load current supply for AC load circuits with more than five items of electromagnetic equipment	②	Galvanic isolation by transformer **recommended**	Galvanic isolation by transformer **recommended**

Permissible cable temperature

Note

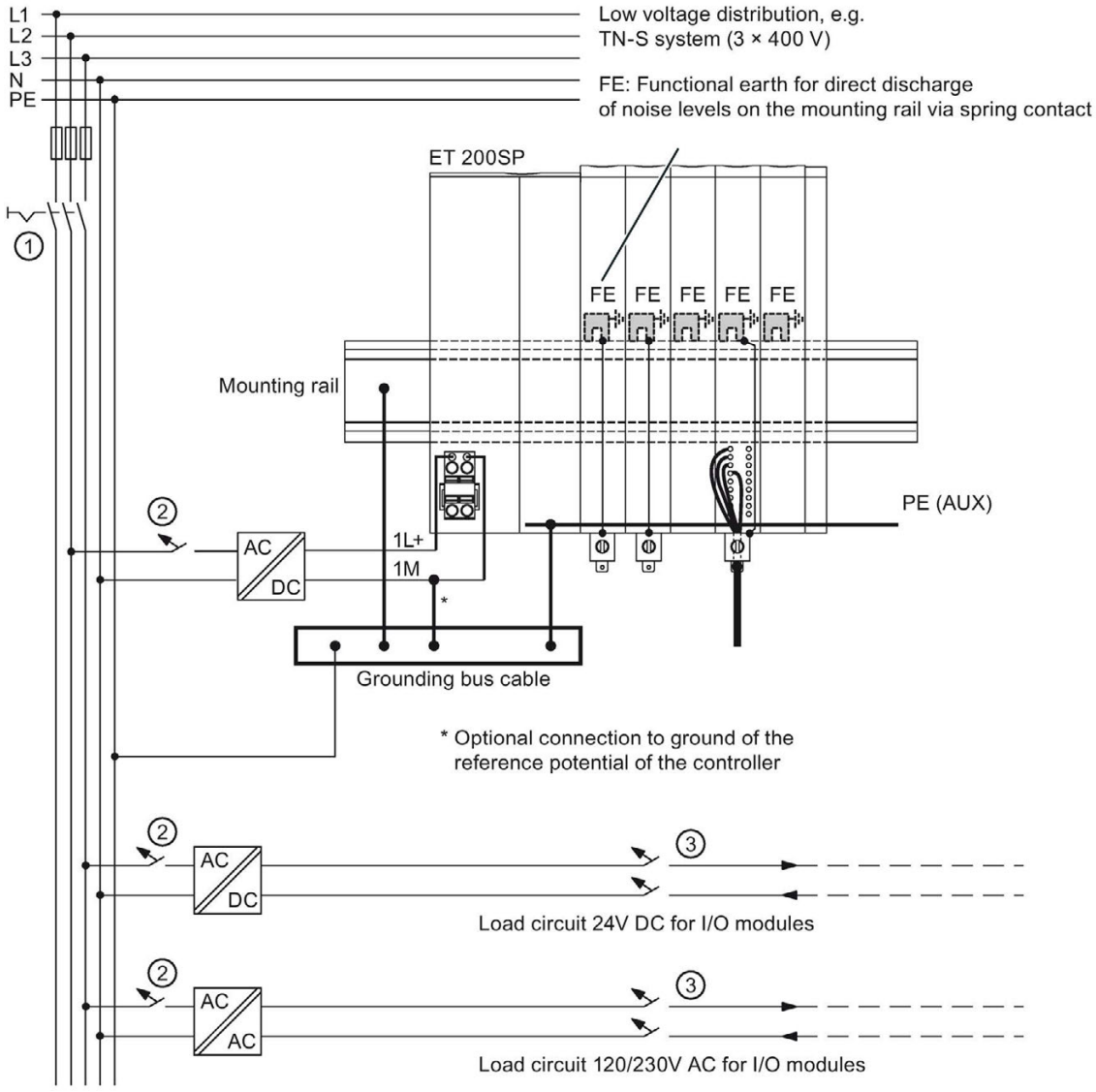
Permissible cable temperature

The minimum permissible cable temperature must be 30 °C more than the ambient temperature of the ET 200SP system (example: at an ambient temperature of 60 °C, a connection conductor must be dimensioned for a temperature range of at least 90 °C).

You should specify other connection types and material requirements based on the electrical characteristics of the circuits you use and the installation environment.

ET 200SP in the overall configuration

The figure below shows the overall configuration of the ET 200SP distributed I/O system (load current supply and grounding concept) with supply from a TN-S network.



① Main switch
② Short-circuit / overload protection
③ The load current supply (galvanic isolation)

Figure 5-1 ET 200SP in the overall configuration

5.5 Electrical configuration of the ET 200SP

Electrical isolation

Electrical relationships

With the ET 200SP distributed I/O system, there is electrical isolation between:

- The load circuits/process and all other circuit components of the ET 200SP distributed I/O system.
- The communication interfaces of the CPU (PROFINET) or of the interface module (PROFINET/PROFIBUS) and all other circuit components.

The figures below show the electrical relationships of the ET 200SP distributed I/O system with the CPU and the interface module. Only the most important components are represented in the figures.

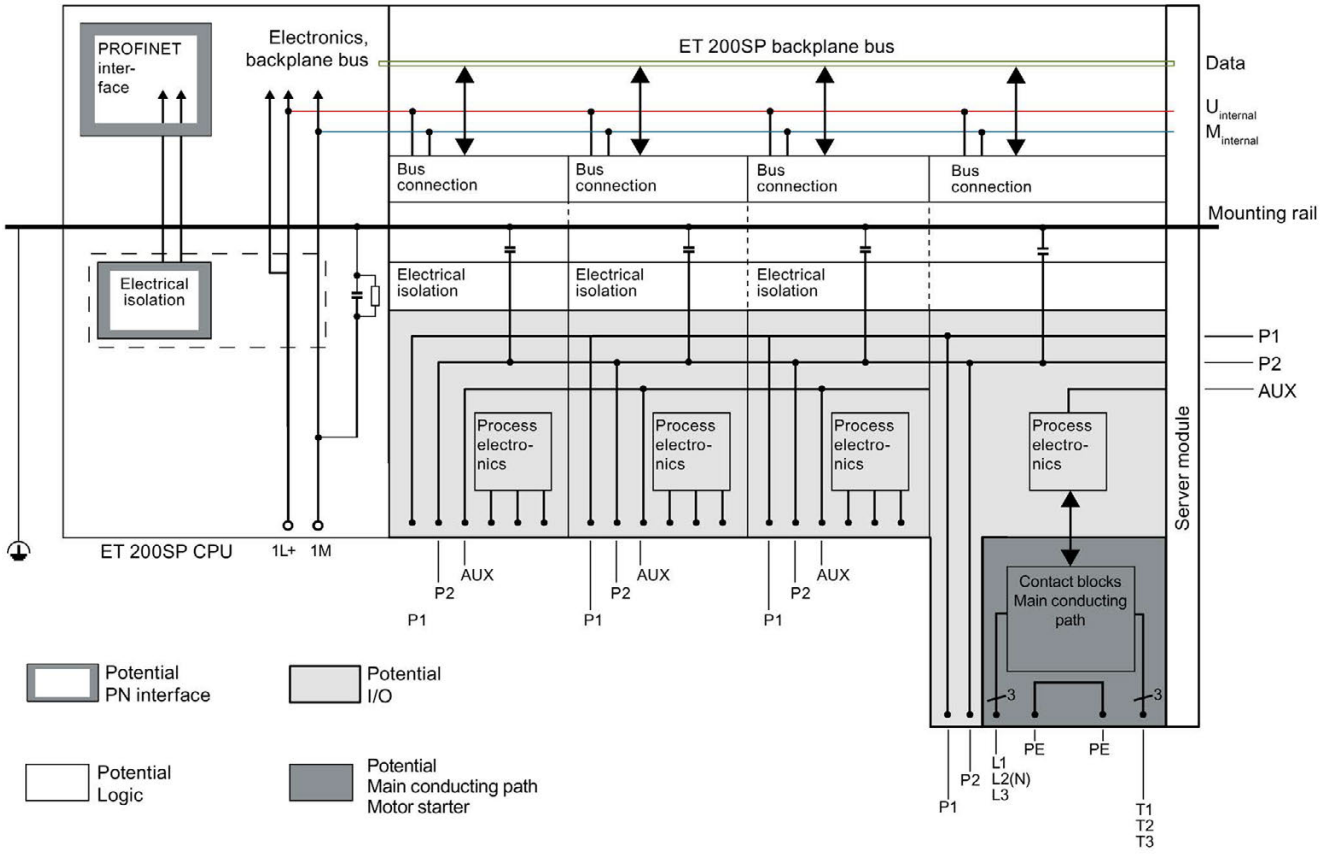


Figure 5-2 Electrical relationships for ET 200SP with CPU

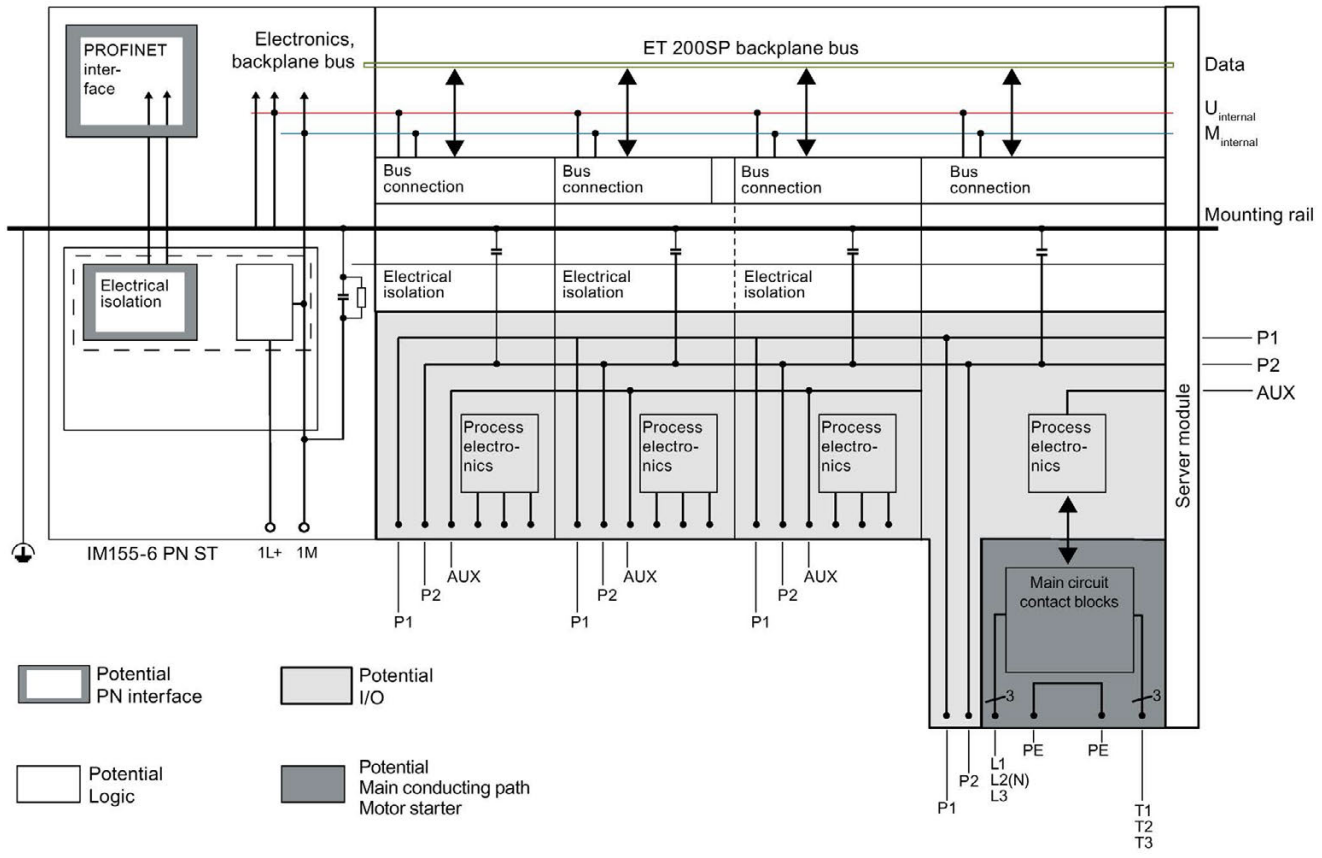


Figure 5-3 Electrical relationships for ET 200SP with interface module (using IM 155-6 PN ST as an example)

5.6 Wiring rules

Wiring rules for the CPU/interface module and BaseUnits for I/O modules

Wiring rules for ...		CPU/interface module (supply voltage)	BaseUnits (push-in terminal)
Connectable cross-sections for solid cables		0.2 to 2.5 mm²	
		AWG*: 24 to 13	
Connectable cross-sections for flexible cables	Without end sleeve	0.2 to 2.5 mm²	
		AWG*: 24 to 13	AWG*: 24 to 14
	With end sleeve (with plastic sleeve)***	0.25 mm to 1.5 mm²**	0.14 mm to 1.5 mm²
		AWG*: 24 to 16	AWG*: 26 to 16
	With TWIN end sleeve***	0.5 mm to 1 mm²	0.5 to 0.75 mm² (see below)
		AWG*: 20 to 17	AWG*: 20 to 18
Stripping length of the wires		8 to 10 mm	
End sleeves in accordance with DIN 46228 with plastic sleeve***		8 and 10 mm long	

* AWG: American Wire Gauge

** End sleeves without plastic sleeve: 0.25 to 2.5 mm²/AWG: 24 to 13

*** See note on end sleeves

Note

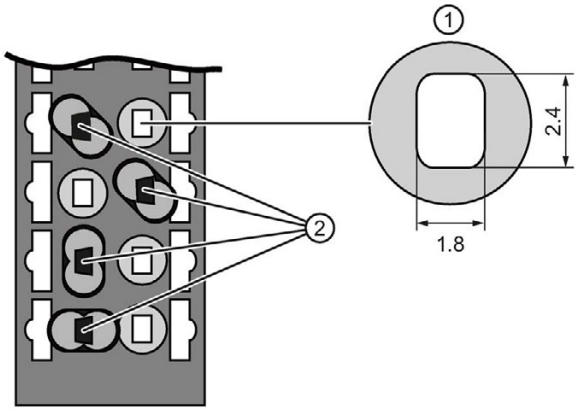
End sleeves

Optimum results with respect to a high-quality and permanent electrical connection with maximum conductor pull forces at the same time can be achieved by using crimping dies, preferably with smooth surfaces, which are provided, for example, with rectangular and trapezoidal crimp cross-sections.

Due to the large number of crimping dies used in the industry, we can recommend others on request. Crimping dies with a pronounced wave profile are unsuitable.

TWIN end sleeves for the cables of the I/O modules' push-in terminals

Due to the space required by TWIN end sleeves with 0.75 mm² cross-section, you must ensure a correct angle for the cable arrangement when crimping the TWIN end sleeve so that the cables are optimally arranged.



① Cross-section of the terminal compartment
② Crimping TWIN end sleeves at the correct angle

Figure 5-4 TWIN end sleeves

Wiring rules for motor starters

Wiring rules for ...		L1(L), L2(N), L3, PE	T1, T2, T3, PE, 24 V DC, F-DI, M	DI1 ... DI3, LC, M, 24 V OUT
Connectable cross-sections for solid cables		1 to 6 mm²	0.5 to 2.5 mm²	0.2 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
Connectable cross-sections for flexible cables	Without end sleeve	1 to 6 mm²	0.5 to 2.5 mm²	0.2 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
	With end sleeve	1 to 6 mm²	0.5 to 2.5 mm²	0.25 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
	With end sleeve (with plastic sleeve)	1 to 4 mm²	0.5 to 1.5 mm²	0.25 to 0.75 mm²
		AWG: 18 to 11	AWG: 20 to 16	AWG: 24 to 18
Stripping length of the wires		15 mm	10 mm	8 mm
End sleeves according to DIN 46228 with plastic sleeve		15 mm long	10 mm long	8 mm long

Safety standards for fail-safe motor starters

Fail-safe motor starters fulfill the following standards under certain conditions:

- PL e/Cat. 4 according to EN ISO 13849-1
- Safety Integrity Level SILCL3 acc. to IEC 62061

To fulfill both standards, lay cross-circuit proof and P-cross-circuit proof control cables from the safe output of a sensor or F-DQ to the safe input of the motor starter, e.g. as a separately sheathed cable or in a separate cable duct.

Line protection

The line protection of the SIMATIC ET 200SP motor starter is provided for the motor outgoing feeder cable when the following condition is met:

The cross-section of the motor outgoing feeder cable must be dimensioned for the load ratios of the motor and for the cable-laying method.

Comply with national regulations. The user is responsible for the correct selection and dimensioning of the motor connection cable to DIN VDE 0100 and DIN VDE 0298-4 and/or UL 508.

The conductor protection for the incoming feeders must be ensured by the owner of the installation depending on the cross-section.

Permissible cable temperature

Note

Permissible cable temperature

The minimum permissible cable temperature must be 30 °C higher than the ambient temperature of the ET 200SP (example: at an ambient temperature of 60 °C, a connection conductor must be dimensioned for a temperature range of at least 90 °C).

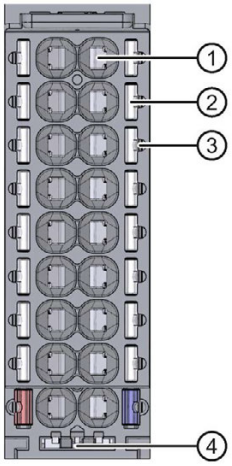
You should specify other connection types and material requirements based on the electrical characteristics of the circuits you use and the installation environment.

5.7 Wiring BaseUnits for I/O modules

Introduction

The BaseUnits connect the ET 200SP distributed I/O system to the process. The following versions of the BaseUnits can be used:

- BaseUnits (with light-colored terminal box) for opening a potential group: BU..D
- BaseUnits (with dark-colored terminal box) for extending the potential group: BU..B
- BaseUnits with additional AUX terminals or additional terminals: BU..+10..
- BaseUnits with integrated thermal resistor for compensation of the reference junction temperature when connecting thermocouples: BU..T



① Push-in terminal
② Spring release
③ Measuring probe (suitable probes: 1 mm diameter, length ≥ 10 mm while observing the permitted voltage category)
④ Holder for shield connection

Figure 5-5 View of the BaseUnit

Note

The pin assignment of the BaseUnit depends on the connected I/O module. Information on the BaseUnits and I/O modules can be found in the associated manuals.

Replacement of the terminal box on the BaseUnit is described in the section Replacing the terminal box on the BaseUnit (Page 243).

Note

Special terminal designations in the wiring and block diagrams of the I/O modules/BaseUnits

- **RES**: Reserve, these terminals must remain unconnected so that they can be used for future expansions
- **n.c.**: Not connected, these terminals have no function. However, they can be connected to potentials specifically defined for a module, for example, for the laying unused wires.

Requirements

- The supply voltages are turned off.
- Follow the wiring rules.
- Color identification labels (Page 137) (optional) have been applied.

Required tools

3 to 3.5 mm screwdriver

Tool-free connection of cables: single-wire without wire end ferrule, multi-wire (stranded) with wire end ferrule or ultrasonically sealed

Watch the video sequence (http://support.automation.siemens.com/WW/view/en/95886218)

To connect a wire without tools, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Only for multi-stranded wires:

   Seal or crimp the wire with wire end ferrules.
3. Insert the wire into the push-in terminal as far as it will go.

Connection of cables: multi-wire (stranded), without wire end ferrule, unprocessed

To connect a wire without a wire end ferrule, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Push with the screwdriver into the spring release.
3. Insert the wire into the push-in terminal as far as it will go.
4. Pull the screwdriver out of the spring release.

Removing wires

Using the screwdriver, press the spring release of the terminal as far as it will go and pull out the wire.

Note

When you press the spring release, you should not pull on the wire/cable at the same time. This prevents you from damaging the terminal.

5.8 Connecting cable shields for I/O modules

Introduction

- You need the shield connector to contact cable shields (e.g. for analog modules). The shield connector conducts interference currents on cable shields to ground via the mounting rail. It is not necessary to contact the shield at where the cable enters the cabinet.
- Attach the shield connector to the BaseUnit.
- The shield connector consists of a shield contact and a shield terminal.
- The shield connector is automatically connected to the functional ground (FG) of the mounting rail after installation.

Requirements

- BaseUnit with a width of 15 mm
- The shield terminal is suitable for cables with max. ∅ 7 mm each.

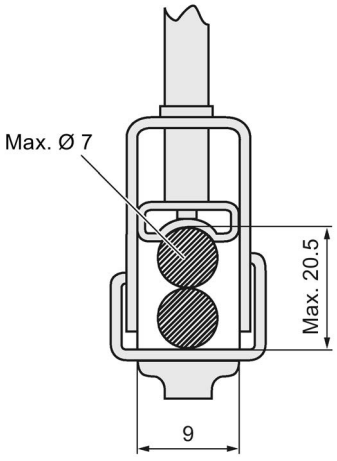


Figure 5-6 Shield terminal

Required tools

- Stripping tool

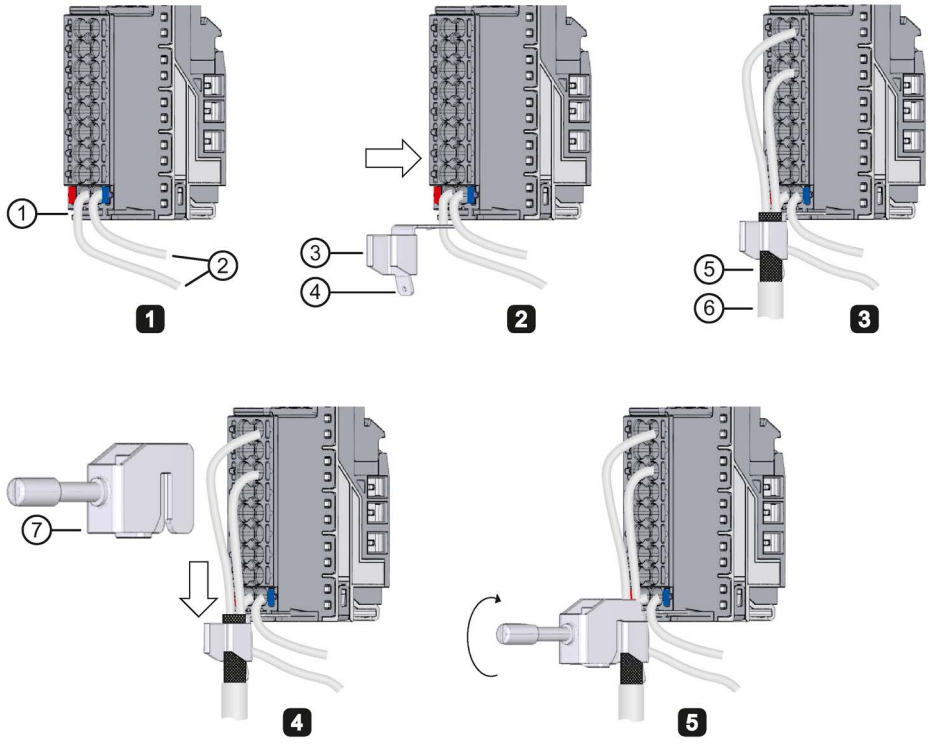
Procedure

Watch the "Wiring BaseUnits" video sequence
(http://support.automation.siemens.com/WW/view/en/95886218)

To connect the cable shield, follow these steps:

1. If necessary, connect the supply voltage L+ and ground to the BaseUnit.
2. Press the shield contact up into the mount until you hear it click into place.
3. Remove the cable insulation material around the shield terminal.

   Connect the cable to the BaseUnit and place the cable in the shield contact.
4. Insert the shield terminal into the shield contact.
5. Tighten the shield terminal with approximately 0.5 Nm.



①	Mount	⑤	Insulation material removed (approx. 20 mm)
②	Supply voltage L+, ground	⑥	Cable to the encoder
③	Shield contact	⑦	Shield terminal
④	Flat connector for push-on contacts (6.3 × 0.8 mm)		

Figure 5-7 Mounting the shield contact

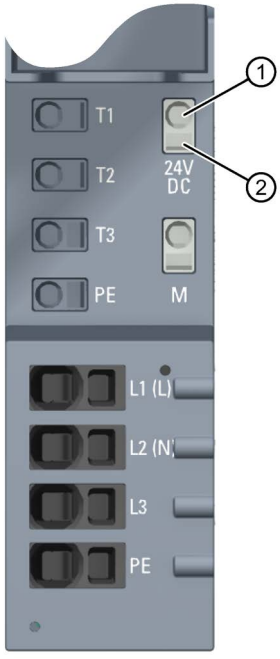
5.9 Wiring BaseUnits for motor starters

Introduction

The following versions of BaseUnits can be used:

- BU30-MS1 (with 500 V and 24 V infeed)
- BU30-MS2 (with 500 V infeed and 24 V forwarding)
- BU30-MS3 (with 24 V infeed and 500 V forwarding)
- BU30-MS4 (with 500 V and 24 V forwarding)
- BU30-MS5 (with 500 V infeed, 24 V and F-DI forwarding)
- BU30-MS6 (with 500 V, 24 V and F-DI forwarding)

The following figure shows an example of a BaseUnit BU30-MS1 (with the maximum number of terminals):



① Push-in terminal
② Spring release

Figure 5-8 Terminals on a BaseUnit BU30-MS1

The following figure shows an example of a BaseUnit BU30-MS5 (with the maximum number of terminals):

① Push-in terminal
② Spring release

Figure 5-9 Terminals on a BaseUnit BU30-MS5

DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage can cause electric shock, burns and property damage.

Turn off and lock out all power supplying this device before working on this device.

For wiring finely-stranded or stranded conductors without end sleeves on push-in connections, a screwdriver is required.

Requirements

- The supply voltages are switched off
- Observe the wiring rules

Required tools

Use the screwdriver "SZF 1-0.6x3.5" (for finely-stranded cables only).

Connecting conductors: Solid without end sleeve, stranded (stranded wire) with end sleeve

To connect a cable, proceed as follows:

1. Insulate the cables in accordance with the table in chapter "Wiring rules (Page 87)".
2. Only in the case of stranded conductors:

   Crimp the cable with end sleeves.
3. Insert the cable into the push-in terminal as far as it will go.
4. Pull on the cable to ensure it is tight.

Connecting conductors: multi-wire (stranded), without end sleeve, unfinished

To connect a cable, proceed as follows:

1. Insulate the cables in accordance with the table in chapter "Wiring rules (Page 87)".
2. Press the screwdriver into the spring release.
3. Insert the conductor into the push-in terminal until it engages.
4. Pull the screwdriver out of the spring release.
5. Check whether or not the conductor is firmly connected by pulling on the cable.

Video sequence

At the following Internet link, you can see a video about connecting conductors: Wire BaseUnits (http://support.automation.siemens.com/WW/view/en/95886218)

Releasing conductors

To release a conductor, proceed as follows:

1. Press the screwdriver into the spring release of the terminal until it engages.
2. Pull the conductor out.

Note

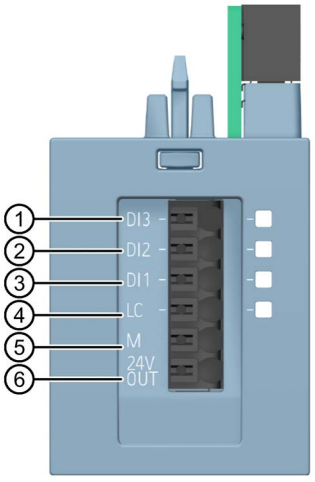
When pressing the spring release, you must not pull on the wire/cable at the same time. In this way, you avoid damaging the terminal.

5.10 Connecting the 3DI/LC module for the motor starter

You will find further information on the 3DI/LC module in the ET 200SP motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.

Procedure

The figure below shows the connections of the 3DI/LC module.



① Digital input 3
② Digital input 2
③ Digital input 1
④ Local control (manual local)
⑤ Ground
⑥ 24 V DC/ 100 mA output

Note

The digital inputs (1 to 4) are not isolated. The reference potential is M (5). Control the digital inputs only via a unit supplied from the 24 V DC output (6).

Connect only cables of a width not exceeding 30 m to the 3DI/LC module.

The supply (5 and 6) is protected against short-circuits.

Terminal sketch of the 3DI/LC module

The following diagram shows a terminal sketch of the 3DI/LC module:

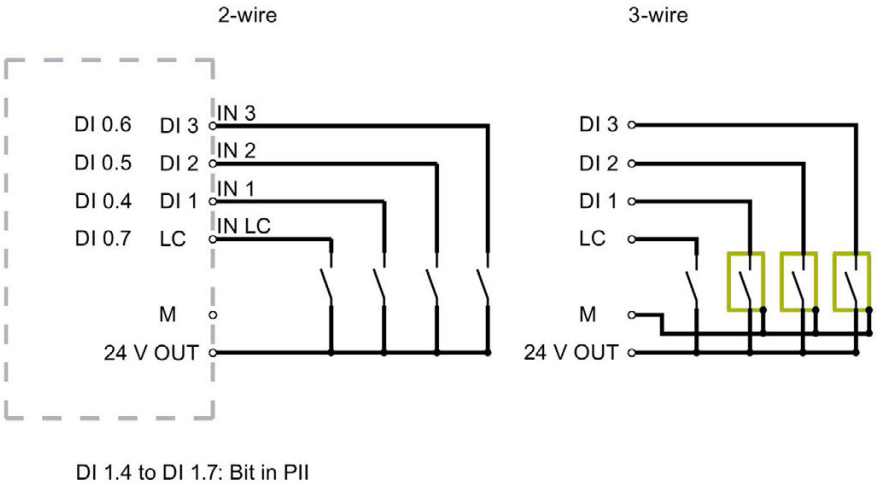


Figure 5-10 Connection example of inputs

5.11 Connecting the supply voltage to the CPU/interface module

Introduction

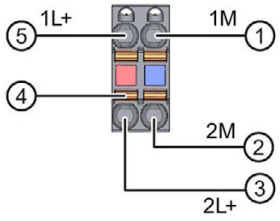
The supply voltage of the CPU/interface module is supplied by means of a 4-pin connector plug located on the front of the CPU/interface module.

Power supply unit

Only use power supply units of type SELV/PELV with safe electrically isolated functional extra low voltage (≤ 28.8 V DC).

Connection for supply voltage (X80)

The connections have the following meaning:



① Ground of the supply voltage
② Ground of the supply voltage for looping through (permitted value 10 A)
③ + 24 V DC of the supply voltage for looping through (permitted value 10 A)
④ Spring release
⑤ + 24 V DC of the supply voltage

1L+ and 2L+ and 1M and 2M are internally jumpered.

Figure 5-11 Supply voltage connection

The maximum cross-section of the connection is 2.5 mm^2. A strain relief is not present. The connector plugs provide you with the option of looping the supply voltage through without interruption, even when it is unplugged.

Requirements

- Only wire up the connector plug when the supply voltage is turned off.
- Follow the wiring rules (Page 87).

Required tools

3 to 3.5 mm screwdriver

Tool-free connection of cables: single-wire without end sleeve, multi-wire (stranded) with end sleeve or ultrasonically sealed

Watch video sequence: "Connect BusAdapter to the interface module" (http://support.automation.siemens.com/WW/view/en/95886218)

To connect a wire without tools, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Only in the case of stranded conductors:

   Seal or crimp the wire with end sleeves.
3. Insert the cable into the push-in terminal as far as it will go.
4. Push the wired connector plug into the plug socket of the interface module.

Connection of cables: multi-wire (stranded), without end sleeve, unfinished

To connect a wire without an end sleeve, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Using a screwdriver, press the spring release and insert the wire into the push-in terminal as far as it will go.
3. Pull the screwdriver out of the spring release.
4. Push the wired connector plug into the socket in the interface module.

Removing a wire

Using the screwdriver, press the spring release as far as it will go and pull out the wire.

5.12 Connecting interfaces for communication

Connect the communication interfaces of the ET 200SP distributed I/O system using the standardized connector or directly. If you want to prepare communication cables yourself, the interface assignment is specified in the manuals of the corresponding modules. Observe the mounting instructions for the connectors.

5.12.1 Connecting PROFINET IO to the CPU/interface module via the bus adapter BA 2xRJ45

Introduction

You connect PROFINET IO to the CPU/interface module via the BusAdapter BA 2×RJ45. To do this, screw the BusAdapter BA 2×RJ45 to the CPU/interface module and insert the PROFINET connecting cable. You can loop PROFINET through via the integrated 2-port switch.

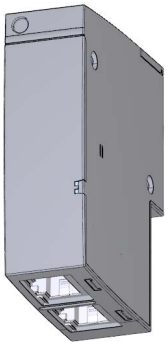


Figure 5-12 BA 2×RJ45 BusAdapter

Required tools

3 to 3.5 mm screwdriver

Required accessories

Please refer to the specifications in the PROFINET Installation Guide (http://www.profibus.com).

Mounting the bus connector

Mount the PROFINET connector according to the instructions in PROFINET Installation Guide (http://www.profibus.com).

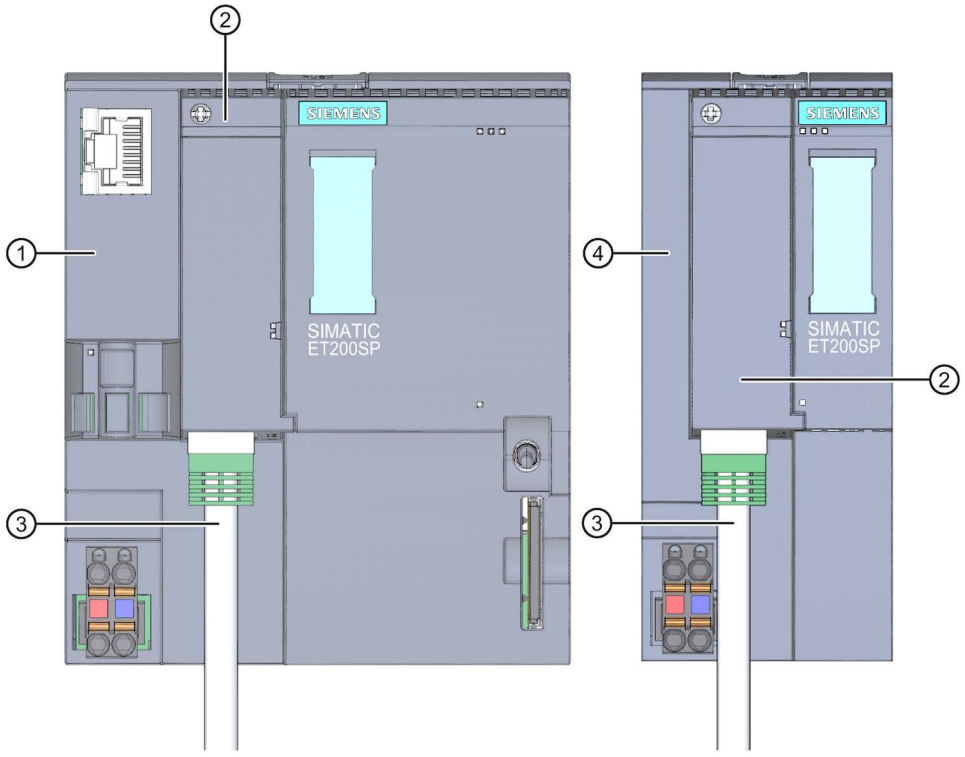
Procedure

Watch video sequence: "Connect BusAdapter BA 2xRJ45 to the interface module" (http://support.automation.siemens.com/WW/view/en/95886218)

To connect PROFINET IO to the CPU/interface module via the BA 2xRJ45 BusAdapter, follow these steps:

1. Plug the BusAdapter BA 2×RJ45 into the CPU/interface module.
2. Screw the BA 2×RJ45 BusAdapter to the CPU/interface module (1 screw with 0.2 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade.
3. Plug the RJ45 bus connector(s) into the PROFINET port on the BusAdapter BA 2×RJ45.

BA 2×RJ45 BusAdapter mounted



① CPU
② BA 2×RJ45 BusAdapter
③ PROFINET connecting cable
④ Interface module

Figure 5-13 Connecting the BA 2×RJ45 BusAdapter to the CPU/interface module

Note

Installation guidelines for modules with PROFINET IO interfaces

Only when all connected nodes are equipped with a SELV/PELV power supply (or have equivalent protection), is it permitted to operate the modules with PROFINET IO interfaces in LANs (Local Area Networks).

A data transfer point is prescribed for connection to the WAN(Wide Area Network) that guarantees this degree of safety.

5.12.2 Connecting PROFINET IO to the CPU/interface module via the BA 2xFC BusAdapter

Introduction

You connect PROFINET IO to the CPU/interface module via the BusAdapter BA 2×FC. To do this, screw the BusAdapter BA 2xFC to the connected PROFINET connecting cable on the CPU/interface module. You can loop PROFINET through via the integrated 2-port switch.

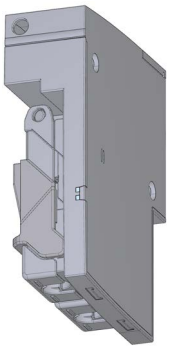


Figure 5-14 BA 2×FC BusAdapter

Required tools

3 to 3.5 mm screwdriver

Required accessories

- If you use Fast Connect Cable, we recommend the Industrial Ethernet Fast Connect Stripping Tool (6GK1901-1GA00) with green knife cassette (6GK1901-1B...). This guarantees fast and safe stripping.
- Fast Connect Cable (recommended types):
  - IE FC TP Standard Cable GP 2x2 (6XV1840-2AH10)
  - IE FC TP Trailing Cable 2x2 (6XV1840-3AH10)
  - IE FC TP Marine Cable (6XV1840-4AH10)
  - IE FC TP Flexible Cable GP 2x2 (6XV1870-2B)
  - IE FC TP Trailing Cable 2x2 (6XV1870-2D)
  - IE TP Torsion Cable 2x2 (6XV1870-2F)
  - FC TP FRNC Cable GP (6XV1871-2F)
  - IE FC TP Food Cable GP 2x2 (6XV1871-2L)
  - IE FC TP Festoon Cable 2x2 (6XV1871-2S)
- Please refer to the specifications in the PROFINET Installation Guide (http://www.profibus.com).

Procedure

Watch video sequence: "Connect BusAdapter BA 2xFC to the interface module" (http://support.automation.siemens.com/WW/view/en/95886218)

To connect PROFINET IO to the CPU/interface module via the BA 2xFC BusAdapter, follow these steps:

1. Strip the sleeve of the PROFINET connecting cable as follows:

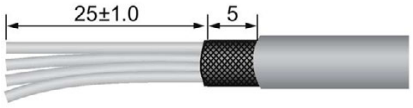
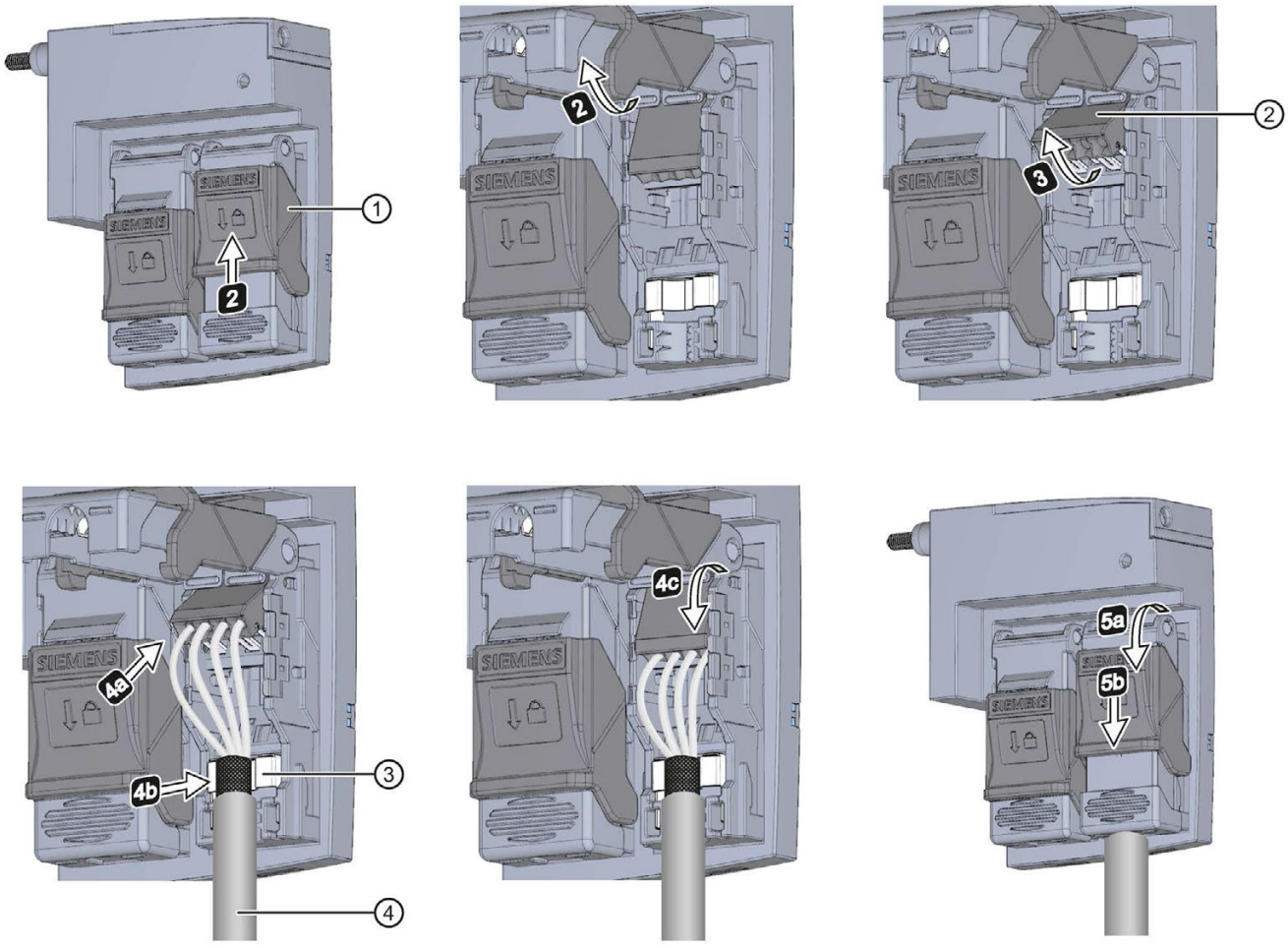


Figure 5-15 PROFINET connecting cable

2. Pull back the locking slide and fold up the cover of the connection element.
3. Pull up the wire guide as far as it will go.
4. Insert the unstripped single wires of the PROFINET connecting cable (according to the attached color coding) into the wire guide and press the guide down **firmly** as far as it will go.

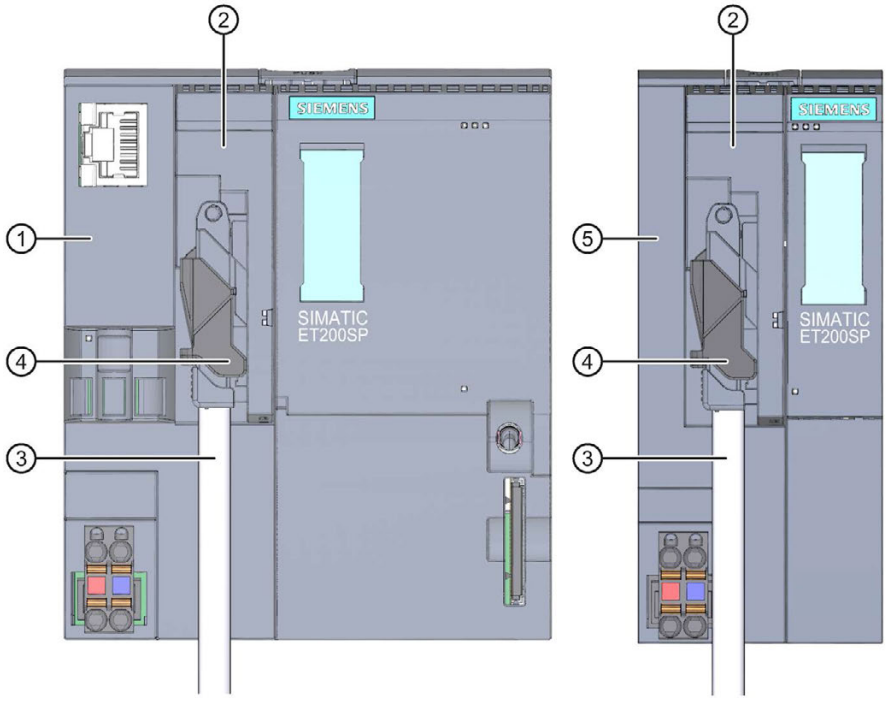
5. Close the cover of the connection element and push the locking slide forwards as far as it will go.
6. Connect and screw the BA 2×FC BusAdapter to the CPU/interface module (1 screw with 0.2 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade.



① Locking slide
② Wire guide
③ Shield contact
④ PROFINET connecting cable

Figure 5-16 Connection of the PROFINET IO BusAdapter BA 2×FC to the CPU/interface module

BA 2×FC BusAdapter mounted



① CPU
② BA 2×FC BusAdapter
③ PROFINET connecting cable
④ Connection element
⑤ Interface module

Figure 5-17 Connecting the BA 2×FC BusAdapter to the CPU/interface module

Note

Installation guidelines for modules with PROFINET IO interfaces

Only when all connected nodes are equipped with a SELV/PELV power supply (or have equivalent protection) is it permitted to operate the modules with PROFINET IO interfaces in LANs (Local Area Networks).

A data transfer point is prescribed for connection to the WAN (Wide Area Network) that guarantees this degree of safety.

5.12.3 Connecting PROFINET IO to the CPU/interface module via BA 2xSCRJ BusAdapter

Introduction

You can connect PROFINET IO to the CPU/interface module optically with fiber-optic cables using an SC RJ connector via the BA 2×SCRJ BusAdapter. To do this, screw the BA 2×SCRJ BusAdapter onto the CPU/interface module and insert the SC RJ connector. You can loop PROFINET through optically via the integrated 2-port switch.

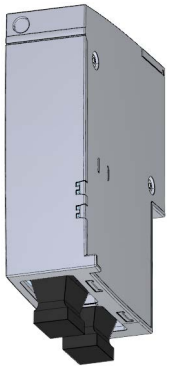


Figure 5-18 BA 2×SCRJ BusAdapter

Required tools

3 to 3.5 mm screwdriver

Required accessories

- Connector for PROFINET connection: IE SC RJ POF plug
- Fiber-optic cable:
  - IE POF standard cable (6XV1874-2A)
  - IE POF trailing cable (6XV1874-2B)
  - IE PCF standard cable (6XV1861-2A)
  - IE PCF trailing cable (6XV1861-2C)
  - IE PCF-GI (6XV1861-2D)

Requirements

- Prepare the IE POF cables with the connectors IE SC RJ POF Plug or IE SC RJ PCF Plug. For detailed information, refer to the assembly instructions POF Fiber-optic Cables with IE Termination Kit SC RJ POF Plug (A5E00351141) or PCF Fiber-optic Cables with the IE Termination Kit SC RJ PCF Plug (A5E00835119).
- When installing the fiber-optic cable, make sure the bending radius is not less than permitted:
  - IE POF/PCF standard cable: 150 mm
  - IE POF/PCF trailing cable: 60 mm
- The maximum lengths of the fiber-optic cables are as follows:
  - IE POF standard cable: 50 m
  - IE POF trailing cable: 50 m
  - IE POF standard cable: 100 m
  - IE PCF trailing cable: 100 m
  - IE PCF-GI: 300 m
- If the CPU/interface module is the last device of the fiber-optic cable network, the unoccupied fiber-optic cable interface must be closed with a blanking plug. When the modules ship, the blanking plugs are inserted in the PROFINET sockets of the BusAdapter.

Procedure

To connect PROFINET IO to the CPU/interface module via the BA 2×SCRJ BusAdapter, follow these steps:

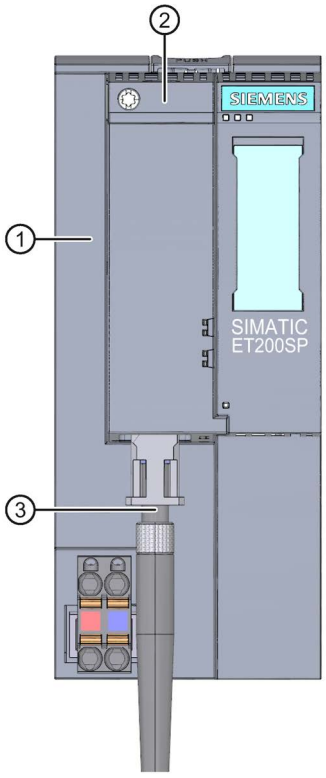
1. Plug the BA 2×SCRJ BusAdapter into the CPU/interface module.
2. Screw the BA 2×SCRJ BusAdapter to the CPU/interface module (1 screw with 0.2 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade.
3. Remove the blanking plugs from the PROFINET sockets.
4. Hold the prepared connector by the housing and insert it into the PROFINET socket on the BA 2×SCRJ BusAdapter until you hear it click into place. The connectors are coded to ensure correct connection.

⚠ CAUTION

Risk of damage to eyes

Do not look directly into the opening of the optical transmitter diodes. The emitted light beam could damage your eyes.

BA 2×SCRJ BusAdapter mounted



① Interface module
② BA 2×SCRJ BusAdapter
③ PROFINET connecting cable (fiber-optic cable)

Figure 5-19 Connecting the BA 2×SCRJ BusAdapter to the interface module

Reusing fiber-optic cable

Note

If you are reusing fiber-optic cables, you must shorten both fiber-optic cores by the amount of the curved lengths and reassemble the connectors. This will prevent any attenuation losses caused by re-bent, heavily stressed portions of the fiber-optic cores.

Reference

For more information on the installation guidelines for fiber-optic cables, refer to the SIMATIC NET PROFIBUS Network Manual (http://support.automation.siemens.com/WW/view/en/35222591).

5.12.4 Connecting PROFINET IO to the interface module via the BA SCRJ/RJ45 BusAdapter

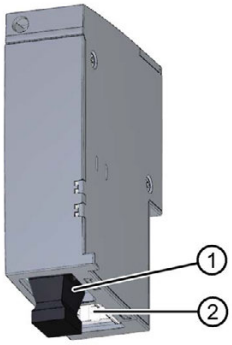
Introduction

You connect PROFINET IO to the interface module via the BA SCRJ/RJ45 BusAdapter:

- Optically coupled to fiber-optic cables (FOC) with an SC RJ connector (port 1) or
- Electrically with a standard RJ45 connector (port 2)

To do this, screw the BA SCRJ/RJ45 BusAdapter onto the interface module and insert the SC RJ connector or RJ45 plug.

You can loop through the PROFINET IO via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.



① Fiber-optic cable SCRJ
② RJ45

Figure 5-20 BA SCRJ/RJ45 BusAdapter

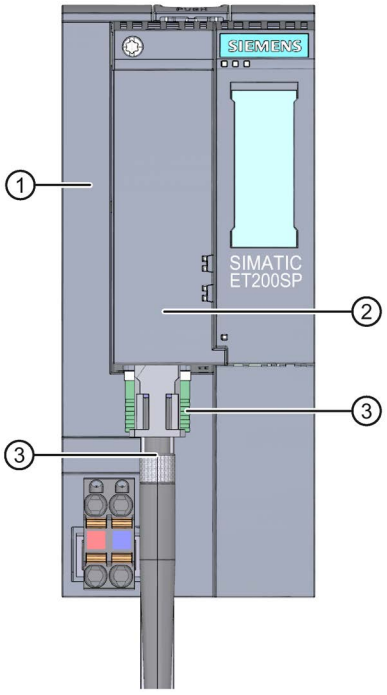
Attaching SC RJ connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting PROFINET IO to an interface module via BA 2×SCRJ BusAdapter (Page 108).

Connecting RJ45 plugs

You can find more information about the required tools, accessories and procedures in the section Connecting PROFINET IO to an interface module via BA 2×RJ45 BusAdapter (Page 101).

BA SCRJ/RJ45 BusAdapter mounted



① Interface module
② BA SCRJ/RJ45 BusAdapter
③ PROFINET connecting cable

Figure 5-21 Connecting the BA SCRJ/RJ45 BusAdapter to the interface module

5.12.5 Connecting PROFINET IO to the interface module via the BA SCRJ/FC BusAdapter

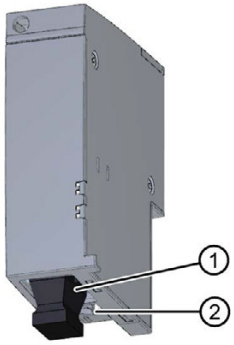
Introduction

You connect PROFINET IO to the interface module via the BA SCRJ/FC BusAdapter:

- Optically coupled to fiber-optic cables (FOC) with an SC RJ connector (port 1) or
- Electrically with direct connection of the Fast Connect bus cable (port 2)

To do this, screw the BA SCRJ/FC BusAdapter with the attached Fast Connect bus cable onto the interface module and insert the SC RJ connector.

You can loop through the PROFINET IO via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.



① Fiber-optic cable SCRJ
② FastConnect FC

Figure 5-22 BA SCRJ/FC BusAdapter

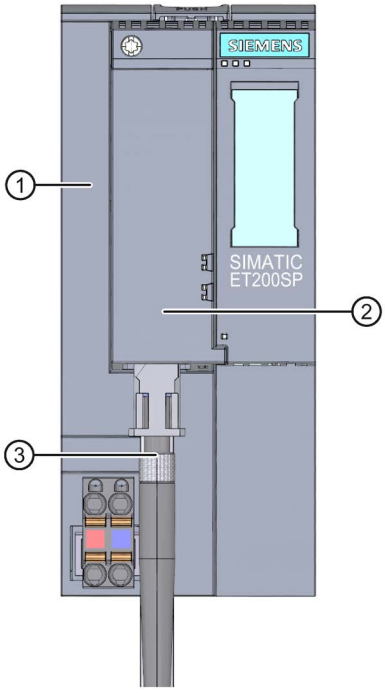
Attaching SC RJ connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting PROFINET IO to an interface module via BA 2×SCRJ BusAdapter (Page 108).

Connecting a Fast Connect bus cable

You can find more information about the required tools, accessories and procedures in the section Connecting PROFINET IO to an interface module via BA 2×FC BusAdapter (Page 104).

BA SCRJ/FC BusAdapter mounted



① Interface module
② BA SCRJ/FC BusAdapter
③ PROFINET connecting cable

Figure 5-23 Connecting the BA SCRJ/FC BusAdapter to the interface module

5.12.6 Connecting PROFINET IO to the interface module via the BA 2xLC BusAdapter

Introduction

Via the BA 2xLC BusAdapter, you connect the PROFINET IO to the interface module optically with fiber-optic cables using an LC connector. To do this, screw the BA 2xLC BusAdapter onto the interface module and insert the LC connector. You can loop PROFINET through optically via the integrated 2-port switch.

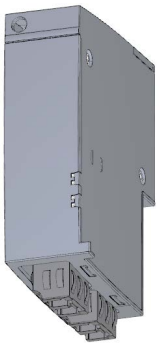


Figure 5-24 BA 2xLC BusAdapter

Required tools

3 to 3.5 mm screwdriver

Required accessories

- If you prepare the FC FO cable with the IE FC FO LC plug, we recommend the FC FO termination kit (LC) (6GK1900-0RL00-0AA0). You can cleave the glassfiber precisely using the FC FO termination kit (LC).

  ⚠ CAUTION

  Cleaving the glassfiber
  - Wear protective glasses during the cleaving process.
  - Dispose of the remaining fibers in a suitable waste container.

- Connector for PROFINET connection: IE FC FO LC Plug (10 duplex plugs: 6GK1900-1RB00-2AB0)
- Fiber-optic cable:
  - IE FC FO Standard Cable GP (62.5/200/230) (6XV1847-2A)
  - IE FC FO Trailing Cable (62.5/200/230) (6XV1847-2C)
  - IE FC FO Robust Cable (6XV1873-5Rxx)
  - IE FC FO Standard Cable (6XV1873-3Axx)

Requirements

- Prepare the IE FC FO cable with the IE FC FO LC plug connectors. For detailed instructions, refer to the assembly instructions Preparing IE FC FO Cable with the plug-in connector IE FC FO LC Plug (A5E36312721).
- When installing the fiber-optic cable, make sure the bending radius is not less than permitted:
  - IE FC FO Standard Cable GP (62.5/200/230): 70 mm
  - IE FC FO Trailing Cable (62.5/200/230) (6XV1847-2C): 88 mm
- The maximum lengths of the fiber-optic cables are as follows:
  - IE FC FO Standard Cable GP (62.5/200/230): 2 km
  - IE FC FO Trailing Cable (62.5/200/230): 2 km
- When the interface module is the last device of the fiber-optic cable network, the unoccupied fiber-optic cable interface must be closed with a blanking plug. When the modules ship, the blanking plugs are inserted in the PROFINET sockets of the BusAdapter.

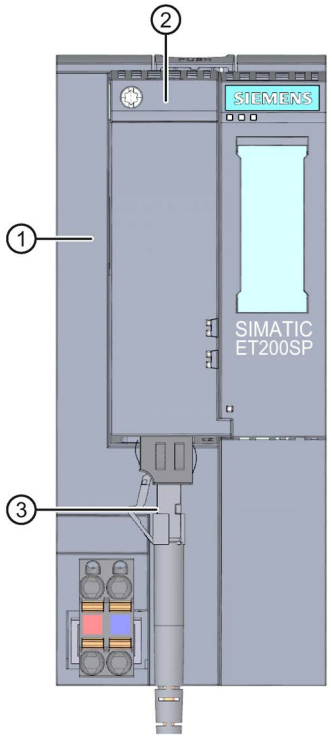
Procedure

To connect PROFINET IO to the interface module via the BA 2xLC BusAdapter, follow these steps:

1. Plug the BA 2xLC BusAdapter into the interface module.
2. Screw the BA 2xLC BusAdapter to the interface module (1 screw with 0.2 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade.
3. Remove the blanking plugs from the PROFINET sockets.
4. Hold the prepared connector by the housing and insert it into the PROFINET socket on the BA 2xLC BusAdapter until you hear it click into place. The connectors are coded to ensure correct connection.

⚠ CAUTION
Risk of damage to eyes Do not look directly into the opening of the optical transmitter diodes. The emitted light beam could damage your eyes.

BA 2xLC BusAdapter mounted



① Interface module
② BA 2xLC BusAdapter
③ PROFINET glassfiber connecting cable

Figure 5-25 Connecting the BA 2xLC BusAdapter to the interface module

Reusing fiber-optic cable

Note

If you are reusing fiber-optic cables, you must shorten both fiber-optic cores by the amount of the curved lengths and reassemble the connectors. This will prevent any attenuation losses caused by re-bent, heavily stressed portions of the fiber-optic cores.

Reference

For more information on the installation guidelines for fiber-optic cables, refer to the SIMATIC NET PROFIBUS Network Manual (http://support.automation.siemens.com/WW/view/en/35222591).

5.12.7 Connecting PROFINET IO to the interface module via the BA LC/RJ45 BusAdapter

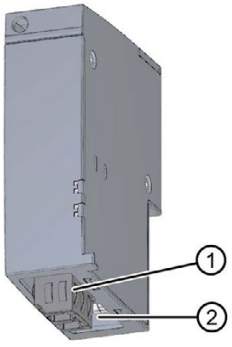
Introduction

You connect PROFINET IO to the interface module via the BA LC/RJ45 BusAdapter:

- Optically coupled to glass fiber-optic cables with an LC connector (port 1) or
- Electrically with a standard RJ45 connector (port 2)

To do this, screw the BA LC/RJ45 BusAdapter onto the interface module and insert the LC connector or RJ45 plug.

You can loop through the PROFINET IO via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.



① Glass fiber-optic cable LC
② RJ45

Figure 5-26 BA LC/RJ45 BusAdapter

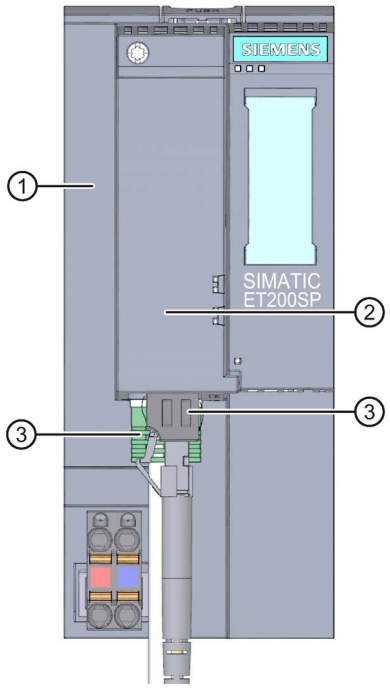
Attaching LC connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting PROFINET IO to an interface module via BA 2×LC BusAdapter (Page 115).

Connecting RJ45 plugs

You can find more information about the required tools, accessories and procedures in the section Connecting PROFINET IO to an interface module via BA 2×RJ45 BusAdapter (Page 101).

BA LC/RJ45 BusAdapter mounted



① Interface module
② BA LC/RJ45 BusAdapter
③ PROFINET connecting cable

Figure 5-27 Connecting the BA LC/RJ45 BusAdapter to the interface module

5.12.8 Connecting PROFINET IO to interface module via BA LC/FC BusAdapter

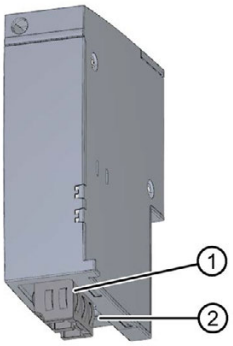
Introduction

You connect PROFINET IO to the interface module via the BA LC/FC BusAdapter:

- Optically coupled to glass fiber-optic cables with an LC connector (port 1) or
- Electrically with direct connection of the Fast Connect bus cable (port 2)

To do this, screw the BA LC/FC BusAdapter with the attached Fast Connect bus cable onto the interface module and insert the LC connector.

You can loop through the PROFINET IO via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.



① Glass fiber-optic cable LC
② FastConnect FC

Figure 5-28 BA LC/FC BusAdapter

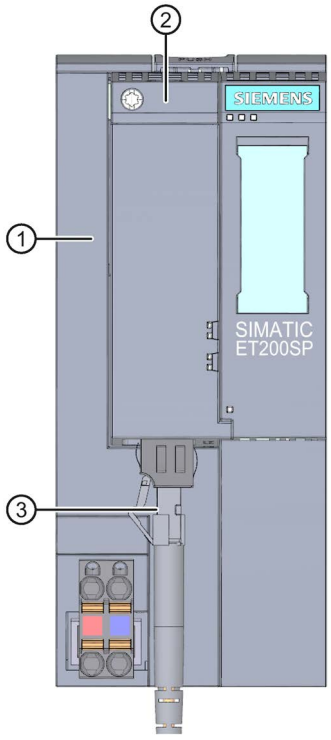
Attaching LC connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting PROFINET IO to an interface module via BA 2×LC BusAdapter (Page 115).

Connecting a Fast Connect bus cable

You can find more information about the required tools, accessories and procedures in the section Connecting PROFINET IO to an interface module via BA 2×FC BusAdapter (Page 104).

BA LC/FC BusAdapter mounted



① Interface module
② BA LC/FC BusAdapter
③ PROFINET connecting cable

Figure 5-29 Connecting the BA LC/FC BusAdapter to the interface module

5.12.9 Connecting PROFINET IO (port P3) to the CPU

Introduction

You use the RJ-45 bus connector to connect PROFINET IO (port P3) directly to the CPU.

Required accessories

- Cable ties with standard width of 2.5 mm or 3.6 mm for strain relief
- Please observe the specifications in the PROFINET Installation Guide (http://www.profibus.com).

Mounting the bus connector

Mount the PROFINET connector in accordance with the instructions in the PROFINET Installation Guide (http://www.profibus.com).

Procedure

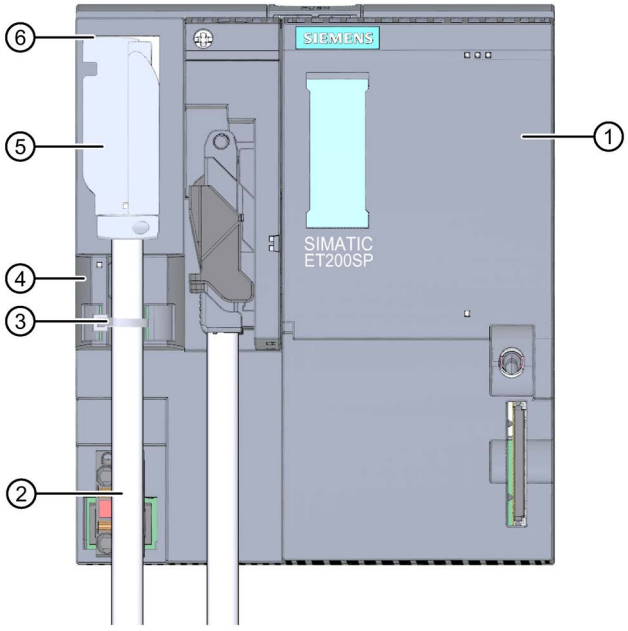
Insert the RJ45 bus connector into the PROFINET port (port P3) on the CPU.

Note

Cable support and strain relief

If you are using a FastConnect RJ-45 bus connector with 90° cable outlet (6GK1901-1BB20-2AA0), we recommend you provide strain relief for the PROFINET connecting cable. To do so, you need a cable tie with a standard width of 2.5 mm or 3.6 mm.

Use it to fasten the PROFINET connecting cable directly after it exits the bus connector to the intended cable support on the CPU (on the front directly below the PROFINET interface X1P3).



① CPU
② PROFINET connecting cable
③ Strain relief (cable tie)
④ Cable support
⑤ FastConnect RJ45 bus connector with 90° cable outlet
⑥ PROFINET connector (port P3)

Figure 5-30 Connecting PROFINET IO (port P3) to the CPU

5.12.10 Connecting the PROFIBUS DP interface to the interface module/communications module CM DP

Introduction

Using the bus connector (RS485), connect the PROFIBUS DP to the interface module/communications module CM DP.

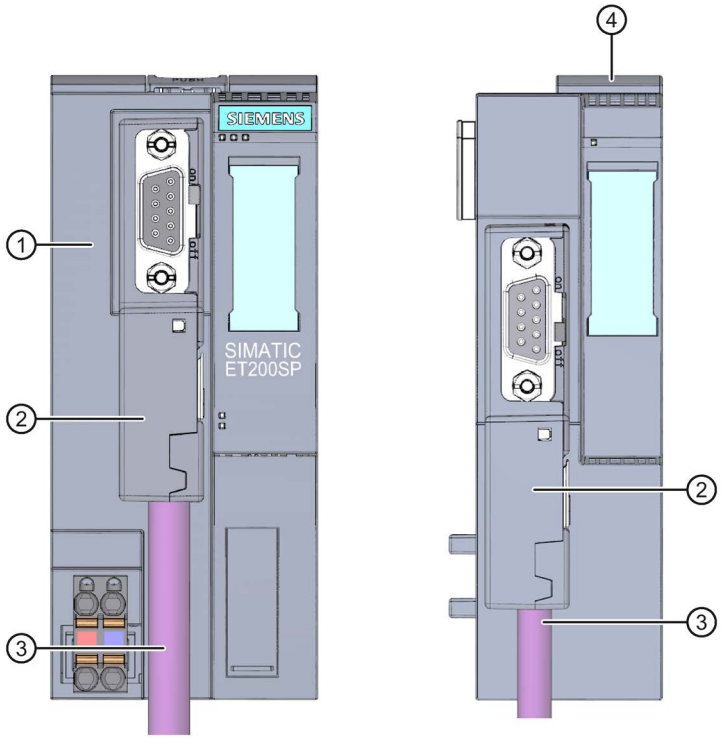
Required tools

3 to 3.5 mm screwdriver

Procedure

To connect the PROFIBUS DP interface to the interface module / DP communication module CM DP, follow these steps:

1. Connect the PROFIBUS cable to the bus connector.
2. Plug the bus connector into the PROFIBUS DP connector.
3. Securely tighten the fixing screws of the bus connector (0.3 Nm).



① Interface module
② PROFIBUS FastConnect bus connector
③ PROFIBUS connecting cable
④ Communications module CM DP

Figure 5-31 Connect PROFIBUS DP to the interface module/communications module CM DP

Reference

You can find additional information on the PROFIBUS FastConnect bus connector in the corresponding product information on the Internet (http://support.automation.siemens.com/WW/view/en/58648998).

5.13 Inserting I/O modules / motor starters and BU covers

Introduction

- The I/O modules are plugged into the BaseUnits. They are self-coding and type-coded.
- The BU covers are fitted to BaseUnits whose slots are not equipped with I/O modules.
- BU covers are plugged onto BaseUnits whose slots have been reserved for future expansion (as empty slots).
- The BU covers for motor starters serve as touch protection covers for unoccupied slots.

  The BU covers have a holder for the reference identification label on the inside. For future expansion of the ET 200SP, remove the reference identification label from the holder and insert it into the final I/O module.
  It is not possible to attach a reference identification label to the BU cover itself.

  There are three versions:

  – BU cover with a width of 15 mm
  – BU cover with a width of 20 mm
  – BU cover with a width of 30 mm (for motor starters)

Requirement

Refer to chapter "Application planning (Page 32)".

Plugging in I/O modules and BU covers

Watch video sequence: "Insert I/O modules"
(http://support.automation.siemens.com/WW/view/en/95886218)

Install the I/O module or BU cover parallel into the BaseUnit until you hear both latches click into place.

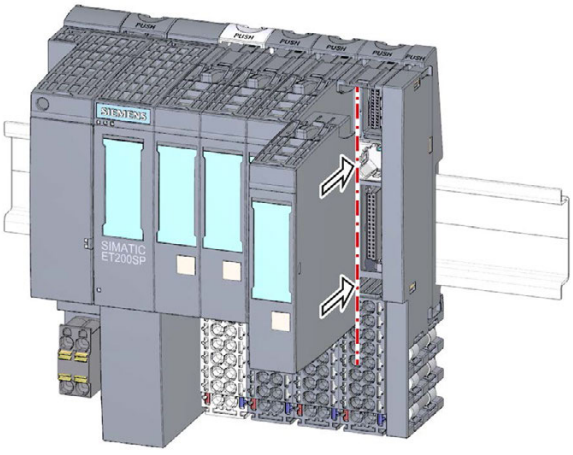


Figure 5-32 Plugging in I/O modules or BU covers (using an I/O module as example)

5.14 Mounting/disassembly of motor starters

5.14.1 Mounting the fan

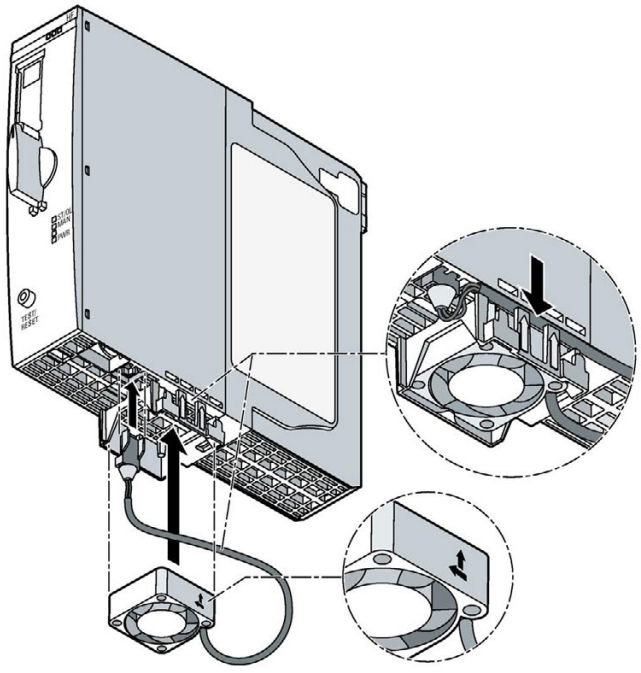
Procedure

Proceed as follows to mount a fan on a SIMATIC ET 200SP motor starter:

1. Slide the fan onto the motor starter until you can hear the fan engage.

   Observe the blowing direction of the fan when mounting. The air stream must be directed to the inside of the motor starter. The correct blowing direction is indicated by arrows on the bottom of the fan.

2. Insert the connection plug into the opening above the fan.



3. Secure the fan cable to the fixing eyes on the right-hand side of the fan cover.

Note

Specified ambient temperatures are not reached if the fan is incorrectly installed

If you do not observe the blowing direction of the fan when mounting, the specified ambient temperatures will not be reached. The device shuts down prematurely due to excessively high temperature.

5.14.2 Mounting/disassembly of motor starters

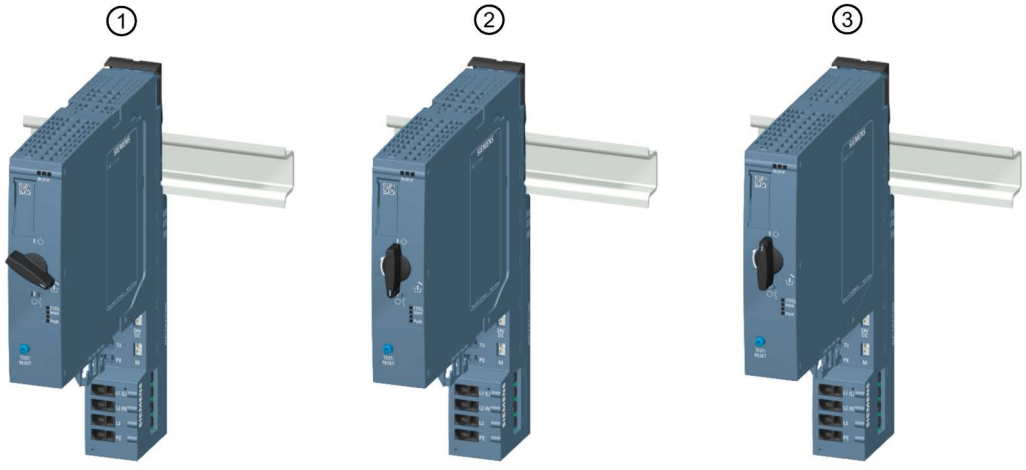
Procedure

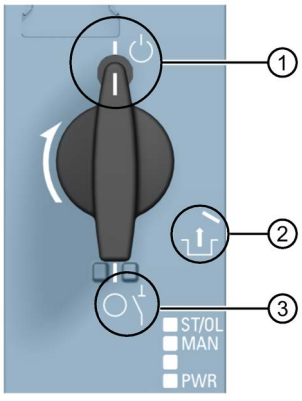
CAUTION
Protection against electrostatic charge When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

To assemble a SIMATIC ET 200SP motor starter, proceed as follows:

1. Set the mechanical rotary interlock of the SIMATIC ET 200SP motor starter to the assembly/disassembly position.
2. Place the SIMATIC ET 200SP motor starter onto the BaseUnit.
3. Turn the mechanical rotary interlock clockwise to the parking position.

4. Turn the mechanical rotary interlock clockwise to the operating position (= end position).





① Operating position/READY

The motor starter is firmly locked in the BaseUnit, and all electrical contacts are connected.

② Assembly/disassembly position

All electrical contacts are open, and you can use the SIMATIC ET 200SP motor starter in the BaseUnit, or you can remove it from the BaseUnit.

③ Parking position/OFF

In this position, you cannot remove the SIMATIC ET 200SP motor starter from the BaseUnit, but all electrical contacts are open. In addition, you can open the locking lever on the mechanical rotary interlock in this position, and fix the position with a padlock (shackle diameter 3 mm). This ensures the isolating function in accordance with IEC 60947-1.

Operating position/READY

The motor starter is firmly locked in the BaseUnit, and all electrical contacts are connected.

Note

Parking position/OFF

This position is only permissible for maintenance purposes and not for continuous operation. In this position, dust protection and mechanical durability are not ensured.

If you do not use the motor starter for an extended period, remove it and attach the BU cover (3RK1908-1CA00-0BP0).

5. Mount the touch protection cover for the infeed bus on the last BaseUnit.

Note

Touch protection cover for the infeed bus

You will find out how to mount the touch protection cover of the infeed bus on a SIMATIC ET 200SP motor starter in chapter "Mounting the cover for the 500 V AC infeed bus (Page 69)".

6. To connect the assembly, mount the server module after the last BaseUnit.

Note

Server module

You can find out how to assemble/disassemble the server module in chapter "Installing the server module (Page 68)".

Note

Removing the motor starter

You will find out how to remove the motor starter in chapter "Replacing a motor starter (Page 242)".

5.14.3 3DI/LC module

Introduction

The optional 3DI/LC module with three inputs and one further LC input can be connected to the motor starter. The status of the inputs of the 3DI/LC module can be seen via the process image input (PII) of the motor starter.

Note

The 3DI/LC module can be used for the motor starter and the fail-safe motor starter.

The input actions can be parameterized. For reasons of operational safety, the LC input is permanently set to manual local mode. For example, by parameterizing the inputs DI1 - DI3 with motor CLOCKWISE or motor COUNTER-CLOCKWISE, you can control the motor in manual local mode.

The figure below shows the 3DI/LC module.

Assembly

⚠ WARNING

Risk of injury from automatic restart

When you mount the the 3DI/LC module, the motor starter can switch on autonomously if an ON command (DI1 to DI3) is active. This can result in property damage or serious injury caused by connected devices that are automatically started up.

Revoke the ON commands at DI1 to DI3 before mounting the 3DI/LC module.

Proceed as follows to mount a 3DI/LC module onto a motor starter:

1. Wire the 3DI/LC module according to the connection diagram.

Note

Connecting the 3DI/LC module

You will find out how to connect the 3DI/LC module in chapter "Connecting the 3DI/LC module for the motor starter (Page 97)".

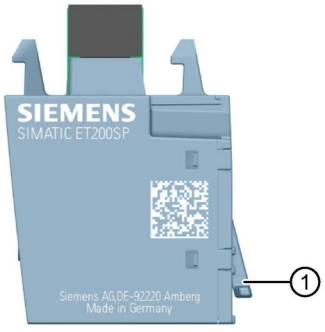
2. Slide the 3DI/LC module into the motor starter until the 3DI/LC module engages.

The figure below shows a motor starter with a mounted 3DI/LC module.

Disassembly

Proceed as follows to remove a 3DI/LC module from a motor starter:

1. Push the release lever on the rear of the 3DI/LC module.



① Release lever

2. Remove the 3DI/LC module from the motor starter while pressing the release lever.

5.15 Labeling ET 200SP

5.15.1 Factory markings

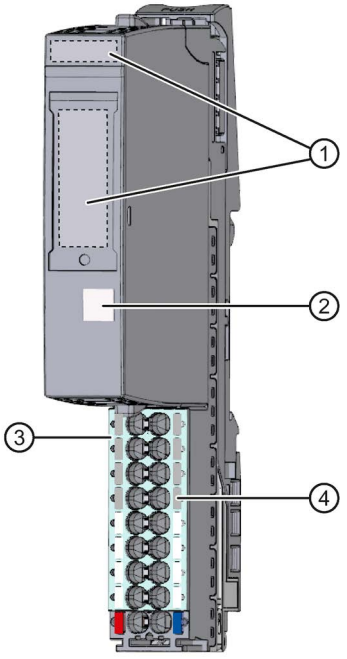
Introduction

For better orientation, the ET 200SP is equipped with various markings ex factory, which help in the configuration and connection of the modules.

Factory markings

- Module labeling
- Color coding of the module classes
  - Digital input modules: white
  - Digital output modules: black
  - Analog input modules: light blue
  - Analog output modules: dark blue
  - Technology module: turquoise
  - Communication module: light gray
  - Special module: mint green

- Color coding of the potential group
  - Opening the potential group: Light-colored terminal box and light-colored mounting rail release button
  - Further conduction of the potential group: Dark-colored terminal box and dark-colored mounting rail release button
- Color coding of the spring releases
  - Process terminals: gray, white
  - AUX terminals: turquoise
  - Additional terminals: red, blue
  - Terminals for self-assembling voltage buses P1, P2: red, blue



① Module labeling
② Color coding of the module classes
③ Color coding of the potential group
④ Color coding of the spring releases (by group)

Figure 5-33 Factory markings

5.15.2 Optional markings

Introduction

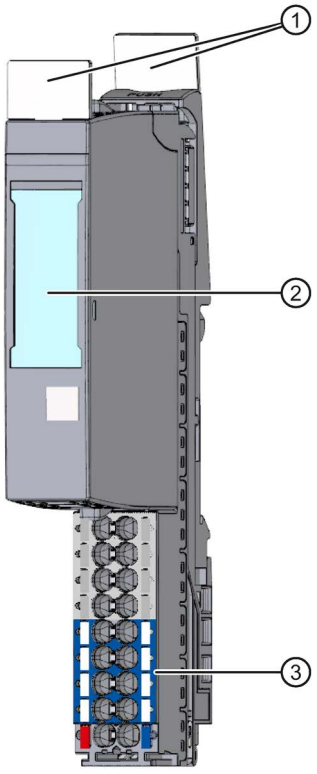
In addition to the factory markings, there are also other options for labeling and/or marking terminals, BaseUnits and I/O modules for the ET 200SP distributed I/O system.

Optional markings

- The color identification labels are module-specific labels for color coding the potentials of the I/O modules. A color code (**C**olor **C**ode, e.g. CC01) is printed on each color identification label and I/O module. The color code allows you to read which color identification label is required for the terminals of the associated BaseUnit directly from the I/O module. The following versions of color coded labels are available:
  - Module-specific color combinations for the process terminals (see the device manuals I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300)). The different colors have the following meaning: Gray = input or output signal, red = potential +, blue = ground.
  - For the AUX terminals in the colors yellow-green, blue or red
  - For the add-on terminals in the colors blue-red
- The reference identification labels (in accordance with EN 81346) can be inserted onto each CPU/interface module, BusAdapter, BaseUnit and I/O module. This makes it possible to create a fixed assignment between the reference identification label of the BaseUnit and the I/O module.

  With the standard plotter setting, the reference identification label is suitable for automatic labeling with E-CAD systems.

- The labeling strips can be inserted in the CPU/interface module, I/O module and BU cover and allow identification of the ET 200SP distributed I/O system. The labeling strips can be ordered on a roll for thermal transfer printers or as DIN A4 format sheets for laser printers.



① Reference identification labels
② Labeling strips
③ Color identification labels

Figure 5-34 Optional markings

5.15.3 Applying color identification labels

Requirements

The BaseUnits must not be wired when you apply the color identification labels.

Required tools

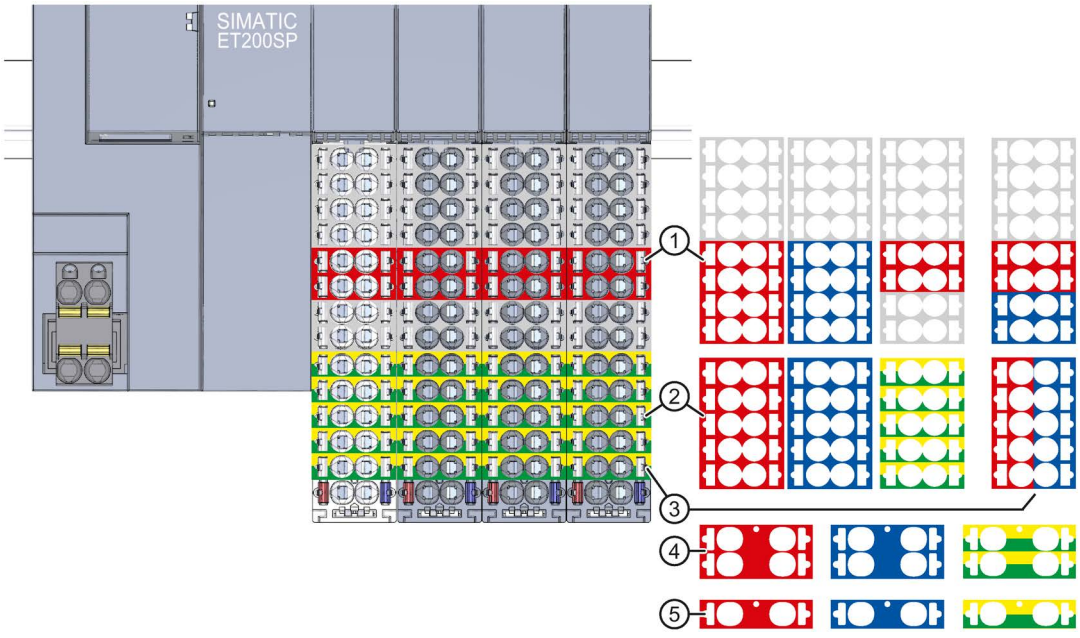
3 mm screwdriver (only for removing the color identification labels)

Applying color identification labels

Press color identification labels into the terminal box of the BaseUnit.

Note

To remove the color identification labels, you must first disconnect the wiring on the BaseUnit and then carefully lever the color identification labels out of the holder using a screwdriver.



① Module-specific color identification labels (15 mm) for the process terminals (see I/O module (http://support.automation.siemens.com/WW/view/en/55679691/133300) Manual)
② Color identification labels (15 mm) for the 10 AUX terminals
③ Color identification labels (15 mm) for the 10 add-on terminals
④ Color identification labels (20 mm) for the 4 AUX terminals
⑤ Color identification labels (20 mm) for the 2 AUX terminals

Figure 5-35 Applying color identification labels

NOTICE
AUX bus as PE bar If you use an AUX bus as a protective conductor (PE), attach the yellow-green color identification labels to the AUX terminals. If you stop using the AUX terminals as a protective conductor bar, remove the yellow-green color identification labels and make sure that the system is still protected.

5.15.4 Applying labeling strips

Procedure

Watch video sequence: "Labeling" (http://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a labeling strip:

1. Label the strips.
2. Insert the labeling strip into the interface module or I/O module.

5.15.5 Applying reference identification labels

Procedure

Watch video sequence: "Labeling"
(http://support.automation.siemens.com/WW/view/en/95886218)

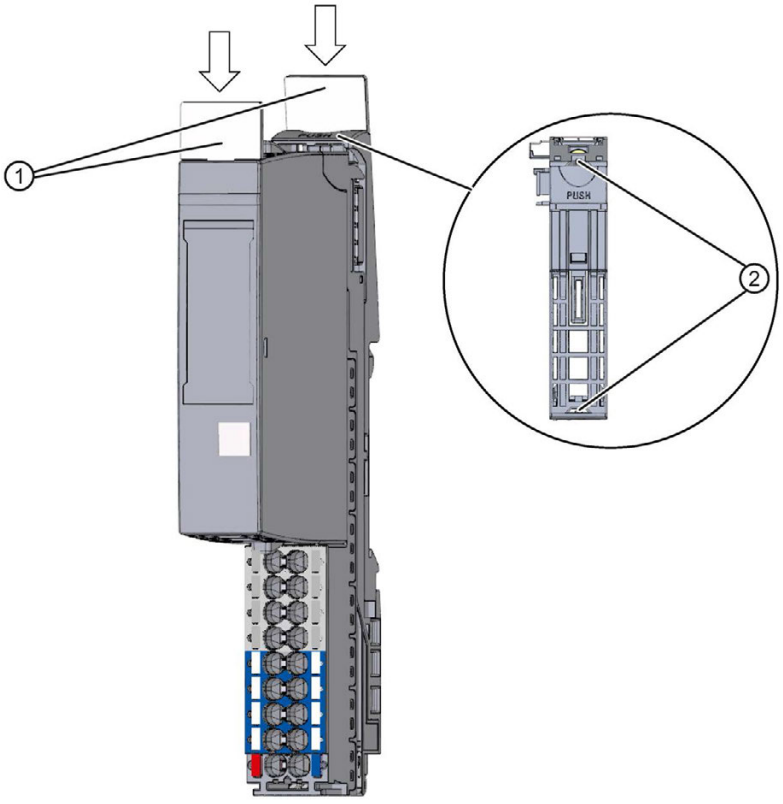
Proceed as follows to install a reference identification label:

1. Break off the reference identification labels from the sheet.
2. Insert the reference identification labels into the opening on the CPU/interface module, BusAdapter, BaseUnit and I/O module. The opening is located on the top of the BaseUnit or I/O module.

Note

Reference identification label

The printable side of the reference identification label must be facing forward.



① Reference identification labels
② Opening for label

Figure 5-36 Applying reference identification labels

Configuring

6

6.1 Configuring ET 200SP

Introduction

You can configure and parameterize the ET 200SP distributed I/O system with STEP 7 (CPU/interface module, I/O modules, motor starter and server module) or with the configuration software of another manufacturer (interface module, I/O modules, motor starter and server module).

"**Configuring**" is understood to mean arranging, setting and networking devices and modules within the device or network view. STEP 7 represents modules and module racks graphically. Just like "real" module racks, the device view allows the insertion of a defined number of modules.

When you insert the modules, STEP 7 automatically assigns the addresses and the unique hardware identifier (HW ID). You can change the addresses later. The hardware identifiers cannot be changed.

When the automation system is started, the CPU/interface module compares the configured planned configuration with the system's actual configuration. You can make parameter settings to control the response of the CPU/interface module to errors in the hardware configuration.

"**Parameterizing**" the components used signifies setting their properties. During parameter assignment, the hardware parameters are set and the settings for data exchange are made:

- Properties of the modules to which parameters can be assigned
- Settings for data exchange between components

The parameters are loaded into the CPU/interface module and transferred to the corresponding modules during startup. Modules can be replaced very easily because the set parameters are automatically loaded into the new module during startup.

Requirements for configuration of the CPU

Table 6- 1 Requirement for installing the CPU

Configuration software	Requirements	Installation information
CPU 151xSP-1 PN: STEP 7 (TIA Portal) as of V13 Update 3	• PROFINET IO • PROFIBUS DP (optional): With the communication module CM DP	STEP 7 online help
CPU 151xSP F-1 PN: STEP 7 (TIA Portal) as of V13 SP1		
CPU 151xSP-1PN (as of FW version V1.8), CPU 151xSP F-1 PN (as of FW version V1.8): STEP 7 (TIA Portal) as of V13 SP1 Update 4		

Requirements for configuration of the interface module

Table 6- 2 Requirement for installing the interface module

Configuration software	Requirements	Installation information
STEP 7 (TIA Portal) as of V11 SP2*	• PROFINET IO: As of Support Package HSP0024	STEP 7 online help
STEP 7 as of V5.5 SP2	• PROFINET IO: GSD file GSDML-Vx.y-siemens-et200sp-"Date in format yyyymmdd".xml (http://support.automation.siemens.com/WW/view/en/19698639/130000) • PROFIBUS DP: GSD file SI0xxxxx.gsx (http://support.automation.siemens.com/WW/view/en/10805317/14280)	
Software of third-party manufacturer		Manufacturer documentation

* The TIA Portal supports GSDML specification V2.25. The ET 200SP distributed I/O system is delivered with a GSD file based on specification V2.3. The GSD file can be installed in the TIA Portal and used without restrictions.

Configuring a motor starter

You configure SIMATIC ET 200SP motor starters in exactly the same way as the I/O modules of the ET 200SP distributed I/O system. The GSD files can be used with STEP 7 V5.5 SP4 and higher, and TIA Portal V13 SP1 and higher.

Configuration of the ET 200SP

See the STEP 7 online help or the documentation of the configuration software manufacturer.

Note

For I/O modules that are installed on a BaseUnit BU..D (light-colored BaseUnit), you always have to set the parameter "Potential group" to "Enable new potential group". If you do not set this parameter correctly, the CPU/interface module goes to STOP and generates a parameter error.

Note

For PROFIBUS with configuration via GSD file

In the configuration software, you must set for the BU covers whether these are on a light-colored or dark-colored BaseUnit.

6.2 Configuring the CPU

6.2.1 Reading out the configuration

Reading out the configuration of an existing station

When a connection exists to a CPU, you can load the configuration of this CPU (including possibly present modules) from the device into your project. To do this, create a new project and configure an "Unspecified CPU".

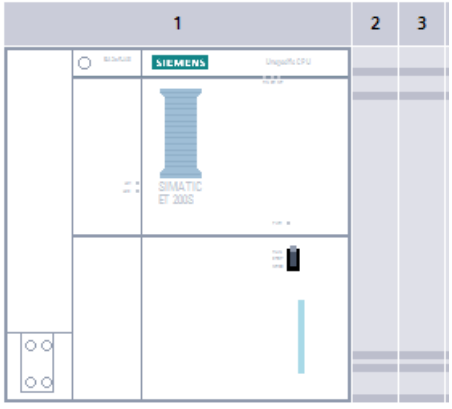


Figure 6-1 Unspecified CPU in the device view

In the device view (or in the network view), select the "Hardware detection" command in the "Online" menu.

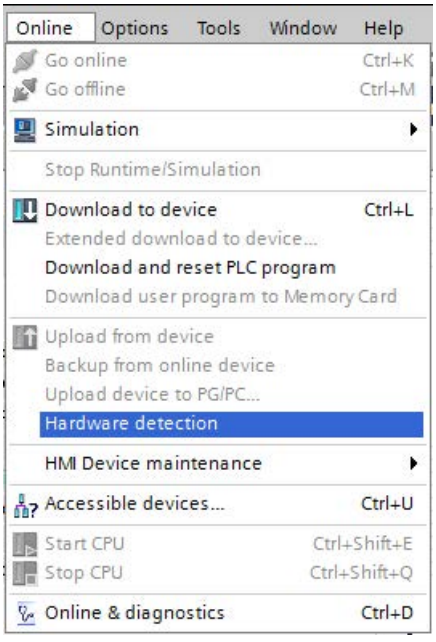


Figure 6-2 Hardware detection in the Online menu

You can also double-click the CPU and click "Detect" in the message.

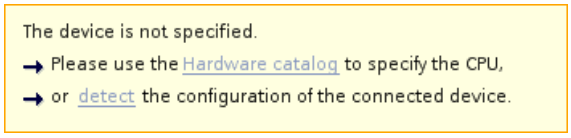


Figure 6-3 Hardware detection message in the device view

After you have selected the CPU and the PG/PC interface in the "Hardware detection for PLC_x" dialog and have clicked the "Detect" button, STEP 7 loads the hardware configuration including the modules from to the CPU into your project.

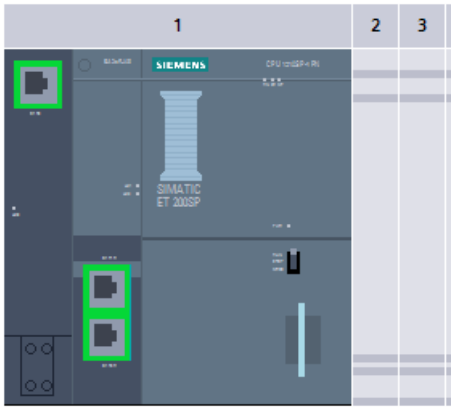


Figure 6-4 Result of the hardware detection in the device view

STEP 7 assigns a valid default parameter assignment for all modules. You can change the parameter assignment subsequently.

Properties of central modules

The properties of the CPUs have special significance for system behavior. You can set the following for a CPU using STEP 7:

- Startup behavior
- Parameter assignment of the interface(s), for example, IP address, subnet mask
- Web server, e.g. activation, user administration, and languages
- Cycle times, e.g. maximum cycle time
- System and clock memory
- Protection level for access protection with assigned password parameter
- Time-of-day settings (daylight saving time/standard time)

The properties that can be set and the corresponding value ranges are specified by STEP 7. Fields that cannot be edited are grayed out.

Reference

Information about the individual settings can be found in the online help and in the manuals of the relevant CPUs.

6.2.2 Addressing

Introduction

In order to address the automation components or I/O modules, they need unique addresses. The various address areas are explained below.

I/O address

I/O addresses (input/output addresses) are required in the user program to read inputs and set outputs.

STEP 7 automatically assigns input and output addresses when you connect the modules. Each module uses a continuous area in the input and/or output addresses corresponding to its volume of input and output data.

Module	Rack	Slot	I address	Q addr...	Type	Order no.	Firmware
PLC_1	0	1			CPU 1510SP-1 PN	6ES7 510-1DJ00-0AB0	V1.6
PROFINET-Schnittstelle_1	0	1 X1			PROFINET interface		
Port_1	0	1 X1 P1			Port		
Port_2	0	1 X1 P2			Port		
Port_3	0	1 X1 P3			Port		
	0	1 X2					
DI 4x120..230VAC ST_1	0	2	0		DI 4x120..230VAC ST	6ES7 131-6FD00-0BB1	V1.0
DQ 8x24VDC/0.5A ST_1	0	3		0	DQ 8x24VDC/0.5A ST	6ES7 132-6BF00-0BA0	V1.1
AI 8xRTD/TC 2-wire HF_1	0	4	1...16		AI 8xRTD/TC 2-wire ...	6ES7 134-6JF00-0CA1	V2.0
AQ 2xU/I HF_1	0	5		1...4	AQ 2xU/I HF	6ES7 135-6HB00-0CA1	V1.0

Figure 6-5 Example with input / output addresses from STEP 7

The address areas of the modules are assigned to the process image partition 0 ("Automatic updating") by default. This process image partition is updated in the main cycle of the CPU.

Device address (e.g. Ethernet address)

Device addresses are addresses of programmable modules with interfaces to a subnet (e.g., IP address or PROFIBUS address). They are required to address the various devices on a subnet, for example, to download a user program.

Hardware identifier

STEP 7 automatically assigns a hardware identifier to identify and address modules and submodules. You use the hardware identifier in the case of diagnostic messages or operations, for example, to identify a defective module or the module addressed.

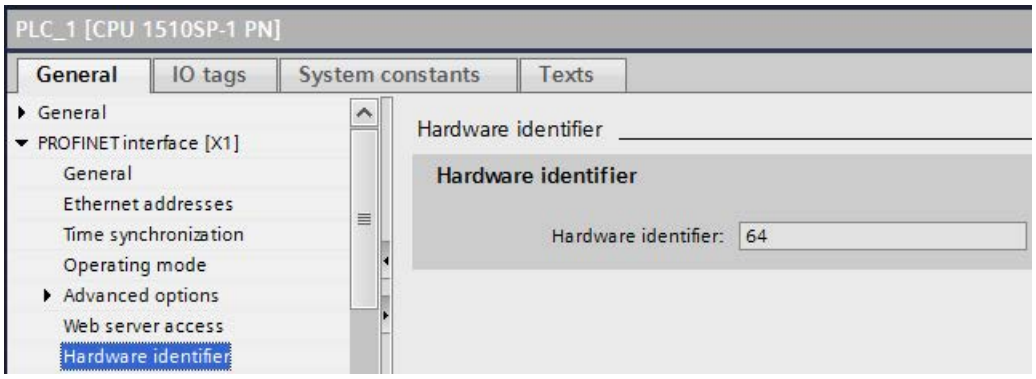


Figure 6-6 Example of a hardware identifier from STEP 7

In the "System constants" tab, you will find all hardware identifiers and their symbolic names (of the hardware identifier) for the selected module.

You can also find the hardware identifiers and names for all modules of a device in the default tag table of the "System constants" tab.

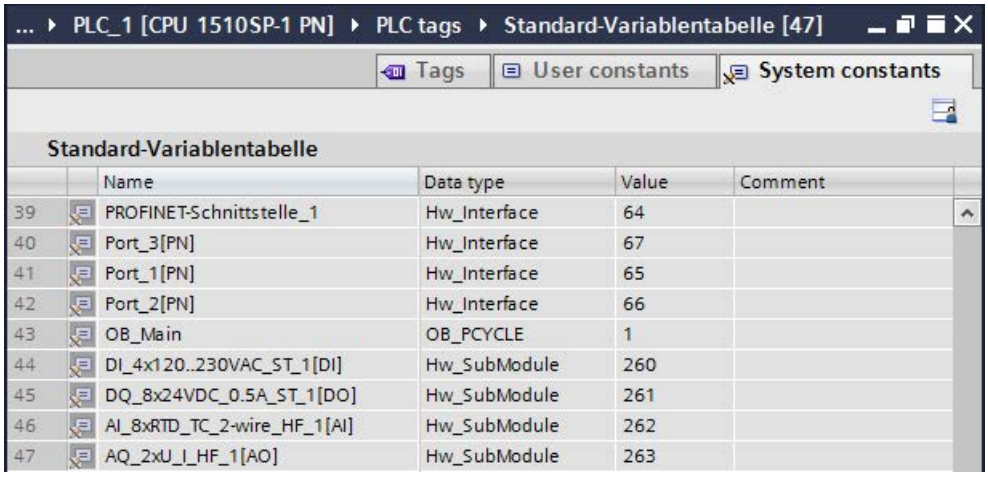


Figure 6-7 Example of an excerpt from a default tag table in STEP 7

6.2.3 Process images and process image partitions

6.2.3.1 Process image - overview

Process image of the inputs and outputs

The process image is a memory area of the CPU and includes an image of the signal states of the input/output modules. At the start of the cyclic program, the CPU transfers the signal states of the input modules to the process image of the inputs. At the end of the cyclic program, the CPU transfers the process image of the outputs as a signal state to the output modules. You access this process image memory area in the user program by addressing the operand areas inputs (I) and outputs (O).

Advantages of the process image

A process image offers the advantage that you can access a consistent image of the process signals during cyclic program execution. If a signal state at an input module changes during program processing, the signal state is retained in the process image. The process image is not updated until the next cycle.

You can only assign the addresses of a module to a single process image partition.

32 process image partitions

The overall process image is subdivided into up to 32 process image partitions (PIP).

The user program updates the PIP 0 in each program cycle (automatic update). The PIP 0 is assigned to OB 1.

You can assign the process image partitions PIP 1 to PIP 31 to the other OBs during configuration of the input/output modules in STEP 7.

6.2.3.2 Automatically updating process image partitions

You can assign one process image partition to each organization block. In this case, the user program automatically updates the process image partition. The exceptions are PIP 0 and isochronous OBs.

Updating the process image partition

The process image partition is divided into two parts:

- Process image partition of the inputs (PIPI)
- Process image partition of the outputs (PIPQ)

The CPU always updates/reads the process image partition of the inputs (PIPI) before processing of the associated OB. The CPU outputs the process image of the outputs (PIPQ) at the end of the OB.

The figure below illustrates the updating of the process image partitions.

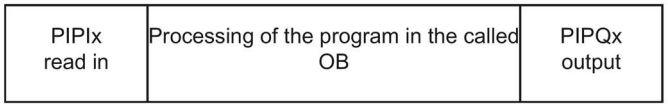


Figure 6-8 Updating process image partitions

6.2.3.3 Update process image partitions in the user program

Requirements

As an alternative to the automatic updating of process image partitions, you can update process images with the "UPDAT_PI" instruction or the "UPDAT_PO" instruction. In STEP 7, these instructions are available on the "Instructions" task card under "Extended instructions". They can be called from any point in the program.

Requirements for updating process image partitions with the "UPDAT_PI" and "UPDAT_PO" instructions:

- The process image partitions are not allowed to be assigned to any OB, which means they are not allowed to be automatically updated.
- PIP 0 (automatic update) can likewise not be updated with the "UPDAT_PI" and "UPDAT_PO" instructions.

UPDAT_PI: updates the process image partition of the inputs

With this instruction you read the signal states from the input modules into the process image partition of the inputs (PIPI).

UPDAT_PO: updates the process image partition of the outputs

With this instruction you transfer the process image partition of the outputs to the output modules.

Synchronous cycle interrupt OB

In the synchronous cycle interrupt OBs, you use the "SYNC_PI" and "SYNC_PO" operations to update the process image partitions of the operations. For additional information on the synchronous cycle interrupt OBs, refer to the STEP 7 Online Help.

Direct I/O access to the inputs and outputs of the module

You also have direct read and write access to the I/O, as an alternative to access via the process image, should direct access be required for programming reasons. This prevents a subsequent output of the process image from again overwriting the value written by direct access.

Reference

Additional information on process image partitions is available in the function manual, Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193558).

6.3 Configuring the interface module

Configuring

Read the STEP 7 online help and/or the documentation of the configuration software manufacturer when configuring the interface module.

The F-destination address is saved permanently on the coding element of the ET 200SP fail-safe modules. Fail-safe motor starters do not need an F-destination address or a coding element.

Note

The supply voltage L+ must be applied to the F-module when the F-destination address is assigned.

Note

Note the following in conjunction with configuration control:

Before you can use configuration control together with F-modules, you must assign the F-destination address to the F-modules at the designated slots. For this, each F-module must be inserted in the slot configured for it. The actual configuration can then differ from the specified configuration.

For additional information on assigning the F-destination address, refer to the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) Programming and Operating Manual and to the online help for the *S7 Configuration Pack*.

Basics of program execution 7

7.1 Events and OBs

Response to triggers

The occurrence of a start event results in the following reaction:

- If the event comes from an event source to which you have assigned an OB, this event triggers the execution of the assigned OB. The event is positioned in a queue according to its priority.
- If the event comes from an event source to which you have not assigned an OB, the CPU executes the default system reaction.

Note

Some event sources, such as startup, pull/plug, exist even if you do not configure them.

The table below provides an overview of the start events, including the possible values for OB priority, possible OB numbers, default system reaction and number of OBs. The table is sorted in ascending order by OB numbers.

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system response [1]	Number of OBs
Starting [2]	1	100, ≥ 123	Ignore	0 to 100
Cyclic program [2]	1	1, ≥ 123	Ignore	0 to 100
Time-of-day interrupt [2]	2 to 24 (2)	10 to 17, ≥ 123	Not applicable	0 to 20
Time-delay interrupt [2]	2 to 24 (3)	20 to 23, ≥ 123	Not applicable	0 to 20
Cyclic interrupt [2]	2 to 24 (8 to 17, frequency dependent)	30 to 38, ≥ 123	Not applicable	0 to 20
Hardware interrupt [2]	2 to 26 (18)	40 to 47, ≥ 123	Ignore	0 to 50
Status interrupt	2 to 24 (4)	55	Ignore	0 or 1
Update interrupt	2 to 24 (4)	56	Ignore	0 or 1
Manufacturer-specific or profile-specific interrupt	2 to 24 (4)	57	Ignore	0 or 1
Synchronous cycle interrupt	16 to 26 (21)	61 to 64, ≥ 123	Ignore	0 to 2
Time error [3]	22	80	Ignore	0 or 1
Cycle monitoring time exceeded once			STOP	
Diagnostics interrupt	2 to 26 (5)	82	Ignore	0 or 1
Pull/plug interrupt for modules	2 to 26 (6)	83	Ignore	0 or 1
Rack error	2 to 26 (6)	86	Ignore	0 or 1
MC-servo [4]	17 to 26 (25)	91	Not applicable	0 or 1

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system response [1]	Number of OBs
MC-PreServo [4]	17 to 26 (25)	67	Not applicable	0 or 1
MC-PostServo [4]	17 to 26 (25)	95	Not applicable	0 or 1
MC-Interpolator [4]	16 to 26 (24)	92	Not applicable	0 or 1
Programming error (only for global error handling)	2 to 26 (7)	121	STOP	0 or 1
I/O access error (only for global error handling)	2 to 26 (7)	122	Ignore	0 or 1

1) If you have not configured the OB.

2) In the case of these event sources, besides the permanently assigned OB numbers (see column: Possible OB numbers) in STEP 7 you can assign OB numbers from the range ≥ 123.

3) If the maximum cycle time has been exceeded twice within one cycle, the CPU always assumes the STOP state, regardless of whether you have configured OB 80.

4) You will find more information on these event sources and the starting behavior in the S7-1500 Motion Control function manual.

Assignment between event source and OBs

The type of OB determines where you make the assignment between OB and event source:

- With hardware interrupts and isochronous mode interrupts, the assignment is made during the configuration of the hardware or when the OB is created.
- In the case of the MC-Servo, MC-PreServo, MC-PostServo and MC-Interpolator, STEP 7 automatically assigns the OBs 91/92 as soon as you add a technology object.
- For all other types of OB, the assignment is made when the OB is created, where applicable after you have configured the event source.

For hardware interrupts, you can change an assignment which has already been made during runtime with the instructions ATTACH and DETACH. In this case, only the actually effective assignment changes, and not the configured assignment. The configured assignment takes effect after loading, and at startup.

The CPU ignores hardware interrupts to which you did not assign an OB in your configuration or which occur after the DETACH instruction. The check as to whether an OB is assigned to an event does not take place when the associated event occurs, but only when the hardware interrupt actually has to be executed.

OB priority and runtime behavior

If you have assigned an OB to the event, the OB has the priority of the event. The CPU supports the priority classes 1 (lowest priority) to 26 (highest priority). The following items are essential to the processing of an event:

- Calling and processing of the assigned OB
- The update of the process image partition of the assigned OB

The user program processes the OBs exclusively on a priority basis. This means the program processes the OB with the highest priority first when multiple OB requests occur at the same time. If an event occurs that has a higher priority than the currently active OB, this OB is interrupted. The user program processes events of the same priority in order of occurrence.

Note

Communication

Communication (e.g. test functions with the PG) always works permanently with the priority 15. So as not to unnecessarily prolong program runtime in the case of time-critical applications, these OBs should not be interrupted by communication. Assign a priority >15 for these OBs.

Reference

You can find more information on organization blocks in the STEP 7 online help.

7.2 CPU overload behavior

Requirement

For the event scenarios considered in the following section, we assume that you have assigned an OB to each event source and that these OBs have the same priority. The second condition, in particular, is only for the sake of a simplified representation.

Principle of CPU overload behavior

An occurring event triggers the execution of the associated OB. Depending on the OB priority and the current processor load, a time delay may occur before the OB is executed when there is an overload. The same event can therefore occur once or several times before the user program processes the OB belonging to the preceding event. The CPU treats such a situation as follows: The operating system positions the events in the order of their occurrence into the queue for their priority level.

To cope with temporary overload situations, you can limit the number of pending events originating from one and the same source. The next event is discarded as soon as the maximum number of pending start events of a specific cyclic interrupt OB, for example, is reached.

An overload occurs when events which originate from the same source occur faster than they can be processed by the CPU.

More detailed information is available in the following sections.

Discarding similar events or handling them later

Below, the term "similar events" refers to events from a single source, such as triggers for a specific cyclic interrupt OB.

The OB parameter "Events to be queued" is used to specify how many similar events the operating system places in the associated queue and therefore post-processes. If this parameter has the value 1, for example, exactly one event is stored temporarily.

Note

The post-processing of cyclic events is often undesirable, as this can lead to an overload with OBs of the same or lower priority. Therefore, it is generally advantageous to discard similar events and to react to the overload situation during the next scheduled OB processing. If the value of the "Events to be queued" parameter is low, this ensures that an overload situation is defused rather than aggravated.

If the maximum number of start events is reached in the queue for a cyclic interrupt OB (Cyclic interrupt), for example, each additional start event is only counted and subsequently discarded. During the next scheduled execution of the OB, the CPU provides the number of discarded start events in the "Event_Count" input parameter (in the start information). You can then react appropriately to the overload situation. The CPU then sets the counter for lost events to zero.

If the CPU discards a start event for a cyclic interrupt OB the first time, its further behavior depends on the OB parameter "Report event overflow into diagnostics buffer": If the check box is selected, the CPU enters the event DW#16#0002:3507 once in the diagnostics buffer for the overload situation at this event source. The CPU suppresses additional diagnostics buffer entries of the event DW#16#0002:3507 that refer to this event source until all events from this source have been post-processed.

Threshold mechanism for time error OB request

The cyclic interrupt OB parameter "Enable time error" is used to specify whether the time error interrupt should be called when a specific overload level is reached for similar events. You can find the OB parameter "Enable time error" in the properties of the OB in the "Attributes" category.

If you enable the time error OB (option box set), you define, with the "Event threshold for time error" OB parameter, the number of similar events in the queue that cause the user program to call the time error OB. If this parameter has the value 1, for example, the CPU enters the event DW#16#0002:3502 once in the diagnostics buffer and requests the time error OB when the second event occurs. The CPU suppresses additional diagnostics buffer entries of the event DW#16#0002:3502 until all events from this source have been post-processed.

In the event of an overload, you therefore have the option of programming a reaction well before the limit is reached for similar events and thus before the events are discarded.

The following value range applies to the "Event threshold for time error" parameter: 1 ≤ "Event threshold for time error" ≤ "Events to be queued".

7.3 Asynchronous instructions

Difference between synchronous/asynchronous instructions

In program processing, a differentiation is made between synchronous and asynchronous instructions.

The "synchronous" and "asynchronous" properties relate to the temporal relationship between the call and execution of the instruction.

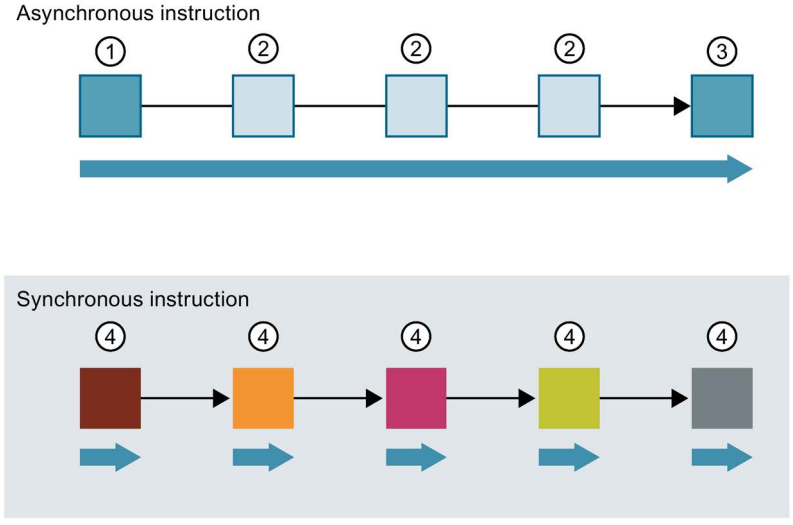
The following applies to synchronous instructions: When the call of a synchronous instruction is ended, the execution is also ended.

This is different in the case of asynchronous instructions: When the call of an asynchronous instruction is ended, the execution of the asynchronous instruction is not necessarily ended yet. This means the execution of an asynchronous instruction can extend over multiple calls. The CPU processes asynchronous instructions in parallel with the cyclic user program. Asynchronous instructions generate jobs in the CPU for their processing.

Asynchronous instructions are usually instructions for transferring data (data records for modules, communication data, diagnostics data).

Processing of asynchronous instructions

The figure below shows the difference between processing an asynchronous instruction and processing a synchronous instruction. In this figure the asynchronous instruction is called five times before the execution is completed, for example, a data record is completely transferred.



① First call of the asynchronous instruction, start of processing
② Intermediate call of asynchronous instruction, continuation of processing
③ Last call of the asynchronous instruction, termination of processing
④ The synchronous instruction is completely processed at each call
➡ Duration of the complete processing

Figure 7-1 Difference between synchronous and asynchronous instructions

Parallel processing of asynchronous instruction jobs

A CPU can process several asynchronous instruction jobs in parallel. The CPU processes the jobs in parallel under the following conditions:

- Several asynchronous instruction jobs are called at the same time.
- The maximum number of concurrently running jobs for the instruction is not exceeded.

The figure below shows the parallel processing of two jobs of the instruction WRREC. The two instructions are processed in parallel for a specific period here.

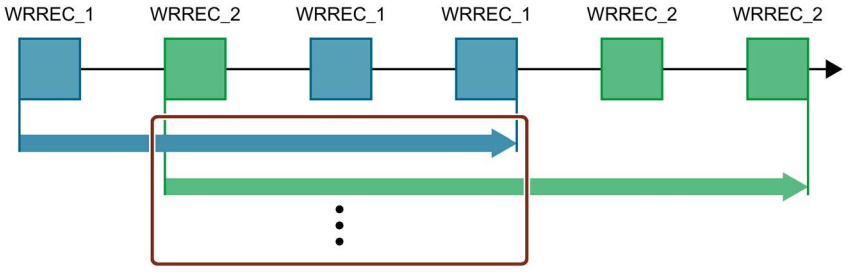


Figure 7-2 Parallel processing of the asynchronous instruction WRREC

Assignment of call to job of the instruction

To execute an instruction over multiple calls, the CPU must be able to uniquely assign a subsequent call to a running job of the instruction.

To assign a call to a job, the CPU uses one of the following two mechanisms, depending on the type of the instruction:

- Via the instance data block of the instruction (in the case of the "SFB" type)
- The input parameters of the instruction identifying the job. These input parameters must match in each call during processing of the asynchronous instruction.
  Example: A "Create_DB" instruction job is identified by the input parameters LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB and SRCBLK.

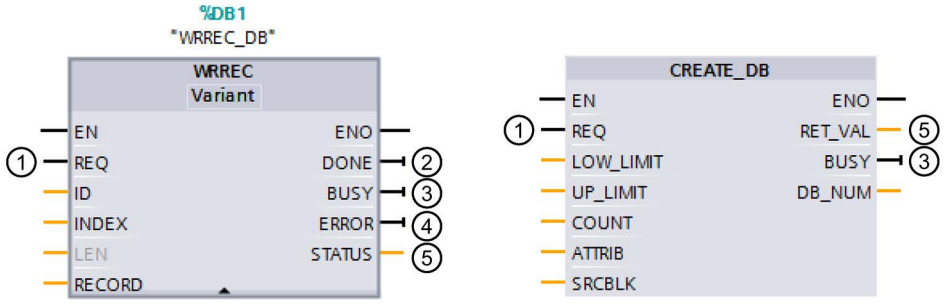
  The following table shows which instruction you can identify with which input parameters.

Instruction	Job is identified by
DPSYC_FR	LADDR, GROUP, MODE
D_ACT_DP	LADDR
DPNRM_DG	LADDR
WR_DPARM	LADDR, RECNUM
WR_REC	LADDR, RECNUM
RD_REC	LADDR, RECNUM
CREATE_DB	LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB, SRCBLK
READ_DBL	SRCBLK, DSTBLK
WRIT_DBL	SRCBLK, DSTBLK
RD_DPARA	LADDR, RECNUM
DP_TOPOL	DP_ID

Status of an asynchronous instruction

An asynchronous instruction shows its status via the block parameters STATUS/RET_VAL and BUSY. Many asynchronous instructions also use the block parameters DONE and ERROR.

The figure below shows the two asynchronous instructions WRREC and CREATE_DB.



① The input parameter REQ starts the job to execute the asynchronous instruction.

② The output parameter DONE indicates that the job was completed without error.

③ The output parameter BUSY indicates whether the job is currently being processed. When BUSY =1, a resource is assigned for the asynchronous instruction. If BUSY = 0, then the resource is free.

④ The output parameter ERROR indicates that an error has occurred.

⑤ The output parameter STATUS/RET_VAL provides information on the status of the job execution. The output parameter STATUS/RET_VAL receives the error information after the occurrence of an error.

Figure 7-3 Block parameters of asynchronous instructions using the instructions WRREC and CREATE_DB as examples.

Summary

The table below provides you with an overview of the relationships described above. It shows in particular the possible values of the output parameters if processing is not completed after a call.

Note

Following every call, you must evaluate the relevant output parameters in your program.

Relationship between REQ, STATUS/RET_VAL, BUSY and DONE during a "running" job.

Seq. no. of the call	Type of call	REQ	STATUS/RET_VAL	BUSY	DONE	ERROR
1	First call	1	W#16#7001	1	0	0
			Error code (for example, W#16#80C3 for lack of resources)	0	0	1
2 to (n - 1)	Intermediate call	Not relevant	W#16#7002	1	0	0
n	Last call	Not relevant	W#16#0000, if no errors have occurred.	0	1	0
			Error code, if errors have occurred	0	0	1

Consumption of resources

Asynchronous instructions occupy resources in the CPU while they are being processed. The resources are limited depending on the type of CPU and instruction; the CPU can only process a maximum number of asynchronous instruction jobs simultaneously. The resources are available again after a job has been successfully completed or processed with an error.

Example: For the RDREC instruction, a 1512SP-1 PN CPU can process up to 20 jobs in parallel.

If the maximum number of simultaneous jobs for an instruction is exceeded, the instruction returns the error code 80C3 (lack of resources) in the block parameter STATUS. The execution of the job is stopped until a resource becomes free again.

Note

Lower-level asynchronous instructions

Several asynchronous instructions use one or more lower-level asynchronous instructions for their processing. This dependence is shown in the tables below.

Please note that, if there are several lower-level instructions, typically only one lower-level instruction is occupied at one time.

Extended instructions: maximum number of concurrently running jobs

The table below shows the maximum number of concurrently running jobs for asynchronous extended instructions.

Extended instructions	CPU 1510SP-1 PN CPU 1510SP F-1 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
Distributed I/O		
RDREC	20	
RD_REC	10	
WRREC	20	
WR_REC	10	
D_ACT_DP	8	
ReconfigIOSystem	uses RDREC, WRREC, D_ACT_DP,	
DPSYC_FR	2	
DPNRM_DG	8	
DP_TOPOL	1	
ASI_CTRL	uses RDREC, WRREC	
PROFIenergy		
PE_START_END	uses RDREC, WRREC	
PE_CMD	uses RDREC, WRREC	
PE_DS3_Write_ET200S	uses RDREC, WRREC	
PE_WOL	uses RDREC, WRREC, TUSEND, TURCV, TCON, TDISCON	
Module parameter assignment		
RD_DPAR	10	
RD_DPARA	10	
RD_DPARM	10	
WR_DPARM	10	
Diagnostics		
Get_IM_Data	10	
GetStationInfo	10	
Recipes and data logging		
RecipeExport	10	
RecipeImport	10	
DataLogCreate	10	
DataLogOpen	10	
DataLogWrite	10	
DataLogClear	10	
DataLogClose	10	
DataLogDelete	10	
DataLogNewFile	10	
Data block functions		
CREATE_DB	10	
READ_DBL	10	
WRIT_DBL	10	
DELETE_DB	10	

Basic instructions: maximum number of concurrently running jobs

The table below shows the maximum number of concurrently running jobs for asynchronous basic instructions.

Basic instructions	CPU 1510SP-1 PN CPU 1510SP F-1 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
Array DB		
ReadFromArrayDBL	uses READ_DBL (see Extended instructions)	
WriteToArrayDBL	uses READ_DBL, WRIT_DBL (see Extended instructions)	

Communication: maximum number of concurrently running jobs

The following table shows the maximum number of simultaneously running jobs for asynchronous instructions (Open User Communication) for the various CPUs.

Open User Communication	CPU 1510SP-1 PN CPU 1510SP F-1 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
TSEND TUSEND	64	88
TRCV TURCV	64	88
TCON	64	88
TDISCON	64	88
T_RESET	64	88
T_DIAG	64	88
T_CONFIG	1	
TSEND_C	uses TSEND, TUSEND, TRCV, TCON, TDISCON	
TRCV_C	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	
TMAIL_C	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	

The following table shows the maximum number of simultaneously running jobs for asynchronous instructions (MODBUS TCP) for the various CPUs.

MODBUS TCP	CPU 1510SP-1 PN CPU 1510P F-1 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
MB_CLIENT	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	
MB_SERVER	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	

The table below shows the maximum number of simultaneously running jobs for asynchronous instructions (S7 communication) for the various CPUs. The S7 communication instructions use a common pool of resources.

S7 communication	CPU 1510SP-1 PN CPU 1510SP F-1 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
PUT GET USEND URCV BSEND BRCV	192	264

The following table shows the maximum number of simultaneously running jobs for asynchronous instructions (communication processors) for the various CPUs.

Communications processors	CPU 1510SP-1 PN CPU 1510SP F-1 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
PtP communication		
Port_Config	uses RDDEC, WRREC	
Send_Config	uses RDDEC, WRREC	
Receive_Config	uses RDDEC, WRREC	
Send_P2P	uses RDDEC, WRREC	
Receive_P2P	uses RDDEC, WRREC	
Receive_Reset	uses RDDEC, WRREC	
Signal_Get	uses RDDEC, WRREC	
Signal_Set	uses RDDEC, WRREC	
Get_Features	uses RDDEC, WRREC	
Set_Features	uses RDDEC, WRREC	
USS communication		
USS_Port_Scan	uses RDDEC, WRREC	
MODBUS (RTU)		
Modbus_Comm_Load	uses RDDEC, WRREC	
ET 200S serial interface		
S_USSI	uses CREATE_DB	
SIMATIC NET		
FTP_CMD	uses TSEND, TRCV, TCON, TDISCON	

Technology: maximum number of concurrently running jobs

The following table shows the maximum number of simultaneously running jobs for asynchronous instructions (Technology).

Technology	CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1512SP-1 PN CPU 1512SP F-1 PN
Motion Control	
MC_Power MC_Reset MC_Home MC_Halt MC_MoveAbsolute MC_MoveRelative MC_MoveVelocity MC_MoveJog MC_GearIn MC_MoveSuperimposed MC_MeasuringInput MC_MeasuringInputCyclic MC_AbortMeasuringInput MC_OutputCam MC_CamTrack MC_TorqueLimiting	300

Additional information

You can find additional information on block parameter assignment in the STEP 7 online help.

Protection

8

8.1 Overview of the protective functions of the CPU

Introduction

This chapter describes the following functions for protecting the ET 200SP against unauthorized access:

- Access protection
- Know-how protection
- Copy protection

Further measures for protecting the CPU

The following measures additionally increase the protection against unauthorized access to functions and data of the CPU from external sources and via the network:

- Deactivation of the Web server
- Deactivation of the OPC UA server (you will find further information on the security mechanisms for OPC UA servers in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual)
- Deactivation of time synchronization via an NTP server
- Deactivation of PUT/GET communication

When using the Web server, you protect your ET 200SP distributed I/O system against unauthorized access

- By setting password-protected access rights for certain users in user management.
- By using the default "Allow access via HTTPS only" option.
  This option allows access to the Web server with the secure Hypertext transfer protocol HTTPS only.

8.2 Configuring access protection for the CPU

Introduction

The CPU offers four access levels, in order to limit access to specific functions.

By setting up the access levels and the passwords for a CPU, you limit the functions and memory areas that are accessible without entering a password. You specify the individual access levels as well as the entry of their associated passwords in the object properties of the CPU.

Access levels of the CPU

Table 8- 1 Access levels of the CPU

Access levels	Access restrictions
Full access (no protection)	Any user can read and change the hardware configuration and the blocks.
Read access	With this access level, read-only access to the hardware configuration and the blocks is possible without entering a password, which means you can download the hardware configuration and blocks to the programming device. In addition, HMI access and access to diagnostics data is possible. Without entering the password, you cannot load any blocks or hardware configuration into the CPU. Additionally, the following are **not** possible without the password: • Writing test functions • Firmware update (online)
HMI access	With this access level only HMI access and access to diagnostics data are possible without entering the password. Without entering the password, you can neither load blocks nor the hardware configuration into the CPU, nor load blocks and hardware configuration from the CPU into the programming device. Additionally, the following are **not** possible without the password: • Writing test functions • Changing the mode (RUN/STOP) • Firmware update (online)
No access (complete protection)	No read or write access to the hardware configuration and the blocks is possible if the CPU is completely protected. HMI access is also not possible. The server function for PUT/GET communication is disabled in this access level (cannot be changed). Authentication with the password will again provide you full access to the CPU.

Properties of the access levels

Each access level allows unrestricted access to certain functions without entering a password, for example, identification using the "Accessible devices" function.

The CPU's default setting is "No restriction" and "No password protection". In order to protect access to a CPU, you need to edit the properties of the CPU and set up a password. In the default access level "Full access (no protection)" every user can read and change the hardware configuration and the blocks. A password is not set and is also not required for online access.

The access level of the CPU does not restrict communication between the CPUs (via the communication functions in the blocks) unless PUT/GET communication is deactivated.

Entry of the right password allows access to all the functions that are allowed in the corresponding level.

Note

Configuring an access level does not replace know-how protection

Configuring access levels offers a high degree of protection against unauthorized changes to the CPU by restricting the rights to download the hardware and software configuration to the CPU. However, blocks on the SIMATIC memory card are not write- or read-protected. Use know-how protection to protect the code of blocks on the SIMATIC memory card.

Behavior of functions with different access levels

The STEP 7 online help includes a table which lists the online functions that are available in the different access levels.

Selecting the access levels

To configure the access levels of a CPU, follow these steps:

1. Open the properties of the CPU in the Inspector window.
2. Open the "Protection" entry in the area navigation.

   A table with the possible access levels is available in the Inspector window.

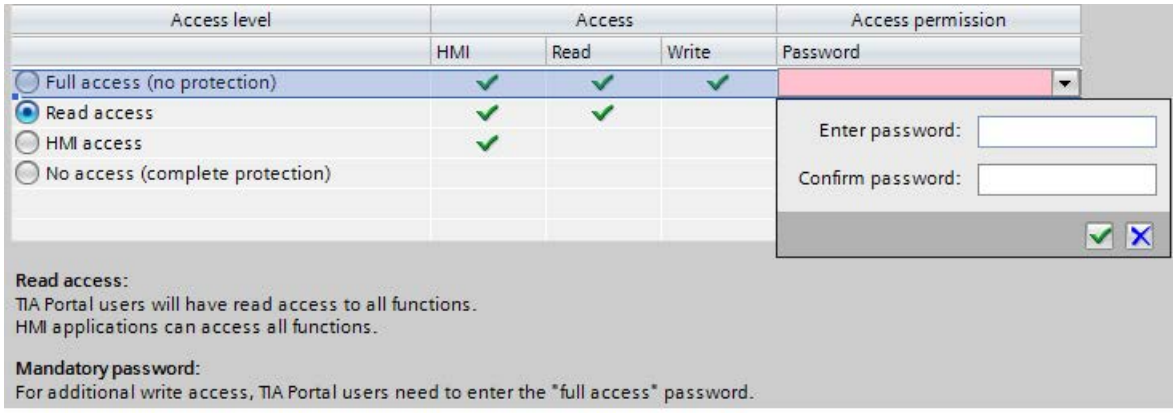


Figure 8-1 Possible access levels

3. Activate the desired protection level in the first column of the table. The green check marks in the columns to the right of the access level show you which operations are still available without entering the password. In the example (see above), read access and HMI access are still possible without a password.
4. In the "Enter password" column, specify a password for the access level "Full access" in the first row. In the "Confirm password" column, enter the selected password again to guard against incorrect entries.

   Ensure that the password is sufficiently secure, i.e. does not follow a pattern that can be recognized by a machine.
5. Assign additional passwords as needed to other access levels if the selected access level allows you to do so.
6. Download the hardware configuration to the CPU, so that the access level will take effect.

The CPU logs the entry of the correct or incorrect password and any changes in the configuration of the access levels by a corresponding entry in the diagnostics buffer.

Behavior of a password-protected CPU during operation

The CPU protection takes effect after you have downloaded the settings to the CPU.

Before an online function is executed, the CPU checks the necessary permission and, if necessary, prompts the user to enter a password. You can only execute password-protected functions from one programming device/PC at any time. Another programming device/PC cannot log on.

Access authorization to the protected data is in effect for the duration of the online connection or until you rescind the access authorization manually with "Online > Delete access rights".

Access levels for F-CPUs

For the fail-safe CPUs, there is an additional access level in addition to the four described access levels. For additional information on this access level, refer to the description of the fail-safe system SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

8.3 Using the user program to set additional access protection

Access protection via user program

You can also restrict access to a password-protected CPU in STEP 7 via the ENDIS_PW operation. You can find a description of this block in the online help under the keyword "ENDIS_PW: Limit and enable password legitimation".

8.4 Know-how protection

Application

You can use know-how protection to protect one or more OB, FB or FC blocks as well as global data blocks in your program from unauthorized access. Enter a password to restrict access to a block. The password offers high-level protection against unauthorized reading or manipulation of the block.

Readable data

If a block is know-how protected, only the following data is readable without the correct password:

- Block title, comments and block properties
- Block parameters (INPUT, OUTPUT, IN, OUT, RETURN)
- Call structure of the program
- Global tags without information on the point of use

Further actions

Further actions that can be carried out with a know-how protected block:

- Copying and deleting
- Calling in a program
- Online/offline comparison
- Load

Global data blocks and array data blocks

You can provide global data blocks (global DBs) with know-how protection. Users who do not possess the valid password can read the global data block but not change it.

You cannot provide array data blocks (array DBs) with know-how protection.

Setting up block know-how protection

To set up block know-how protection, follow these steps:

1. Open the properties of the block in question.
2. Select the "Protection" option under "General".

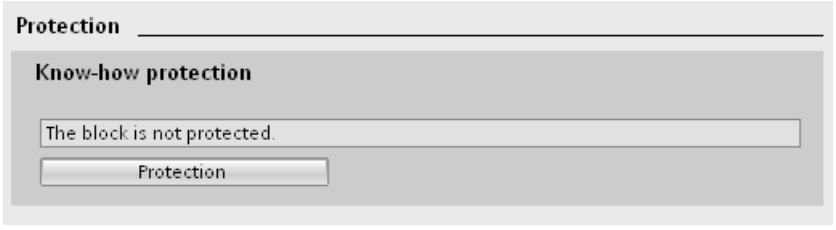


Figure 8-2 Setting up block know-how protection (1)

3. Click the "Protection" button to display the "Know-how protection" dialog.

Figure 8-3 Setting up block know-how protection (2)

4. Click the "Define" button to open the "Define Password" dialog.

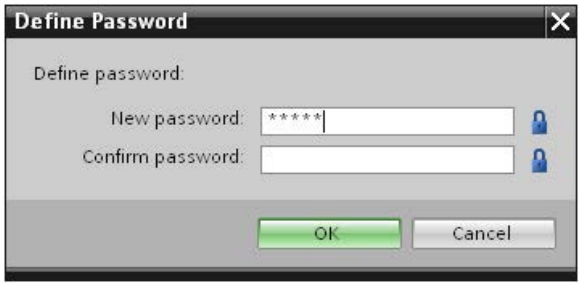


Figure 8-4 Setting up block know-how protection (3)

5. Enter the new password in the "New password" box. Enter the same password in the "Confirm password" box.
6. Click "OK" to confirm your entry.
7. Close the "Know-how protection" dialog by clicking "OK".

Result: The selected blocks are now know-how protected. Know-how protected blocks are marked with a lock in the project tree. The password entered applies to all blocks selected.

Opening know-how protected blocks

To open a know-how protected block, follow these steps:

1. Double-click the block to open the "Access protection" dialog.
2. Enter the password for the know-how protected block.
3. Click "OK" to confirm your entry.

Result: The know-how-protected block is open.

Once you have opened the block, you can edit the program code and the block interface of the block for as long as the block or STEP 7 is open. You must enter the password again the next time you open the block. If you close the "Access protection" dialog with "Cancel", you will be able to open the block but you cannot display the block code or edit the block.

If you copy the block or add it to a library, for example, this does not cancel the know-how protection of the block. The copies will also be know-how-protected.

Removing block know-how protection

To remove block know-how protection, follow these steps:

1. Select the block from which you want to remove know-how protection. The protected block must not be open in the program editor.
2. In the "Edit" menu, select the "Know-how protection" command to open the "Know-how protection" dialog.
3. Clear the "Hide code (Know-how protection)" check box.

Figure 8-5 Removing block know-how protection (1)

4. Enter the password.

Figure 8-6 Removing block know-how protection (2)

5. Click "OK" to confirm your entry.

Result: Know-how protection is removed from the selected block.

8.5 Copy protection

Application

Copy protection allows you to link the program or the blocks to a specific SIMATIC memory card or CPU. By linking this program or block to the serial number of a SIMATIC memory card or a CPU, you allow its use only in combination with this specific SIMATIC memory card or CPU.

Copy and know-how protection

Recommendation: to prevent unauthorized reset of copy protection, additionally apply know-how protection to a copy-protected block. To do this, first set up copy protection and then apply know-how protection for the block.

Setting up copy protection

To set up copy protection, follow these steps:

1. Open the properties of the block in question.
2. Select the "Protection" option under "General".

Figure 8-7 Setting up copy protection (1)

3. In the "Copy protection" area, select either the "Bind to serial number of the CPU" entry or the "Bind to serial number of the memory card" entry from the drop-down list.

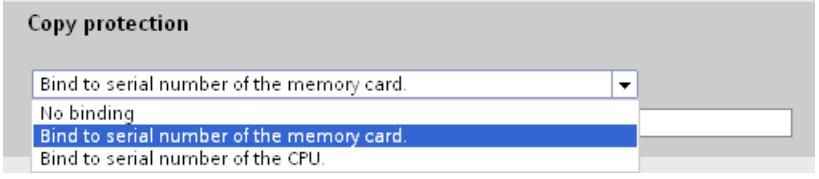


Figure 8-8 Setting up copy protection (2)

4. Activate the option "Serial number is inserted when downloading to a device or a memory card" if the serial number is to be inserted automatically during the download process (dynamic binding). Assign a password using the "Define password" button to link the use of a block additionally to the input of a password.
   Activate the option "Enter serial number" if you want to manually bind the serial number of the CPU or the SIMATIC memory card to a block (static binding).
5. You can now set up the know-how protection for the block in the "Know-how protection" area.

Note

If you download a copy-protected block to a device that does not match the specified serial number, the entire download operation will be rejected. This means that blocks without copy protection will also not be downloaded.

Removing copy protection

To remove copy protection, follow these steps:

1. Remove any existing know-how protection.
2. Open the properties of the block in question.
3. Select the "Protection" option under "General".
4. In the "Copy protection" area, select the "No binding" entry from the drop-down list.

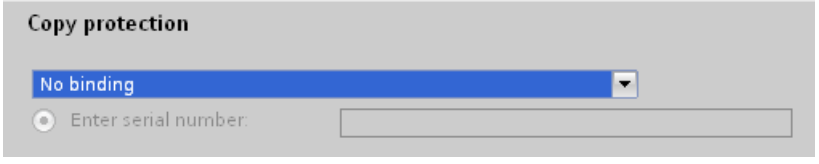


Figure 8-9 Removing copy protection

Configuration control (option handling) 9

Introduction

Configuration control (option handling) is used to operate various standard machine configuration levels in one project without changing the configuration or the user program.

Operating principle of configuration control

You can use configuration control to operate different standard machine configurations with a single configuration of the ET 200SP distributed I/O system.

- A station master is configured in a project (maximum configuration). The station master comprises all modules needed for all possible plant parts of a modular standard machine.
- The project's user program provides for several station options for various standard machine configuration levels as well as selection of a station option. A station option uses, for example, only some of the configured modules of the station master and these modules are inserted in the slots in a different order.
- The standard machine manufacturer selects a station option for a configuration of the standard machine. To do this, the project need not be modified, and it is not necessary to load a modified configuration.

You use a control data record you have programmed to notify the CPU/interface module as to which modules are missing or located on different slots in a station option as compared to the station master. The configuration control does not have an impact on the parameter assignment of the modules.

Configuration control allows you to flexibly vary the centralized/distributed configuration. This is only possible if the station option can be derived from the station master.

The following figure shows three configurations of a standard machine with the corresponding station options of the ET 200SP distributed I/O system.

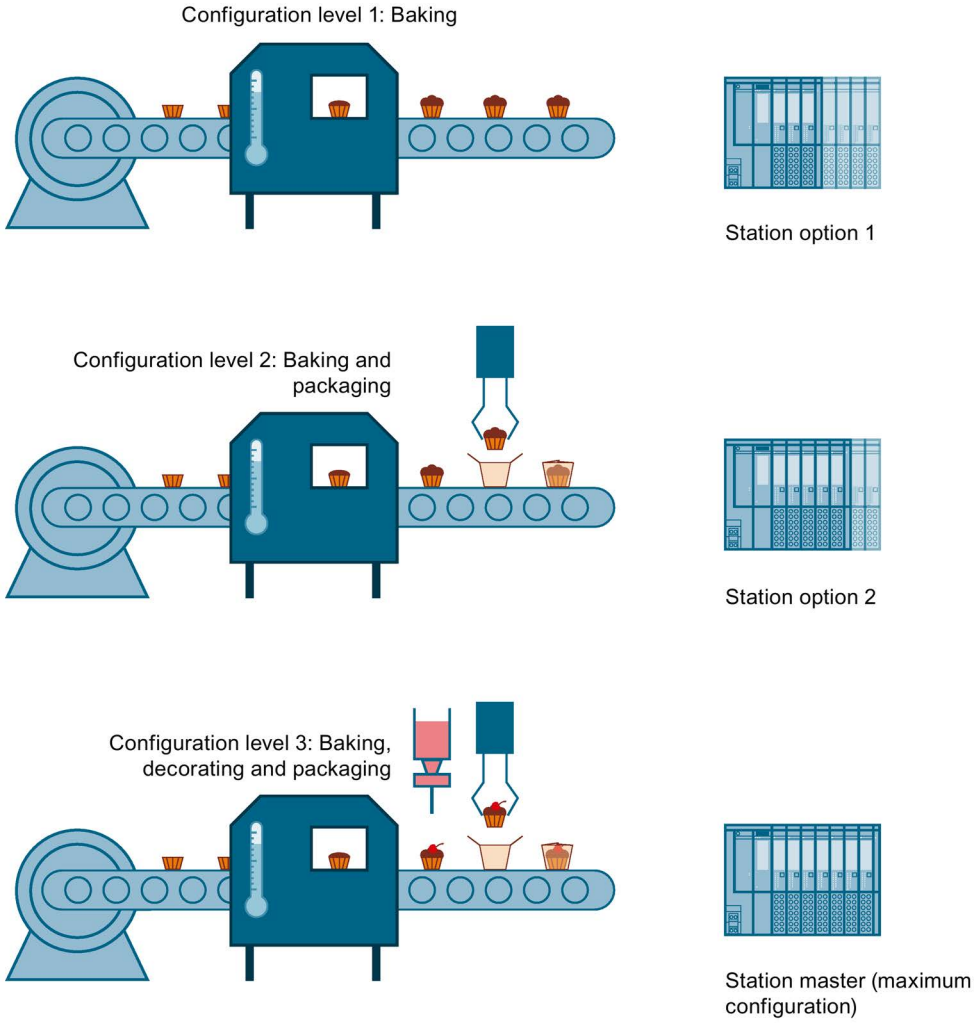


Figure 9-1 Various configuration levels of a standard machine with the corresponding station options of the ET 200SP distributed I/O system.

Advantages

- Simple project management and commissioning by using a single STEP 7 project for all station options.
- Simple handling for maintenance, versioning and upgrade:
- Hardware savings: Only those I/O modules are installed that are required for the machine's current station option.
- Savings potential in the creation, commissioning and the documentation for standard machines.
- Simple station expansion by using pre-wired empty slots. To expand, you simply exchange the BU cover for the new model.

Procedure

To set up the configuration control, follow these steps:

Step	Procedure	See...
1	Enable configuration control in STEP 7	Section Configuring (Page 175)
2	Create control data record	Section Creating the control data record (Page 177)
3	Transfer control data record	Section Transferring the control data record in the startup program of the CPU (Page 187)

Block library "OH_S71x00_Library"

The block library OH_S71x00_Library (https://support.industry.siemens.com/cs/#document/29430270?lc=en-WW) is available for download from the Internet. The block library contains data types with the structure of the control data records for the ET 200SP distributed I/O system. You can implement your flexible automation solution inexpensively with the help of these data types.

Note

Configuration control in the case of motor starters

"Manual local" mode is possible in the case of motor starters when configuration control is active. The motor starter works with the last valid parameters. Do not change the parameterization while "manual local" mode is active.

9.1 Configuring

Requirements

Configuration control is supported by the ET 200SP distributed I/O system with both an ET 200SP CPU and with interface modules via PROFINET IO and PROFIBUS DP.

Centrally for ET 200SP CPU:

- STEP 7 Professional V13 Update 3 or higher
- CPU 1510SP-1 PN/CPU 1512SP-1 PN
- Firmware version V1.6 or higher
- All modules of the CPU must be able to start up even with different configurations.
  - The startup parameter "Comparison preset to actual configuration" of the CPU is set to "Startup CPU even if mismatch" (default setting) and the module parameter "Comparison preset to actual module" of the module is set to "From CPU" (default setting).
    or
  - The module parameter "Comparison preset to actual module" for the module is set to "Startup CPU even if mismatch".

Distributed via PROFINET IO:

- Engineering Tool (e.g. STEP 7)
- IM 155-6 PN BA/ST/HF/HS
- You have assigned the interface module to an IO controller.

Distributed via PROFIBUS DP:

- Engineering Tool (e.g. STEP 7)
- IM 155-6 DP HF
- You have assigned the interface module to a DP master.
- The startup parameter is set to "Operate if preset configuration does not match actual configuration"

Required steps

Enable the "Allow to reconfigure the device via the user program" parameter when configuring the CPU/interface module in STEP 7 (TIA Portal).

- The "Allow to reconfigure the device via the user program" parameter is located in the "Configuration control" area for an ET 200SP CPU.
- The "Allow to reconfigure the device via the user program" parameter is located in the "Module parameter" area under "General" for an IM 155-6 PN interface module.

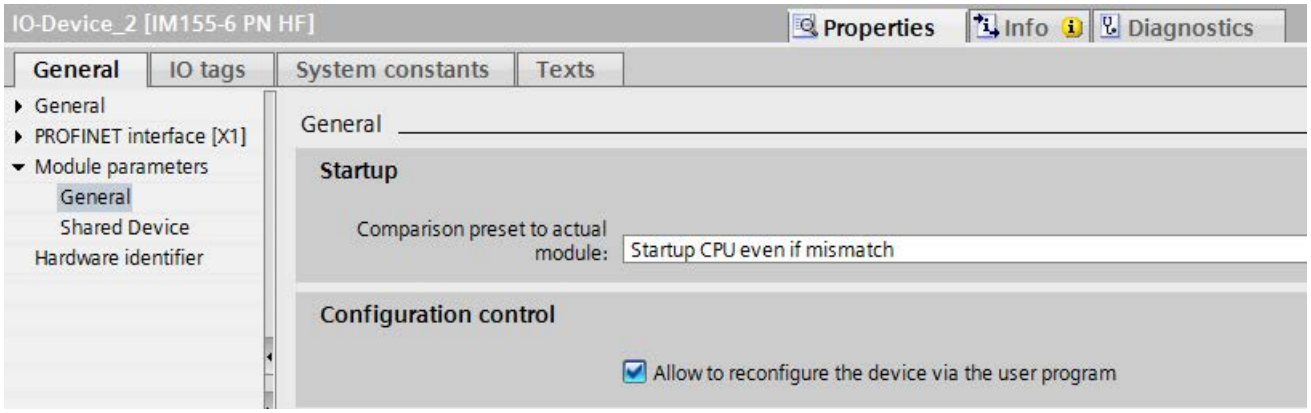


Figure 9-2 Enabling configuration control using an IM 155-6 PN HF as an example

9.2 Creating the control data record

9.2.1 Introduction

Required steps

To create a control data record for the configuration control, follow these steps:

1. Create a PLC data type which contains the structure of the control data record.
   The following figure shows a PLC data type "CTR_REC", which contains the structure of the control data record for an ET 200SP interface module.

CTR_REC

		Name	Data type	Default value	A...	V...	S...	Comment
1		Block_Lenght	USInt	134	☑	☑	☐	4 + (2 x number of Slots)
2		Block_ID	USInt	196	☑	☑	☐	
3		Version	USInt	2	☑	☑	☐	ET 200SP
4		Subversion	USInt	0	☑	☑	☐	
5		Slot 1	USInt	1	☑	☑	☐	assigned "real" slot
6		Add 1	USInt	0	☑	☑	☐	additional function
7		Slot 2	USInt	2	☑	☑	☐	assigned "real" slot
8		Add 2	USInt	0	☑	☑	☐	additional function
9		Slot 3	USInt	3	☑	☑	☐	assigned "real" slot
10		Add 3	USInt	0	☑	☑	☐	additional function
11		Slot 4	USInt	4	☑	☑	☐	assigned "real" slot
12		Add 4	USInt	0	☑	☑	☐	additional function
			USInt	5	☑	☑	☐	

Figure 9-3 Creating control data record 196 using an IM 155-6 PN HF as an example

2. Create a global data block.

3. In the data block, create an array that is based on the created PLC data type.
4. In the control data records, enter the slot assignments in the "Start value" column.

   The figure below shows the global data block "ConfDB". The data block "ConfDB" contains an array [0..5] of the PLC_DataType "CTR_REC".

ConfDB

	Name	Data type	Start value	R..	A...	V...	S..	Comment
1	Static			☐	☐	☐	☐	
2	Option	Int	0	☑	☑	☑	☐	Selection of record
3	ConfigControl	Array[0..5] of "CTR_REC"		☐	☑	☑	☐	
4	ConfigControl[0]	"CTR_REC"		☐	☑	☑	☐	
5	ConfigControl[1]	"CTR_REC"		☐	☑	☑	☐	
6	Block_Length	USInt	0	☐	☑	☑	☐	4 + (2 x number of slots)
7	Block_ID	USInt	196	☐	☑	☑	☐	
8	Version	USInt	2	☐	☑	☑	☐	ET 200SP
9	Subversion	USInt	0	☐	☑	☑	☐	
10	Slot 1	USInt	1	☐	☑	☑	☐	assigned "real" slot
11	Add 1	USInt	0	☐	☑	☑	☐	additional function
12	Slot 2	USInt	2	☐	☑	☑	☐	assigned "real" slot
13	Add 2	USInt	0	☐	☑	☑	☐	additional function
14	Slot 3	USInt	3	☐	☑	☑	☐	assigned "real" slot
15	Add 3	USInt	0	☐	☑	☑	☐	additional function
16	Slot 4	USInt	4	☐	☑	☑	☐	assigned "real" slot
17	Add 4	USInt	0	☐	☑	☑	☐	additional function

Figure 9-4 Data block for configuration control

Rules

Observe the following rules:

- Slot entries in the control data record outside the station master are ignored by the CPU/interface module.
- The control data record must contain the entries up to the last slot of the station option.
- Multiple configured slots may not be assigned to the same actual slot. In other words, each station option slot may be present only once in the control data record.

9.2.2 Control data record for an ET 200SP CPU

Slot assignment

The following table shows the possible slots for the various modules for an ET 200SP CPU:

Table 9- 1 Slot assignment

Modules	Possible slots	Comment
CPU	1	Slot 1 is always the CPU
I/O modules	2 - 65	Downstream of CPU
Server module	2 - 66	The server module completes the configuration of the ET 200SP station after the CPU/the last I/O module.

Control data record

For the configuration control of an ET 200SP CPU, you define a control data record 196 V2.0, which includes a slot assignment. The maximum slot corresponds to the slot of the server module.

The table below shows the structure of a control data record with explanations of the individual elements.

Table 9- 2 Configuration control: Structure of control data record 196

Byte	Element	Code	Explanation
0	Block length	4 + (number of slots × 2)	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1 of the station master	Slot assignment 1 in the station option (always 1, because the CPU is always in slot 1)	**Control element** Contains the information on which module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot
5	Additional function for slot 1		
6	Slot 2 of the station master	Slot assignment in the station option	
7	Additional function for slot 2		
8	Slot 3 of the station master	Slot assignment in the station option	

Byte	Element	Code	Explanation
9	Additional function for slot 3		
:	:	:	
4 + ((max. slot - 1) × 2)	Server module slot	Server module slot assignment in the station option*	
4 + ((max. slot - 1)× 2) + 1	Additional function for server module slot		

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

9.2.3 Control data record for an interface module

Slot assignment

The following table shows the possible slots for the various modules for an ET 200SP interface module:

Table 9- 3 Slot assignment

Modules	Possible slots		Comment
Interface module	0		The interface module (slot 0) is not an element of the configuration control, but instead controls this.
Station extension BA-Send	1		For mixed configuration with ET 200AL modules, BA-Send is always on slot 1.
ET 200SP I/O module	1 - 12	for IM 155-6 PN BA	Downstream from the interface module
	1 - 30	for IM 155-6 PN HS	
	1 - 32	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 64	for IM 155-5 PN HF	
Server module	1 - 13	for IM 155-6 PN BA	The server module completes the configuration of the ET 200SP station after the last I/O module.
	1 - 31	for IM 155-6 PN HS	
	1 - 33	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 65	for IM 155-5 PN HF	
ET 200AL I/O module	34 - 49	for IM 155-6 DP HF	For mixed configuration with ET 200AL modules
	66 - 81	for IM 155-6 PN ST, IM 155-6 PN HF	

Simplified control data record (V1)

For the configuration control of interface modules of the ET 200SP distributed I/O system, you define a control data record 196 V1.0, which includes a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or ET 200AL I/O module (in a mixed ET 200SP / ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 9- 4 Structure of the simplified control data record V1.0

Byte	Element	Code	Explanation
0	Block length	4 + maximum slot	Header
1	Block ID	196	
2	Version	1	
3	Version	0	
4	Slot 1 of the station master	Slot assignment in the station option	**Control element ET 200SP** Contains the information on which ET 200SP module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element) • If the module does not exist in the station option, enter 0.
5	Slot 2 of the station master	Slot assignment in the station option	
:	:	:	
4 + (slot server module - 1)	Server module slot	Server module slot assignment in the station option*	
:	:	:	:
4 + (first slot ET 200AL - 1)	First slot ET 200AL	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
:	:	:	
4 + (last slot ET 200AL - 1)	Last slot ET 200AL	Slot assignment in the station option	

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Control data record (V2)

If you change the potential groups in the station option compared to the station master, define a control data record 196 V2.0 for the ET 200SP interface module which contains a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or ET 200AL I/O module (in a mixed ET 200SP / ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 9- 5 Structure of control data record 196 V2.0

<table>
<tr><th>Byte</th><th>Element</th><th>Code</th><th>Explanation</th></tr>
<tr><td>0</td><td>Block length</td><td>4 + (maximum slot x 2)</td><td rowspan="4">Header</td></tr>
<tr><td>1</td><td>Block ID</td><td>196</td></tr>
<tr><td>2</td><td>Version</td><td>2</td></tr>
<tr><td>3</td><td>Version</td><td>0</td></tr>
<tr><td>4</td><td>Slot 1 of the station master</td><td>Slot assignment in the station option</td><td rowspan="14">Control element ET 200SP
Contains the information on which ET 200SP module is inserted in which slot.
The value that you need to enter in the corresponding byte depends on the following rule:
• If the module exists in the station option, enter the slot number of the module.
• If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element)
• If the module does not exist in the station option, enter 0.
Additional function
Contains information on whether a new potential group will be opened in the station option - by replacing a dark-colored BaseUnit with a light-colored BaseUnit.
• If you replace a dark-colored BaseUnit with a light-colored BaseUnit, enter 1 as additional function.
• If you accept the BaseUnit from the station master, enter 0 as additional function.</td></tr>
<tr><td>5</td><td colspan="2">Additional function for slot 1</td></tr>
<tr><td>6</td><td>Slot 2 of the station master</td><td>Slot assignment in the station option</td></tr>
<tr><td>7</td><td colspan="2">Additional function for slot 2</td></tr>
<tr><td>8</td><td>Slot 3 of the station master</td><td>Slot assignment in the station option</td></tr>
<tr><td>9</td><td colspan="2">Additional function for slot 3</td></tr>
<tr><td>:</td><td>:</td><td>:</td></tr>
<tr><td>4 + ((server module slot - 1) × 2)</td><td>Server module slot</td><td>Server module slot assignment in the station option*</td></tr>
<tr><td>4 + ((server module slot - 1) × 2) + 1</td><td colspan="2">Additional function for server module slot</td></tr>
</table>

Byte	Element	Code	Explanation
:	:	:	:
4 + ((first slot ET 200AL - 1) x 2)	First slot ET 200AL	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
4 + ((first slot ET 200AL - 1) x 2) + 1	Reserved		
:	:	:	
4 + ((last slot ET 200AL - 1) x 2)	Last slot ET 200AL	Slot assignment in the station option	
4 + ((last slot ET 200AL - 1) x 2) + 1	Reserved		

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Note

If a BU cover or no I/O module is plugged on a light-colored BaseUnit, you should enter 1 in the additional function for the slot.

The function "Group diagnostics: Missing supply voltage L+" requires proper assignment of the slots to a shared supply voltage L+ (potential group). All light-colored BaseUnits must be known to the interface module. By entering 1 in the additional function, you make a light-colored BaseUnit known to the interface module, even if an I/O module is not inserted.

Combination of configuration control and shared device (for PROFINET)

The configuration control function in a shared device is therefore only for the I/O modules of the IO controller to which the interface module has subscribed. I/O modules that are assigned to no controller or a different controller behave like a station without activated configuration control.

You cannot make any change to the slot assignment for modules that are assigned to another IO controller or are not assigned to an IO controller (shared device on module level). The CPU assumes a one-to-one assignment for the modules.

If additional IO controllers subscribe to a module intended for configuration control (shared device on submodule level), only one-to-one assignment is permitted for this module. It is not possible to deselect such a module using the control data record (code 0 for this slot in the control data record). This means the combination of "Configuration control" and "Shared device on submodule level" is only possible to a limited extent.

Please note that all modules affected by the configuration control including all assigned submodules are reset when you change the module assignment. Submodules that are assigned to a second IO controller are affected as well.

9.2.4 Feedback data record for interface modules

Operating principle

The feedback data record informs you about the accuracy of the module assignment and gives you the option of detecting assignment errors in the control data record. The feedback data record is mapped via a separate data record 197 V2.0. The feedback data record exists only with configured configuration control.

Slot assignment

The feedback data record refers to the configured station configuration and always includes the maximum configuration limits. The maximum configuration limits comprise 13/49/81 slots depending on the interface module in use. Partial reading of the feedback data record is possible.

The following table shows the slot assignment of the modules:

Table 9- 6 Slot assignment

Modules	Possible slots		Comment
Station extension BA-Send	1		For mixed configuration with ET 200AL modules, BA-Send is always on slot 1.
ET 200SP I/O module	1 - 12	for IM 155-6 PN BA	Downstream from the interface module
	1 - 30	for IM 155-6 PN HS	
	1 - 32	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 64	for IM 155-5 PN HF	
Server module	1 - 13	for IM 155-6 PN BA	The server module completes the configuration of the ET 200SP station after the last I/O module.
	1 - 31	for IM 155-6 PN HS	
	1 - 33	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 65	for IM 155-5 PN HF	
ET 200AL I/O module	34 - 49	for IM 155-6 DP HF	For mixed configuration with ET 200AL modules
	66 - 81	for IM 155-6 PN ST, IM 155-6 PN HF	

Feedback data record

Table 9- 7 Feedback data record

Byte	Element	Code	Explanation
0	Block length	4 + (number of slots x 2)	Header
1	Block ID	197	
2	Version	2	
3		0	
4	Slot 1 status	0/1	Status = 1: • Module from station master is inserted in the station option • Slot is marked as not available in the control data record Status = 0: • Module pulled • Incorrect module is inserted in the station option*
5	Reserved	0	
6	Slot 2 status	0/1	
7	Reserved	0	
:	:	:	
4 + ((max. slot - 1) × 2)	Max. slot status	0/1	
4 + ((max. slot - 1) × 2) + 1	Reserved	0	

* Not possible if the slot is marked as not available.

Note

The data in the feedback data record is always mapped for all modules. In a shared device configuration, it is therefore irrelevant which IO controller the respective modules are assigned to.

As long as no control data record has been sent, a one-to-one module assignment is assumed for the compilation of data record 197 (station master → station option).

Error messages

In case of error, the RDREC instruction returns the following error messages via the STATUS block parameter while reading the feedback data record:

Table 9- 8 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 197 is not correct.
$80B5_H$	Configuration control not configured
$80B8_H$	Parameter error The following events cause a parameter error: • Incorrect block ID in the header (not equal to 197) • Invalid version identifier in the header • A reserved bit has been set • The same slot in the station option has been assigned to more than one slot in the station master

9.2.5 Data records and functions

Supported data records and functions

The table below shows a comparison of the supported data records and functions depending on the CPU/interface module used.

	CPU...		Interface module (IM...)				
Supported data records and functions	1510SP-1 PN 1510SP F-1 PN	1512SP-1 PN 1512SP F-1 PN	155-6 PN HS	155-6 PN HF	155-6 PN ST	155-6 PN BA	155-6 DP HF
Control data record (V2)	✓	✓	✓	✓	✓	✓	✓
Simplified control data record (V1)	--	--	✓	✓	✓	✓	--
Read back control data record *	✓	✓	✓	✓	✓	✓	✓
Read feedback data record	--	--	✓	✓	✓	✓	✓

* You can read back the control data record with the RDREC instruction.

9.3 Transferring control data record in the startup program of the CPU

Required steps

Transfer the created control data record 196 to the CPU/the interface module using the instruction WRREC (Write data record) instruction.

Parameters of the instruction WRREC

Below, you will find explanations of individual parameters of the WRREC instruction which you must supply with specific values in the configuration control context. You can find additional information on the WRREC instruction in the STEP 7 online help.

ID	Hardware identifier • Use the HW identifier of the CPU for the configuration control for centrally arranged modules. If you have selected the CPU in the network view or device view, the HW identifier is available in the **System constants** tab of the Inspector window. Use the value of the system constant "Local~Configuration". • Use the HW identifier of the interface module for the configuration control for distributed I/O. If you have selected the interface module in the network view or device view, the HW identifier is available in the **System constants** tab of the Inspector window. Use the value of the system constant "<Name_of_the_interface_module>~Head".
INDEX	Data record number: 196 (decimal)
RECORD	Control data record to be transferred. See the section Creating the control data record (Page 177) for the structure of the control data record.

Error messages

In case of error, the instruction WRREC returns the following error messages via the STATUS block parameter:

Table 9- 9 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 196 is not correct.
$80B5_H$	Configuration control parameters not assigned.
$80E2_H$	Data record was transferred in the wrong OB context. The data record must be transferred in the startup program.
$80B8_H$	Parameter error A parameter error is caused by: • Incorrect block ID in the header (not equal to 196) • Invalid version identifier in the header • A reserved bit was set • A station master slot was assigned an invalid slot in the station option • Multiple slots in the station master are assigned to the same slot in the station option • For shared device on submodule level: Violation of defined restrictions

Selection of the station option in the user program

In order for the CPU to know which station option you want to operate, you must set up a selection option between the various control data records in the user program. You can implement the selection, for example, via an Int tag which references an array element.

Note that the tag for selecting the control data record must be located in the retentive memory area. If the tag is not retentive it will be initialized during the startup of the CPU and thus be unavailable for selection of the station option.

Special aspects relating to the transfer of the control data record to the CPU

- If you have enabled configuration control, the CPU is not ready for operation without a control data record. The CPU returns from startup to STOP if a valid control data record is not transferred in the startup OB. The central I/O is not initialized in this case. The cause for the STOP mode is entered in the diagnostics buffer.

  Note

  If an incorrect control data record is transferred to the CPU in the startup OB, the startup of the CPU may be prevented.

  In this case, perform a reset to factory settings of the CPU and then transfer a correct control data record.

- The CPU processes the WRREC instruction for transfer of the control data record asynchronously. For this reason, you must call WRREC in the startup OB repeatedly in a loop until the output parameters "BUSY" or "DONE" indicate that the data record has been transferred.
  - Tip: To program the loop, use the SCL programming language with the REPEAT ... UNTIL instruction.

```
REPEAT
 "WRREC_DB"(REQ := "start_config_control",
            ID := "Local~Configuration",
            INDEX := 196,
            LEN := "conf_LEN",
            DONE => "conf_DONE",
            BUSY => "conf_BUSY",
            RECORD := "ConfDB".ConfigControl["ConfDB".Option],
 //Selection of control data record
            ERROR => "conf_ERROR",
            STATUS => "conf_STATUS");
UNTIL NOT "conf_BUSY"
END_REPEAT;
```

  - In the graphical programming languages, you implement the loop using instructions for program control.

Example in FBD: Use the LABEL (jump label) and JMP (jump at RLO=1) instructions to program a loop.

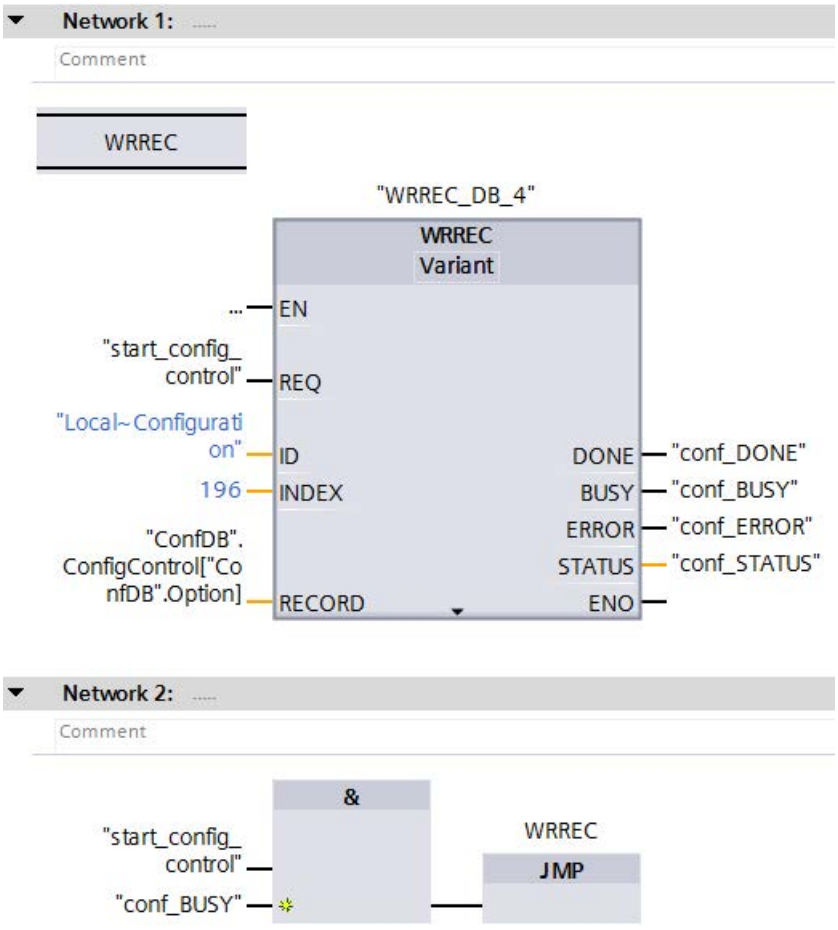


Figure 9-5 WRREC

- The control data record is stored retentively in the CPU. Note:
  - The retentivity of the control data record is independent of the retentivity settings in the STEP 7 memory area. This means that the memory area in which the control data record is configured does not have to be configured as retentive for this purpose.
  - If you write a control data record with modified configuration, the original data record 196 is deleted and the new data record 196 is saved retentively. The CPU will then restart with the modified configuration.

Special aspects relating to the transfer of the control data record to the interface module

- If you have enabled configuration control, the ET 200SP station is not ready for operation without a control data record. As long as no valid control data record has been transferred, the I/O modules are considered as failed by the CPU and exhibit substitute value behavior. The interface module continues to exchange data.
- The control data record is stored retentively in the interface module. Note:
  - If there have been no changes to the configuration, you do not need to rewrite the control data record 196 during restart.
  - If you write a control data record with modified configuration to the interface module, it will result in a station failure in the distributed I/O system. The original data record 196 is deleted and the new data record 196 is saved retentively. The station will then restart with the modified configuration.

9.4 Behavior during operation

Effect of discrepancy between station master and station option

For the online display and for the display in the diagnostics buffer (module OK or module faulty), the station master is always used and not the differing station option.

Example: A module supplies diagnostic information. This module is configured in slot 4 in the station master, but is inserted in slot 3 in the station option (missing module; see example in the next section). The online view (station master) shows a faulty module in slot 4. In the real configuration, the module in slot 3 indicates an error via an LED display.

Response when modules are missing

If modules are entered as not present in the control data record, the automation system behaves as follows:

- Modules designated as not present in the control data record do not supply diagnostics and their status is always OK. The value status is OK.
- Direct write access to the outputs that are not present or write access to the process image of the outputs that are not present: Remains without effect; no access error is signaled.
- Direct read access to the inputs that are not present or read access to the process image of the inputs that are not present: Value "0" is supplied; no access error is signaled.
- Write data record to module that is not present: Remains without effect; no error is signaled.
- Read data record from module that is not present: An error is signaled because a valid data record cannot be returned.

9.5 Examples of configuration control

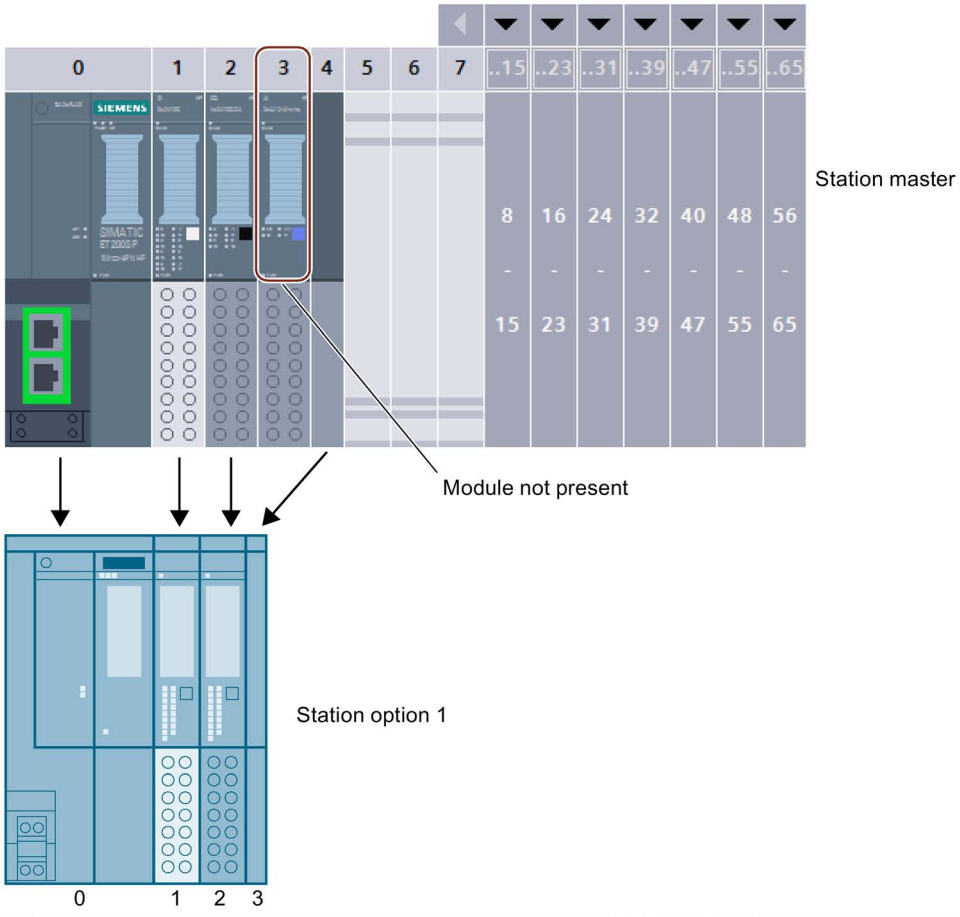
A station master consisting of an interface module, three I/O modules and the server module is configured in STEP 7 in the following section.

Four station options are derived from the station master with the configuration control:

- Station option 1 with module that is not present
- Station option 2 with modified order of modules
- Station option 3 with empty slot
- Station option 4: Opening a new potential group

Station option 1 with module that is not present

The module that is located in slot 3 in the station master is not present in the station option 1. Slot 3 must be designated in the control data record accordingly with 0 (= not present). The server module is located in slot 3 in the station option.

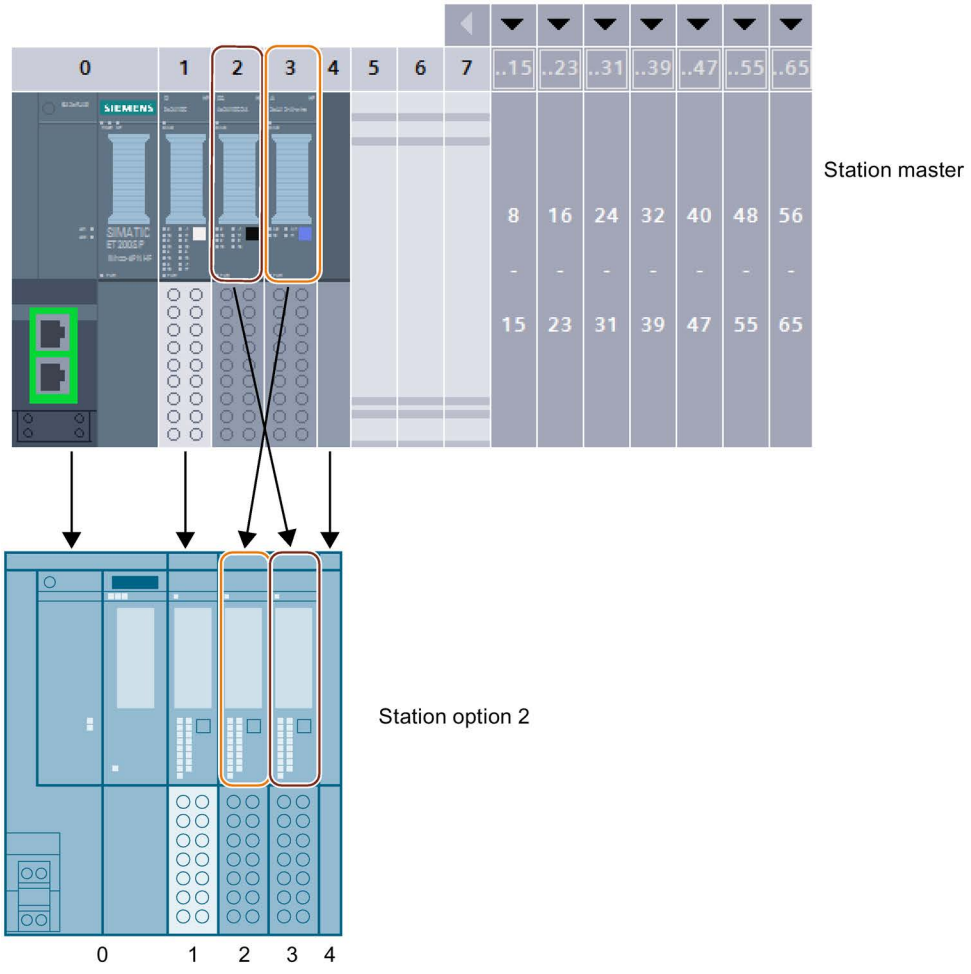


5		ConfigControl[1]	"CTR_REC"			
6		Block_Lenght	USInt	134		4 + (2 x number of slots)
7		Block_ID	USInt	196		
8		Version	USInt	2		ET 200SP
9		Subversion	USInt	0		
10		Slot 1	USInt	1		assigned "real" slot
11		Add 1	USInt	0		additional function
12		Slot 2	USInt	2		assigned "real" slot
13		Add 2	USInt	0		additional function
14		Slot 3	USInt	0		assigned "real" slot
15		Add 3	USInt	0		additional function
16		Slot 4	USInt	3		assigned "real" slot
		Add 4	USInt	0		additional function

Figure 9-6 Example: Hardware configuration of station option 1 with the associated control data record in STEP 7

Station option 2 with modified order of modules

The order of the modules at slots 2 and 3 is interchanged.

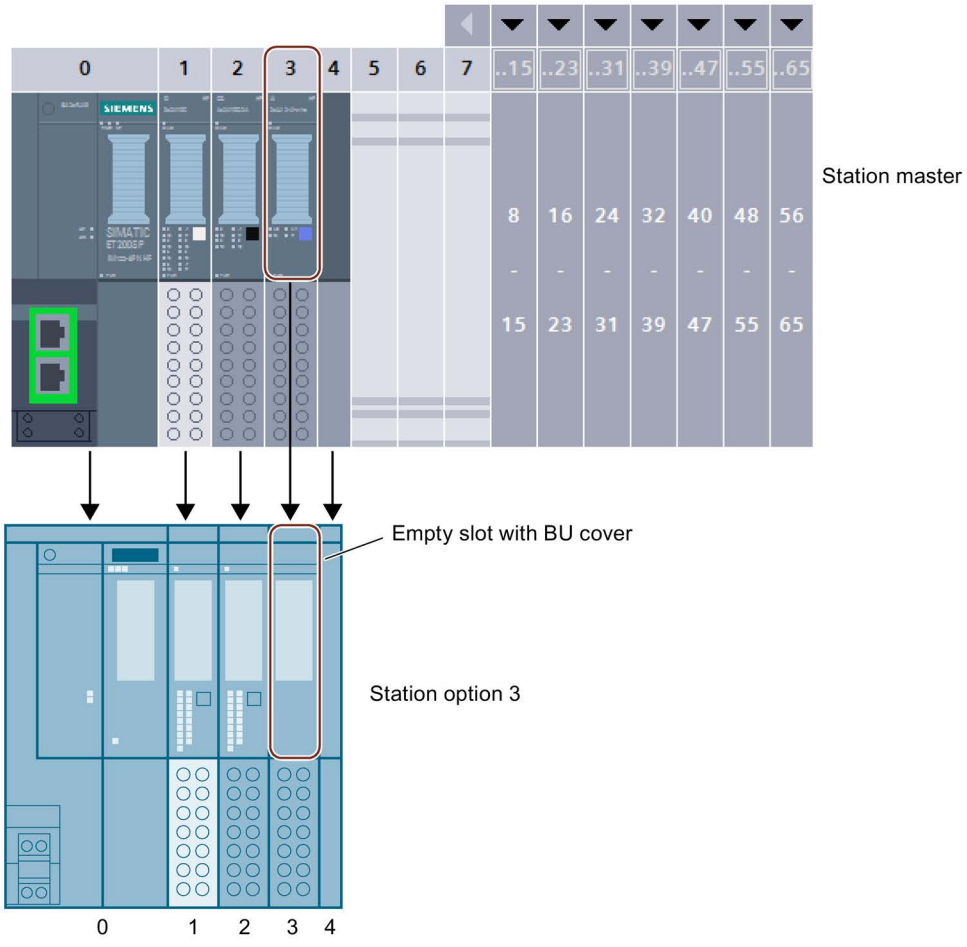


6	ConfigControl[2]	"CTR_REC"			
7	Block_Lenght	USInt	134		4 + (2 x number of slots)
8	Block_ID	USInt	196		
9	Version	USInt	2		ET 200SP
10	Subversion	USInt	0		
11	Slot 1	USInt	1		assigned "real" slot
12	Add 1	USInt	0		additional function
13	Slot 2	USInt	3		assigned "real" slot
14	Add 2	USInt	0		additional function
15	Slot 3	USInt	2		assigned "real" slot
16	Add 3	USInt	0		additional function
17	Slot 4	USInt	4		assigned "real" slot
		USInt	0		

Figure 9-7 Example: Hardware configuration of station option 2 with the associated control data record in STEP 7

Station option 3 with empty slot

The module that is located in slot 3 in the station master occupies an empty slot with BU cover in the station option. Enter the value 130 in slot 3 in the control data record.

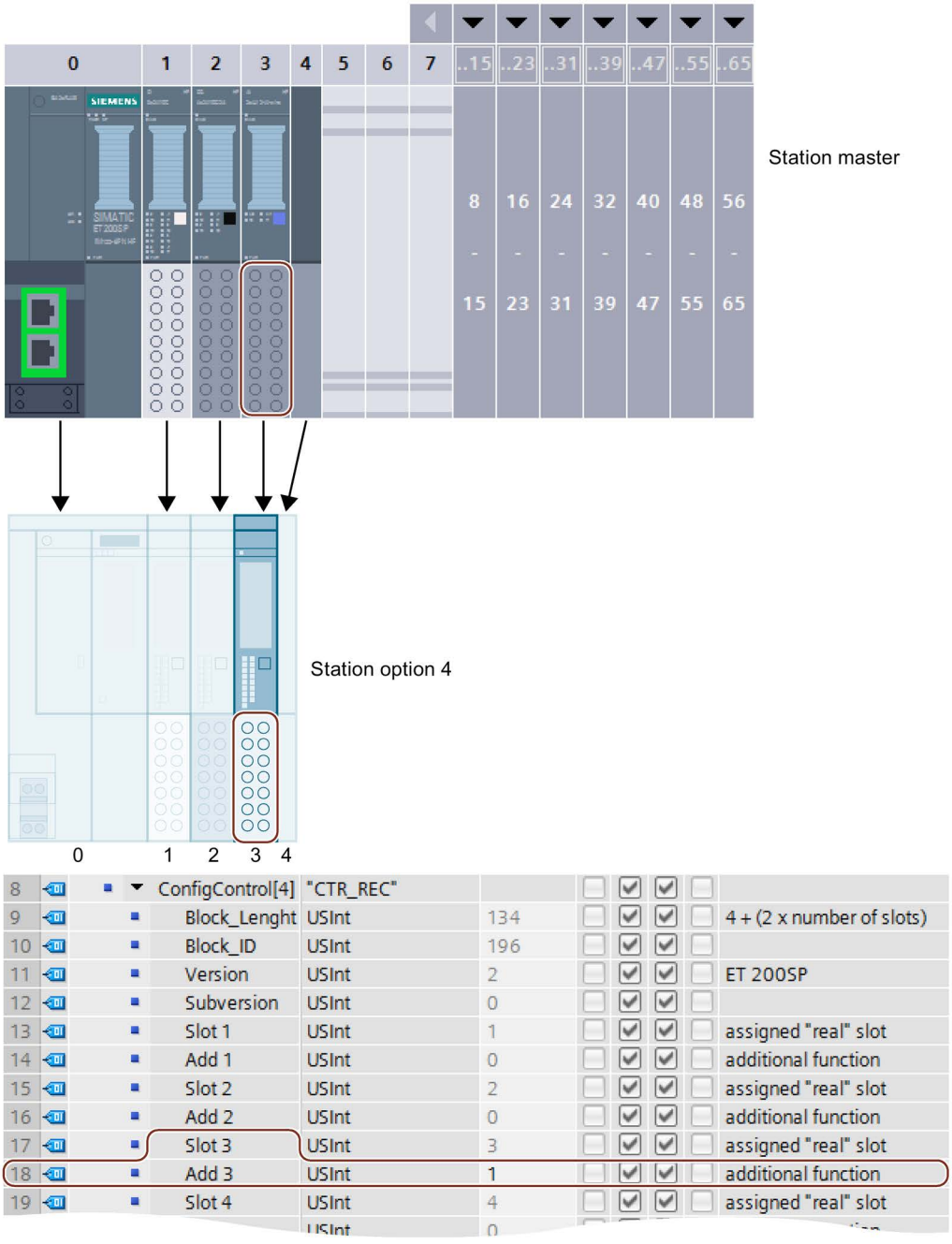


7		ConfigControl[3]	"CTR_REC"			
8		Block_Lenght	USInt	134		4 + (2 x number of slots)
9		Block_ID	USInt	196		
10		Version	USInt	2		ET 200SP
11		Subversion	USInt	0		
12		Slot 1	USInt	1		assigned "real" slot
13		Add 1	USInt	0		additional function
14		Slot 2	USInt	2		assigned "real" slot
15		Add 2	USInt	0		additional function
16		Slot 3	USInt	131		assigned "real" slot
17		Add 3	USInt	0		additional function
		Slot 4	USInt	4		assigned "real" slot

Figure 9-8 Example: Hardware configuration of station option 3 with the associated control data record in STEP 7

Station option 4: Opening a new potential group

A new potential group is opened at slot 3 of station option 4. Compared to the station master, a dark-colored BaseUnit is replaced by a light-colored BaseUnit. Enter the value 1 as additional function.



8		ConfigControl[4]	"CTR_REC"					
9		Block_Lenght	USInt	134				4 + (2 x number of slots)
10		Block_ID	USInt	196				
11		Version	USInt	2				ET 200SP
12		Subversion	USInt	0				
13		Slot 1	USInt	1				assigned "real" slot
14		Add 1	USInt	0				additional function
15		Slot 2	USInt	2				assigned "real" slot
16		Add 2	USInt	0				additional function
17		Slot 3	USInt	3				assigned "real" slot
18		Add 3	USInt	1				additional function
19		Slot 4	USInt	4				assigned "real" slot

Figure 9-9 Example: Hardware configuration of station option 4 with the associated control data record in STEP 7

Commissioning 10

10.1 Overview

Introduction

This section includes information on the following topics:

- Commissioning the ET 200SP distributed I/O system on the PROFINET IO
- Commissioning the ET 200SP distributed I/O system on the PROFIBUS DP
- Startup of the ET 200SP distributed I/O system with empty slots
- Removing/inserting the SIMATIC memory card
- Operating modes of the CPU
- CPU memory reset
- Reassigning parameters during operation
- Identification and maintenance data

Commissioning requirements

Note

Performing tests

You must ensure the safety of your plant. You therefore need to run a complete functional test and make the necessary safety checks before the final commissioning of a plant.

Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

PRONETA

SIEMENS PRONETA is a PC-based software tool that is provided free-of-charge, which simplifies the commissioning of PROFINET plants by performing the following tasks:

- Topology overview that automatically scans PROFINET and displays all connected components. This overview can be exported in the form of a device list. You have the option of "initializing" the components and performing other simple configuration tasks, as well as comparing the actual configuration with a reference plant.
- IO Check to quickly test the wiring of a plant and the module configuration of the components. By reading and writing the inputs and outputs, PRONETA makes sure that the distributed I/O devices with their sensors and actuators are wired correctly. PRONETA can create test profile templates and store test logs to document the test results.
- All tasks can be performed even before a CPU is integrated into the network. Moreover, since no other engineering tools or hardware are required, PRONETA enables a fast and convenient check of a plant configuration at an early stage.

Additional information about PRONETA can be found here (http://support.automation.siemens.com/WW/view/en/67460624).

SIMATIC Automation Tool

SIMATIC Automation Tool is a free, PC-based software tool which supports you during commissioning of the S7-1500 automation system/ET 200MP and ET 200SP distributed I/O system.

You carry out commissioning and service activities with this tool independent of the TIA Portal.

It offers the following functions:

- Scanning the network and creating a table that maps the devices accessible in the network. Unconfigured and configured CPUs and modules are included in the table, which is stored in a secure SAT project file.
- LED flashing on a device to physically locate it
- Loading addresses (IP, subnet, gateway) into a device
- Loading the PROFINET name (station name) into a device name
- Setting the time in a CPU to the current time of your PG/PC (programming device/personal computer)
- Loading a new program into a CPU
- Loading a firmware update into a CPU or a module
- Setting a CPU to RUN or STOP mode
- General reset of a CPU's memory
- Reading the diagnostics buffer of a CPU
- Loading service data out of a CPU
- Saving/restoring CPU data to/from a backup file
- Resetting devices to factory settings

Additional information on the SIMATIC Automation Tool is available here (https://support.industry.siemens.com/cs/ww/de/view/98161300).

10.2 Commissioning the ET 200SP for PROFINET IO

Requirements

- The CPU/interface module is in the "Factory settings" status or has been reset to factory settings (see section Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300)).
- For CPU: The SIMATIC memory card is as delivered or has been formatted.

10.2.1 ET 200SP CPU as an IO controller

Configuration example

To use the ET 200SP distributed I/O system as an IO controller, you require the CPU 151xSP-1 PN.

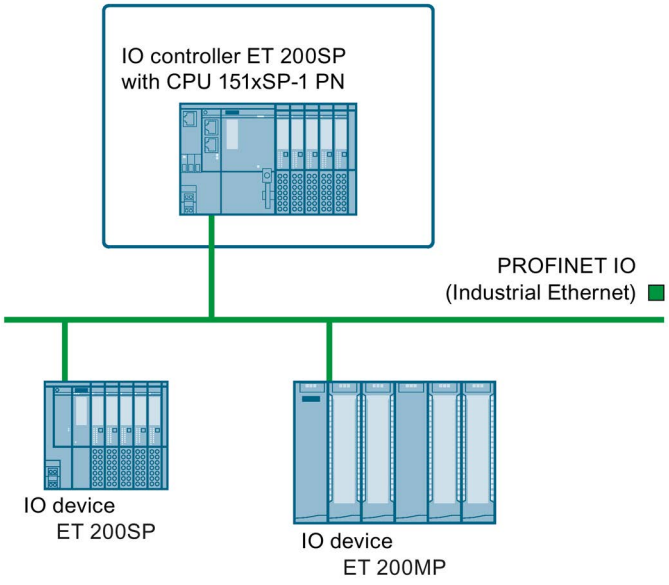


Figure 10-1 ET 200SP CPU as an IO controller

Commissioning procedure

To commission the ET 200SP distributed I/O system CPU as an IO controller for PROFINET IO, we recommend the following procedure:

Table 10- 1 Procedure for commissioning the ET 200SP CPU as an IO controller for PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 54)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 75)
3	Inserting a SIMATIC memory card in the IO controller	Section Removing/inserting a SIMATIC memory card on the CPU (Page 209)
4	Configuring the IO controller[1]	Section Configuring (Page 140)
5	Switching on supply voltages for the IO controller	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
6	Switching on supply voltages for IO devices	Documentation of the IO device
7	Downloading the configuration to the IO controller	STEP 7 online help
8	Switching IO controller to RUN mode	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
9	Checking LEDs	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test functions and eliminating problems (Page 259)

[1] The IO devices are configured with the IO controller.

10.2.2 ET 200SP CPU as an I-device

Configuration example

You need the CPU 151xSP-1 PN to use the ET 200SP distributed I/O system as an I-device.

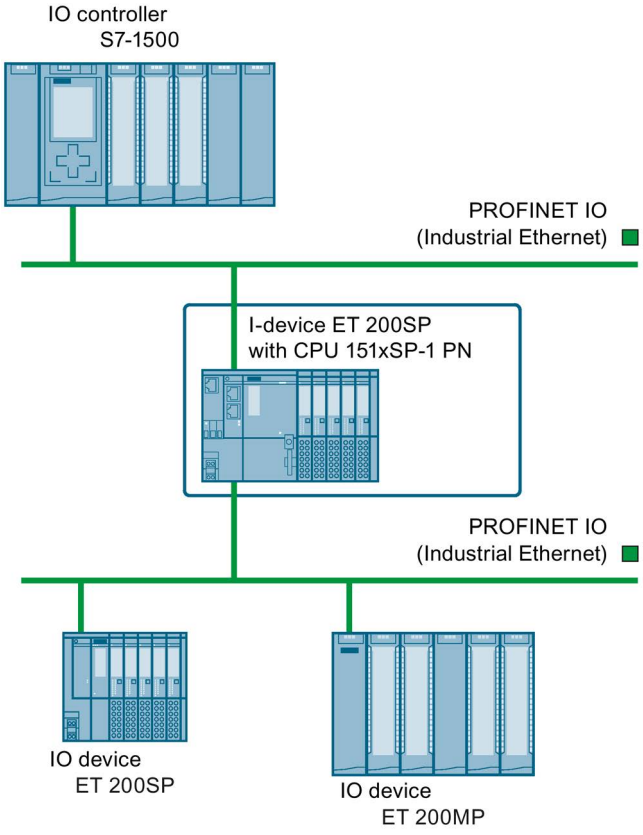


Figure 10-2 ET 200SP CPU as an I-device

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an I-device on the PROFINET IO, we recommend the following procedure:

Table 10- 2 Procedure for commissioning the ET 200SP as an I-device on the PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 54)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 75)
3	Inserting a SIMATIC memory card in the I-device	Section Removing/inserting a SIMATIC memory card on the CPU (Page 209)
4	Configuring the I-device	Section Configuring (Page 140)
5	Switching on supply voltages for the IO controller	Documentation of the IO controller
6	Switching on supply voltages for I-device and IO devices	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual and documentation of the IO devices
7	Download configuration to the I-device	STEP 7 online help
8	Switching IO controller and I-device to RUN mode	Documentation of the IO controller and CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
9	Checking LEDs	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test functions and eliminating problems (Page 259)

10.2.3 ET 200SP as an IO device

Configuration example

To use the ET 200SP distributed I/O system as an IO device, you need the IM 155-6 PNxx interface module.

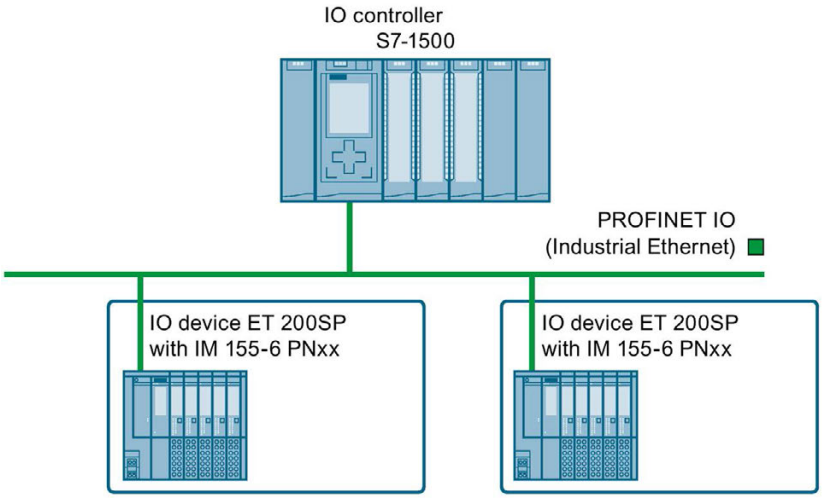


Figure 10-3 ET 200SP as an IO device

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an IO device on the PROFINET IO, we recommend the following procedure:

Table 10- 3 Procedure for commissioning the ET 200SP as an IO device for PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 54)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 75)
4	Configuring IO controller	Documentation of the IO controller
5	Switching on supply voltages for the IO controller	Documentation of the IO controller
6	Switching on supply voltages for IO devices	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
7	Downloading the configuration to the IO controller	STEP 7 online help
8	Switching IO controller to RUN mode	Documentation of the IO controller

Step	Procedure	See ...
9	Checking LEDs	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. Refer to section Test functions and eliminating problems (Page 259)

10.3 Commissioning the ET 200SP on PROFIBUS DP

Requirements

- The CPU/interface module is in the "Factory settings" status or has been reset to factory settings (see section Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300)).
- For CPU: The SIMATIC memory card is as delivered or has been formatted.

10.3.1 ET 200SP as a DP master

Configuration example

To use the ET 200SP distributed I/O system as a DP master, you need the CPU 151xSP-1 PN and the CM DP communication module.

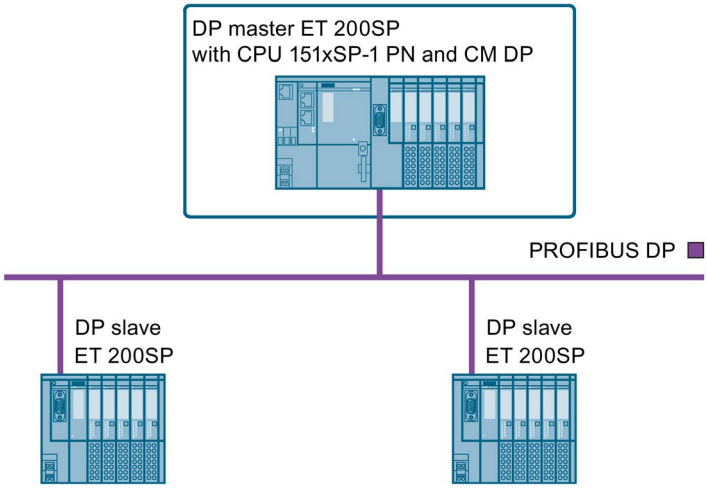


Figure 10-4 ET 200SP as a DP master

Commissioning procedure

To commission the ET 200SP distributed I/O system as a DP master on PROFIBUS DP, we recommend the following procedure:

Table 10- 4 Procedure for commissioning the ET 200SP as a DP master on the PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with CPU and CM DP)	Section Installation (Page 54)
2	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 75)
3	Inserting a SIMATIC memory card in the DP master (CPU)	Section Removing/inserting a SIMATIC memory card on the CPU (Page 209)
4	Configuring DP master (including PROFIBUS address)	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) and CM DP manual
5	Switching on supply voltages for DP master	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
6	Switching on supply voltages for DP slaves	Documentation of the DP slave
7	Download configuration to the DP master	STEP 7 online help
8	Switching DP master to RUN	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
9	Checking LEDs	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test functions and eliminating problems (Page 259)

10.3.2 ET 200SP as I-slave

Configuration example

To use the ET 200SP distributed I/O system as I-slave, you need the CPU 151xSP-1 PN and the CM DP communication module.

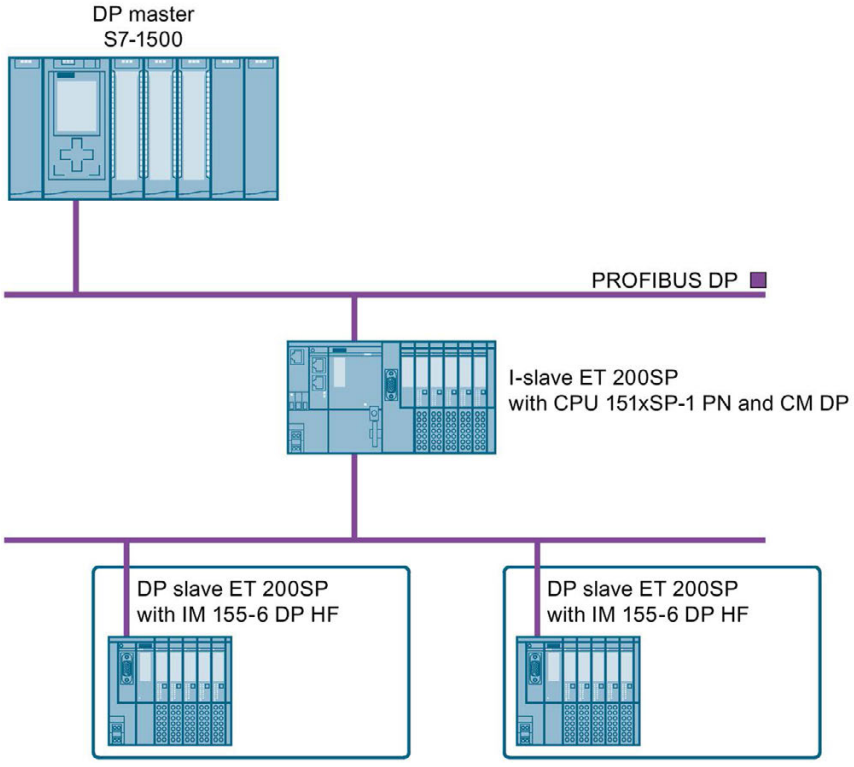


Figure 10-5 ET 200SP as I-slave

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an I-slave on the PROFIBUS DP, we recommend the following procedure:

Table 10- 5 Procedure for commissioning the ET 200SP as an I-slave for PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with CPU and CM DP)	Section Installation (Page 54)
2	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 75)
3	Configuring DP master (including PROFIBUS address)	Documentation of the DP master
4	Inserting a SIMATIC memory card in the I-slave (CPU)	Section Removing/inserting a SIMATIC memory card on the CPU (Page 209)
5	Configuring I-slave (including PROFIBUS address)	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) and CM DP manual
6	Switching on supply voltages for DP master	Documentation of the DP master
7	Switching on supply voltages for I-slaves	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
8	Loading configuration in the DP master and I-slaves	STEP 7 online help
9	Switching DP master and I-slaves to RUN	Documentation of the DP master and CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Checking LEDs	CPU 15xxSP-1 PN (http://support.automation.siemens.com/WW/view/en/90466439/133300) manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See the Test functions and fault resolution (http://support.automation.siemens.com/WW/view/en/90466439/133300) section

10.3.3 ET 200SP as a DP slave

Configuration example

To use the ET 200SP distributed I/O system as a DP slave, you need the IM 155-6 DP HF.

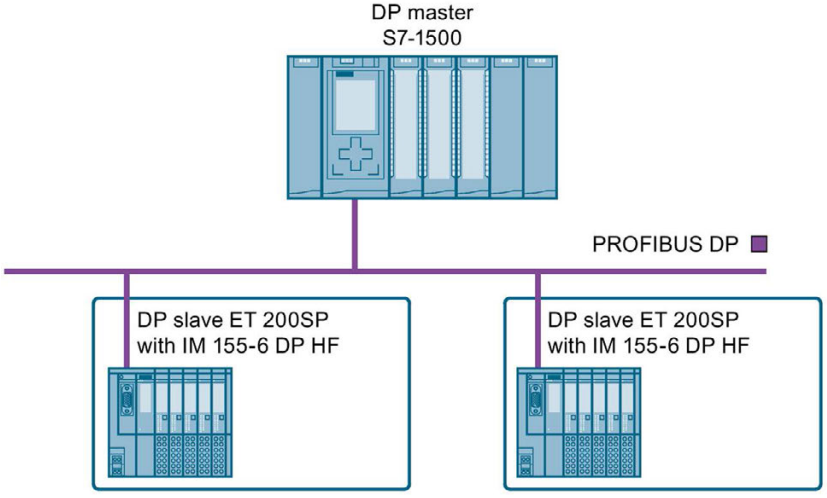


Figure 10-6 ET 200SP as a DP slave

Commissioning procedure

To commission the ET 200SP distributed I/O system as a DP slave on PROFIBUS DP, we recommend the following procedure:

Table 10- 6 Procedure for commissioning the ET 200SP as a DP master for PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with IM 155-6 DP HF)	Section Installation (Page 54)
2	Setting the PROFIBUS address on the interface module	Section Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300)
3	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 75)
4	Configuring DP master (including PROFIBUS address)	Documentation of the DP master
5	Switching on supply voltages for DP master	Documentation of the DP master
6	Switching on supply voltages for DP slaves	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
7	Download configuration to the DP master	STEP 7 online help

Step	Procedure	See ...
8	Switching DP master to RUN	Documentation of the DP master
9	Checking LEDs	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. Refer to section Test functions and eliminating problems (Page 259)

10.4 Startup of the ET 200SP with empty slots

Procedure

You can configure the ET 200SP distributed I/O system with any number of empty slots.

To build the ET 200SP distributed I/O system with any number of empty slots, follow these steps:

1. Cover all empty slots with BU covers.
2. Finish the configuration with a server module.

Special consideration: A "Module missing in slot x" diagnostic message is generated by the CPU/interface module for empty slots in which I/O modules are configured.

10.5 Removing/inserting a SIMATIC memory card on the CPU

Requirement

The CPU only supports pre-formatted SIMATIC memory cards. If necessary, delete all previously stored data before using the SIMATIC memory card. Additional information about deleting the contents of the SIMATIC memory card can be found in the section, SIMATIC memory card - overview (Page 229).

In order to work with the SIMATIC memory card, first ensure that the SIMATIC memory card is not write-protected. If it is, move the slider out of the lock position.

Inserting the SIMATIC memory card

To insert a SIMATIC memory card, follow these steps:

1. Ensure that the CPU is either switched off or in STOP mode.
2. Insert the SIMATIC memory card, as depicted on the CPU, into the slot for the SIMATIC memory card.

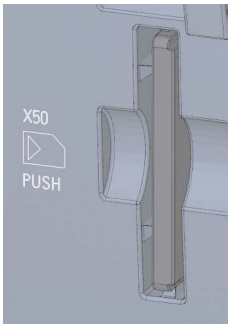


Figure 10-7 Slot for the SIMATIC memory card

3. Insert the SIMATIC memory card with light pressure into the CPU, until the SIMATIC memory card latches.

Removing the SIMATIC memory card

To remove a SIMATIC memory card, follow these steps:

1. Switch the CPU to STOP mode.
2. Press the SIMATIC memory card into the CPU with light pressure. After audible unlatching of the SIMATIC memory card, remove it.

Reactions after removing/inserting the SIMATIC memory card

Inserting and removing the SIMATIC memory card in STOP, STARTUP or RUN mode triggers a re-evaluation of the SIMATIC memory card. The CPU compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If the data differs, the CPU automatically performs a memory reset (which means the retentive data is deleted) and then goes to STOP.

The CPU evaluates the SIMATIC memory card and indicates this by the RUN/STOP LED flashing.

Reference

Additional information on the SIMATIC memory card can be found in the section SIMATIC memory card (Page 229).

10.6 Operating modes of the CPU

Introduction

Operating modes describe the status of the CPU. The following operating modes are possible using the mode selector:

- STARTUP
- RUN
- STOP

In these operating modes, the CPU can communicate, for example, via the PROFINET interface.

The status LEDs on the front of the CPU indicate the current operating mode.

10.6.1 STARTUP mode

Function

Before the CPU starts to execute the cyclic user program, a startup program is executed.

By suitably programming startup OBs, you can specify initialization tags for your cyclic program in the startup program. You have the option of programming no, one or several startup OBs.

Special features during startup

Note the following points regarding the STARTUP mode:

- All outputs are disabled or react according to the parameter settings for the particular I/O module: They provide a substitute value as set in the parameters or retain the last value output and bring the controlled process to a safe operational status.
- The process image is initialized.

  The process image is not updated.

  In order to read the current state from inputs during STARTUP, you can access inputs directly via I/O access.

  In order to initialize outputs during STARTUP, values can be written via the process image or via direct I/O access. The values are output at the outputs during the transition to the RUN mode.
- The CPU always starts up in warm restart mode.
  - The non-retentive bit memory, timers and counters are initialized.
  - The non-retentive tags in data blocks are initialized.
- During startup, cycle time monitoring is not yet running

- The startup OBs are executed in the order of the startup OB numbers. All startup OBs that you have programmed are executed, regardless of the selected startup mode.
- The following OBs can be started during startup, if a corresponding event occurs:
  - OB 82: Diagnostics interrupt
  - OB 83: Pull/plug interrupt for modules
  - OB 86: Rack error
  - OB 121: Programming error (only for global error handling)
  - OB 122: I/O access error (only for global error handling)

    You can find a description of how to use global and local error handling in the STEP 7 online help.

  No other OBs can be started until after the transition to RUN mode.

Response when expected and actual configurations do not match

The configuration downloaded to the CPU represents the expected configuration. The actual configuration is the actual configuration of the ET 200SP distributed I/O system. If the expected configuration and the actual configuration do not match, the setting of the "Comparison preset to actual configuration" parameter determines the reaction of the CPU (see section Operating mode transitions (Page 215)).

Canceling a startup

If errors occur during startup, the CPU cancels the startup and returns to STOP mode.

The CPU does not execute a startup or cancels a startup under the following conditions:

- If no SIMATIC memory card is inserted or an invalid SIMATIC memory card is inserted.
- If no hardware configuration has been downloaded.

Setting the startup behavior

To set the startup behavior, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the CPU.
2. In the properties under "General" select the "Startup" area.

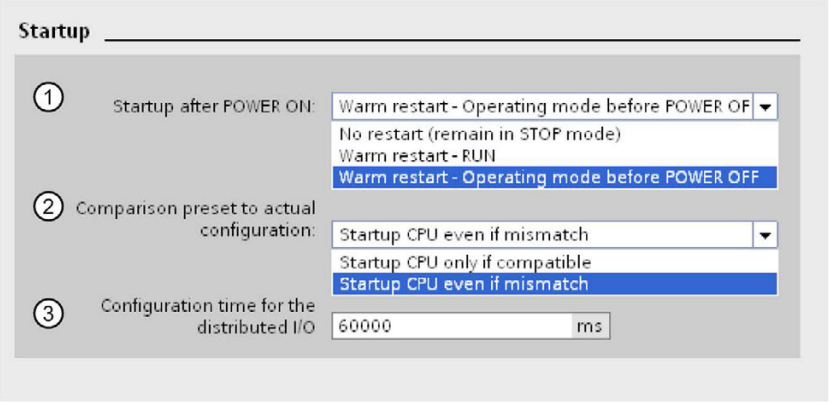


Figure 10-8 Setting the startup behavior

① Sets the startup type after POWER ON

② Defines the startup behavior when a module in a slot does not correspond to the configured module. You can set this parameter centrally, on the CPU or for each module. When you change the setting for a module, the setting made centrally for this module no longer applies.

- Startup CPU only if compatible: In this setting a module on a configured slot has to be compatible with the configured module. Compatible means that the module matches in terms of the number of inputs and outputs and with respect to its electrical and functional properties.
- Startup CPU even if mismatch: With this setting the CPU starts up regardless of the type of module plugged in.

③ Specifies a maximum period (default: 60000 ms) in which the I/O must be ready for operation. The CPU changes to RUN.

If the central and distributed I/O is not ready for operation within the configuration time, the startup characteristics of the CPU depends on the setting of the "Comparison preset to actual configuration" parameter.

Example for the "Comparison preset to actual configuration" parameter

"Startup CPU only if compatible":

The input module DI 16x24VDC ST with 16 digital inputs is a compatible replacement for the input module DI 8x24VDC ST with 8 digital inputs, because the pin assignment and all the electrical and functional properties match.

"Startup CPU even if mismatch":

Instead of a configured digital input module, you insert an analog output module or no module is present in this slot and thus in all subsequent slots. Although the configured inputs cannot be accessed, the CPU starts up.

Note that the user program cannot function correctly in this case and take the appropriate measures.

10.6.2 STOP mode

Function

The CPU does not execute the user program in STOP mode.

All outputs are disabled or react according to the parameter settings for the particular I/O module: They provide a substitute value as set in the parameters or retain the last value output keeping the controlled process in a safe operating status.

In STOP mode, the motor starter responds according to how it was parameterized for the CPU STOP state. The CPU STOP state can be circumvented with the manual local control (Local Control) function. If the CPU is switched off, a motor can be switched on in the motor starter's commissioning mode.

You will find additional information in the Motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.

10.6.3 RUN mode

Function

In "RUN" mode the cyclic, time-driven, and interrupt-driven program is executed. Addresses that are in the "Automatic Update" process image are automatically updated in each program cycle. See also the section Process images and process image partitions (Page 147).

Execution of the user program

Once the CPU has read the inputs, the cyclic program is executed from the first instruction to the last instruction.

If you have configured a minimum cycle time, the CPU will not end the cycle until this minimum cycle time is finished even if the user program is completed sooner.

A cycle monitoring time is set to ensure that the cyclic program is completed within a specified time. You can change the cycle monitoring time to suit your requirements. If the cyclic program has not finished running within this time, the system responds with a time error.
Further events such as hardware interrupts and diagnostics interrupts can interrupt the cyclic program flow and prolong the cycle time.

Reference

Further information about cycle and response times is available in the Function Manual Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193558).

10.6.4 Operating mode transitions

Operating modes and operating mode transitions

The following figure shows the operating modes and the operating mode transitions:

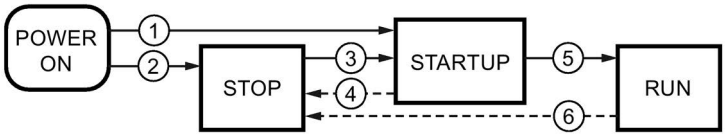


Figure 10-9 Operating modes and operating mode transitions

The table below shows the effects of the operating mode transitions:

Table 10- 7 Operating mode transitions

No.	Operating mode transitions		Effect
①	POWER ON → STARTUP	After switching on, the CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • The "Warm restart-RUN" startup type is set or • The "Warm restart mode before POWER OFF" is set and was in RUN mode before POWER OFF.	Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
②	POWER ON → STOP	After switching on, the CPU goes to "STOP" mode if: • The hardware configuration and program blocks are inconsistent or • The "No restart" startup type is set.	Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
③	STOP → STARTUP	The CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • The programming device sets the CPU to "RUN" and the mode selector is in the RUN setting or • The mode selector is switched from STOP to RUN.	Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
④	STARTUP → STOP	The CPU returns to the "STOP" mode in the following cases of "STARTUP": • The CPU detects an error during startup. • The programming device or the mode selector sets the CPU to "STOP". • A STOP command is executed in the Startup OB.	
⑤	STARTUP → RUN	The CPU goes to the "RUN" mode in the following cases of "START-UP": • The CPU has initialized the PLC tags. • The CPU has executed the startup blocks successfully.	
⑥	RUN → STOP	The CPU returns to the "STOP" mode in the following cases of "RUN": • An error is detected that prevents continued processing. • A STOP command is executed in the user program. • The programming device or the mode selector sets the CPU to "STOP".	

10.7 CPU memory reset

Basics of a memory reset

A memory reset on the CPU is possible only in the STOP mode.

When memory is reset, the CPU is changed to a so-called "initial status".

This means that:

- An existing online connection between your programming device/PC and the CPU is terminated.
- The content of the work memory and the retentive and non-retentive data (applies only to manual memory reset by the user) are deleted.
- The diagnostics buffer, time of day, and IP address are retained.
- Subsequently the CPU is initialized with the loaded project data (hardware configuration, code and data blocks, force jobs). The CPU copies this data from the load memory to the work memory.

  Result:

  – If you set an IP address in the hardware configuration ("Set IP address in the project" option) and a SIMATIC memory card with the project is in the CPU, this IP address is valid after the memory reset.

  – Data blocks no longer have current values but rather their configured start values.

  – Force jobs remain active.

How can I tell if the CPU is performing a memory reset?

The RUN/STOP LED flashes yellow at 2 Hz. After completion the CPU goes into STOP mode, and the RUN/STOP LED is switched on (permanently lit yellow).

Result after memory reset

The following table provides an overview of the contents of the memory objects after memory reset.

Memory object	Content
Actual values of the data blocks, instance data blocks	Initialized
Bit memory, timers and counters	Initialized
Retentive tags from technology objects (for example, adjustment values of absolute encoders)*	Retained
Diagnostics buffer entries (retentive area)	Retained
Diagnostics buffer entries (non-retentive area)	Initialized
IP address	Retained
Counter readings of the runtime meters	Retained
Time of day	Retained

* The retentive tags from technology objects are retained but the content of specific tags is partly re-initialized.

10.7.1 Automatic memory reset

Possible cause of an automatic memory reset

The CPU executes an automatic memory reset if an error occurs that prevents normal further processing.

Causes for such errors can be:

- User program is too large, and cannot be completely loaded into work memory.
- The project data on the SIMATIC memory card is corrupt, for example, because a file was deleted.
- If you remove or insert the SIMATIC memory card and the backed-up retentive data differs in structure from that of the configuration on the SIMATIC memory card.

10.7.2 Manual memory reset

Reason for a manual memory reset

A memory reset is required to reset the CPU to its "original state".

CPU memory reset

There are two options for performing a CPU memory reset:

- Using the mode selector
- Using STEP 7

Procedure using the mode selector

Note

Memory reset ↔ Reset to factory settings

The operation described below also reflects the procedure for resetting to factory settings:

- Selector operation with inserted SIMATIC memory card: CPU executes a memory reset
- Selector operation without inserted SIMATIC memory card: CPU executes reset to factory settings

To reset the CPU memory using the mode selector, proceed as follows:

1. Set the mode selector to the STOP position.

   Result: The RUN/STOP LED lights up yellow.

2. Set the mode selector to the MRES position. Hold the selector in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (this takes three seconds). After this, release the switch.

3. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes memory reset.

Procedure using STEP 7

For a memory reset of the CPU using STEP 7 proceed as follows:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" in response to the confirmation prompt.

Result: The CPU switches to STOP mode and performs a memory reset.

10.8 Reassigning parameters during operation

Introduction

You have the option of reassigning the parameters for the ET 200SP I/O modules during operation.

Changing parameters during operation

You make the parameter settings of the I/O modules using data records. Each I/O module has a separate data record. The instruction "WRREC" applies the changed parameters to the I/O module.

If you are using the CPU as an I-device, you reassign the parameters of the I/O modules via the I-device.

Note

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can evaluate OB83 for this purpose. After inserting a module, the CPU does not call OB83 until the module has started up and its parameters are assigned. This ensures the execution of the data record operations without errors.

Note

You need to transfer the new parameters with the "WRREC" instruction after a POWER OFF/POWER ON of the ET 200SP.

Instruction for parameter assignment

The following instruction is provided for assigning parameters to the I/O module in the user program:

Instruction	Application
"WRREC"	Transfer the modifiable parameters to the addressed ET 200SP module.

Error message

In the event of an error, the following return values are reported:

Table 10- 8 Error message

Error code	Meaning
$80E0_H$	Error in header information
$80E1_H$	Parameter error

Reference

You will find the setup of the parameter data record in the manuals of the I/O modules (http://support.automation.siemens.com/WW/view/es/55679691/133300).

10.9 Identification and maintenance data

10.9.1 Reading out and entering I&M data

I&M data

I&M identification data is information which is stored on the module either as read-only data (I-data) or read/write data (M-data).

Identification data (I&M0): Manufacturer information about the module that can only be read and is in part also printed on the housing of the module, for example, article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and written to the module.
All modules of the ET 200SP distributed I/O system support identification data (I&M0 to I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a plant
- Correcting errors in a plant

Modules can be clearly identified online using the I&M identification data.

STEP 7 allows you to read the identification I&M data (see STEP 7 online help).

Note

The BusAdapter and the interface module IM 155-6 PN HF support the identification data I&M0 to I&M4 (signature).

Options for reading out I&M data

- Via the user program
- Using STEP 7 or HMI devices
- Via the Web server of the CPU

Procedure for reading I&M data by means of the user program

In order to read the I&M data of the modules in the user program, use the RDREC instruction.
The data record structure for modules that are distributed and accessible via PROFINET IO/ PROFIBUS DP is described in the section Structure of the data record for I&M data (Page 223).

Procedure for reading the I&M data using STEP 7

Requirements: There must be an online connection to the CPU/interface module.

Proceed as follows to read the I&M data via STEP 7:

1. In the project tree, under "Distributed I/O" select the IO device IM 155-6 PN ST (for example).
2. Select **> IO device > Online & diagnostics > Identification & Maintenance**.

Procedure for input of maintenance data using STEP 7

STEP 7 assigns a default module name. You can enter the following information:

- Plant designation (I&M1)
- Location identifier (I&M1)
- Installation date (I&M2)
- Additional information (I&M3)

To enter maintenance data via STEP 7, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the interface module, for example.
2. In the properties under "General", select the "Identification & Maintenance" area and enter the data.

During the loading of the hardware configuration, the I&M data is also loaded.

Procedure for reading I&M data via the Web server

The procedure is described in detail in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) Function Manual.

10.9.2 Data record structure for I&M data

Reading I&M data records (distributed via PROFINET IO)

You can directly access specific identification data by selecting **Read data record** (RDREC instruction). You obtain the corresponding part of the identification data under the relevant data record index.

The data records are structured as follows:

Table 10- 9 Basic structure of data records with I&M identification data

Content	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	I&M0/index $AFF0_H$: 54 I&M1/index $AFF1_H$: 54 I&M2/index $AFF2_H$: 16 I&M3/index $AFF3_H$: 54	

Table 10- 10 Data record structure for I&M identification data

Identification data	Access	Default	Explanation
Identification data 0: (data record index AFF0 hex)			
VendorIDHigh	Read (1 byte)	00_H	This is where the name of the manufacturer is stored (42_D = SIEMENS AG).
VendorIDLow	Read (1 byte)	2 A_H	
Order_ID	Read (20 bytes)	6ES7155-6AU00-0BN0	Article number of the module (e.g. of the interface module)
IM_SERIAL_NUMBER	Read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	Read (2 bytes)	1	Corresponding HW version
IM_SOFTWARE_REVISION	Read	Firmware version	Provides information about the firmware version of the module
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_ Enhancement	(1 byte)	00 - FF_H	
• IM_SWRevision_Bug_Fix	(1 byte)	00 - FF_H	

Identification data	Access	Default	Explanation
• IM_SWRevision_Internal_ Change	(1 byte)	00 - FF_H	
IM_REVISION_COUNTER	Read (2 bytes)	0000_H	Provides information about parameter changes on the module (not used)
IM_PROFILE_ID	Read (2 bytes)	0000_H	Generic Device
IM_PROFILE_SPECIFIC_TYPE	Read (2 bytes)	0005_H	Interface modules/BusAdapters
		0003_H	I/O modules and motor starters
		0001_H	CPU
IM_VERSION	Read	0101_H	Provides information on the version of the identification data (0101_H = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	Read (2 bytes)	$000E_H$	Provides information about the available identification data (I&M1 to I&M3)
Maintenance data 1: (data record index AFF1 hex)			
IM_TAG_FUNCTION	Read/write (32 bytes)	-	Enter a module identifier here that is unique plant-wide.
IM_TAG_LOCATION	Read/write (22 bytes)	-	Enter the installation location of the module here.
Maintenance data 2: (data record index AFF2 hex)			
IM_DATE	Read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the module here.
Maintenance data 3: (data record index AFF3 hex)			
IM_DESCRIPTOR	Read/write (54 bytes)	-	Enter a comment describing the module.

Reading I&M data records with data record 255 (distributed via PROFIBUS DP)

The modules support standardized access to identification data via DS 255 (index 65000 to 65003). For further information on the DS 255 data structure, refer to the specifications of the Profile Guidelines Part 1: Identification & Maintenance Functions, Order No.: 3.502, Version 2.1, May 2016

10.10 Shared commissioning of projects

Team Engineering

In Team Engineering several users from various engineering systems work on a project at the same time and access one ET 200SP CPU.

The users can edit separate parts of a master project independently of one another at the same time. The changes of the other editors are displayed in a synchronization dialog during the loading of the configuration in the CPU and synchronized automatically, if possible.

Certain online functions can also be executed at the same time from several engineering systems on a shared CPU, such as:

- Monitoring blocks on the CPU
- Modifying blocks on the CPU
- Trace functions

You can find detailed information on the topic of Team Engineering in the STEP 7 online help.

10.11 Backing up and restoring the CPU configuration

10.11.1 Overview

Backup from online device

You will make a number of changes to your plant over time, for example, add new devices, replace existing devices or adapt the user program. If these changes result in undesirable behavior, you can restore the plant to an earlier state. Before you load a changed configuration to the CPU, first use the option "Backup from online device" to create a complete backup of the current device status.

Upload from device (software)

With the option "Upload from device (software)", you load the software project data from the CPU to an existing CPU in the project.

Upload device as new station

If you are operating a new programming device/PC in the plant, the STEP 7 project that was used to create the plant configuration might not be available. In this case you can use the option "Upload device as new station" to load the device's data into a project in your PG/PC.

Snapshot of the monitor values

You can use the option "Snapshot of the monitor values" to backup the current values of the data block, in order to be able to restore the current values if necessary at a later date.

Overview of backup types

The table below shows the backup of CPU data depending on the selected type of backup and its specific characteristics:

	Backup from online device	Upload from device (software)	Upload device as new station	Snapshot of the monitor values
Current values of all DBs (global and instance data blocks) [1]	✓	✓	✓	✓
Blocks of the type OB, FC, FB and DB	✓	✓	✓	--
PLC tags (tag names and constant names)	✓	✓	✓	--
Technology objects	✓	✓	✓	--
Hardware configuration	✓	--	✓	--
Actual values (bit memories, timers, counters)*	✓	--	--	--
Contents of the SIMATIC memory card	✓	--	--	--
Archives, recipes	✓	--	--	--
Entries in the diagnostics buffer	--	--	--	--
Current time	--	--	--	--
Properties of the type of backup				
Backup possible for fail-safe CPUs	✓	✓ [2]	--	✓
Backup can be edited	--	✓	✓	✓
Backup possible in operating mode	STOP	RUN, STOP	RUN, STOP	RUN, STOP

[1] Only the values of the tags that are set as retentive are saved.

[2] Only possible in the STOP operating state and for individual fail-safe blocks.

Reference

You can find more information on the different backup types in the STEP 7 online help.

Emergency address (emergency IP)

The emergency address (emergency IP address) of a CPU was conceived for diagnostic and downloading functions, e.g. if the CPU can no longer be reached via the IP protocol due to loading of an incorrect project. You can find information on the emergency address in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/97649773).

Archiving multilingual project texts

When you configure a CPU, different categories of texts come into being, e.g.

- Object names (names of blocks, modules, tags, etc.)
- Comments (for blocks, networks, watch tables, etc.)
- Messages and diagnostic texts

Texts are provided by the system (e.g. diagnostic buffer texts) or are created during configuration (e.g. messages).

In a project, texts exist in one single language or in several languages after a translation process. You can maintain project texts in all languages, which are at your disposal in the project navigator (Languages & Resources > Project Texts). The texts arising during configuration can be loaded into the CPU.

The following texts containing the project data are loaded into the CPU in the chosen languages and are also used by the Web server:

- Diagnostic buffer texts (not editable)
- Module status texts (not editable)
- Message texts with associated text lists
- Tag comments and step comments for GRAPH and PLC Code Viewer
- Comments in watch tables

The following texts containing the project languages are also loaded into the CPU in the chosen languages, but are not used by the Web server:

- Comments in tag tables (for tags and constants)
- Comments in global data blocks
- Comments of elements in block interfaces of FBs, FCs, DBs and UDTs
- Network titles in data blocks that are written in ladder logic (LAD), function block diagram (FBD) or statement list (STL)
- Block comments
- Network comments
- Comments of LAD and FBD elements

The CPUs support archiving of multilingual project texts in up to three different project languages. If the project texts belonging to a specific project language nevertheless exceed the memory space reserved for them, it is not possible to load the project into the CPU. The operation is canceled with a message indicating that not enough free storage space is available. In such a case, take measures to reduce the required storage space, for example by shortening comments.

Note

Size of the SIMATIC memory card

If the storage space needed to load projects exceeds the storage space available on the SIMATIC memory card in use, loading into the CPU is canceled with an error message.

Therefore, make sure that there is enough available storage space on your SIMATIC memory card for loading projects.

You will find information on reading out the storage space capacity utilization of the CPU and the SIMATIC memory card in the Structure and use of the CPU memory (https://support.industry.siemens.com/cs/de/de/view/59193101/en) function manual.

You will find information on parameterization of multilingual project texts in STEP 7 in the STEP 7 online help.

SIMATIC memory card

11

11.1 SIMATIC memory card - overview

Introduction

The CPU uses a SIMATIC memory card as the program memory. The SIMATIC memory card is a preformatted memory card compatible with the Windows file system. The memory card is available in different memory sizes and can be used for the following purposes:

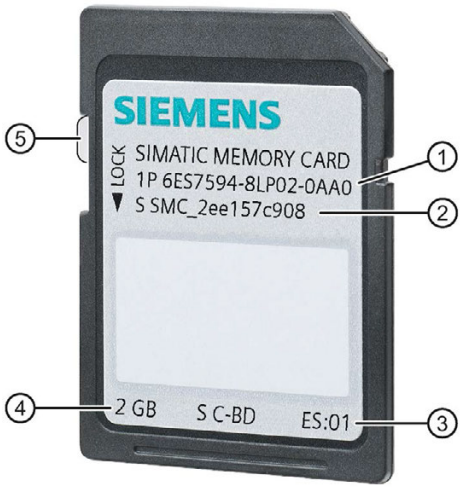
- Transportable data carrier
- Program card
- Firmware update card
- Service data card

When you transfer the user program to the CPU through an online connection, it is written into the SIMATIC memory card's load memory, which must be in the CPU's card slot for this purpose.

You can also write to the SIMATIC memory card in the PG/PC. A commercially available SD card reader is required to write/read the SIMATIC memory card with the programming device/PC. This is used, for example, to copy files directly to the SIMATIC memory card using the Windows Explorer.

The SIMATIC memory card is mandatory to operate the CPU.

Labeling of the SIMATIC memory card



① Article number
② Serial number
③ Product version
④ Memory size
⑤ Slider for enabling write protection:
- Slider up: Not write-protected
- Slider down: Write-protected

Figure 11-1 Labeling of the SIMATIC memory card

Folders and files on the SIMATIC memory card

The following folders and files can be found on the SIMATIC memory card:

Table 11- 1 Folder structure

Folder	Description
FWUPDATE.S7S	Firmware update files for CPU and I/O modules
SIMATIC.S7S	User program, i.e. all blocks (OBs, FCs, FBs, DBs) and system blocks, project data of the CPU
SIMATIC.HMI	HMI-relevant data
DataLogs	DataLog files
Recipes	Recipe files
Backups	Files for backing up and restoring via the display

Table 11- 2 File structure

File type	Description
S7_JOB.S7S	Job file
SIMATIC.HMI\Backup*.psb	Panel backup files
SIMATICHMI_Backups_DMS.bin	Protected file (required to use panel backup files in STEP 7)
__LOG__	Protected system file (required in order to use the card)
crdinfo.bin	Protected system file (required in order to use the card)
DUMP.S7S	Service data file
*.pdf, *.txt, *.csv, etc.	Additional files with different formats that you can also store in folders of the SIMATIC memory card

Use the serial number for copy protection

You can set up copy protection for CPUs which binds execution of the block to a specific SIMATIC memory card. Configuration is carried out in STEP 7 in the properties of the block "Bind to serial number of the SIMATIC memory card".

Users can only execute the block if it is on the SIMATIC memory card with the defined serial number (see chapter Copy protection (Page 170)).

Removing a SIMATIC memory card

Only remove the SIMATIC memory card in the POWER OFF or STOP state of the CPU. Make sure that no writing functions (e.g. loading/deleting a block) are active in STOP mode, or were active at POWER OFF. To do this, disconnect the communication connections.

If you remove the SIMATIC memory card during a write process, the following problems can occur:

- The data contents of a file are incomplete.
- The file is no longer readable, or no longer exists.
- The entire content of the card is corrupted.

Inserting the SIMATIC memory card in the CPU in the STOP operating state triggers re-evaluation of the SIMATIC memory card. The CPU compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If this data differs, the CPU automatically triggers general reset (i.e. the retentive data is deleted) and then changes to STOP.

In connection with removal of the SIMATIC memory card, also pay attention to the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59457183).

Removing a SIMATIC memory card from Windows computers

If you are using the card in a commercially available card reader under Windows, use the "Eject" function before you remove the card from the card reader. If you remove the card without using the "Eject" function, you may lose data.

Deleting the contents of the SIMATIC memory card

You have the following options for deleting the content of the SIMATIC memory card:

- Delete files using Windows Explorer
- Format with STEP 7

Note

If you format the card with Windows utilities, you will render the SIMATIC memory card unusable as a storage medium for a CPU.

Deletion of files and folders is permitted, with the exception of the "__LOG__" and "crdinfo.bin" system files. The CPU needs these system files. When you delete the files, you will no longer be able to use the SIMATIC memory card with the CPU.

If you have deleted the "__LOG__" and "crdinfo.bin" system files, format the SIMATIC memory card as described in the following section.

Formatting the SIMATIC memory card

Note

You may only format a SIMATIC memory card in the CPU as otherwise the SIMATIC memory card will be rendered useless for use in the CPU.

If you want to format the SIMATIC memory card using STEP 7, an online connection to the relevant CPU must exist. The CPU is in STOP mode.

Proceed as follows to format a SIMATIC memory card:

1. Open the Online and Diagnostics view of the CPU (either from the project context or via "Accessible devices").
2. In the "Functions" folder, select the "Format memory card" group.
3. Click the "Format" button.
4. Click "Yes" in response to the confirmation prompt.

Result:

- The SIMATIC memory card is formatted for use in the CPU.
- The data on the CPU is deleted with the exception of the IP address.

You will find information on how to repair an inconsistently or incorrectly formatted card in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/69063974).

Service life of a SIMATIC memory card

The service life of a SIMATIC memory card depends essentially on the following factors:

- Number of delete or write operations per memory block
- Number of bytes written
- External influences such as ambient temperature

Reference

You will find further information on the service life of the SIMATIC memory card and also storage space capacity utilization, and on the memory areas used, in the Structure and use of the CPU memory (https://support.industry.siemens.com/cs/de/de/view/59193101/en) function manual.

11.2 Setting the card type

Introduction

You can use the SIMATIC memory card as a program card or as a firmware update card.

Procedure

1. To set the card type, insert the SIMATIC memory card into the card reader of the programming device.
2. Select the "SIMATIC Card Reader" folder in the project navigator.
3. In the properties of the selected SIMATIC memory card, specify the card type:

- **Program card**

  You use a program card as an external load memory for the CPU. It contains the entire user program for the CPU. The CPU transfers the user program from the load memory into the work memory. The user program runs in the work memory.

  The following folder is created on the SIMATIC memory card: SIMATIC.S7

- **Firmware update card**

  You can save firmware for CPUs and for I/O modules on a SIMATIC memory card. It is thus possible to perform a firmware update with the help of a specifically prepared SIMATIC memory card.

  The following folder is created on the SIMATIC memory card: FWUPDATE.S7S

Reference

You can find more information on this topic in the STEP 7 online help.

11.3 Data transfer with SIMATIC memory cards

Transferring objects from the project to a SIMATIC memory card

When the SIMATIC memory card is inserted into the programming device or into an external card reader, you can transfer objects from the project tree (STEP 7) to the SIMATIC memory card as follows:

- Individual blocks (multiple selection possible)

  In this case, the transfer is consistent, i.e. the function takes dependencies between blocks due to block calls into account.

- CPU folder

  In this case, all runtime-relevant objects including blocks and the hardware configuration are transferred onto the SIMATIC memory card - just as when downloading.

- Service data
  In this case, the service data previously saved (see chapter Reading out/saving service data (Page 265)) is transferred to the SIMATIC memory card.

To perform a transfer, you can transfer the objects by dragging and dropping, or use the "Card Reader/USB memory > Write to memory card" command in the "Project" menu.

Firmware update using a SIMATIC memory card

You can find information on how to perform a firmware update using a SIMATIC memory card in the section Firmware update (Page 245).

Reference

For additional information about the SIMATIC memory card, refer to the STEP 7 online help.

Maintenance

12

12.1 Removing and inserting I/O modules/motor starters

Introduction

The ET 200SP distributed I/O system supports removal and insertion of I/O modules/motor starters during operation (RUN operating state).

Requirements

The following table describes which modules you may insert and remove under which conditions:

Table 12- 1 Removal and insertion of modules

Modules	Removal and insertion	Conditions
CPU	No	---
BusAdapter	No	---
CM DP module	No	---
Interface module	No	---
I/O modules	Yes	• Digital output modules: Only when load is switched off • Digital modules: For load voltage above the safe extra-low voltage: Only with switched off load voltage supply • Technology modules: Only with switched off supply voltage L+ • AI Energy Meter ST: – Only when measuring voltage on primary side is switched off, or – Without the special current transformer terminal, measuring voltage and load current must be through the converters, which means the machine or the load must be switched off in the process. With the special terminal, the process can continue because the current transformer is isolated safely. However, the measuring voltage on the module at the connections UL1-UL3 still needs to be isolated.
Motor starter	Yes	Only when the load is disconnected; when switched on, the motor starter switches off automatically when the rotary interlock is operated.
Server module	No	---

NOTICE

Risk of hazardous system states

If you remove and insert digital output modules with the load switched on or technology modules with the supply voltage switched on, this can result in hazardous system states.

The ET 200SP distributed I/O system or the connected sensors may be damaged as a result.

Therefore, a digital output module may only be inserted and removed when the load is switched off and a technology module may only be inserted and removed when the supply voltage is switched off.

NOTICE

Risk of hazardous system states

If you remove and insert the AI Energy Meter ST with the primary-side voltage switched on at the current transformer, this can result in hazardous system states.

The ET 200SP distributed I/O system may be damaged as a result.

- For this reason, remove and insert the AI Energy Meter ST only when the measuring voltage on the primary side is switched off
  or
- Only when a special current transformer terminal is used which short-circuits the secondary end of the transformer when a module is removed. Do not remove or insert the AI Energy Meter ST until you have removed this current transformer terminal. With the special terminal, the process can continue because the current transformer is isolated safely. However, the measuring voltage on the module at the connections UL1-UL3 still needs to be isolated.

⚠ WARNING

Risk of injury from automatic restart

Inserting a motor starter may result in dangerous plant conditions. The motor starter can restart again autonomously if an ON command is active.

This can result in serious injury caused by connected devices that are automatically started up.

Withdraw and insert a motor starter only after disconnecting the load.

Operating principle with CPU/interface module HF, HS

You can remove and insert any number of I/O modules during operation. The CPU/interface module and the inserted I/O modules remain in operation.

NOTICE
Reaction of the CPU when removing and inserting the ET 200SP server module Please note that the backplane bus is deactivated when you remove the server module, regardless of the CPU operating state. Also note that the outputs do not adopt their configured substitute value behavior when you remove the server module. This means you should not remove the server module in the CPU operating states STARTUP, RUN and STOP. If you have nevertheless removed the server module, perform a POWER OFF/POWER ON after you have inserted the server module once again.

Operating principle with BusAdapter/CM DP module

It is not permitted to remove or insert the BusAdapter/CM DP module when the supply voltage is switched on. If you remove the BusAdapter/CM DP module unintentionally after startup of the CPU, the supply voltage of the BusAdapter/CM DP module is switched off automatically. To switch on the supply voltage again, you need to perform a POWER OFF/POWER ON after inserting the BusAdapter/CM DP module.

Operating principle with ST, BA interface module

1. You can remove **one** I/O module during operation. If you remove another I/O module, this results in a station stop of the ET 200SP distributed I/O system:
   - All I/O modules of the ET 200SP distributed I/O system fail → substitute value behavior.
   - The interface module continues to exchange data with the IO controller and report diagnostics.

   Note

   If you want to replace several I/O modules during operation, you must replace them one after the other.

2. If you insert all but one of the I/O modules withdrawn during operation, all I/O modules will start up again.

   Note

   I/O modules inserted in empty slots and then removed are also regarded as withdrawn during operation.

3. After a POWER OFF/POWER ON of the supply voltage 1L+ of the interface module, all available I/O modules start up again in keeping with the configuration. The evaluation of the I/O modules removed during operation starts again (see 1).

Removing I/O modules

To remove an I/O module, follow these steps:

1. Simultaneously press the top and bottom release buttons of the I/O module.
2. Pull the I/O module out of the BaseUnit, parallel in a forward direction.

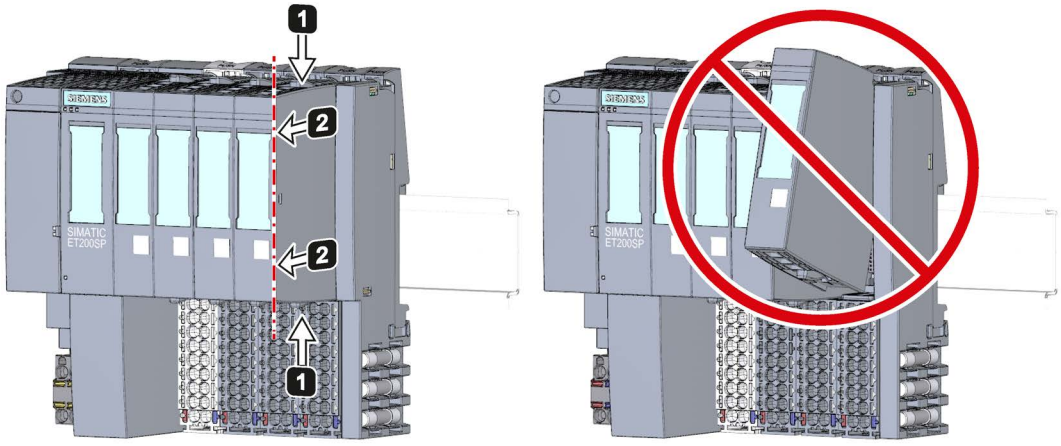


Figure 12-1 Removing I/O modules

See also

Interface modules (http://support.automation.siemens.com/WW/view/en/55683316/133300)

12.2 Changing the type of an I/O module

Introduction

The coding element is a two-part element. When shipped from the factory, both parts are in the I/O module. When an I/O module is installed for the first time, a part of the coding element clicks into the BaseUnit. This mechanically prevents the insertion of a different module type.

There are two versions of the ET 200SP distributed I/O system:

- Mechanical coding element: Ensures the mechanical coding described above.
- Electronic coding element: In addition to the above-mentioned mechanical coding, this version also has an electronic, rewritable memory for module-specific configuration data (such as the F-destination address for fail-safe modules, parameter data for IO link master).

Requirement

Refer to section Application planning (Page 32).

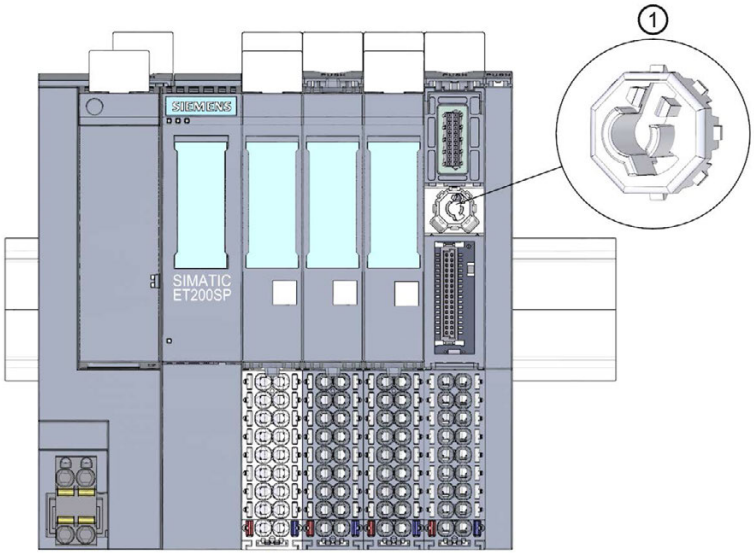
NOTICE
Do not manipulate the coding element Making changes to the coding element may cause dangerous conditions in your plant and/or result in damage to the outputs of the ET 200SP distributed I/O system. To avoid physical damage, do not manipulate the coding.

Changing the type of an I/O module

You have already removed the I/O module.

To make a type change for an I/O module, follow these steps:

1. Push the coding element out of the BaseUnit using a screwdriver.
2. Put the coding element back onto the removed I/O module.
3. Insert the new I/O module (other module type) into the BaseUnit until you hear it click into place.
4. Label the new I/O module.



① Coding element

Figure 12-2 Changing the type of an I/O module

12.3 Replacing an I/O module

Introduction

When an I/O module is installed for the first time, a part of the coding element clicks into the BaseUnit. When you replace an I/O module with the same type of module, the correct coding element is already present in the BaseUnit.

Requirement

Refer to section Application planning (Page 32).

Replacing an I/O module

You have already removed the I/O module.

To replace an I/O module, follow these steps:

1. Remove the coding element (part) from the underside of the new I/O module.
2. Insert the new I/O module (same module type) into the BaseUnit until you hear it click into place.
3. Mark the new I/O module (labeling strip, equipment labeling plate).

12.4 Replacing a motor starter

The SIMATIC ET 200SP motor starter is wired.

To replace a SIMATIC ET 200SP motor starter, proceed as follows:

1. Turn the mechanical rotary interlock counter-clockwise to the assembly/disassembly position.

   Note

   Operating position/READY

   Turn the mechanical rotary interlock out of the READY position only in the current-free state (motor off).

2. Remove the SIMATIC ET 200SP motor starter from the BaseUnit.
3. Assemble the new motor starter as described.

   Note

   Mounting the motor starter

   You will find out how to mount the motor starter in chapter "Mounting/disassembly of motor starters (Page 126)".

WARNING

Risk of injury from automatic restart

When you replace the motor starter, the motor starter can restart again autonomously if an ON command is active. This can result in property damage or serious injury caused by connected devices that are automatically started up.

Revoke the ON commands on the motor starter before replacing the motor starter.

CAUTION

Protection against electrostatic charge

When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

12.5 Replacing the terminal box on the BaseUnit

Introduction

The terminal box is part of the BaseUnit. You can replace the terminal box if necessary. You do not need to dismantle the BaseUnit to do this.

The power and AUX buses of the potential group are not interrupted when you replace the terminal box.

Requirements

- The BaseUnit is mounted, wired and fitted with an I/O module.
- The terminal may only be replaced when the supply voltage is switched off.

Required tools

3 to 3.5 mm screwdriver

Procedure

Watch the video sequence: "Replace terminal box on BaseUnit" (http://support.automation.siemens.com/WW/view/en/95886218)

To replace the terminal box on a BaseUnit, follow these steps:

1. If present, turn off the supply voltage on the BaseUnit.
2. Simultaneously press the top and bottom release buttons of the I/O module and pull the module out of the BaseUnit.
3. Disconnect the wiring on the BaseUnit.
4. The release button of the terminal box is located on the underside of the BaseUnit. Use a screwdriver to push in the small opening at an angle from above.
5. Swivel the screwdriver slightly upwards to loosen the locking mechanism of the terminal box and lever the terminal box up out of the BaseUnit at the same time.
6. Remove the coding element (part) from the terminal box and press it onto the coding element (part) of the I/O module that you have removed in the second step.
7. Insert the new terminal box into the BaseUnit at the top and swivel it downwards until it clips into the BaseUnit.
8. Wire up the BaseUnit.

9. Insert the I/O module into the BaseUnit.
10. Switch on a supply voltage on the BaseUnit.

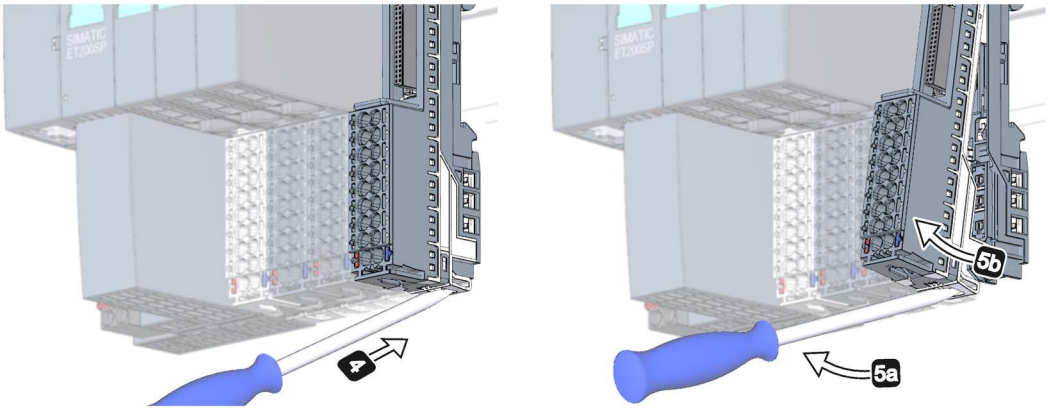


Figure 12-3 Replacing the terminal box on the BaseUnit

12.6 Firmware update

Introduction

During operation it may be necessary to update the firmware (e.g. to extend the available functions).

Update the firmware of the CPU/interface module and the I/O modules using firmware files. The retentive data is retained after the firmware has been updated.

Requirement

- You have downloaded the file(s) for the firmware update from the Product Support (https://support.industry.siemens.com/cs/ww/en/ps) web page.

  On this web page, select:

  – Automation Technology > Automation Systems > Industrial Automation Systems SIMATIC > SIMATIC ET 200 I/O Systems > ET 200 systems for the cabinet > ET 200SP.

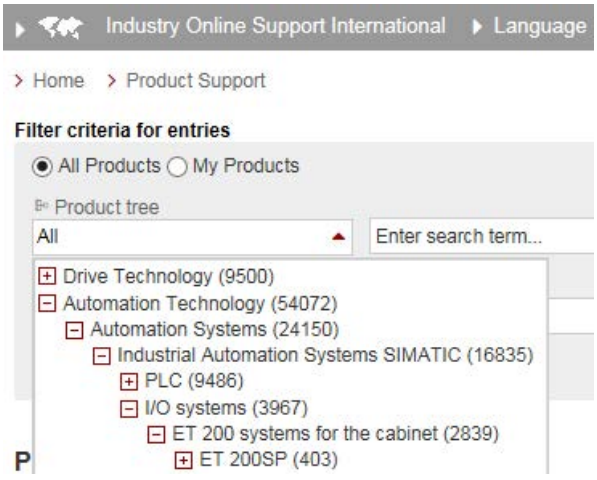


Figure 12-4 ET 200SP in the product tree

From there, navigate to the specific type of module that you want to update. To continue, click on the "Software downloads" link under "Support". Save the desired firmware update files.

Figure 12-5 Selecting the software downloads

- Before installing the firmware update, make sure that the modules are not being used.

Note

Firmware update of I/O modules

The L+ supply voltage must be present on the module at the start of and during the firmware update.

Additional requirement for fail-safe modules

WARNING

Check the firmware version for fail-safe approval

When using a new firmware version, always check that the version is approved for use in the module in question.

The attachments of the certificate (http://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Options for the firmware update

The following options are available for updating firmware:

- Online via PROFINET IO/PROFIBUS DP (with STEP 7)
- Via a SIMATIC memory card (possible for CPU and centralized I/O modules)
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules)

Note

Firmware files of the CPU

If you perform a CPU update with STEP 7, you require STEP 7 (TIA Portal as of V13 Update 3).

The table below provides an overview of the media that can be used to update the firmware of a specific module.

Table 12- 2 Overview of firmware update options

Firmware update	CPU	Interface module	I/O module
STEP 7 (TIA Portal)	✓ [1]	✓	✓
STEP 7 (V5.5 SP2 or higher) [2]	--	✓	✓
SIMATIC Memory Card	✓	--	✓
Web server of the CPU	✓	--	✓

[1] V13 update 3 or higher

[2] If firmware files are only available in this format, you can also load the files via STEP 7 (TIA Portal), but not via a SIMATIC memory card and the Web server.

Firmware update for the motor starter

The following options are available for updating firmware for the motor starter.

- Online via PROFINET IO/PROFIBUS DP (with STEP 7)
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules)
- With the TIA Portal:
  - SIMATIC STEP 7 V13 SP1 or higher with installed HSP for the ET 200SP motor starter
  - SIMATIC STEP 7 V14 or higher

  Via a SIMATIC memory card
- With SIMATIC STEP 7 Version V5.5 SP4 or higher
- For fail-safe motor starters with the TIA Portal Version V14 SP1 or higher and installed HSP.

Note

The firmware update for fail-safe motor starters must take place in a separate ET 200SP system in which only the fail-safe motor starter to be updated is inserted.

Installation of the firmware update

WARNING

Risk of impermissible system states

The CPU switches to STOP mode or the interface module to "station failure" as a result of the firmware update being installed. STOP or station failure can have an adverse effect on the operation of an online process or a machine.

Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to material damages.

Make sure that the CPU/interface module is not executing any active process before installing the firmware update.

Procedure using STEP 7

Proceed as follows to perform an online firmware update with STEP 7:

1. Select the module in the device view.
2. Select the "Online & diagnostics" command from the shortcut menu.
3. Select the "Firmware update" group in the "Functions" folder.
4. Click the "Browse" button to select the path to the firmware update files in the "Firmware update" area.
5. Select the suitable firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module.

Updating the firmware

The "Run firmware after update" check box is always selected.

When the loading process is complete, the CPU adopts the firmware and then operates with this new firmware.

Note

If a firmware update is interrupted, you need to remove and insert the module before starting the firmware update again.

Procedure using the SIMATIC memory card

Proceed as follows to perform a firmware update via the SIMATIC memory card:

1. Insert a SIMATIC memory card into an SD card reader of your programming device / computer.
2. To store the update file on the SIMATIC memory card, select the SIMATIC memory card in the "Card Reader/USB memory" folder in the project tree.
3. Select the "Card Reader/USB memory > Create firmware update memory card" command in the "Project" menu.
4. Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether you want to delete the content of the SIMATIC memory card or whether you want to add the firmware update files to the SIMATIC memory card.
5. Insert the SIMATIC memory card with the firmware update files into the CPU.

Point to note when updating firmware for analog modules and the IO-Link Master CM 4xIO-Link communication module

If you want to update firmware for analog modules or the IO-Link Master CM 4xIO-Link communication module, you must supply a load current of 24 V DC to the modules through the infeed element.

Procedure

1. Remove any inserted SIMATIC memory card.
2. Insert the SIMATIC memory card with the firmware update files into the CPU.
3. The firmware update begins shortly after the SIMATIC memory card has been plugged in.
4. Remove the SIMATIC memory card after the firmware update has been completed. The RUN LED on the CPU lights up yellow, the MAINT LED flashes yellow.

If you then use the SIMATIC memory card as program card, delete the firmware update files manually.

Note

If your hardware configuration contains several modules, the CPU updates all affected modules in the slot sequence, which means in ascending order of the module position in the STEP 7 device configuration.

Procedure using the Web server

The procedure is described in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual.

Behavior during the firmware update

Note the following behavior of the relevant I/O module when carrying out a firmware update:

- The DIAG LED display flashes red.
- The I/O module retains its current diagnostic status.
- Diagnostics alarm: Channel temporarily unavailable (error code $31_D/1F_H$)
- All outputs are in a current-free/voltage-free state

Note the following behavior during the firmware update of the motor starter:

- RN flashes green and ER flashes red.
- ST/OL flashes green and MAN flashes yellow.
- The motor starter powers up after completion of the firmware update. Diagnoses are reset. The firmware update does not affect the TMM and the cooling time.
- The sensor supply of the DI module remains active.

Behavior after the firmware update

After the firmware update, check the firmware version of the updated module.

Reference

You can find more information on the procedure in the STEP 7 online help.

12.7 Resetting CPU/interface module (PROFINET) to factory settings

12.7.1 Resetting the CPU to factory settings

Function

The CPU can be reset to its delivery state using "Reset to factory settings". The function deletes all information saved internally on the CPU.

Recommendation:

If you want to remove a PROFINET CPU and use it elsewhere with a different program, or put it into storage, we recommend that you reset the CPU to its factory settings. When restoring factory settings, remember that the IP address parameters are also deleted.

Options for resetting a CPU to factory settings

The following options are available for resetting the CPU to its factory settings:

- Using the mode selector
- Using STEP 7

Procedure using the mode selector

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (the RUN/STOP LED is lit yellow).

Perform a reset to factory settings when there is no SIMATIC memory card inserted as follows:

1. Set the mode selector to the STOP position.

   Result: The RUN/STOP LED lights up yellow.

2. Set the mode selector to the MRES position. Hold the mode selector in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (after three seconds). After this, release the switch.

3. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes the "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, the CPU has been reset to factory settings and is in the STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Procedure using STEP 7

Make sure that an online connection to the CPU exists.

To reset a CPU to factory settings using STEP 7, follow these steps:

1. Open the Online and Diagnostics view of the CPU.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. If you want to keep the IP address, select the "Retain IP address" option button. If you want to delete the IP address, select the "Reset IP address" option button.
4. Click the "Reset" button.
5. Click "OK" in response to the confirmation prompts.

Result: The CPU executes the "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, the CPU has been reset to factory settings and is in the STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Result after resetting to factory settings

The following table provides an overview of the contents of the memory objects after the reset to factory settings.

Table 12- 3 Result after resetting to factory settings

Memory object	Content
Actual values of the data blocks, instance data blocks	Initialized
Bit memory, timers and counters	Initialized
Certain retentive tags from technology objects (e.g. adjustment values of absolute encoders)	Initialized
Diagnostics buffer entries (retentive area)	Initialized
Diagnostics buffer entries (non-retentive area)	Initialized
Counter readings of the runtime meters	Initialized
Time of day	Initialized

If a SIMATIC memory card was inserted prior to the factory reset, the CPU downloads the configuration contained on the SIMATIC memory card (hardware and software). A configured IP address then becomes valid again.

Reference

Additional information on the topic "Resetting to factory settings" can be found in the Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) function manual, section on memory areas and retentivity, and in the STEP 7 online help.

12.7.2 Resetting interface module (PROFINET IO) to factory settings

Function

The "Reset to factory settings" function returns the interface module (PROFINET) to its delivery state.

Reset options

- Using STEP 7 (online via PROFINET IO)
- Using a reset button on the interface module (on rear). Exception: The IM 155-6 PN BA does not possess this reset button. See section Resetting the interface module (PROFINET IO) to factory settings with a RESET button (Page 255).

Procedure using STEP 7

To reset an interface module to factory settings using STEP 7, follow these steps:

Make sure that an online connection to the interface module exists.

1. Open the online and diagnostics view of the interface module.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Click the "Reset" button.
4. Click "OK" in response to the confirmation prompt.

Result: The interface module then performs "Reset to factory settings".

Result after resetting to factory settings

The following table shows the values of the interface module properties after a factory reset:

Table 12- 4 Properties of the interface module as shipped

Properties	Value
Parameters	Default setting
IP address	Not available
Device name	Not available
MAC address	Available
I&M data	Identification data (I&M0) available Maintenance data (I&M1, 2, 3, 4) reset *
Firmware version	Available

* Can be selected with STEP 7 V14 or higher: "Keep maintenance data"/"Delete maintenance data"

Note

Failure of downstream stations is possible

Downstream stations on a bus segment can fail when the factory settings are restored on an interface module.

Note

Substitute value behavior of the inserted I/O modules on reset to factory settings

The I/O modules of the ET 200SP distributed I/O system do not have the configured status after a reset to factory settings.

Reference

You will find more information on the procedure in the STEP 7 online help.

12.7.3 Resetting the interface module (PROFINET IO) to factory settings with a RESET button

Requirement

The supply voltage to the interface module is turned on.

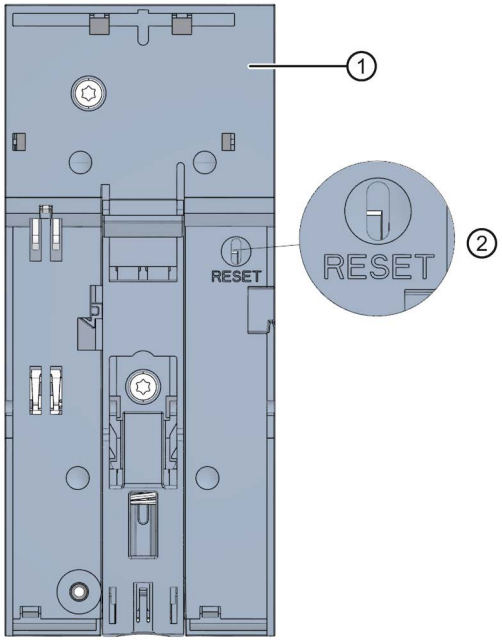
Required tools

3 to 3.5 mm screwdriver (for resetting with a RESET button)

Procedure

Proceed as follows to reset an interface module to factory settings by means of the RESET button:

1. Remove the interface module from the mounting rail (see Mounting the CPU/interface module (Page 60)) and swivel it downwards.
2. The RESET button is located on the rear of the interface module behind a small opening: Press a screwdriver into the small opening for at least 3 seconds to activate the RESET button.
3. Install the interface module back on the mounting rail (see Mounting the CPU/interface module (Page 60)).
4. Assign parameters to the interface module again.



① Rear of the interface module
② RESET button

Figure 12-6 RESET button

12.8 Reaction to faults in fail-safe modules and fail-safe motor starters

Safe state (safety concept)

The basic principle behind the safety concept is the existence of a safe state for all process variables.

Note

For digital F-modules, this safe state is the value "0". This applies to both sensors and actuators. In the case of the fail-safe motor starters, the load is shut down in a fail-safe manner.

Fault reactions and startup of the F-system

The safety function means that fail-safe modules use substitute values (safe state) instead of process values (**passivation of the fail-safe module**) in the following situations:

- When the F-system is started up
- If errors are detected during safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error)
- If F-I/O faults or channel faults are detected (e.g. wire break, discrepancy error)

Detected faults are written to the diagnostic buffer of the F-CPU and communicated to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. After a POWER OFF / POWER ON, any faults still existing are detected again during startup. However, you have the option of saving faults in your safety program.

WARNING

For channels that you set to "deactivated" in STEP 7, no diagnostic response or error handling is triggered when a channel fault occurs, not even when such a channel is affected indirectly by a channel group fault ("Channel activated/deactivated" parameter).

Remedying faults in the F-system

To remedy faults in your F-system, follow the procedure described in IEC 61508-1:2010 section 7.15.2.4 and IEC 61508-2:2010 section 7.6.2.1 e.

The following steps must be performed:

1. Diagnosing and repairing the fault
2. Revalidation of the safety function
3. Recording in the service report

Substitute value output for fail-safe modules

In the case of F-modules with inputs, if there is passivation, the F-system provides substitute values (0) for the safety program instead of the process data pending at the fail-safe inputs.

In the case of F-modules with outputs, if there is passivation, the F-system transfers substitute values (0) to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized. This also applies when the F-CPU goes into STOP mode. Assignment of substitute values is not possible.

Depending on which F-system you are using and the type of fault that occurred (F-I/O fault, channel fault or communication error), substitute values are used either for the relevant channel only or for all channels of the relevant fail-safe module.

Reintegration of a fail-safe module

The system changes from fail-safe to process values (reintegration of an F-module) either automatically or only after user acknowledgment in the safety program. If channel faults occur, it may be necessary to remove and reinsert the F-module. A detailed listing of faults requiring removal and insertion of the F-module can be found in the section Diagnostic messages of the respective F-module.

After reintegration, the following occurs:

- In the case of an F-module with inputs, the process data pending at the fail-safe inputs is made available to the safety program again
- In the case of an F-module with outputs, the output values provided in the safety program are transferred to the fail-safe outputs again

Additional information on passivation and reintegration

For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety, Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Behavior of the fail-safe module with inputs in the event of a communication disruption

F-modules with inputs respond differently to communication errors compared to other errors.

If a communication error is detected, the current process values remain set at the inputs of the F-module. There is no passivation of the channels. The current process values are passivated in the F-CPU.

12.9 Maintenance and repair

The components of the SIMATIC ET 200SP system are maintenance-free.

Note

Repairs to a SIMATIC ET 200SP system may only be carried out by the manufacturer.

12.10 Warranty

To meet the conditions of the warranty, you must observe the safety and commissioning instructions.

Test functions and eliminating problems 13

13.1 Test functions

Introduction

You have the option of testing the operation of your user program on the CPU. You can then monitor signal states and values of tags and can assign values to tags to simulate specific situations in the running of the program.

Note

Using test functions

The use of test functions can influence the program execution time and thus the cycle and response times of the controller to a slight extent (a few milliseconds).

Requirements

- There is an online connection to the relevant CPU.
- An executable program is in the CPU.

Test options

- Testing with program status
- Testing with a watch table
- Testing with a force table
- Testing with PLC tag table
- Testing with data block editor
- Testing with the LED flash test
- Testing with trace function

Testing with program status

The program status allows you to monitor the execution of the program. You can display the values of operands and the results of logic operations (RLO) allowing you to recognize and fix logical errors in your program.

Note

Restrictions for the "Program status" function

Monitoring loops can clearly increase the cycle time, depending on the number of tags monitored and depending on the actual number of loops run through.

WARNING

Testing with program status

A test with the "Program status" function can produce serious property damage and personal injury in the event of malfunctions or program errors.

Make sure that you take appropriate measures to exclude the risk of hazardous conditions occurring before running a test with the "Program status" function.

Testing with watch tables

The following functions are available in the watch table:

- Monitoring of tags

  With watch tables, you can monitor the current values of individual tags of a user program or a CPU on the PG/PC and Web server. For the Web server to be able to display the value of tags, you must specify a symbolic name for each tag in the "Name" column of the watch table.

  You can monitor the following operand areas:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs
  – Timers and counters

- Modifying tags

  Use this function to assign fixed values to the individual tags of a user program or CPU. Modifying is also possible for testing with program status.

  You can control the following operand areas:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs (for example, %I0.0:P, %Q0.0:P)
  – Timers and counters

- "Enable peripheral outputs" and "Control immediately"

  These two functions enable you to assign fixed values to individual peripheral outputs of a CPU in the STOP mode. You can also use them to check your wiring.

Testing with the force table

The following functions are available in the force table.

- Monitoring of tags

  With force tables, you can display the current values of individual tags of a user program or a CPU on the PG/PC and Web server. You can monitor the table with or without a trigger condition. For the Web server to be able to display the value of tags, you must specify a symbolic name for each tag in the "Name" column of the force table.

  You can monitor the following tags:

  – Bit memory
  – Contents of data blocks
  – Peripheral inputs (e.g. %I0.0:P)

- Modifying tags

  With this function, you assign fixed values to the individual tags of a user program or a CPU on the PG/PC and Web server. Modifying is also possible for testing with program status.

  You can control the following tags:

  – Bit memories
  – Contents of data blocks
  – Peripheral inputs (e.g. %I0.0:P)

- Forcing of peripheral inputs and peripheral outputs

  You can force individual peripheral inputs or peripheral outputs.

  – Peripheral inputs: Forcing of peripheral inputs (for example %I0.0:P) represents the "bypassing" of sensors/inputs by specifying fixed values to the program. Instead of the actual input value (via process image or via direct access) the program receives the force value.
  – Peripheral outputs: Forcing of peripheral outputs (for example %Q0.0:P) represents the "bypassing" of the complete program by setting fixed values for the actuators.

The force table offers the advantage both of being able to simulate different test environments and also of being able to overwrite tags in the CPU with a fixed value. Thus, you have a possibility of intervening in the ongoing process to regulate it.

Difference between modifying and forcing

The fundamental difference between the modifying and forcing functions consists in the storage behavior:

- Modifying: Modifying of tags is an online function and is not stored in the CPU. You can end modifying of tags in the watch table or by disconnecting the online connection.
- Forcing: A force job is written to the SIMATIC memory card and is retained after a POWER OFF. You can only end the forcing of peripheral inputs and peripheral outputs in the force table.

Testing with PLC tag table

You can monitor the data values that tags currently assume in the CPU directly in the PLC tag table. To do this, open the PLC tag table and start monitoring.

Additionally, you have a possibility of copying PLC tags to a monitoring or force table and of monitoring, controlling or forcing them there.

Testing with data block editor

Various possibilities of monitoring and controlling tags are at your disposal in the data block editor. These functions directly access the current values of the tags in the online program. Current values are the values that the tags assume at the current time during program execution in the CPU's work memory. The following functions for monitoring and control are possible via the data block editor:

- Monitoring tags online
- Controlling individual actual values
- Creating a snapshot of the actual values
- Overwriting actual values with a snapshot

Note

Setting data values during commissioning

During commissioning of a system, data values often have to be adjusted to optimally adapt the program to the general conditions prevailing locally. To this end, the declaration table offers a few functions for data blocks.

Testing with the LED flash test

In many online dialogs, you can perform an LED flash test. This function is useful, for example, when you are not sure which device in the hardware configuration corresponds to the device currently selected in the software.

When you click the "Flash LED" button, an LED flashes on the currently selected device. In the case of the CPU, the RUN/STOP, ERROR and MAINT LEDs flash. They flash until you cancel the flashing test.

Testing with trace function

The trace function is used to record the CPU tags, depending on the settable trigger conditions. Tags are, for example, the drive parameters or system and user tags of a CPU. The CPU saves the recordings. You can display and evaluate the recordings with STEP 7, if necessary.

The trace function can be called from the CPU's folder in the project tree, under the name "Traces".

In connection with trace functions, also pay attention to the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/102781176).

Simulation

With STEP 7 you can run and test the hardware and software of the project in a simulated environment. Start the simulation using the menu command "Online" > "Simulation" > "Start".

Reference

You can find more information on test functions in the STEP 7 online help.

Further information about testing with trace and logic analyzer functions is available in the Function Manual Using the trace and logic analyzer function (http://support.automation.siemens.com/WW/view/en/64897128).

13.2 Reading out/saving service data

Introduction

In addition to the contents of the diagnostics buffer, the service data contains a wide range of extra information about the internal status of the CPU. If a problem occurs the CPU that cannot be solved with other methods, send the service data to our Service & Support team. The service data allows Service & Support to run fast analysis of the problems that have occurred.

Requirement

You can read service data with:

- The Web server
- STEP 7
- SIMATIC memory card

Procedure using the Web server

To read service data using the Web server, follow these steps:

1. Open a Web browser that is suitable for communication with the CPU.
2. Enter the following address in the web browser's address bar:
   https://<CPU IP address>/save_service_data.html, e.g.
   https://172.23.15.3/save_service_data.html
3. The service data page will appear on your screen, with a button for saving the service data.

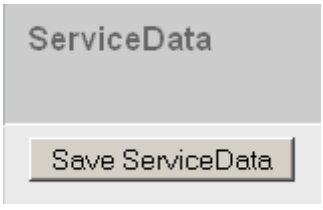


Figure 13-1 Reading out service data with the Web server

4. Save the service data locally on your PC/programming device, by clicking "Save ServiceData".

Result: The CPU stores the data in a .dmp file with the following naming convention: "<Article number> <Serial number> <Time stamp>.dmp". The file name cannot be changed.

Note

If you have defined your user page as the Web server's home page, direct access to the service data by entering the CPU's IP address is not possible. You will find further information on reading out service data via a user-defined page in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual.

Procedure using STEP 7

A description of how to save service data is available under the keyword "Save service data" in STEP 7 online help.

Procedure using the SIMATIC memory card

Use the SIMATIC memory card to read out the service data only if you are no longer able to communicate with the CPU via Ethernet. In all other cases it is preferable to read out the service data via the Web server or STEP 7.

To read service data using the SIMATIC memory card, follow these steps:

1. Insert the SIMATIC memory card into the card reader of your PC / programming device.
2. Open the job file S7_JOB.S7S in an editor.
3. Overwrite the entry PROGRAM with the string DUMP in the editor.
   Do not use any spaces/line breaks/quotation marks to ensure that the file size is exactly 4 bytes.
4. Save the file under the existing file name.
5. Make sure that the SIMATIC memory card is not write-protected and insert it in the card slot of the CPU. Pay attention to the procedure described in Removing/inserting the SIMATIC memory card on the CPU (Page 209).

Result: The CPU writes the service data file DUMP.S7S to the SIMATIC memory card and remains in STOP mode.

The transfer of the service data has been completed as soon as the STOP LED stops flashing and lights up continuously. If transfer was successful, the STOP LED lights up. If transfer was not successful, the STOP LED and the ERROR LED flash. In case of an error, the CPU stores a text file with a note on the error that occurred in the DUMP.S7S folder.

Technical specifications

14

Introduction

This chapter lists the technical specifications of the system:

- The standards and test values that the ET 200SP distributed I/O system complies with and fulfills.
- The test criteria according to which the ET 200SP distributed I/O system was tested.

Technical specifications for the modules

The technical specifications of the individual modules can be found in the manuals of the modules themselves. In the event of deviations between the statements in this document and the manuals, the statements in the manuals take priority.

14.1 Standards, approvals and safety notes

Currently valid markings and approvals

Note

Information on the components of the ET 200SP

The currently valid markings and approvals are printed on the components of the ET 200SP distributed I/O system.

Safety information

WARNING

Personal injury and damage to property may occur

In hazardous areas, personal injury and damage to property may occur if you disconnect plug-in connections during operation of an ET 200SP distributed I/O system.

Always switch off the power to the ET 200SP distributed I/O system when disconnecting plug-in connections in hazardous areas.

WARNING

Explosion hazard

If you replace components, compliance with Class I, DIV 2 can become invalid.

WARNING

Area of application

This device is only suitable for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

Five safety rules for work in or on electrical installations

A set of rules, which are summarized in DIN VDE 0105 as the "five safety rules", are defined for work in or on electrical installations as a preventative measure against electrical accidents:

1. Isolate
2. Secure against switching on again
3. Verify that the equipment is not live
4. Ground and short-circuit
5. Erect barriers around or cover adjacent live parts

These five safety rules must be applied in the above order prior to starting work on an electrical system. After completing the work, proceed in the reverse order.

It is assumed that every electrician is familiar with these rules.

CE marking

The ET 200SP distributed I/O system meets the general and safety-related requirements of the following directives and conforms to the harmonized standards (EN) for programmable controllers published in the official journals of the European Union:

- 2014/35/EU "Electrical equipment designed for use within certain voltage limits" (Low Voltage Directive)
- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)
- 2014/34/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" (Explosion Protection Directive)
- For ET 200SP fail-safe modules, the following also applies: 2006/42/EC "Machinery Directive"

The EC declarations of conformity are available for the responsible authorities at:

Siemens AG
Digital Factory

Factory Automation
DF FA AS DH AMB
Postfach 1963
D-92209 Amberg

You will also find these for downloading on the Internet pages of Siemens Industry Online Support under the key words "Declaration of conformity".

cULus approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)

OR

cULus HAZ. LOC. approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Installation Instructions for cULus haz.loc.

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

OR

CSA

CSA C22.2 (Industrial Control Equipment Motor Controllers)

OR

UL

UL 60947-4-2 Low-Voltage Switchgear and Controlgear

OR

FM approval

Factory Mutual Research (FM) according to
Approval Standard Class Number 3611, 3600, 3810 (ANSI/ISA 82.02.01)
CSA C22.2 No. 213
CSA C22.2 No. 1010-1
APPROVED for use in Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

OR

ATEX approval

According to EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC Tx Gc
DEKRA 12ATEX0038X

OR

IECEx approval

According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements)

Ex nA IIC Tx Gc
IECEx DEK 13.0011X

Marking for Australia and New Zealand

or

The ET 200SP distributed I/O system meets the requirements of the standard AS/NZS CISPR 16.

Korea Certificate KCC-REM-S49-ET200SP

Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

Marking for the Eurasian Customs Union

EAC (Eurasian Conformity)

Customs Union of Russia, Belarus and Kazakhstan

Declaration of conformity with the technical requirements of the Customs Union (TR CU).

IEC 61131

The ET 200SP distributed I/O system meets the requirements and criteria of the standard IEC 61131-2 (Programmable logic controllers, part 2: Equipment requirements and tests).

IEC 60947

The motor starters belonging to the ET 200SP distributed I/O system meet the requirements and criteria of the IEC 60947 standard.

PROFINET standard

The ET 200SP distributed I/O system is based on IEC 61158 Type 10.

PROFIBUS standard

The ET 200SP distributed I/O system is based on IEC 61158 Type 3.

IO-Link standard

The ET 200SP distributed I/O system is based on IEC 61131-9.

Shipbuilding approval

Classification societies:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- DNV (Det Norske Veritas)
- GL (Germanischer Lloyd)
- LRS (Lloyds Register of Shipping)
- Class NK (Nippon Kaiji Kyokai)

Use in industrial environments

SIMATIC products are designed for use in industry.

Table 14- 1 Use in industrial environments

Area of application	Interference emission requirements	Interference immunity requirements
Industry	EN 61000-6-4:2007 + A1:2011	EN 61000-6-2:2005

Use in residential areas

Note

The ET 200SP is intended for use in industrial areas; use in residential areas may have an impact on radio/TV reception.

If you want to use the ET 200SP distributed I/O system in residential areas, you must ensure that its radio frequency interference emission complies with limit class B in accordance with EN 55011.

Suitable measures for achieving RF interference level Class B include, for example:

- Installation of the ET 200SP distributed I/O system in grounded control cabinets/control boxes
- Use of filters in the supply lines

Reference

The certificates for the markings and approvals can be found on the Internet under Service&Support (http://www.siemens.com/automation/service&support).

14.2 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Among other things, the ET 200SP distributed I/O system also meets the requirements of the EMC legislation for the European single market. The prerequisite is that the ET 200SP distributed I/O system complies with the requirements and guidelines relating to electrical equipment.

EMC in accordance with NE21

The ET 200SP distributed I/O system meets the EMC specifications of the NAMUR recommendation NE21.

Pulse-shaped disturbance variables of the ET 200SP system

The table below shows the electromagnetic compatibility of the ET 200SP distributed I/O system with regard to pulse-shaped disturbance variables.

Table 14- 2 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Equivalent to severity
Electrostatic discharge in accordance with IEC 61000-4-2	Air discharge ±8 kV Contact discharge: ±6 kV	3 3
Burst pulses (fast transients) in accordance with IEC 61000-4-4	±2 kV (power supply line) ±2 kV (signal line >30 m) ±1 kV (signal cable <30 m)	3 3
High-energy single pulse (surge) in accordance with IEC 61000-4-5 External protective circuit required (see Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566))		3
• Asymmetric coupling	±2 kV (power supply lines) DC with protective elements ±2 kV (signal lines/data lines only >30 m) with protective elements if necessary	
• Symmetric coupling	±1 kV (power supply line) DC with protective elements ±1 kV (signal line/data line only >30 m) with protective elements if necessary	

Pulse-shaped disturbance variables of motor starters

The following table shows the electromagnetic compatibility of the ET 200SP motor starters with regard to pulse-shaped interference.

Table 14- 3 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Equivalent to severity
Burst pulses (fast transients) in accordance with IEC 61000-4-4, tested with 5 kHz.	±2 kV (24 V supply cables) ±2 kV (500 V AC infeed*) ±1 kV (signal cable <30 m)	3
*If you mount the motor starter to the right of a 15 mm or 20 mm I/O module or immediately next to a header module, use a dummy module. You will find further information in "Selecting motor starters with a suitable BaseUnit (Page 38)."		
High-energy single pulse (surge) in accordance with IEC 61000-4-5	500 V AC infeed ±2 kV conducted interference - phase to ground ±1 kV conducted interference - phase to phase 24 V supply cable: ±1 kV conducted interference - phase to ground** ±0.5 kV conducted interference - phase to phase**	3
**External protective circuit required (see the Function Manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)) if values of 2 kV (phase to ground) or 1 kV (phase to phase) are required.		

Sinusoidal disturbance variables

The tables below show the electromagnetic compatibility of the ET 200SP distributed I/O system with regard to sinusoidal disturbance variables.

- RF radiation

Table 14- 4 Sinusoidal disturbance variables with RF radiation

RF radiation according to IEC 61000-4-3/NAMUR 21 **Electromagnetic RF field, amplitude-modulated**		**Corresponds to degree of severity**
80 to 1000 MHz; 1.0 to 2.0 GHz	2.0 GHz to 2.7 GHz	3
10 V/m	3 V/m	
80% AM (1 kHz)		

- RF coupling

Table 14- 5 Sinusoidal disturbance variables with RF coupling

RF coupling in accordance with IEC 61000-4-6	**Corresponds to degree of severity**
(10 kHz) 150 kHz to 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

Emission of radio frequency interference

Interference emission of electromagnetic fields in accordance with EN 55016: Limit class A, group 1 (measured at a distance of 10 m).

Table 14- 6 Interference emission of electromagnetic fields in accordance with EN 55016

Frequency	**Interference emission**
30 MHz to 230 MHz	< 40 dB (µV/m) QP
230 MHz to 1000 MHz	< 47 dB (µV/m) QP

Interference emission via the AC power supply in accordance with EN 55016: Limit class A, Group 1.

Table 14- 7 Interference emission via the AC power supply in accordance with EN 55016

Frequency	**Interference emission**
0.15 MHz to 0.5 MHz	< 79 dB (µV/m)Q < 66 dB (µV/m) M
0.5 MHz to 30 MHz	< 73 dB (µV/m)Q < 60 dB (µV/m) M

14.3 Electromagnetic compatibility of fail-safe modules

Protecting ET 200SP with fail-safe modules against overvoltages

If your equipment requires protection from overvoltage, we recommend that you use an external protective circuit (surge filter) between the load voltage power supply and the load voltage input of the BaseUnits to ensure surge immunity for the ET 200SP with fail-safe modules.

Note

Lightning protection measures always require a case-by-case examination of the entire plant. Almost complete protection from overvoltages, however, can only be achieved if the entire building surroundings have been designed for overvoltage protection. In particular, this involves structural measures in the building design phase.

For detailed information regarding overvoltage protection, we recommend that you contact your Siemens representative or a company specializing in lightning protection.

The following figure shows an example configuration with fail-safe modules. Voltage is supplied by 1 power supply unit. Note, however, that the total current of the modules fed by the power supply unit must not exceed the permissible limits. You can also use multiple power supply units.

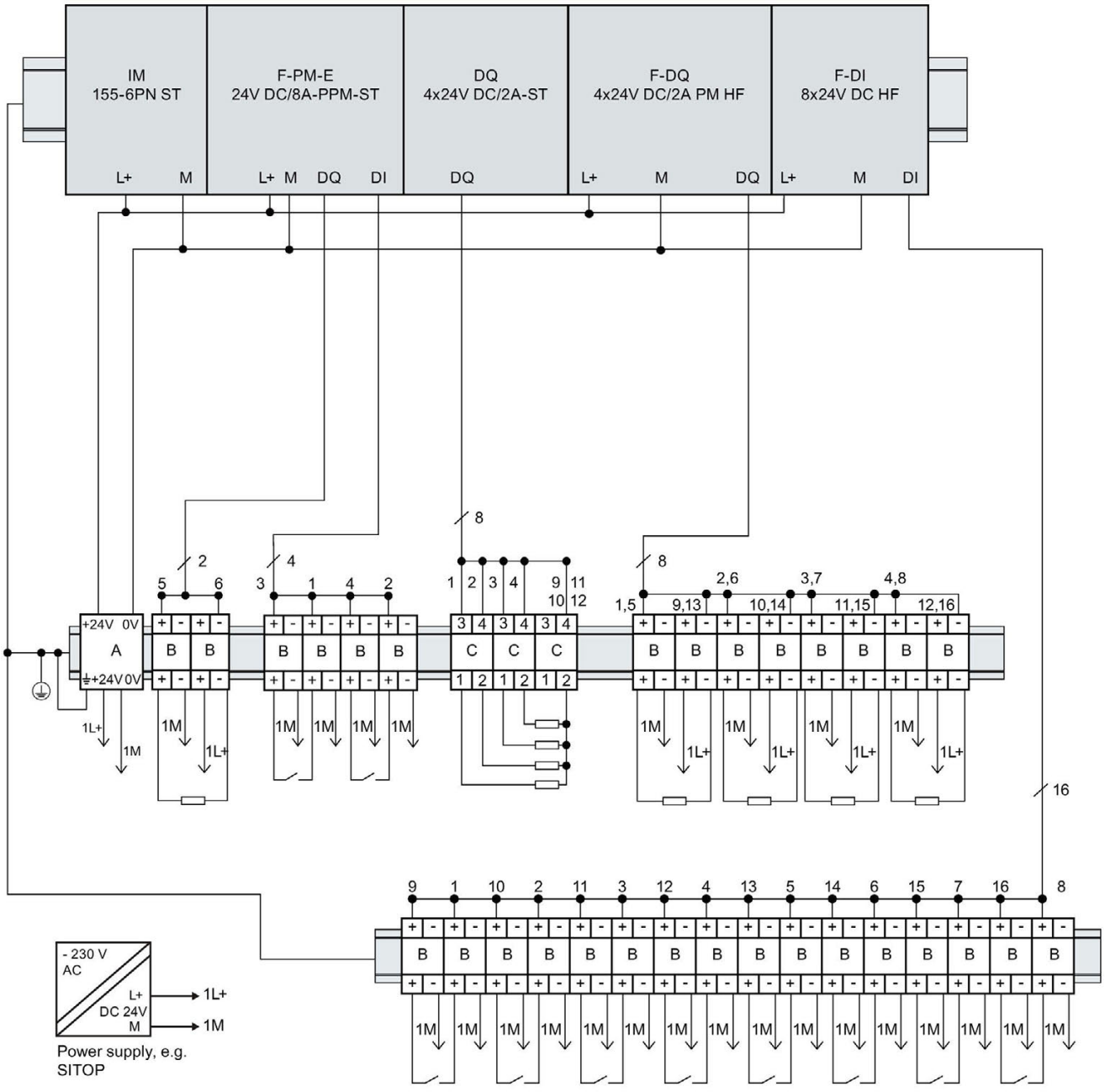


Figure 14-1 External protective circuit (surge filter) for ET 200SP with fail-safe modules

Name	Part number of Dehn Co.
A = BVT AD 24	918 402
B = DCO RK D 5 24	919 986
C = DEHNconnect DCO RK E 60	919 990

14.4 Shipping and storage conditions

Introduction

The ET 200SP distributed I/O system exceeds requirements in terms of shipping and storage conditions according to IEC 61131-2. The following information applies to modules that are shipped and/or stored in their original packaging.

Table 14- 8 Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤1 m
Temperature	From -40 °C to +70 °C
Barometric pressure	1080 hPa to 660 hPa (corresponds with an altitude of -1000 m to 3500 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal oscillations according to IEC 60068-2-6	5 - 8.4 Hz: 3.5 mm 8.4 - 500 Hz: 9.8 m/s^2
Impact acc. to IEC 60068-2-27[1)]	250 m/s^2, 6 ms, 1000 shocks

1) Not applicable to motor starters

14.5 Mechanical and climatic environmental conditions

Operating conditions

The ET 200SP distributed I/O system is suitable for use in weather-proof, fixed locations. The operating conditions exceed requirements according to DIN IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (climatic requirements)

You will find the permissible ambient conditions for the motor starter in the Technical data of the motor starter (https://support.industry.siemens.com/cs/ww/en/ps/21859/td).

Mechanical environmental conditions

The following table shows the mechanical environmental conditions in the form of sinusoidal vibrations.

Table 14- 9 Mechanical environmental conditions

Frequency band	ET 200SP with BusAdapters BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC and BA LC/FC	ET 200SP with BusAdapters BA 2×RJ45, BA SCRJ/RJ45 and BA LC/RJ45	ET 200SP with IM 155-6 PN BA	ET 200SP with digital output module F-RQ 1x24VDC/24..230VAC/5 A
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude			
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration			
10 ≤ f ≤ 60 Hz	0.35 mm amplitude	---	---	---
60 ≤ f ≤ 1000 Hz	5 g constant acceleration			

Tests of mechanical environmental conditions

The following table provides important information with respect to the type and scope of the tests of environmental mechanical conditions.

Table 14- 10 Tests of mechanical environmental conditions

Condition tested	Test standard	Comment
Vibrations 2)	Vibration test according to IEC 60068-2-6 (sinusoidal)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. BA 2×RJ45, BA SCRJ/RJ45, BA LC/RJ45, IM 155-6 PN BA, digital output module F-RQ 1x24VDC/24..230VAC/5A • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC • 10 Hz ≤ f ≤ 60 Hz, 0.35 mm constant amplitude • 60 Hz ≤ f ≤ 1000 Hz, 5 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each of three vertically aligned axes
Shock 2)	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes
Repetitive shock 1) 2)	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 25 g peak value, 6 ms duration Direction of shock: 1000 shocks in each direction (+/-) at each of three vertically aligned axes

1) Not applicable in the case of the digital output module F-RQ 1x24VDC/24..230VAC/5A

2) Not applicable for motor starters

Climatic environmental conditions

The table below shows the permissible climatic environmental conditions for the ET 200SP distributed I/O system:

Table 14- 11 Climatic environmental conditions

Environmental conditions	Permissible range	Comments
Temperature: horiz. mounting position: vertical mounting position:	 0 to 60 °C 0 to 50 °C	-
Permitted temperature change	10 K/h	-
Relative humidity	from 10 to 95%	Without condensation, corresponds to relative humidity (RH) stress grade 2 in accordance with IEC 61131 part 2
Barometric pressure	1080 hPa to 795 hPa	Corresponds to an altitude of -1000 to 2000 m
Pollutant concentration	SO_2: <0.5 ppm; RH <60%, no condensation H_2S: <0.1 ppm; RH <60%, no condensation	-
	ISA-S71.04 severity level G1; G2; G3	-

14.6 Insulation, protection class, degree of protection and rated voltage

Insulation

The insulation for the I/O modules is designed in accordance with the requirements of EN 61131-2:2007. The insulation for the motor starters is designed in accordance with the requirements of IEC 60947-1.

Note

In the case of modules with 24 V DC (SELV/PELV) supply voltage, galvanic isolations are tested with 707 V DC (type test).

Pollution degree/overvoltage category according to IEC 61131

- Pollution degree 2
- Overvoltage category: II

Pollution degree/overvoltage category according to IEC 60947

- Pollution degree 2
- Overvoltage category: III

Protection class according to IEC 61131-2:2007

The ET 200SP distributed I/O system meets protection class I and includes parts of protection classes II and III.

The grounding of the mounting rail must meet the requirements for a functional earth FE.

Recommendation: For a configuration immune to interference, the line for the ground should have a cross-section > 6 mm^2.

The installation location (e.g. enclosure, control cabinet) must have a protective conductor connection that meets the standard to maintain protection class I.

Degree of protection IP20

Degree of protection IP20 in accordance with IEC 60529 for all modules of the ET 200SP distributed I/O system, which means:

- Protection against contact with standard probes
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Note

Use a BU cover

To meet the requirements of the degree of protection "IP20", fit a BU cover onto unfitted BaseUnits.

To ensure touch safety, fit a cover onto the opening of the infeed bus contacts belonging to the last plugged-in motor starter BaseUnit.

Rated voltage for operation

The ET 200SP distributed I/O system works with the rated voltage and corresponding tolerances listed in the following table.

Note the supply voltage of each module when selecting the rated voltage.

Table 14- 12 Rated voltage for operation

Rated voltage	Tolerance range
24 V DC	19.2 to 28.8 V DC [1]
	18.5 to 30.2 V DC [2]
120 V AC	93 to 132 V AC
230 V AC	187 to 264 V AC
400 V AC [3]	48 to 500 V AC

[1] Static value: Creation as functional extra-low voltage with safe electrical isolation according to IEC 60364-4-41

[2] Dynamic value: Including ripple, e.g. as in the case of three-phase bridge power rectification

[3] Valid for the infeed bus of the modules and BaseUnits of motor starters only

14.7 Use of the ET 200SP in zone 2 potentially explosive atmospheres

See product information "Use of subassemblies/modules in Zone 2 Hazardous Area" (http://support.automation.siemens.com/WW/view/en/19692172).

Dimension drawings

A

A.1 Shield connector

Dimensional diagram of the shield connector

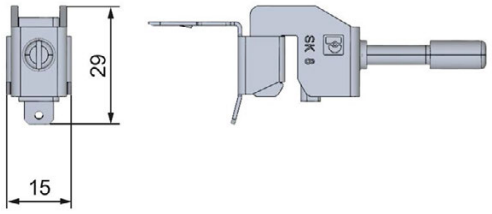


Figure A-1 Dimensional diagram of the shield connector

A.2 Labeling strip

Dimensional diagram of labeling strips and roll

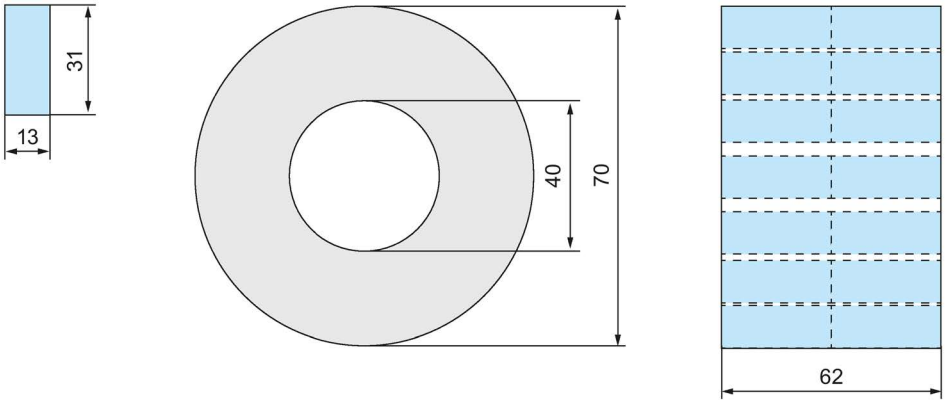


Figure A-2 Dimensional diagram of labeling strips and roll

A.3 Reference identification labels

Dimensional diagram of reference identification label and sheet

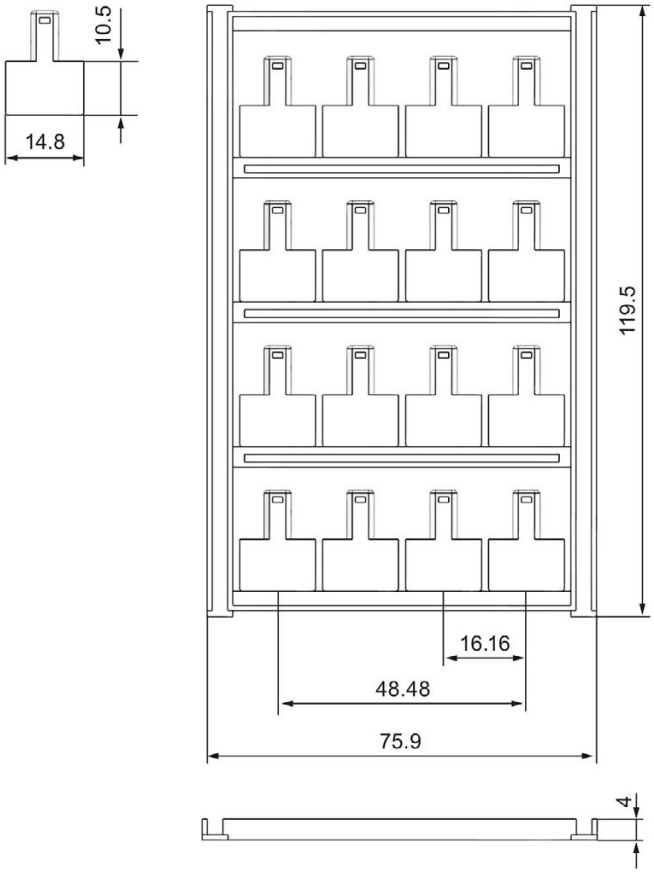


Figure A-3 Dimensional diagram of reference identification label and sheet

Accessories/spare parts

B

Accessories for the ET 200SP distributed I/O system

Table B- 1 Accessories, general

Accessories, general	Packing unit	Article number
BusAdapter		
• BA 2×RJ45 (PROFINET BusAdapter with standard Ethernet socket)	1 unit	6ES7193-6AR00-0AA0
• BA 2×FC (PROFINET BusAdapter with FastConnect Ethernet connection)	1 unit	6ES7193-6AF00-0AA0
• BA 2×SCRJ (PROFINET BusAdapter with POF/PCF fiber-optic cable connection)	1 unit	6ES7193-6AP00-0AA0
• BA SCRJ/RJ45 (media converter, PROFINET BusAdapter with POF/PCF fiber-optic cable ⇔ standard RJ45 connector)	1 unit	6ES7193-6AP20-0AA0
• BA SCRJ/FC (media converter, PROFINET BusAdapter with POF/PCF fiber-optic cable ⇔ direct connection of bus cable)	1 unit	6ES7193-6AP40-0AA0
• BA 2xLC (PROFINET BusAdapter with glass fiber-optic cable connection)	1 unit	6ES7193-6AG00-0AA0
• BA LC/RJ45 (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ standard RJ45 connector)	1 unit	6ES7193-6AG20-0AA0
• BA LC/FC (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ direct connection of bus cable)	1 unit	6ES7193-6AG40-0AA0
• BA-Send 1xFC (for the station expansion via ET-Connection, mixed configuration ET 200SP/ET 200AL)	1 unit	6ES7193-6AS00-0AA0
Cover for the BusAdapter interface	5 units	6ES7591-3AA00-0AA0
PROFIBUS FastConnect bus connector	1 unit	6ES7972-0BB70-0XA0
Server module (spare part)	1 unit	6ES7193-6PA00-0AA0
BU cover		
• 15 mm wide	5 units	6ES7133-6CV15-1AM0
• 20 mm wide	5 units	6ES7133-6CV20-1AM0
24 V DC connector	10 units	6ES7193-4JB00-0AA0
Shield connection for BaseUnit (shield contacts and shield terminals)	5 units	6ES7193-6SC00-1AM0

Accessories, general	Packing unit	Article number
Reference identification label, sheet with 16 labels	10 units	6ES7193-6LF30-0AW0
Labeling strips (for labeling the I/O modules)		
• Roll, light-gray labeling strips (with a total of 500 units)	1 unit	6ES7193-6LR10-0AA0
• Roll, yellow labeling strips (with a total of 500 units)	1 unit	6ES7193-6LR10-0AG0
• DIN A4 sheets, light-gray labeling strips (with a total of 1000 units)	10 units	6ES7193-6LA10-0AA0
• DIN A4 sheets, yellow labeling strips (with a total of 1000 units)	10 units	6ES7193-6LA10-0AG0
Electronic coding element (type H)	5 units	6ES7193-6EH00-1AA0
Electronic coding element (type F, for fail-safe modules)	5 units	6ES7193-6EF00-1AA0
Mounting rails, tinned steel strip		
• Length: 483 mm	1 unit	6ES5710-8MA11
• Length: 530 mm	1 unit	6ES5710-8MA21
• Length: 830 mm	1 unit	6ES5710-8MA31
• Length: 2000 mm	1 unit	6ES5710-8MA41

Table B- 2 Accessories, color identification labels (push-in terminals), 15 mm wide

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit	Article number
16 process terminals (see I/O module manual)		
• Gray (terminals 1 to 16); color code CC00	10 units	6ES7193-6CP00-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	10 units	6ES7193-6CP01-2MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	10 units	6ES7193-6CP02-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), gray (terminals 13 to 16); color code CC03	10 units	6ES7193-6CP03-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), blue (terminals 13 to 16); color code CC04	10 units	6ES7193-6CP04-2MA0
• Gray (terminals 1 to 12), red (terminals 13 and 14), blue (terminals 15 and 16)	10 units	6ES7193-6CP05-2MA0
10 AUX terminals (for BU15-P16+**A10**+2D, BU15-P16+**A10**+2B)		
• Yellow-green (terminals 1 A to 10 A); color code CC71	10 units	6ES7193-6CP71-2AA0
• Red (terminals 1 A to 10 A); color code CC72	10 units	6ES7193-6CP72-2AA0
• Blue (terminals 1 A to 10 A); color code CC73	10 units	6ES7193-6CP73-2AA0
10 add-on terminals (for BU15-P16+A0+**12**D/T, BU15-P16+A0+**12**B/T)		
• Red (terminals 1B to 5B), blue (terminals 1 to 5C); color code CC74	10 units	6ES7193-6CP74-2AA0

Table B- 3 Accessories, color identification labels (push-in terminals), 20 mm wide

Accessories, color identification labels (push-in terminals), 20 mm wide	Packing unit	Article number
12 process terminals (see I/O module manual)		
• Gray (terminals 1 to 4), red (terminals 5 to 8), blue (terminals 9 to 12); color code CC41	10 units	6ES7193-6CP41-2MB0
• Gray (terminals 1 to 8), red (terminals 9 and 10), blue (terminals 11 and 12), color code CC42	10 units	6ES7193-6CP42-2MB0
6 process terminals (see I/O module manual)		
• Gray (terminals 1 to 4), red (terminal 5), blue (terminal 6); color code CC51	10 units	6ES7193-6CP51-2MC0
• Gray (terminals 1, 2 and 5), red (terminals 3 and 4), blue (terminal 6); color code CC52	10 units	6ES7193-6CP52-2MC0
4 AUX terminals (for BU20-P12+**A4**+0B)		
• Yellow-green (terminals 1 A to 4 A); color code CC81	10 units	6ES7193-6CP81-2AB0
• Red (terminals 1 A to 4 A); color code CC82	10 units	6ES7193-6CP82-2AB0
• Blue (terminals 1 A to 4 A); color code CC83	10 units	6ES7193-6CP83-2AB0
2 AUX terminals (for BU20-P6+**A2**+4D, BU20-P6+**A2**+4B)		
• Yellow-green (terminals 1 A and 2 A); color code CC84	10 units	6ES7193-6CP84-2AC0
• Red (terminals 1 A and 2 A); color code CC85	10 units	6ES7193-6CP85-2AC0
• Blue (terminals 1 A and 2 A); color code CC86	10 units	6ES7193-6CP86-2AC0

Table B- 4 SIMATIC memory card accessories

Capacity	Packing unit	Article number
4 MB	1 unit	6ES7954-8LCxx-0AA0
12 MB	1 unit	6ES7954-8LExx-0AA0
24 MB	1 unit	6ES7954-8LFxx-0AA0
256 MB	1 unit	6ES7954-8LL02-0AA0
2 GB	1 unit	6ES7954-8LPxx-0AA0
32 GB	1 unit	6ES7954-8LT02-0AA0

Table B- 5 Accessories for motor starters

Short designation	Packing unit	Article number
3DI/LC module (connecting terminal)	1 unit	3RK1908-1AA00-0BP0
Fan	1 unit	3RW4928-8VB00
BU cover 30	1 unit	3RK1908-1CA00-0BP0
Touch protection cover for the infeed bus	10 units	3RK1908-1DA00-2BP0
Mechanical bracket for BaseUnit	5 units	3RK1908-1EA00-1BP0

Components for lightning protection (lightning protection zone transition 0_B to 1, 1 to 2 and 2 to 3)

You must install overvoltage protection devices in the ET 200SP distributed I/O system for lightning protection purposes. You can find more information in the Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

Online catalog

Additional article numbers for ET 200SP can be found on the Internet (http://mall.industry.siemens.com) in the online catalog and online ordering system.

B.1 Lightning protection and overvoltage protection for fail-safe modules

Overvoltage arrestors for fail-safe modules

Note

This section only lists the overvoltage arrestors that may be used to protect the fail-safe modules.

Be sure to observe the detailed information on lightning protection and overvoltage protection of the ET 200SP distributed I/O system in Electromagnetic compatibility of fail-safe modules (Page 277).

Components for overvoltage protection of fail-safe modules (lightning protection zone transition 0_B to 1)

The overvoltage arrestors are only required for unshielded cables. The Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual lists the overvoltage arrestors which you may use for fail-safe modules.

Calculating the leakage resistance

C

Introduction

If you wish to protect the ET 200SP using a ground-fault detector or a residual current circuit breaker, then you need the leakage resistance to select the correct safety components.

Ohmic resistance

When determining the leakage resistance of the ET 200SP, you must take into account the ohmic resistance from the RC combination of the module in question:

Table C- 1 Ohmic resistance

Module	Ohmic resistance from RC network
CPU/interface module	10 MΩ (±5 %)
BaseUnit BU15...D	10 MΩ (±5 %)
BaseUnit BU30-MSx	10 MΩ (±5 %)

Formula

You can calculate the leakage resistance of the ET 200SP using the following formula if you protect all of the modules listed above with one ground-fault detector:

$R_{ET200SP} = R_{module} / N$

$R_{ET200SP}$ = Leakage resistance of the ET 200SP

R_{module} = Leakage resistance of a module

N = Number of BaseUnits BU15...D and interface module in the ET 200SP

$R_{CPU/IM} = R_{BU15...D} = R_{Module} = 9.5\ M\Omega$

$R_{CPU/IM}$ = Leakage resistance of CP/interface module

$R_{BU15...D}$ = Leakage resistance of the BaseUnit BU15...D

If you protect the modules listed above within an ET 200SP with several ground-fault detectors, you must determine the leakage resistance for each individual ground-fault detector.

Example

The structure of an ET 200SP system consists of an IM 155-6 PN ST, two BaseUnits BU15...D and various input and output modules. The entire ET 200SP is protected with **one** ground-fault detector:

$$R_{ET\ 200SP} = \frac{9.5\ M\Omega}{3} = 3.17\ M\Omega$$

Figure C-1 Calculation example for leakage resistance

Glossary

1oo1 evaluation

Type of → sensor evaluation – in the case of the 1oo1 evaluation, there → is one sensor with a 1-channel connection to the F module.

1oo2 evaluation

Type of → sensor evaluation – in the case of 1oo2 evaluation , two input channels are assigned one two-channel sensor or two one-channel sensors. The input signals are compared internally for equivalence or nonequivalence.

Acknowledgment time

During the acknowledgment time, the → F-I/O acknowledge the sign of life specified by the → F-CPU. The acknowledgment time is included in the calculation of the → monitoring time and → response time of the overall fail-safe system.

Actuator

Actuators are, for example, power relays or contactors for switching on load devices or load devices themselves (e.g. directly controlled solenoid valves).

Automation system

Programmable logic controller for the open-loop and closed-loop control of process sequences of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions depending on the automation task.

AUX bus

Self-assembling bus, can be used individually, for example, as a protective conductor bus or for additional required voltage.

Availability

Availability is the probability that a system is functional at a specific point in time. Availability can be increased by redundancy, e.g., by using multiple -> sensors at thesame measuring point.

AWG (American Wire Gauge)

A standard measure for conductors used in the USA, which is assigned to a specific cross-sectional area of a conductor or wire. Each AWG number represents a jump of 26% in the cross-sectional area. The thicker the wire, the smaller the AWG number.

BaseUnit

BaseUnits realize the electrical and mechanical connection of the I/O modules with the interface module and the server module.

The inserted I/O module determines the signals at the terminals of the BaseUnits. Depending on the selected BaseUnit, only certain terminals are available.

BaseUnit, dark-colored

Conduction of the internal power and AUX buses from the left adjacent module to the subsequent modules on the right.

BaseUnit, light-colored

Inserted as first BaseUnit and opens a new potential group with electrical isolation. The power and AUX buses are separate from the adjacent module on the left. It feeds the supply voltage.

Baud rate

Speed at which data is transferred, indicating the number of transmitted bits per second (baud rate = bit rate).

BU cover

Cover for unused slots on the BaseUnit or placeholder for planned I/O modules. For a future expansion, the reference identification label of the planned I/O module can be kept here.

Bus

Joint transmission path to which all participants of a fieldbus system are connected; has two defined ends.

BusAdapter

Enables free selection of the connection technology for the PROFINET fieldbus.

Channel fault

Channel-specific fault, such as a wire break or short circuit.

In channel-specific passivation, the affected channel is either automatically reintegrated or the fail-safe module must be removed and reinserted after the fault has been eliminated.

Channel group

The channels of a module are grouped together in a channel group. Certain parameters in STEP 7 can only be assigned to channel groups, rather than to individual channels.

Channel number

Channel numbers are used to uniquely identify the inputs and outputs of a module and to assign channel-specific diagnostic messages.

Channel-specific passivation

With this type of passivation, only the affected channel is passivated in the event of a → channel fault. In the event of a → module fault, all channels of the → fail-safe module are passivated.

Configuration

Systematic arrangement of the individual modules.

Configuration control

Function that enables a flexible adjustment of the actual configuration based on a configured maximum configuration via the user program. Input, output and diagnostics addresses remain unchanged.

Connecting to common potential

Configuring a new potential group for which a new infeed is set up for the supply voltage.

Connection plug

Physical connection between device and cable.

CPU

The CPU uses the integrated system power supply to supply the electronics of the modules via the backplane bus. The CPU contains the operating system and executes the user program. The user program is located on the SIMATIC memory card and is processed in the work memory of the CPU. The PROFINET interfaces of the CPU establish an Industrial Ethernet connection. The CPUs of the ET 200SP support operation as an IO controller, I-device or standalone CPU.

CRC

Cyclic Redundancy Check

CRC signature

The validity of the process values in the safety frame, the accuracy of the assigned address references, and the safety-related parameters are validated by means of the CRC signature in the safety frame.

Crimping

Procedure in which two components, e.g. end sleeve and cable, are connected with each other by plastic strain.

Dark period

Dark periods occur during shutdown tests and complete bit pattern tests. The fail-safe output module switches test-related zero signals to the active output. This output is then briefly disabled (= dark period). An adequate carrier → actuator will not respond to this and will remain activated.

Derating

Derating allows devices to be used even in harsh operating conditions by selectively restricting the output capacity. In the case of motor starters, this usually refers to operation at high ambient temperatures.

Device name

Before an IO device can be addressed by an IO controller, it must have a device name. An IO device is delivered without a device name. An IO device can only be addressed by the IO controller after it has been assigned a device name via the PG/PC or via the topology, e.g. for the transfer of configuration data (such as IP address) during startup or for the exchange of user data during cyclic operation.

Diagnostics

Monitoring functions for the recognition, localization, classification, display and further evaluation of errors, faults and alarms. They run automatically during plant operation. This increases the availability of plants because commissioning times and downtimes are reduced.

Discrepancy analysis

The discrepancy analysis for equivalence/non-equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same levels). A check is performed to determine whether the difference (for nonequivalence testing: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

The discrepancy analysis compares the two input signals of the 1oo2 sensor evaluation in the fail-safe input module.

Discrepancy time

Configurable time for the → discrepancy analysis. If the discrepancy time is set too high, the fault detection time and → fault reaction time are extended unnecessarily. If the discrepancy time is set too low, availability is decreased unnecessarily since a discrepancy error is detected when, in reality, no error exists.

Distributed I/O system

System with input and output modules that are configured on a distributed basis, far away from the CPU controlling them.

DP

→ *Distributed I/O system*

Earth

Conductive earth whose electrical potential can be set equal to zero at any point.

Equipotential bonding

Electrical connection (potential equalization conductor) that brings the bodies of electrical equipment and other conductive bodies to the same or almost the same potential, in order to prevent disruptive or dangerous voltages between these bodies.

Explosion protection

Prerequisite for using electrical equipment in hazardous areas conforming to DIN EN 50014 (VDE 0170/0171). For explosion protection, you must ensure that equipment which may generate explosive arcs (plasma) during operation is enclosed in a flameproof casing. This means that, although the potentially explosive mixture could penetrate the enclosure, if an explosion were to occur inside it then no explosive flame could escape.

Fail-safe modules

ET 200SP modules with integrated safety functions that can be used for safety-related operation (safety mode).

Fail-safe systems

Fail-safe systems (F-systems) remain in a safe state or immediately assume another safe state as soon as particular failures occur.

Fault reaction time

The maximum fault reaction time of an F-system defines the interval between the occurrence of any fault and a safe reaction at all affected fail-safe outputs.

For → F-system overall: The maximum fault reaction time defines the interval between the occurrence of any fault in any → F-I/O and a safe response at the relevant fail-safe output.

For digital inputs: The maximum fault reaction time defines the interval between the occurrence of the fault and the safe reaction on the backplane bus.

For digital outputs: The maximum fault reaction time defines the interval between the occurrence of the fault and the safe reaction at the digital output.

Fault tolerance time

The fault tolerance time of a process is the time a process can be left unattended without risk to life and limb of the operating personnel, or damage to the environment.

Any type of F-system control is tolerated within this fault tolerance time, i.e. the → F-system can control its processes incorrectly or even not at all. The fault tolerance time depends on the type of process and must be determined on a case-by-case basis.

F-CPU

An F-CPU is a central processing unit with fail-safe capability that is permitted for use in SIMATIC Safety. A standard user program can also be run on the F-CPU.

F-I/O

Collective name for fail-safe inputs and outputs available in SIMATIC S7 for integration into the SIMATIC Safety F-system. Available F-I/O modules:

- Fail-safe I/O module for ET 200eco
- Fail-safe signal modules S7-300 (F-SMs)
- Fail-safe modules for ET 200S
- Fail-safe modules for ET 200SP
- Fail-safe DP standard slaves
- Fail-safe PA field devices
- Fail-safe IO devices

Firmware update

Upgrade of firmware for modules (interface modules, I/O modules etc.), e.g. after function extensions, to the newest firmware version (update).

F-monitoring time

→ PROFIsafe monitoring time

F-Systems

→ fail-safe systems

Functional ground

Functional ground is a low-impedance current path between electric circuits and ground. It is not designed as a safety measure but instead, for example, as a measure to improve interference immunity.

Ground

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

Grounding

Grounding means connecting an electrically conductive part to a grounding electrode by means of a grounding system.

GSD file

As a Generic Station Description, this file contains all properties of a PROFINET or PROFIBUS device that are necessary for its configuration in XML format.

I/O modules

All modules, with the exception of the motor starters, that can be operated with a CPU or an interface module.

Identification data

Information that is saved in modules and that supports the user in checking the plant configuration and locating hardware changes.

Infeed system

The infeed system with the terminals L1(L), L2(N), L3, PE enables several SIMATIC ET 200SP motor starters to be supplied using a single infeed terminal.

Interface module

Module in the distributed I/O system. The interface module connects the distributed I/O system via a fieldbus to the CPU (IO controller) and prepares the data for and from I/O modules.

IO-Link

IO-Link is a point-to-point connection to conventional and intelligent sensors/actuators by unshielded standard cables in proven 3-wire technology. IO-Link is downward compatible to all DI/DQ sensors/actuators. Switching status channel and data channel are designed in proven 24 V DC technology.

Line

All the modules attached to a mounting rail.

Load current supply

Supply of modules like the interface module, power supply modules, I/O modules, and (if applicable) sensors and actuators.

MAC address

Device identification unique worldwide, which is already assigned to each PROFINET device in the factory. Its 6 bytes are divided into 3 bytes for the manufacturer ID and 3 bytes for the device ID (serial number). The MAC address is usually legible on the device.

Main switch

Every industrial machine that falls under the scope of DIN EN 60204 Part 1 (VDE 0113, Part 1) must be equipped with a main switch that disconnects all electrical equipment from the network while cleaning, maintenance, and repair work is being carried out, as well as during long periods of downtime. Usually a switch which can be operated by hand that is stipulated for electrical or mechanical prevention of a hazard. The main switch can also function as an EMERGENCY-OFF device.

The main switch must meet the following requirements:

- Externally accessible mechanical rotary lock.
- Only one OFF position and one ON position with allocated stops.
- Two positions labeled "0" and "I". 4th lockable OFF position.
- Cover for the power supply terminals to protect against accidental contact.
- The switching capacity must correspond to AC-23 for motor switches and AC-22 for load-break switches (utilization category).
- Switch position displayed automatically.

Module fault

Module faults can be external faults (e.g. missing load voltage) or internal faults (e.g. processor failure). Internal faults always require module replacement.

Monitoring time

→ PROFIsafe monitoring time

Motor starter

Motor starter is the generic term for direct-on-line and reversing starters.

M-switch

Each fail-safe digital output of ET 200SP F-modules consists of a P-switch DO-P_x (current sourcing) and an M-switch DO-M_x (current sinking). The load is connected between the P-switch and M-switch. The two switches are always activated so that voltage is applied to the load.

Node

Device that can send, receive or amplify data via the bus, e.g. IO device via PROFINET IO.

Nonequivalent sensor

A nonequivalent → sensor is a two-way switch that is connected to two inputs of an → F-I/O (via 2 channels) in → fail-safe systems (for → 1oo2 evaluation of sensor signals).

Overload release

Overcurrent release that provides protection against overload.

Parameter assignment

Parameter assignment is the transfer of parameters from the IO controller/DP master to the IO device/DP slave.

Passivation

If an → F-I/O module detects a fault it switches either the affected channel or all channels to a → safe state, i.e. the channels of this F-I/O module are passivated. The F-I/O module signals the detected faults to the → F-CPU.

When passivating channels at F-I/O with inputs, the → F-System provides fail-safe values for the → safety program instead of the process values pending at the fail-safe inputs.

When passivating channels at F-I/O with outputs, the F-system returns fail-safe values (0) to the fail-safe outputs instead of the output values provided by the safety program.

PELV

Protective **E**xtra **L**ow **V**oltage

Performance Level

Performance Level (PL) according to ISO 13849-1:2006 or EN ISO 13849-1:2008

Potential group

Group of I/O modules that are jointly supplied with voltage.

Prewiring

Wiring the electrics on a mounting rail before the I/O modules are connected.

Process image (I/O)

The CPU transfers the values from the input and output modules to this memory area. At the start of the cyclic program, the signal states of the input modules are transmitted to the process image input. At the end of the cyclic program, the process image output is transmitted as signal state to the output modules.

Product version (ES) = Functional status (FS)

The product version or functional status provides information on the hardware version of the module.

PROFIBUS

PROcess FIeld BUS, process and fieldbus standard that is specified in IEC 61158 Type 3. It specifies functional, electrical and mechanical properties for a bit-serial fieldbus system. PROFIBUS is available with the following protocols: DP (= Distributed Periphery), FMS (= Fieldbus Message Specification), PA (= Process Automation) or TF (= Technological Functions).

PROFINET

PROcess FIeld NETwork, open industrial Ethernet standard which continues PROFIBUS and Industrial Ethernet. A cross-manufacturer communication, automation and engineering model by PROFIBUS International e.V., defined as an automation standard.

PROFINET IO controller

Device used to address connected I/O devices (e.g. distributed I/O systems). This means: The IO controller exchanges input and output signals with assigned I/O devices. The IO controller often corresponds to the CPU in which the automation program is running.

PROFINET IO

Communication concept for the realization of modular, distributed applications within the scope of PROFINET.

PROFINET IO device

Distributed field device that can be assigned to one or more IO controllers (e.g. distributed I/O system, valve terminals, frequency converters, switches).

PROFIsafe

Safety-oriented PROFINET I/O bus profile for communication between the → safety program and the → F-I/O module in a → fail-safe system.

PROFIsafe address

The PROFIsafe address (code name according to IEC 61784-3-3: 2010) is used to protect standard addressing mechanisms such as IP addresses. The PROFIsafe address consists of the F-source address and F-destination address. Every → fail-safe module therefore has two address portions, the F-source address and the F-destination address.

The PROFIsafe address must be configured in the hardware and network editor.

PROFIsafe monitoring time

Monitoring time for safety-related communication between the F-CPU and F-I/O

Proof-test interval

Period after which a component must be forced to fail-safe state, that is, it is either replaced with an unused component, or is proven faultless.

Provider-Consumer principle

Principle of data communication on the PROFINET IO: in contrast to PROFIBUS, both parties are independent providers when sending data.

P-switch

→ M-switch

Push-in terminal

Push-in connections are a form of spring-loaded terminals allowing wiring without tools for rigid conductors or conductors equipped with end sleeves.

Redundancy, availability-enhancing

Multiple instances of components with the objective of maintaining component functionality in the event of hardware faults.

Redundancy, safety-enhancing

Multiple availability of components with the aim of exposing hardware faults based on comparison; such as → 1oo2 evaluation in → fail-safe modules.

Reference identification

In accordance with EN 81346, a specific object is clearly referenced in relation to the system to whose components the object belongs. Thus, unique identification of the modules in the entire system is possible.

Reference potential

Potential from which the voltages of the participating circuits are considered and/or measured.

Reintegration

After the elimination of a fault, it is necessary to ensure the reintegration (depassivation) of the → F-I/O. Reintegration (switchover from fail-safe values to process values) occurs either automatically or only after a user acknowledgment in the safety program.

In the case of a fail-safe input module, the process values pending at the fail-safe inputs are made available to thesafety program again after reintegration. In the case of a fail-safe output module, the → fail-safe system transfers the output values in the safety program to the fail-safe outputs again.

RIOforFA-Safety

Remote IO for Factory Automation with PROFIsafe; Profile for F-I/O

RoHS

EC Directive 2011/65/EU concerning the restriction of certain dangerous substances in electrical and electronic devices regulates the use of hazardous substances in devices and components. The English abbreviation RoHS is used to refer to this directive: (Restriction of the use of certain hazardous substances), as well as all related measures for implementing it into national legislation.

Safe state

The basic principle of the safety concept in F-systems is the existence of a safe state for all process variables. For the digital F-I/O, for example, the safe state is the value "0".

Safety class

Safety level (Safety Integrity Level) SIL according to IEC 61508:2010. The higher the Safety Integrity Level, the more rigid the measures for prevention of systematic faults and for management of systematic faults and hardware failures.

The fail-safe modules support operation in safety mode up to safety class SIL3.

Safety frame

In safety mode, data are transferred between the → F-CPU and → F-I/O in a safety frame.

Safety function

A mechanism integrated in the → F-CPU and → F-I/O that enables their use in → the fail-safe system SIMATIC Safety.

According to IEC 61508:2010: A safety function is implemented by a safety system in order to maintain or force a system safe state in the event of a specific fault.

Safety mode

Operating mode of → F-I/O that enables → safety-related communication via → safety frames.

→ ET 200SP fail-safe modules can only used in safety mode.

Safety program

Safety-related user program

Safety-related communication

Communication used to exchange fail-safe data.

Self-assembling voltage buses

Two internal, self-assembling buses (P1 and P2) that supply the I/O modules with voltage.

SELV

Safety **E**xtra **L**ow **V**oltage

Sensor evaluation

There are two types of sensor evaluation:

→ 1oo1 evaluation – sensor signal is read once

→ 1oo2 evaluation – sensor signal is read in twice by the same F-module and compared internally

Sensors

Sensors are used for accurate detection of digital and analog signals as well as routes, positions, velocities, rotational speeds, masses, etc.

Server module

The server module completes the configuration of the ET 200SP.

Service life

Period of time for which the switching device will work properly under normal operating conditions. This is specified as the number of operating cycles, the electrical durability (e.g. contact erosion), and the mechanical durability (e.g. operating cycles without load).

SIL

Safety Integrated Level → safety class

SIL (Safety Integrity Level)

Discrete level (one of three possibilities) for defining safety integrity specifications of safety-related control functions. Safety integrity level 3 is the highest possible level, level 1 the lowest.

Slave station

A slave can only exchange data after being requested to do so by the master.

SNMP

SNMP (Simple Network Management Protocol) is the standardized protocol for diagnosing and also configuring the Ethernet infrastructure.

In the office area and in automation technology, devices support a wide range of manufacturers on the Ethernet SNMP.

SNMP-based applications can be operated on the same network in parallel to applications with PROFINET.

Standard mode

Operating mode of F-I/O in which standard communication is possible by means of → safety frames, but not → safety-related communication.

Fail-safe ET 200SP modules can only be operated in safety mode.

Switch

PROFIBUS is a linear network. The communication nodes are linked by means of a passive cable - the bus.

By contrast, Industrial Ethernet consists of point-to-point connections: each communication node is interconnected directly with precisely one other communication node.

If a communication node is linked to several communication nodes, this communication node is connected to the port of an active network component - the switch. Other communications devices (including switches) can then be connected to the other ports of the switch. The connection between a communication node and the switch remains a point-to-point connection.

The task of a switch is thus to regenerate and distribute received signals. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those signals that are intended for the connected PROFINET device or switch.

A switch has a specific number of connections (ports). You connect at most one PROFINET device or additional switch to each port.

Technology object

A technology object supports you in the configuration and commissioning of a technological function.

The properties of real objects are represented by the technology objects in the controller. Real objects can be, for example, controlled systems or drives.

The technology object includes all data of the real object that is required for its open-loop or closed-loop control, and it signals the status information.

TIA Portal

Totally Integrated Automation Portal

The TIA Portal is the key to the full performance capability of Totally Integrated Automation. The software optimizes all operating, machine and process sequences.

Total current

Sum of the currents of all output channels of a digital output module.

TWIN end sleeve

End sleeve for two cables

Type of coordination 1

The motor starter may be non-operational after a short circuit has been cleared. Damage to the motor starter is permissible.

Types of coordination

The IEC 60947-4-1 (VDE 0660 Part 102) standard distinguishes between two types of coordination referred to as coordination type "1" and coordination type "2". The short circuit that needs to be dealt with is cleared reliably and safely with both types of coordination; the only differences are in the extent of the damage sustained by the device following a short circuit.

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SIMATIC

ET 200SP Product information on the documentation of the ET 200SP distributed I/O system

Product Information

05/2017
A5E03799595-AY

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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Preface

Validity

This product information supplements the documentation for the ET 200SP and takes precedence over our system manuals, function manuals and product manuals.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

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Module overview of ET 200SP

1

1.1 Possible combinations of BaseUnits and I/O modules

Contents

This product information includes amendments and corrections to the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/55679227/133300).

Which I/O modules / motor starters fit on a BaseUnit?

The following table provides an overview of the I/O modules / motor starters that fit on the corresponding compatible BaseUnits:

Table 1- 1 Possible combinations of BaseUnits and I/O modules

I/O module	BaseUnit BU15-		BaseUnit BU20-						Color-coded label for process terminals	
	BU type A0 P16+A10+2D P16+A0+2D P16+A10+2B P16+A0+2B	BU type A1 P16+A0+12D/T P16+A0+2D/T P16+A0+12B/T P16+A0+2B/T	BU type B0 P12+A4+0B	BU type B1 P12+A0+4B	BU type C0 P6+A2+4D	BU type C1 P6+A2+4B	BU type D0 P12+A0+0B	BU type F0 P8+A4+0B		
Digital I/O modules										
DI 16x24VDC ST	✓								CC00	
DI 8x24VDC ST	✓								CC01	
DI 8x24VDC HF	✓								CC01	
DI 8x24VDC HS	✓								CC01	

I/O module	BaseUnit BU15-		BaseUnit BU20-						Color-coded label for process terminals	
	BU type A0 P16+A10+2D P16+A0+2D P16+A10+2B P16+A0+2B	**BU type A1** P16+A0+12D/T P16+A0+2D/T P16+A0+12B/T P16+A0+2B/T	**BU type B0** P12+A4+0B	**BU type B1** P12+A0+4B	**BU type C0** P6+A2+4D	**BU type C1** P6+A2+4B	**BU type D0** P12+A0+0B	**BU type F0** P8+A4+0B		
DI 8x24VDC BA	✓								CC01	
DI 8x24VDC SRC BA	✓								CC02	
DI 8xNAMUR HF	✓								CC01	
DI 4x120..230VAC ST				✓					CC41	
DQ 16x24VDC/0.5A ST	✓								CC00	
DQ 4x24VDC/2A ST	✓								CC02	
DQ 8x24VDC/0.5 ST	✓								CC02	
DQ 8x24VDC/0.5A HF	✓								CC02	
DQ 8x24VDC/0.5A BA	✓								CC02	

I/O module	BaseUnit BU15-		BaseUnit BU20-						Color-coded label for process terminals	
	BU type A0 P16+A10+2D P16+A0+2D P16+A10+2B P16+A0+2B	**BU type A1** P16+A0+12D/T P16+A0+2D/T P16+A0+12B/T P16+A0+2B/T	**BU type B0** P12+A4+0B	**BU type B1** P12+A0+4B	**BU type C0** P6+A2+4D	**BU type C1** P6+A2+4B	**BU type D0** P12+A0+0B	**BU type F0** P8+A4+0B		
DQ 8x24VDC/0.5A SNK BA	✓								CC01	
DQ 4x24..230VAC/2A ST				✓					CC41	
DQ 4x24VDC/2A HF	✓								CC02	
DQ 4x24VDC/2A HS	✓								CC00	
RQ 4x24VUC/2A CO ST	✓								CC00	
RQ 4x120VDC-230VAC/5A NO ST			✓	✓					---	---
RQ 4x120VDC-230VAC/5A NO MA ST			✓	✓					---	---
Analog I/O modules										
AI 4xRTD/TC 2-/3-/4-wire HF	✓	✓							CC00	
AI 8xRTD/TC 2-wire HF	✓	✓							CC00	
AI 8xU BA	✓	✓							CC02	

I/O module	BaseUnit BU15-		BaseUnit BU20-						Color-coded label for process terminals	
	BU type A0 P16+A10+2D P16+A0+2D P16+A10+2B P16+A0+2B	**BU type A1** P16+A0+12D/T P16+A0+2D/T P16+A0+12B/T P16+A0+2B/T	**BU type B0** P12+A4+0B	**BU type B1** P12+A0+4B	**BU type C0** P6+A2+4D	**BU type C1** P6+A2+4B	**BU type D0** P12+A0+0B	**BU type F0** P8+A4+0B		
AI 2xU ST	✓	✓							CC00	
AI 2xI 2-/4-wire ST	✓	✓							CC05	
AI 4xU/I 2-wire ST	✓	✓							CC03	
AI 2xU/I 2-/4-wire HF	✓	✓							CC03	
AI 2xU/I 2-/4-wire HS	✓	✓							CC00	
AI 8xI 2-/4-wire BA	✓	✓							CC01	
AI 4xI 2-/4-wire ST	✓	✓							CC03	
AI 4xI 2-wire 4...20mA HART	✓	✓							CC03	
AQ 2xU ST	✓	✓							CC00	

I/O module	BaseUnit BU15-		BaseUnit BU20-						Color-coded label for process terminals	
	BU type A0 P16+A10+2D P16+A0+2D P16+A10+2B P16+A0+2B	**BU type A1** P16+A0+12D/T P16+A0+2D/T P16+A0+12B/T P16+A0+2B/T	**BU type B0** P12+A4+0B	**BU type B1** P12+A0+4B	**BU type C0** P6+A2+4D	**BU type C1** P6+A2+4B	**BU type D0** P12+A0+0B	**BU type F0** P8+A4+0B		
AQ 2xI ST	✓	✓							CC00	
AQ 4xU/I ST	✓	✓							CC00	
AQ 2xU/I HS	✓	✓							CC00	
AQ 2xU/I HF	✓	✓							CC00	
AI Energy Meter 400VAC ST							✓		---	---
AI Energy Meter 480VAC ST							✓		---	---
Fail-safe modules										
F-PM-E 24VDC/8A PPM ST					✓				CC52	
F-DI 8x24VDC HF	✓								CC01	
F-DQ 4x24VDC/2A PM HF	✓								CC02	
F-RQ 1x24VDC/24..230 VAC/5A								✓	CC42	

I/O module	BaseUnit BU15-		BaseUnit BU20-						Color-coded label for process terminals	
	BU type A0 P16+A10+2D P16+A0+2D P16+A10+2B P16+A0+2B	**BU type A1** P16+A0+12D/T P16+A0+2D/T P16+A0+12B/T P16+A0+2B/T	**BU type B0** P12+A4+0B	**BU type B1** P12+A0+4B	**BU type C0** P6+A2+4D	**BU type C1** P6+A2+4B	**BU type D0** P12+A0+0B	**BU type F0** P8+A4+0B		
Communication modules										
CM 4xIO-Link	✓								CC04	
CM AS-i Master ST					✓				---	---
F-CM AS-i Safety ST					✓	✓			---	---
CM PtP	✓								---	---
Technology modules										
TM Count 1x24V	✓								---	---
TM PosInput 1	✓								---	---
TM Timer DIDQ 10x24V	✓								---	---
TM Pulse 2x24V				✓					---	---
SIWAREX WP321	✓								---	---

Table 1- 2 Possible combinations of BaseUnits and motor starters

Motor starters	BaseUnit BU30-						Color-coded label for process terminals	
	MS1 with infeed 24 V DC and 500 V AC	**MS2** with infeed 500 V AC	**MS3** with infeed 24 V DC	**MS4** without infeed	**MS5** with infeed 500 V AC and F-DI terminals	**MS6** without infeed with F-DI terminals		
Direct starter								
DS 0.3 - 1 A HF	✓				✓*		---	---
DS 0.9 - 3 A HF	✓				✓*		---	---
DS 2.8 - 9 A HF	✓				✓*		---	---
DS 4.0 - 12 A HF	✓				✓*		---	---
Reversing starter								
RS 0.3 - 1 A HF	✓				✓*		---	---
RS 0.9 - 3 A HF	✓				✓*		---	---
RS 2.8 - 9 A HF	✓				✓*		---	---
RS 4.0 - 12 A HF	✓				✓*			
Failsafe direct starter								
F-DS 0.3 - 1 A HF	✓				✓		---	---
F-DS 0.9 - 3 A HF	✓				✓		---	---
F-DS 2.8 - 9 A HF	✓				✓		---	---
F-DS 4.0 - 12 A HF	✓				✓		---	---
Fail-safe reversing starter								
F-RS 0.3 - 1 A HF	✓				✓		---	---
F-RS 0.9 - 3 A HF	✓				✓		---	---
F-RS 2.8 - 9 A HF	✓				✓		---	---
F-RS 4.0 - 12 A HF	✓				✓		---	---

* The F-DI terminals do not have a function in this combination.

1.2 CPUs

CPUs

CPU	Number in pack	Article number
CPU 1510SP-1 PN with server module	Pack of 1	6ES7510-1DJ0x-0AB0
CPU 1510SP F-1 PN with server module	Pack of 1	6ES7510-1SJ0x-0AB0
CPU 1512SP-1 PN with server module	Pack of 1	6ES7512-1DK0x-0AB0
CPU 1512SP F-1 PN with server module	Pack of 1	6ES7512-1SK0x-0AB0
CPU 1515SP PC with server module	Pack of 1	6ES7677-2AAxx-0xx0

Important differences between CPUs...PN				
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**
Bus connection	PROFINET: BusAdapter (port 1, 2) • BA 2xRJ45 (as of firmware version 1.6) • BA 2xFC (as of firmware version V1.6) RJ45, integrated (port 3)		PROFINET: BusAdapter (port 1, 2) • BA 2xRJ45 (as of firmware version 1.6) • BA 2xFC (as of firmware version V1.6) • BA 2xSCRJ (as of firmware V1.8)[1] • BA SCRJ/RJ45 (as of firmware V1.8)[1] • BA SCRJ/FC (as of firmware V1.8)[1] • BA 2xLC (as of firmware V2.0)[1] • BA LC/RJ45 (as of firmware V2.0)[1] • BA LC/FC (as of firmware V2.0)[1] RJ45, integrated (port 3)	
	PROFIBUS: PROFIBUS DP connection socket via CM DP communication module			
Number of modules	64			
Data work memory	750 KB	750 KB	1 MB	1 MB
Code work memory	100 KB	150 KB	200 KB	300 KB
Address space	1280 bytes/2560 bytes[2]			
Multi hot-swapping	Yes			
Can be used for safety applications (supports PROFIsafe V2.0)	No	Yes	No	Yes

1 Only with article numbers 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0

2 Only 6ES7510-1DJ01-0AB0, 6ES7512-1SJ01-0AB0, 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0 with FW version V2.0

Note

The CM AS-i Master ST and F-CM AS-i Safety ST communication modules are supported as of firmware V1.8 of the CPUs. Note the following additional requirements:

CM AS-i Master ST:

- Firmware version of the CM AS-i Master ST: V1.1
- STEP 7 (TIA Portal): V13 SP1 Update 4 or higher

F-CM AS-i Safety ST

- Firmware version of the CM AS-i Safety ST: V1.0
- STEP 7 (TIA Portal): as of V13 SP1 Update 4 and HSP0070 V3.0

1.3 Interface modules

Interface modules

Interface modules	Number in pack	Article number
Interface module IM 155-6 PN BA	Pack of 1	6ES7155-6AR00-0AN0
Interface module IM 155-6 PN ST		
• with BusAdapter BA 2xRJ45 and server module	Pack of 1	6ES7155-6AA00-0BN0
• with server module	Pack of 1	6ES7155-6AU00-0BN0
Interface module IM 155-6 PN HF with server module	Pack of 1	6ES7155-6AU00-0CN0
Interface module IM 155-6 PN HS with server module	Pack of 1	6ES7155-6AU00-0DN0
Interface module IM 155-6 DP HF with PROFIBUS FastConnect bus connector (6ES7972-0BB70-0XA0) and server module	Pack of 1	6ES7155-6BA00-0CN0

Important differences between the interface modules					
Features	**IM 155-6 PN BA**	**IM 155-6 PN ST**	**IM 155-6 PN HF**	**IM 155-6 PN HS**	**IM 155-6 DP HF**
Bus connection	PROFINET: 2xRJ45, integrated	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V1.0) • BA 2xFC (as of firmware V1.0)	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V2.0) • BA 2xFC (as of firmware V2.0) • BA 2xSCRJ (as of firmware V2.2) • BA SCRJ/RJ45 (as of firmware V3.1) • BA SCRJ/FC (as of firmware V3.1) • BA 2xLC (as of firmware V3.3) • BA LC/RJ45 (as of firmware V3.3) • BA LC/FC (as of firmware V3.3)	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V4.0) • BA 2xFC (as of firmware V4.0) • BA 2xSCRJ (as of firmware V4.0) • BA SCRJ/RJ45 (as of firmware V4.0) • BA SCRJ/FC (as of firmware V4.0) • BA 2xLC (as of firmware V4.0) • BA LC/RJ45 (as of firmware V4.0) • BA LC/FC (as of firmware V4.0)	PROFIBUS: PROFIBUS DP connection socket
Number of modules	12	32	64	30	32
RESET button	No	Yes	Yes	Yes	Not necessary
Address space (I/O data)	32 bytes	798 bytes	1440 bytes	968 bytes	244 bytes
Multi hot-swapping	No	No	Yes	Yes	Yes

Table 1- 3 Station expansion via ET-Connection (mixed configuration ET 200SP/ET 200AL)

Modules	Number in pack	Article number
BU-Send	Pack of 1	6ES7193-6BN00-0NE0
BA-Send 1xFC	Pack of 1	6ES7193-6AS00-0AA0

1.4 BaseUnits

BaseUnits

Table 1- 4 BaseUnits for I/O modules

BU type	BaseUnits (short name)	Color-coded labels*	Packaging unit	Article number
A0	BU15-P16+A10+2D	**P16:** CC00 to CC05 **A10:** CC71 to CC73	Pack of 1	6ES7193-6BP20-0DA0
			Pack of 10	6ES7193-6BP20-2DA0
A0	BU15-P16+A0+2D	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0DA0
			Pack of 10	6ES7193-6BP00-2DA0
A0	BU15-P16+A10+2B	**P16:** CC00 to CC05 **A10:** CC71 to CC73	Pack of 1	6ES7193-6BP20-0BA0
			Pack of 10	6ES7193-6BP20-2BA0
A0	BU15-P16+A0+2B	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0BA0
			Pack of 10	6ES7193-6BP00-2BA0
A1	BU15-P16+A0+12D/T	**P16:** CC00 to CC05 **12D:** CC74	Pack of 1	6ES7193-6BP40-0DA1
A1	BU15-P16+A0+2D/T	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0DA1
A1	BU15-P16+A0+12B/T	**P16:** CC00 to CC05 **12B:** CC74	Pack of 1	6ES7193-6BP40-0BA1
A1	BU15-P16+A0+2B/T	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0BA1
B0	BU20-P12+A4+0B	**A4:** CC81 to CC83	Pack of 1	6ES7193-6BP20-0BB0
			Pack of 10	6ES7193-6BP20-2BB0
B1	BU20-P12+A0+4B	**P12:** CC41	Pack of 1	6ES7193-6BP20-0BB1
C0	BU20-P6+A2+4D	**P6:** CC51, CC52 **A2:** CC84 to CC86	Pack of 1	6ES7193-6BP20-0DC0
C1	BU20-P6+A2+4B	**P6:** CC51 **A2:** CC84 to CC86	Pack of 1	6ES7193-6BP20-0BC1
D0	BU20-P12+A0+0B	---	Pack of 1	6ES7193-6BP00-0BD0
F0	BU20-P8+A4+0B	**P8:** CC42	Pack of 1	6ES7193-6BP20-0BF0

* not shipped with the BaseUnit

Table 1- 5 BaseUnits for motor starters

BU type	BaseUnits (short name)	Color-coded labels	Packaging unit	Article number
MS1	BU30-MS1	---	Pack of 1	3RK1908-0AP00-0AP0
MS2	BU30-MS2	---	Pack of 1	3RK1908-0AP00-0CP0
MS3	BU30-MS3	---	Pack of 1	3RK1908-0AP00-0BP0
MS4	BU30-MS4	---	Pack of 1	3RK1908-0AP00-0DP0
MS5	BU30-MS5	---	Pack of 1	3RK1908-0AP00-0EP0
MS6	BU30-MS6	---	Pack of 1	3RK1908-0AP00-0FP0

1.5 I/O modules

I/O modules

Digital I/O modules	Number in pack	Article number
DI 16x24VDC ST	Pack of 1	6ES7131-6BH00-0BA0
	Pack of 10	6ES7131-6BH00-2BA0
DI 8x24VDC ST	Pack of 1	6ES7131-6BF00-0BA0
	Pack of 10	6ES7131-6BF00-2BA0
DI 8x24VDC HF	Pack of 1	6ES7131-6BF00-0CA0
DI 8x24VDC HS	Pack of 1	6ES7131-6BF00-0DA0
DI 8xNAMUR HF	Pack of 1	6ES7131-6TF00-0CA0
DI 8x24VDC BA	Pack of 1	6ES7131-6BF00-0AA0
	Pack of 10	6ES7131-6BF00-2AA0
DI 8x24VDC SRC BA	Pack of 1	6ES7131-6BF60-0AA0
DI 4x120..230VAC ST	Pack of 1	6ES7131-6FD00-0BB1
DQ 16x24VDC/0.5A ST	Pack of 1	6ES7132-6BH00-0BA0
	Pack of 10	6ES7132-6BH00-2BA0
DQ 8x24VDC/0.5A ST	Pack of 1	6ES7132-6BF00-0BA0
	Pack of 10	6ES7132-6BF00-2BA0
DQ 8x24VDC/0.5A HF	Pack of 1	6ES7132-6BF00-0CA0
DQ 8x24VDC/0.5A BA	Pack of 1	6ES7132-6BF00-0AA0
	Pack of 10	6ES7132-6BF00-2AA0
DQ 8x24VDC/0.5A SNK BA	Pack of 1	6ES7132-6BF60-0AA0
DQ 4x24VDC/2A ST	Pack of 1	6ES7132-6BD20-0BA0
	Pack of 10	6ES7132-6BD20-2BA0
DQ 4x24..230VAC/2A ST	Pack of 1	6ES7132-6FD00-0BB1
	Pack of 10	6ES7132-6FD00-2BB1
DQ 4x24VDC/2A HF	Pack of 1	6ES7132-6BD20-0CA0
DQ 4x24VDC/2A HS	Pack of 1	6ES7132-6BD20-0DA0
RQ 4x24VUC/2A CO ST	Pack of 1	6ES7132-6GD50-0BA0
RQ 4x120VDC-230VAC/5A NO ST	Pack of 1	6ES7132-6HD00-0BB1
	Pack of 10	6ES7132-6HD00-2BB1
RQ 4x120VDC-230VAC/5A NO MA ST	Pack of 1	6ES7132-6MD00-0BB1

Analog I/O modules	Number in pack	Article number
AI 8xU BA	Pack of 1	6ES7134-6FF00-0AA1
AI 2xU ST	Pack of 1	6ES7134-6FB00-0BA1
AI 4xU/I 2-wire ST	Pack of 1	6ES7134-6HD00-0BA1
	Pack of 10	6ES7134-6HD00-2BA1
AI 2xU/I 2-/4-wire HF	Pack of 1	6ES7134-6HB00-0CA1
AI 2xU/I 2-/4-wire HS	Pack of 1	6ES7134-6HB00-0DA1
AI 8xI 2-/4-wire BA	Pack of 1	6ES7134-6GF00-0AA1
AI 2xI 2-/4-wire ST	Pack of 1	6ES7134-6GB00-0BA1
AI 4xI 2-/4-wire ST	Pack of 1	6ES7134-6GD00-0BA1
AI 8xRTD/TC 2-wire HF	Pack of 1	6ES7134-6JF00-0CA1
	Pack of 10	6ES7134-6JF00-2CA1
AI 4xRTD/TC 2-/3-/4-wire HF	Pack of 1	6ES7134-6JD00-0CA1
	Pack of 10	6ES7134-6JD00-2CA1
AI 4xI 2-wire 4...20mA HART	Pack of 1	6ES7134-6TD00-0CA1
AQ 2xU ST	Pack of 1	6ES7135-6FB00-0BA1
AQ 2xI ST	Pack of 1	6ES7135-6GB00-0BA1
AQ 4xU/I ST	Pack of 1	6ES7135-6HD00-0BA1
AQ 2xU/I HF	Pack of 1	6ES7135-6HB00-0CA1
AQ 2xU/I HS	Pack of 1	6ES7135-6HB00-0DA1
AI Energy Meter 400VAC ST	Pack of 1	6ES7134-6PA01-0BD0
AI Energy Meter 480VAC ST	Pack of 1	6ES7134-6PA20-0BD0

Fail-safe modules	Number in pack	Article number
F-PM-E 24VDC/8A PPM ST	Pack of 1	6ES7136-6PA00-0BC0
F-DI 8x24VDC HF	Pack of 1	6ES7136-6BA00-0CA0
F-DQ 4x24VDC/2A PM HF	Pack of 1	6ES7136-6DB00-0CA0
F-RQ 1x24VDC/24..230VAC/5A	Pack of 1	6ES7136-6RA00-0BF0

Communication modules	Number in pack	Article number
CM 4xIO-Link	Pack of 1	6ES7137-6BD00-0BA0
CM AS-i Master ST	Pack of 1	3RK7137-6SA00-0BC1
F-CM AS-i Safety ST	Pack of 1	3RK7136-6SC00-0BC1
CM PtP	Pack of 1	6ES7137-6AA00-0BA0
CM DP (for CPU)	Pack of 1	6ES7545-5DA00-0AB0

Technology module	Number in pack	Article number
TM Count 1x24V	Pack of 1	6ES7138-6AA00-0BA0
TM PosInput 1	Pack of 1	6ES7138-6BA00-0BA0
TM Timer DIDQ 10x24V	Pack of 1	6ES7138-6CG00-0BA0
TM Pulse 2x24V	Pack of 1	6ES7138-6DB00-0BB1
SIWAREX WP321	Pack of 1	7MH4138-6AA00-0BA0

1.6 Motor starters

Motor starters

Direct starter	Packaging unit	Article number
DS 0.3 - 1 A HF	Pack of 1	3RK1308-0AB00-0CP0
DS 0.9 - 3 A HF	Pack of 1	3RK1308-0AC00-0CP0
DS 2.8 - 9 A HF	Pack of 1	3RK1308-0AD00-0CP0
DS 4.0 - 12 A HF	Pack of 1	3RK1308-0AE00-0CP0

Reversing starter	Packaging unit	Article number
RS 0.3 - 1 A HF	Pack of 1	3RK1308-0BB00-0CP0
RS 0.9 - 3 A HF	Pack of 1	3RK1308-0BC00-0CP0
RS 2.8 - 9 A HF	Pack of 1	3RK1308-0BD00-0CP0
RS 4.0 - 12 A HF	Pack of 1	3RK1308-0BE00-0CP0

Failsafe direct starter	Number in pack	Article number
F-DS 0.3 - 1 A HF	Pack of 1	3RK1308-0CB00-0CP0
F-DS 0.9 - 3 A HF	Pack of 1	3RK1308-0CC00-0CP0
F-DS 2.8 - 9 A HF	Pack of 1	3RK1308-0CD00-0CP0
F-DS 4.0 - 12 A HF	Pack of 1	3RK1308-0CE00-0CP0

Fail-safe reversing starter	Number in pack	Article number
F-RS 0.3 - 1 A HF	Pack of 1	3RK1308-0DB00-0CP0
F-RS 0.9 - 3 A HF	Pack of 1	3RK1308-0DC00-0CP0
F-RS 2.8 - 9 A HF	Pack of 1	3RK1308-0DD00-0CP0
F-RS 4.0 - 12 A HF	Pack of 1	3RK1308-0DE00-0CP0

1.7 Accessories

Accessories

General accessories	Packaging unit	Article number
BusAdapter		
• BA 2×RJ45 (PROFINET BusAdapter with standard Ethernet socket)	Pack of 1	6ES7193-6AR00-0AA0
• BA 2×FC (PROFINET BusAdapter with FastConnect Ethernet connection)	Pack of 1	6ES7193-6AF00-0AA0
• BA 2xSCRJ (PROFINET BusAdapter with POF/PCF fiber-optic cable connection)	Pack of 1	6ES7193-6AP00-0AA0
• BA SCRJ/RJ45 (media converter, PROFINET BusAdapter with fiber-optic cable FOC ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AP20-0AA0
• BA SCRJ/FC (media converter, PROFINET BusAdapter with fiber-optic cable FOC ⇔ direct connection of bus cable)	Pack of 1	6ES7193-6AP40-0AA0
• BA 2xLC (PROFINET BusAdapter with glass fiber-optic cable connection)	Pack of 1	6ES7193-6AG00-0AA0
• BA LC/RJ45 (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AG20-0AA0
• BA LC/FC (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ direct connection of bus cable)	Pack of 1	6ES7193-6AG40-0AA0
PROFIBUS FastConnect bus connector	Pack of 1	6ES7972-0BB70-0XA0
Server module (spare part)	Pack of 1	6ES7193-6PA00-0AA0
BU cover		
• 15 mm wide	Pack of 5	6ES7133-6CV15-1AM0
• 20 mm wide	Pack of 5	6ES7133-6CV20-1AM0
Shield connector for BaseUnit (shield contacts and shield terminals)	Pack of 5	6ES7193-6SC00-1AM0
Reference identification label, sheet with 16 labels	Pack of 10	6ES7193-6LF30-0AW0
Labeling strips (for labeling the I/O modules)		
• Roll, light gray (with a total of 500 labeling strips)	Pack of 1	6ES7193-6LR10-0AA0
• Roll, yellow (with a total of 500 labeling strips)	Pack of 1	6ES7193-6LR10-0AG0
• DIN A4 sheets, light gray (with a total of 1000 labeling strips)	Pack of 10	6ES7193-6LA10-0AA0
• DIN A4 sheets, yellow (with a total of 1000 labeling strips)	Pack of 10	6ES7193-6LA10-0AG0
Mounting rails, tin-plated steel strip		
• Length: 483 mm	Pack of 1	6ES5710-8MA11
• Length: 530 mm	Pack of 1	6ES5710-8MA21
• Length: 830 mm	Pack of 1	6ES5710-8MA31
• Length: 2000 mm	Pack of 1	6ES5710-8MA41

Accessories color-coded labels (push-in terminals), 15 mm wide	**Packaging unit**		**Article number**
16 process terminals (see manual for I/O module)			
• Gray (terminals 1 to 16); color code CC00	Pack of 10		6ES7193-6CP00-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	Pack of 10		6ES7193-6CP01-2MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	Pack of 10		6ES7193-6CP02-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), gray (terminals 13 to 16); color code CC03	Pack of 10		6ES7193-6CP03-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), blue (terminals 13 to 16); color code CC04	Pack of 10		6ES7193-6CP04-2MA0
• Gray (terminals 1 to 12), red (terminals 13 and 14), blue (terminals 15 and 16); color code CC05	Pack of 10		6ES7193-6CP05-2MA0
10 AUX terminals (for BU15-P16+**A10**+2D, BU15-P16+**A10**+2B)			
• Yellow-green (terminals 1A to 10A); color code CC71	Pack of 10		6ES7193-6CP71-2AA0
• Red (terminals 1A to 10A); color code CC72	Pack of 10		6ES7193-6CP72-2AA0
• Blue (terminals 1A to 10A); color code CC73	Pack of 10		6ES7193-6CP73-2AA0
10 add-on terminals (for BU15-P16+A0+**12**D/T, BU15-P16+A0+**12**B/T)			
• Red (terminals 1B to 5B), blue (terminals 1C to 5C); color code CC74	Pack of 10		6ES7193-6CP74-2AA0

Accessories color-coded labels (push-in terminals), 20 mm wide	**Packaging unit**		**Article number**
12 process terminals (see manual for I/O module)			
• Gray (terminals 1 to 4), red (terminals 5 to 8), blue (terminals 9 to 12); color code CC41	Pack of 10		6ES7193-6CP41-2MB0
• Gray (terminals 1 to 8), red (terminals 9 and 10), blue (terminals 11 and 12), color code CC42	Pack of 10		6ES7193-6CP42-2MB0
6 process terminals (see manual for I/O module)			
• Gray (terminals 1 to 4), red (terminal 5), blue (terminal 6); color code CC51	Pack of 10		6ES7193-6CP51-2MC0
• Gray (terminals 1, 2 and 5), red (terminals 3 and 4), blue (terminal 6); color code CC52	Pack of 10		6ES7193-6CP52-2MC0
4 AUX terminals (for BU20-P12+**A4**+0B)			
• Yellow-green (terminals 1A to 4A); color code CC81	Pack of 10		6ES7193-6CP81-2AB0
• Red (terminals 1A to 4A); color code CC82	Pack of 10		6ES7193-6CP82-2AB0
• Blue (terminals 1A to 4A); color code CC83	Pack of 10		6ES7193-6CP83-2AB0
2 AUX terminals (for BU20-P6+**A2**+4D, BU20-P6+**A2**+4B)			
• Yellow-green (terminals 1A and 2A); color code CC84	Pack of 10		6ES7193-6CP84-2AC0
• Red (terminals 1A and 2A); color code CC85	Pack of 10		6ES7193-6CP85-2AC0
• Blue (terminals 1A and 2A); color code CC86	Pack of 10		6ES7193-6CP86-2AC0

Accessories for motor starter	**Packaging unit**	**Article number**
3DI / LC module	Pack of 1	3RK1908-1AA00-0BP0
Fan	Pack of 1	3RW4928-8VB00
Additional mechanical bracket for BaseUnit	Pack of 1	3RK1908-1EA00-1BP0
Cover for an empty BaseUnit	Pack of 1	3RK1908-1CA00-0BP0
Touch protection cover for infeed bus	Pack of 1	3RK1908-1DA00-2BP0

Supplements to ET 200SP documentation 2

2.1 System manual

System manual ET 200SP Distributed I/O system, Edition 12/2016

Section 2.3 How are SIMATIC Safety F-systems configured with ET 200SP?

Correction in the section Hardware and software requirements:

The interface module IM 155-6PN BA does not support Profisafe communication.

Section 5.6 Wiring rules

Supplement in the table: Wiring rules for the CPU / interface module and BaseUnits for I/O modules

- Permitted cable cross-sections of solid cables (Cu)
- Permitted cable cross-sections of flexible cables (Cu)

2.2 CPU manuals

Manual CPU 1512SP-1 PN, Edition 09/2016

Section 4.1 Status and error display of the CPU

MT1/MT2 LEDs on BusAdapter BA 2xSCRJ, BA SCRJ/RJ45, BA SCRJ/FC

Table 2- 1 Status and error displays of MT1/MT2 LEDs

LED MT1/MT2*	Meaning	Solution
□ Off	No error	---
■ On	• Fiber-optic error • Maintenance demanded: Attenuation through the fiber-optic cable is so high that operation will soon no longer be possible.	Causes and measures for the transmission route: • Replacement of fiber-optic cable if damaged or aged • Correct installation of the PROFINET connector/PROFINET connections • Adherence to maximum length of 50 m for POF cable or 100 m for PCF cable • Secure fit of the FOC connector.

* Only available on BusAdapter BA 2xSCRJ

Section 6 Technical specifications

Technical specifications of the BusAdapters BA 2×SCRJ, BA SCRJ/RJ45, BA SCRJ/FC

The maximum length of the PCF-GI fiber-optic cable is 250 m.

2.3 Interface module manuals

Configuration notes on interface modules depending on the I/O modules

Module		IM 155-6 PN BA	IM 155-6 PN ST				IM 155-6 PN HF						IM 155-6 PN HS	IM 155-DP HF			
	Firmware version	V3.2	V1.0	V1.1	V3.1	V3.3	V2.0	V2.1	V2.2	V3.0	V3.1	V3.3	V4.0	V1.0	V1.1	V3.0	V3.1
AI 2xI 2-/4-wire ST	V1.0	✓	---	---	✓	✓	---	---	---	✓	✓	✓	✓	---	---	✓	✓
AI 2xU ST	V1.0	✓	---	---	✓	✓	---	---	---	✓	✓	✓	✓	---	---	✓	✓
AI 2xU/I 2-/4-wire HF	V2.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AI 8xI 2-/4-wire BA	V1.0	✓	---	✓	✓	✓	---	---	✓	✓	✓	✓	✓	---	✓	✓	✓
AI 8xU BA	V1.0	✓	---	✓	✓	✓	---	---	✓	✓	✓	✓	✓	---	✓	✓	✓
AI Energy Meter 400VAC ST	V3.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AI Energy Meter 480VAC ST	V4.0	✓	---	---	✓	✓	---	---	---	✓	✓	✓	✓	---	---	✓	✓
AQ 2xI ST	V1.0	✓	---	---	✓	✓	---	---	---	✓	✓	✓	✓	---	---	✓	✓
AQ 2xU ST	V1.0	✓	---	---	✓	✓	---	---	---	✓	✓	✓	✓	---	---	✓	✓
DI 8x24VDC BA	V1.0	✓	---	✓	✓	✓	---	---	✓	✓	✓	✓	✓	---	✓	✓	✓
DI 8x24VDC HS	V1.0	✓	---	✓	✓	✓	---	---	✓	✓	✓	✓	✓	---	✓	✓	✓
DI 8x24VDC HF	V2.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DI 16x24VDC ST	V1.1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DQ 4x24VDC/2A HS	V1.0	✓	---	✓	✓	✓	---	---	✓	✓	✓	✓	✓	---	✓	✓	✓
DQ 4x24VDC/2A HF	V2.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RQ 4x120VDC-230VAC/5A NO MA ST	V1.0	✓	---	---	✓	✓	---	---	---	✓	✓	✓	✓	---	---	✓	✓
DQ 8x24VDC/0.5A HF	V2.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DQ 8x24VDC/0.5A BA	V1.0	✓	---	---	✓	✓	---	---	---	✓	✓	✓	✓	---	---	✓	✓
DQ 16x24VDC/0.5A ST	V1.1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

--- This combination is not permitted in the configuration

IM 155-6 PN ST manual, Edition 12/2015

Section 3.1 Pin assignment

PROFINET interface X1 Port 2:

If autonegotiation is disabled, the RJ-45 socket (X1 Port 2) has the switch assignment (MDI-X).

Response times

The response time of the IM 155-6 PN ST is made up of:

- Backplane bus cycle time and
- Operating system processing

Note

Validity of the formula

The following formula applies to the ET 200SP backplane bus.

The following formula does not apply to the ET-Connection bus.

Backplane bus cycle time

The backplane bus cycle time is the time the interface module requires to output new output data, read new input data and then copy the data to the PROFINET send buffer.

The backplane bus cycle time is the result of the update time configured for the interface module as IO device and is at least 1 ms.

- If the configured update time ≥ 1 ms, the backplane bus cycle time is equal to the configured update time.
- If the configured update time < 1 ms, the backplane bus cycle time is the product of an integer multiple of the configured update time.

Table 2- 2 Example calculation

Configured update time	Backplane bus cycle time (integer multiple, minimum 1 ms)
250 µs	4 x 250 µs = 1000 µs
750 µs	2 x 750 µs = 1500 µs
1000 µs	1000 µs
2000 µs	2000 µs

Operating system processing time

The operating system processing time is calculated based on the following formula:

Operating system processing time output

Operating system processing time_output[µs] = 147 + 3.775 number_m + 0.275 bytes_out

Operating system processing time input

Operating system processing time_input[µs] = 158.3 + 2.325 number_m + 0.325 bytes_in

Explanation of the parameters:

Number_m: Total number of all modules (incl. server module)

Bytes_out: Sum of all output bytes

Bytes_in: Sum of all input bytes

Calculating the response time

Response time output

The response time output of the IM 155-6 PN ST is made up of:

- Backplane bus cycle time and
- Operating system processing time_output.

Response time input

The response time input of the IM 155-6 PN ST is made up of:

- Backplane bus cycle time and
- Operating system processing time_input.

IM 155-6 PN HF manual, Edition 12/2015

Section 3.1 Pin assignment

PROFINET interface X1 Port 2:

If autonegotiation is disabled, the RJ-45 socket (X1 Port 2) has the switch assignment (MDI-X).

Section 5.3.3 Channel diagnostics

Coding of the extended channel diagnostics (as of firmware version V3.3.0)

With the IM 155-6 PN HF interface module, the following extended channel diagnostics are reported:

Slot number	ChannelError-Type (CET)	ExtendedChannel-ErrorType (ECET)	Associated value AddValue	Diagnostics
Module slot	0x0602	0x0691	Slot	Station stop - module parameter "Potential group" faulty or incorrect BaseUnit in actual slot (AddValue)
Slot 0	0x0602	0x0693	0x00	Diagnostics with missing server module
	0x0602	0x0698	0x00	Diagnostics backplane bus too long
	0x0602	0x0699	Slot	Diagnostics with incorrect bus configuration
	0x0602	0x069C	0x00	Diagnostics with incorrectly plugged BusAdapter
Server module slot	0x0610	0x06B0	0x00	Group diagnostics: Missing supply voltage L+ for the potential groups Note: The slot in which the light-colored BaseUnit of the respective load module is located is coded in the "ChannelNumber" element.

Section 6.1 Compatibility of modules

Compatibility of the interface module IM 155-6 PN HF:

For assessing the compatibility of the interface module IM 155-6 PN ST take into account that the interface module IM 155-6 PN HF solely supports the transmission rate of 100 Mbps for Ethernet services.

Section 7 Technical specifications

- Technical specifications of the BusAdapters BA 2×SCRJ, BA SCRJ/RJ45, BA SCRJ/FC: The maximum length of the PCF-GI fiber-optic cable is 250 m.
- Technical specifications of the BusAdapters BA 2xLC, BA LC/RJ45, BA LC/FC: Cable length:
  - Multimode graded index fiber 50/125 µm: 3 km
  - Multimode graded index fiber 62.5/125 µm: 3 km

IM 155-6 PN HS manual, Edition 09/2016

Section 3.1 Pin assignment

PROFINET interface X1 Port 2:

If autonegotiation is disabled, the RJ-45 socket (X1 Port 2) has the switch assignment (MDI-X).

Section 7 Technical specifications

- PROFINET certification of network class 3 is in preparation.
- Technical specifications of the BusAdapters BA 2×SCRJ, BA SCRJ/RJ45, BA SCRJ/FC: The maximum length of the PCF-GI fiber-optic cable is 250 m.

2.4 I/O module manuals

Configuration notes on the I/O modules (supplement to Product overview section in the manual)

I/O module		Order number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Digital input modules	DI 16x24VDC ST	6ES7131-6BH00-0BA0	V1.1.0	HSP0162 V13 SP1 or higher	HSP0229 V6.0
	DI 8x24VDC BA	6ES7131-6BF00-0AA0	V1.0.0	HSP0126	HSP0229 V5.0
	DI 8x24VDC ST	6ES7131-6BF00-0BA0	V1.1.0	V13 Update 3	HSP0229 V4.0
	DI 8x24VDC HF	6ES7131-6BF00-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0229 V6.0
	DI 8x24VDC HS	6ES7131-6BF00-0DA0	V1.0.2	Integrated as of V14	HSP0229 V5.0
Digital output modules	DQ 8x24VDC/0.5A BA	6ES7132-6BF00-0AA1	V1.0.0	HSP0162 V13 SP1 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	V1.1.0	V13 Update 3	HSP0230 V4.0
	DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	V1.1.0	V13 Update 3	HSP0230 V4.0
	DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	V1.1.0	HSP0162 V13 SP1 or higher	HSP0230 V6.0
	DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A HS	6ES7132-6BD20-0DA0	V1.0.2	Integrated as of V14	HSP0230 V5.0
	RQ 4x120VDC-230VAC/5A NO ST	6ES7132-6HD00-0BB1	V1.0.0	HSP0128	HSP0232 V5.0
	RQ 4x120VDC-230VAC/5A NO MA ST	6ES7132-6MD00-0BB1	V1.0.0	HSP0162 V13 SP1 or higher	HSP0232 V6.0

I/O module		Order number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Analog input modules	AI 8xU BA	6ES7134-6FF00-0AA1	V1.0.0	HSP0126	HSP0227 V5.0
	AI 2xU ST	6ES7134-6FB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0227 V6.0
	AI 8xI 2-/4-wire BA	6ES7134-6GF000AA1	V1.0.0	HSP0126	HSP0227 V5.0
	AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	V1.1.0	V13 Update 3	HSP0227 V4.0
	AI 2xI 2-/4-wire ST	6ES7134-6GB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0227 V6.0
	AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	V1.1.0	V13 Update 3	HSP0227 V4.0
	AI 2xU/I 2-/4-wire HF	6ES7134-6HB00-0CA1	V2.0.0	HSP0161 V13 SP1 or higher	HSP0227 V6.0 V5.5 SP4 HF7 or higher
	AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	V2.0.1	Integrated as of V14	HSP0227 V5.0
	AI Energy Meter 400VAC ST	6ES7134-6PA01-0BD0	V3.0.0	V13 SP1 Update 4 HSP0159	HSP0227 V6.0
	AI Energy Meter 480VAC ST	6ES7134-6PA20-0BD0	V4.0.0	V13 SP1 Update 4 HSP0159	HSP0227 V6.0 V5.5 SP4 HF7 or higher
Analog output modules	AQ 2xU ST	6ES7135-6FB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0228 V6.0
	AQ 2xI ST	6ES7135-6GB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0228 V6.0
	AQ 4xU/I ST	6ES7135-6HD00-0BA1	V1.1.0	V13 Update 3	HSP0228 V4.0
	AQ 2xU/I HS	6ES7135-6HB00-0DA1	V2.0.1	Integrated as of V14	HSP0228 V5.0

2.4.1 Digital module device manuals

Manuals for I/O modules ST, BA

When you have deactivated all channels of the I/O module, a diagnostics alarm is still generated in the case of a fault if the "Missing supply voltage L+" diagnostics is enabled. For the following I/O modules, this behavior is corrected as of firmware version > V1.1.0:

- DI 16x24VDC ST
- DI 8x24VDC ST
- DQ 16x24VDC/0.5A ST
- DQ 8x24VDC/0.5 A ST
- DQ 4x24VDC/0.5A ST

Manuals for digital input modules with wire-break detection

When wire-break detection is configured the module requires a low quiescent current at the digital input in case of "0" signal for the monitoring. The parallel connection of a resistor with 25 kΩ to 45 kΩ is required in order that this quiescent current can flow when encoder contacts are open.

If wire-break detection is disabled in the configuration, no parallel connection of the resistor is required.

If wire-break detection is configured, connect a resistor with 25 kΩ to 45 kΩ parallel to each mechanical encoder contact.

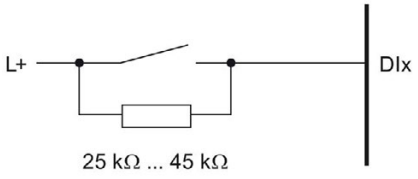


Figure 2-1 Connect mechanical encoder contact with resistor

Manuals DI 4x120...230VAC ST, Edition 02/2014; DQ 4x24...230VAC/2A ST, Edition 02/2014

Section 4.3 Address space

If you have enabled value status, the module returns value status 1, regardless of the state of the connected supply voltage.

Manual DI 8x24VDC HF, Edition 02/2014

Section 6.1 Technical specifications

- 24 V encoder supply
  - Output current, max.: 700 mA, total current

Manual DI 8xNAMUR HF, Edition 02/2014

Section A.2 Parameter assignment and structure of parameter data record

With data records 0 to 7, you can configure individual channels.

When the interface module IM 155-6 DP HF (PROFIBUS DP) is used and data records 0 and 1 are read, the module returns the diagnostics data records and not the parameter data records of the DI 8xNAMUR HF.

DQ 4x24VDC/2A HS manual, Edition 09/2016

Section 6.1 Technical specifications

For this module, the marine approval for the bridge and deck zone is valid from a bus cycle time of at least 250 µs.

Manual DQ 4x24..230VAC/2A ST digital output module, Edition 03/2015

Section 3.1 Pin assignment; Supply voltage fuse protection

The module has neither short-circuit protection nor overload protection. Protect the module from being destroyed by impermissible high current and install a fine fuse in the supply line. The maximum rated current of the fine fuse depends on the hardware function status (FS) of the module.

HW functional status of the module	Max. rated current of fuse	Tripping characteristic
FS ≤ 3	8 A	Quick response
FS ≥ 4	10 A	Quick response

Section 6.1 Technical specifications, Switching frequency with inductive load

The switching frequency of the outputs with inductive loads is max. 0.5 Hz.

Higher switching frequency is possible in spite of this, and depends on the alternating voltage and switched inductors or the power factor of the electric motor used.

Alternating voltage	Condition	Max. switching frequency
200 VAC or lower	---	10 Hz
200 VAC or higher	• Power factor of the electric motor cos φ > 0.35 • Electric motor must only be turned off after startup (no jogging mode). Electric motors which are turned off during startup could create inductive shutoff voltages > 600 V , which could destroy the output electronics (Triac).	10 Hz

DQ 8x24VDC/0.5A ST manual, Edition 07/2014

Section 4.2 Explanation of the parameters (as of functional version FS-05 of DQ 8x24VDC/0.5A ST)

Diagnostics: Wire break:
The module responds to a wire break as follows:

- Disabled:
  - Channel status LED lit green
  - Output voltage present at channel
- Enabled:
  - Channel status LED is off
  - Output is switched off
  - In addition, the wire break diagnostics is signaled and the DIAG LED on the module flashes red

Note

If one of the two parameters "Diagnostics: Short-circuit to L+" or "Diagnostics: Wire break" is enabled and one of these diagnostics occurs, the affected channel is switched off. This prevents undefined load switching and supports detection of a faulty channel for module diagnostics.

RQ 4x24VUC/2A CO ST manual, Edition 02/2014

Section 4.3 Address space

Configuration options for the RQ 4x24VUC/2A CO ST digital output module:

The following configurations are possible:

- Configuration 1: without value status
- Configuration 2: with value status

Evaluating the value status:

An additional byte is allocated in the input address space if you enable the value status for the digital module. Each bit in this byte is assigned to a channel and returns information on the validity of the digital value (0 = incorrect value).

Address space for the RQ 4x24VUC/2A CO ST digital output module:

The following figure shows the assignment of the address space for the RQ 4x24VUC/2A CO ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

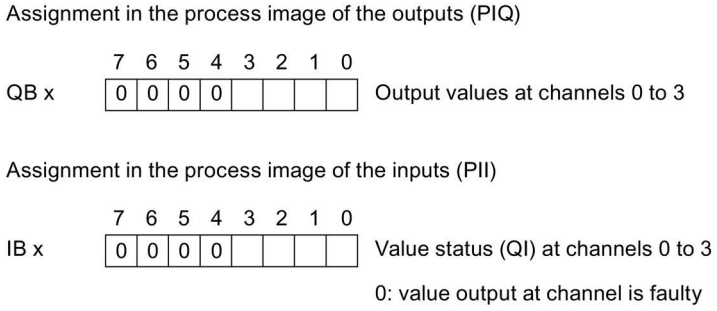


Figure 2-2 Address space for the RQ 4x24VUC/2A CO ST digital output module

Section 6.1 Technical specifications

Correction / additions to the technical specifications:

- Switching capacity of the contacts (DC)
  - Rated switching voltage (DC): 24 V
  - With resistive load, max.: 2 A
  - Thermal continuous current, max.: 2 A
- Switching capacity of the contacts (AC)
  - Rated switching voltage (AC): 24 V
  - With resistive load, max.: 0.5 A
  - Thermal continuous current, max.: 0.5 A

RQ 4x120VDC-230VAC/5A NO ST manual, Edition 03/2015 and RQ 4x120VDC-230VAC/5A NO MA ST manual, Edition 12/2015

Section 3.1 Wiring and block diagram

The AUX terminals of the self-assembling voltage bus can be used for the connection of the protective conductor (PE) or for voltages up to a maximum of 24 V DC.

2.4.2 Analog module device manuals

Manuals for analog input modules

Manual	Edition
AI 8xI 2-/4-wire BA	03/2015
AI 8xU BA	03/2015
AI 2xI 2-/4-wire ST	12/2015
AI 2xU ST	12/2015
AI 4xI 2-/4-wire ST	07/2014
AI 4xU/I 2-wire ST	07/2014
AI 4xI 2-wire 4..20mA HART	11/2014
AI 2xU/I 2-/4-wire HF	12/2015
AI 4xRTD/TC 2-/3-/4-wire HF	02/2014
AI 8xRTD/TC 2-wire HF	02/2014

Section 5.2 Parameters

Note

Please note that the settings in the "Interference frequency suppression" parameter have a direct effect on the cycle time of the module. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

Manuals AI 4xRTD/TC 2-/3-/4-wire HF, Edition 02/2014; AI 8xRTD/TC 2-wire HF, Edition 02/2014

Section 3 Wiring

Note

When potential-free sensors are used, the M- inputs can be bridged and connected to ground/FE. This is not necessary for disabled inputs.

Section 4.1 Measurement types and measuring ranges, figure 4-1, Assignment in the process image input (PII)

Assignment in the process image input (PII) with SIMATIC S7

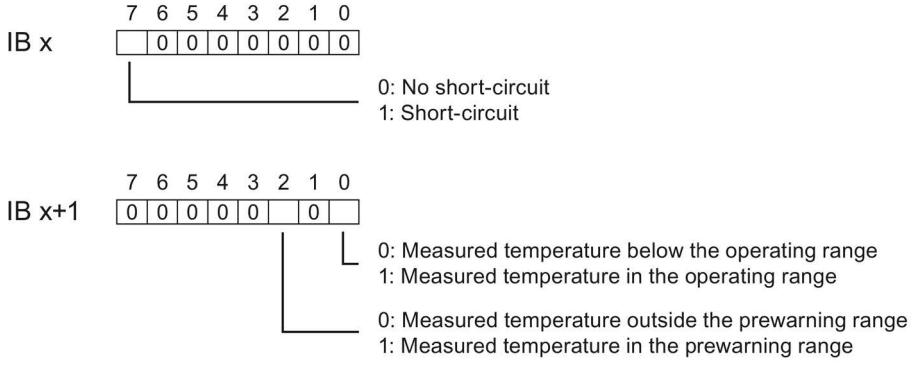


Figure 2-3 Assignment in the process image input (PII)

Manuals AI 4xRTD/TC 2-/3-/4-wire HF, Edition 02/2014; AI 8xRTD/TC 2-wire HF, Edition 02/2014; AQ 2xU/I HF, Edition 02/2014

Note

The "Channel temporarily not available" diagnostics is reported on a change to user calibration.

Other diagnostics alarms cannot be used to detect a change to user calibration.

Manuals AI 2xU/I 2-/4-wire HF, Edition 12/2015; AI Energy Meter 480VAC ST, Edition 12/2015

For configuration with STEP 7 V13 or higher (TIA Portal), real values between $-7x10^{28}$ and $+7x10^{28}$ can be input. This is true for configuration via HSP and via GSD file (PROFINET).

For configuration with STEP 7 V5.5 SP4 as of HF7, configuration by means of GSD file (PROFINET) with REAL values of $-1.175x10^{38}$ to $+3.402x10^{38}$ is possible.

With STEP 7 SP4 to HF6, parameter assignment of REAL values is not possible. Functions that require REAL values are not available in this case.

Manuals AI Energy Meter 400VAC ST, Edition 12/2015; AI Energy Meter 480VAC ST, Edition 12/2015

Requirements for the operation of the AI Energy Meter on slot 1 of the ET 200SP:

Interface module / CPU	AI Energy Meter 400VAC ST (6ES7134-6PA01-0BD0)	AI Energy Meter 480VAC ST (6ES7134-6PA20-0BD0)
IM 155-6 PN BA (6ES7155-6AR00-0AN0)	Can be operated on slot 1 for all IM 155-6 PN BA	
IM 155-6 PN ST (6ES7155-6AU00-0BN0)	Can be operated on slot 1 for IM 155-6 PN ST from firmware version V3.1 and higher and functional status FS 07	
IM 155-6 PN HF (6ES7155-6AU00-0CN0)	Can be operated on slot 1 for IM 155-6 PN HF from firmware version V3.0 and higher and functional status FS 05	
IM 155-6 DP HF (6ES7 155-6BU00-0CN0)	Can be operated on slot 1 for IM 155-6 DP HF from firmware version V3.0 and higher	
CPU 1510SP-1 PN, CPU 1512SP-1 PN, CPU 1515SP PC	Can be operated on slot 1 for all CPUs	

Manual AI Energy Meter 480VAC ST, Edition 12/2015

Section 9 Limit monitoring

You cannot use the following measured variables for limit monitoring:

Measured value ID	Measured variables
61180	Active energy inflow L1
61181	Active energy outflow L1
61182	Reactive energy inflow L1
61183	Reactive energy outflow L1
61184	Apparent energy L1
61185	Active energy L1
61186	Reactive energy L1
61200	Active energy inflow L2
61201	Active energy outflow L2
61202	Reactive energy inflow L2
61203	Reactive energy outflow L2
61204	Apparent energy L2
61205	Active energy L2
61206	Reactive energy L2
61220	Active energy inflow L3
61221	Active energy outflow L3
61222	Reactive energy inflow L3
61223	Reactive energy outflow L3
61224	Apparent energy L3
61225	Active energy L3
61226	Reactive energy L3

If you set these IDs in the configuration of the limit monitoring (TIA Portal, STEP 7, GSD), the module reports a parameter assignment error.

Section B Measured variables

The following tables show which measured variables are available for limit monitoring or user data mapping:

Measured value ID	Measured variables	Use for	
		Limit monitoring	User data mapping
1	Voltage UL1-N	Yes	Yes
2	Voltage UL2-N	Yes	Yes
3	Voltage UL3-N	Yes	Yes
4	Voltage UL1- L2	Yes	Yes
5	Voltage UL2- L3	Yes	Yes
6	Voltage UL3- L1	Yes	Yes
7	Current L1	Yes	Yes
8	Current L2	Yes	Yes
9	Current L3	Yes	Yes
10	Apparent power L1	Yes	Yes
11	Apparent power L2	Yes	Yes
12	Apparent power L3	Yes	Yes
13	Active power L1	Yes	Yes
14	Active power L2	Yes	Yes
15	Active power L3	Yes	Yes
16	Reactive power L1	Yes	Yes
17	Reactive power L2	Yes	Yes
18	Reactive power L3	Yes	Yes
19	Power factor L1	Yes	Yes
20	Power factor L2	Yes	Yes
21	Power factor L3	Yes	Yes
30	Frequency	Yes	Yes
34	Total active power L1L2L3	Yes	Yes
35	Total reactive power L1L2L3	Yes	Yes
36	Total apparent power L1L2L3	Yes	Yes
37	Total power factor L1L2L3	Yes	Yes
38	Amplitude unbalance for voltage	Yes	Yes
39	Amplitude unbalance for current	Yes	Yes
40	Max. voltage UL1-N	Yes	Yes
41	Max. voltage UL2-N	Yes	Yes
42	Max. voltage UL3-N	Yes	Yes
43	Max. voltage UL1- L2	Yes	Yes
44	Max. voltage UL2- L3	Yes	Yes
45	Max. voltage UL3- L1	Yes	Yes
46	Max. current L1	Yes	Yes
47	Max. current L2	Yes	Yes
48	Max. current L3	Yes	Yes
49	Max. apparent power L1	Yes	Yes
50	Max. apparent power L2	Yes	Yes

Measured value ID	Measured variables	Use for	
		Limit monitoring	User data mapping
51	Max. apparent power L3	Yes	Yes
52	Max. active power L1	Yes	Yes
53	Max. active power L2	Yes	Yes
54	Max. active power L3	Yes	Yes
55	Max. reactive power L1	Yes	Yes
56	Max. reactive power L2	Yes	Yes
57	Max. reactive power L3	Yes	Yes
58	Max. power factor L1	Yes	Yes
59	Max. power factor L2	Yes	Yes
60	Max. power factor L3	Yes	Yes
61	Max. frequency	Yes	Yes
65	Max. total active power	Yes	Yes
66	Max. total reactive power	Yes	Yes
67	Max. total apparent power	Yes	Yes
68	Max. total power factor	Yes	Yes
70	Min. voltage UL1-N	Yes	Yes
71	Min. voltage UL2-N	Yes	Yes
72	Min. voltage UL3-N	Yes	Yes
73	Min. voltage UL1- L2	Yes	Yes
74	Min. voltage UL2- L3	Yes	Yes
75	Min. voltage UL3- L1	Yes	Yes
76	Min. current L1	Yes	Yes
77	Min. current L2	Yes	Yes
78	Min. current L3	Yes	Yes
79	Min. apparent power L1	Yes	Yes
80	Min. apparent power L2	Yes	Yes
81	Min. apparent power L3	Yes	Yes
82	Min. active power L1	Yes	Yes
83	Min. active power L2	Yes	Yes
84	Min. active power L3	Yes	Yes
85	Min. reactive power L1	Yes	Yes
86	Min. reactive power L2	Yes	Yes
87	Min. reactive power L3	Yes	Yes
88	Min. power factor L1	Yes	Yes
89	Min. power factor L2	Yes	Yes
90	Min. power factor L3	Yes	Yes
91	Min. frequency	Yes	Yes
95	Min. total active power	Yes	Yes
96	Min. total reactive power	Yes	Yes
97	Min. total apparent power	Yes	Yes
98	Min. total power factor	Yes	Yes
200	Total active energy inflow L1L2L3	Yes	Yes
201	Total active energy outflow L1L2L3	Yes	Yes
202	Total reactive energy inflow L1L2L3	Yes	Yes
203	Total reactive energy outflow L1L2L3	Yes	Yes

Measured value ID	Measured variables	Use for	
		Limit monitoring	User data mapping
204	Total apparent energy L1L2L3	Yes	Yes
205	Total active energy L1L2L3	Yes	Yes
206	Total reactive energy L1L2L3	Yes	Yes
210	Total active energy inflow L1L2L3	-	Yes
211	Total active energy outflow L1L2L3	-	Yes
212	Total reactive energy inflow L1L2L3	-	Yes
213	Total reactive energy outflow L1L2L3	-	Yes
214	Total apparent energy L1L2L3	-	Yes
215	Total active energy L1L2L3	-	Yes
216	Total reactive energy L1L2L3	-	Yes
61149	Neutral conductor current	Yes	Yes
61178	Phase angle L1	Yes	Yes
61180	Active energy inflow L1	-	Yes
61181	Active energy outflow L1	-	Yes
61182	Reactive energy inflow L1	-	Yes
61183	Reactive energy outflow L1	-	Yes
61184	Apparent energy L1	-	Yes
61185	Active energy L1	-	Yes
61186	Reactive energy L1	-	Yes
61190	Overflow counter active energy inflow L1	-	Yes
61191	Overflow counter active energy outflow L1	-	Yes
61192	Overflow counter reactive energy inflow L1	-	Yes
61193	Overflow counter reactive energy outflow L1	-	Yes
61194	Overflow counter apparent energy L1	-	Yes
61198	Phase angle L2	Yes	Yes
61200	Active energy inflow L2	-	Yes
61201	Active energy outflow L2	-	Yes
61202	Reactive energy inflow L2	-	Yes
61203	Reactive energy outflow L2	-	Yes
61204	Apparent energy L2	-	Yes
61205	Active energy L2	-	Yes
61206	Reactive energy L2	-	Yes
61210	Overflow counter active energy inflow L2	-	Yes
61211	Overflow counter active energy outflow L2	-	Yes
61212	Overflow counter reactive energy inflow L2	-	Yes
61213	Overflow counter reactive energy outflow L2	-	Yes
61214	Overflow counter apparent energy L2	-	Yes
61218	Phase angle L3	Yes	Yes
61220	Active energy inflow L3	-	Yes
61221	Active energy outflow L3	-	Yes
61222	Reactive energy inflow L3	-	Yes
61223	Reactive energy outflow L3	-	Yes
61224	Apparent energy L3	-	Yes
61225	Active energy L3	-	Yes
61226	Reactive energy L3	-	Yes

Measured value ID	Measured variables	Use for	
		Limit monitoring	User data mapping
61230	Overflow counter active energy inflow L3	-	Yes
61231	Overflow counter active energy outflow L3	-	Yes
61232	Overflow counter reactive energy inflow L3	-	Yes
61233	Overflow counter reactive energy outflow L3	-	Yes
61234	Overflow counter apparent energy L3	-	Yes
65500	Qualifier L1	-	Yes
65501	Qualifier L2	-	Yes
65502	Qualifier L3	-	Yes
65503	Qualifier L1L2L3	-	Yes
65504	Cumulative operating hours counters L1L2L3	Yes	Yes
65505	Operating hours counter L1	Yes	Yes
65506	Operating hours counter L2	Yes	Yes
65507	Operating hours counter L3	Yes	Yes
65510	Counter limit violation GW1	Yes	Yes
65511	Counter limit violation GW2	Yes	Yes
65512	Counter limit violation GW3	Yes	Yes
65513	Counter limit violation GW4	Yes	Yes
65514	Counter limit violation GW5	Yes	Yes
65515	Counter limit violation GW6	Yes	Yes
65516	Counter limit violation GW7	Yes	Yes
65517	Counter limit violation GW8	Yes	Yes
65518	Counter limit violation GW9	Yes	Yes
65519	Counter limit violation GW10	Yes	Yes
65520	Counter limit violation GW11	Yes	Yes
65521	Counter limit violation GW12	Yes	Yes
65522	Counter limit violation GW13	Yes	Yes
65523	Counter limit violation GW14	Yes	Yes
65524	Counter limit violation GW15	Yes	Yes
65525	Counter limit violation GW16	Yes	Yes

In the manual for Energy Meter 480VAC ST, Edition 12/2015

In the device manual for Energy Meter 480VAC ST, the measured value ID and the associated measured variables for the complete performance are reversed. The correct association is shown in the table below:

Measured value ID	Measured variables	Unit
34	Total active power L1L2L3	W
35	Total reactive power L1L2L3	var
36	Total apparent power L1L2L3	VA
65	Max. total active power	W
66	Max. total reactive power	var
67	Max. total apparent power	VA
95	Min. total active power	W
96	Min. total reactive power	var
97	Min. total apparent power	VA

If you use the user-data mapping via data record DS 130, please note that the texts for the measured variables are also displayed incorrectly during configuration.

During configuration of the measured variables for the total active, reactive, and apparent power, select the following texts:

Desired measured variable for the user-data mapping	Text to select during configuration
Total active power L1L2L3	Total apparent power L1L2L3 (ID00034)
Total reactive power L1L2L3	Total active power L1L2L3 (ID00035)
Total apparent power L1L2L3	Total reactive power L1L2L3 (ID00036)
Max. total active power	Max. total apparent power (ID00065)
Max. total reactive power	Max. total active power (ID00066)
Max. total apparent power	Max. total reactive power (ID00067)
Min. total active power	Min. total apparent power (ID00095)
Min. total reactive power	Min. total active power (ID00096)
Min. total apparent power	Min. total reactive power (ID00097)

The incorrect texts appear during use of the following tools and GSD files:

- STEP 7 (TIA Portal) V13 SP1
- STEP 7 (TIA Portal) V5.5 SP4
- GSD file GSDML-V2.31-ET200SP-20151126

This error will be corrected in the next versions of the tools and GSD files.

In the manual for Energy Meter 480VAC ST, Edition 12/2015

Section 6.2 Quality information

With phase-specific measurement with user data variants 154 to 159, the allocation of the quality information in byte 1 of the user data for current and voltage measurement and operating quadrant is identical for all three phases; see following figure.

If you switch between the user data variants for phase-specific measurements, you can therefore keep the evaluation of the quality information unchanged in your user program.

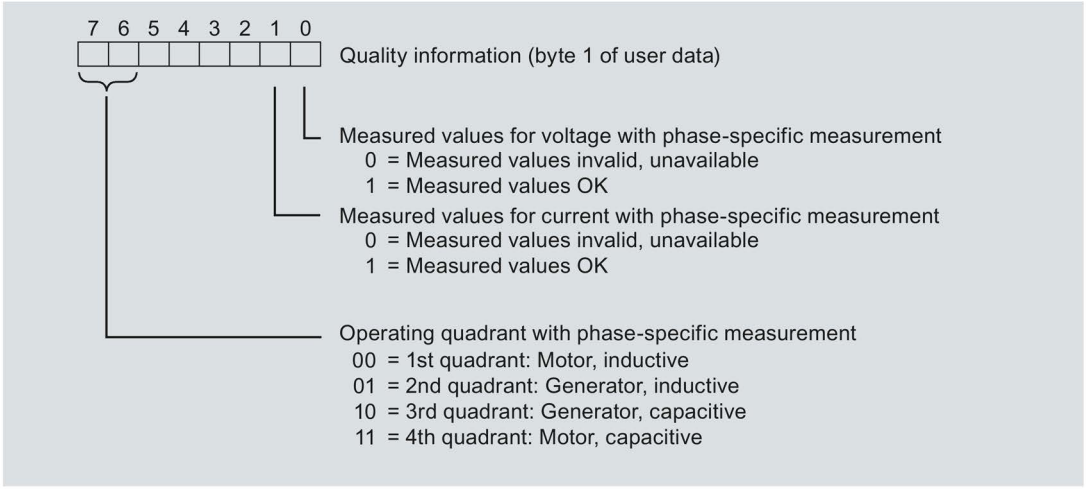
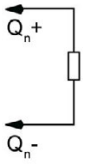
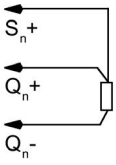
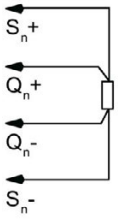


Figure 2-4 Allocation of the quality information for user data variants 154 to 159

Manual for AQ 2xU/I HF, Edition 02/2014

Section 3.1 Wiring and block diagram, pin assignment

You can now also use the 3-wire connection in addition to the 2-wire and 4-wire connection for the analog module AQ 2xU/I HF.

Pin assignment for AQ 2xU/I HF			Explanation
Voltage 2-wire connection	Voltage 3-wire connection	Voltage 4-wire connection	• Qn+: Analog output voltage/current (positive), channel n • Qn-: Analog output voltage/current (negative), channel n • Sn+: Sensor line positive, channel n • Sn-: Sensor line negative, channel n
			

The 3-wire connection and 4-wire connection make compensation for line impedance possible. The compensation is not possible for 2-wire connections due to the missing sensor cable.

2.4.3 Communications module manuals

Communication module CM DP, Edition 12/2014

The communication module CM DP supports the PROFIsafe protocol V2.

Exception: Fail-safe modules that only support PROFIsafe V1 mode.

2.4.4 Device manuals Technology modules

Technology module TM Pulse 2x24V, Edition 09/2015

Supplement in the section Preface

Please read the information about Open Source Software on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109740777).

2.5 Function manuals

Function manual Cycle and response times, edition 09/2016

Section 3.4 Response time for cyclic and time-driven program processing,

Update time of the backplane bus for the CPUs ET 200SP (addendum to table 3-6 Update time of the ET 200SP CPUs)

The duration of the update time of the backplane bus for the ET 200SP CPUs depends on the number of I/O modules. The following table is for orientation purposes. It shows the approximate relationship between the number of I/O modules for the ET 200SP and the bus cycle used. The example in the table assumes there is 8 bytes of I/O data per I/O module.

Number of ET 200SP I/O modules	Input data (bytes)	Output data (bytes)	Bus cycle used (µs)
8	64	64	250
16	128	128	250
24	192	192	281.25
32	256	256	312.50
40	320	320	343.75
48	384	384	375
56	448	448	406.25
64	512	512	437.50

The bus cycle for I/O modules with more than 32 bytes of I/O data is calculated with an I/O module with 32 bytes. The I/O module requires additional bus cycles to update its I/O data in this case.

SIEMENS

SIMATIC

ET 200SP
PROFIenergy product information

Product Information

12/2015
A5E03871936-AH

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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PROFIenergy 1

Security information

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

1.1 Introduction

Introduction

PROFIenergy is a data interface based on PROFINET for switching off consumers centrally and in a coordinated manner during idle times, regardless of the manufacturer or device type. The goal is that the process is only provided with the energy that is absolutely required. The majority of the energy is saved by the process itself; the PROFINET device itself only contributes a few watts of saving potential. This operating mode is termed "pause" in PROFIenergy.

The PROFINET devices are turned off by special commands in the user program of the PROFINET IO controller. No additional hardware is required; the PROFIenergy commands are directly interpreted by the PROFINET devices.

The device which provides the PROFIenergy interface and supports the required control data record has the so-called PE-Entity, the access point for these control data records. This PE-Entity is located on the interface module as a substitute for I/O modules that do not have their own PE-Entity. I/O modules that have their own PE-Entity are always addressed directly.

Requirements

- Interface module IM 155-6 PN ST
- Interface module IM 155-6 PN HF
- ET 200SP I/O modules which support PROFIenergy
  - Digital input module DI 8x24VDC ST (6ES7131-6BF00-0BA0)
  - Digital input module DI 8x24VDC HF (6ES7131-6BF00-0CA0)
  - Digital input module DI 8xNAMUR HF (6ES7131-6TF00-0CA0)
  - Digital input module DI 8x24VDC HS (6ES7131-6BF00-0DA0)
  - Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD20-0BA0)
  - Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD20-0CA0)
  - Digital output module DQ 4x24VDC/2A HS (6ES7132-6BD20-0DA0)
  - Digital output module DQ 8x24VDC/0,5A ST (6ES7132-6BF00-0BA0)
  - Digital output module DQ 8x24VDC/0,5A HF (6ES7132-6BF00-0CA0)
  - Digital output module DQ 16x24VDC/0,5A ST (6ES7132-6BH00-0BA0)
  - Digital output module DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)
  - Digital output module RQ 4x24VUC/2A CO ST (6ES7132-6GD50-0BA0)
  - Digital output module RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB0)
  - Digital output module RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)
  - Analog input module AI 2xU ST (6ES7134-6FB00-0BA1)
  - Analog input module AI 2xI 2-/4-wire ST (6ES7134-6GB00-0BA1)
  - Analog input module AI 4xI 2-/4-wire ST (6ES7134-6GD00-0BA1)
  - Analog input module AI 2xU/I 2-/4-wire HF (6ES7134-6HB00-0CA1)
  - Analog input module AI 4xU/I 2-wire ST (6ES7134-6HD00-0BA1)
  - Analog input module AI 2xU/I 2-/4-wire HS (6ES7134-6HB00-0DA0)
  - Analog output module AQ 2xU ST (6ES7135-6FB00-0BA1)
  - Analog output module AQ 2xI ST (6ES7135-6GB00-0BA1)
  - Analog output module AQ 4xU/I ST (6ES7135-6HD00-0BA1)
  - Analog output module AQ 2xU/I HF (6ES7135-6HB00-0CA1)
  - Analog output module AQ 2xU/I HS (6ES7135-6HB00-0DA1)
  - Communication module IO-Link Master CM 4xIO-Link (6ES7137-6BD00-0BA0)
- User program for sending the parameter data record, index 3
- User program with the function blocks for controlling the PROFIenergy commands ("PE_START_END" - FB 815, "PE_CMD" - FB 816).

Procedure

1. Create the parameter data record, Index 3 in STEP 7
2. Transfer the parameter data record to the interface module with the instruction "WRREC" - SFB 53.
3. Create the user program with the FBs for controlling the PROFIenergy commands ("PE_START_END" - FB 815, "PE_CMD" - FB 816).
4. Transfer the user program to the CPU.

Additional information

- System manual ET 200SP Distributed I/O System
- Device manual Interface Module
- Device manuals Digital and Analog I/O Modules
- System manual PROFINET System Description
- You will find additional information on PROFIenergy services, parameters of the service IDs on the Internet under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.
- Additional information on PROFIenergy FBs ("PE_START_END" - FB 815, "PE_CMD" - FB 816) is available in the online help for STEP 7 V5.5 as of SP2 "Help on System Functions/System Function Blocks".

1.2 Principle of operation

"Pause" control and "Pause" behavior

At the beginning and end of pauses, you enable or disable the pause function of the system; the IO controller then sends the PROFIenergy command "Start_Pause" or "End_Pause" to the PROFINET devices. The device then interprets the contents of the PROFIenergy command and switches on or off. The interface module is the PE-Entity for I/O modules with PROFIenergy capability of the ET 200SP.

Other PROFIenergy commands allow device information to be accessed during the pauses. You can use these commands to transfer the "Start_Pause" / "End_Pause" command in good time.

Note

A complete PROFIenergy sequence consists of the commands "Start_Pause" and "End_Pause". Always observe this sequence during programming.

LED displays

In general, PROFIenergy does not have an effect on the LED display. Please see the device manuals of the relevant I/O modules for exceptions.

Response to error detection

All channels whose pause mode is set to "PE_MODE_PROCEED" report errors as in productive operation.

The following rules apply to channels which switch to a pause mode other than "PE_MODE_PROCEED":

- All errors that are unrelated to the switch to "Pause" are reported.
- If error recognition is possible during "Pause", these errors continue to be reported.
- All error messages which are caused by the switch to "Pause" are suppressed.
- The following applies if error recognition is not possible during the "Pause":
  - The status of errors already pending before the "Pause" is retained.
  - Incoming and outgoing errors are reported once the "pause" has ended.

Note

Switching to "Pause" and out of "Pause" may cause an error to be reported.

Additional information

Additional information on diagnostics can be found in the I/O module device manuals.

Hardware interrupt

No hardware interrupts are triggered within the "pause". The hardware interrupts are re-evaluated when the "pause" ends.

"Pause" behavior under certain operating conditions

A "Pause" is ended in the following cases:

Table 1- 1 Ending a "pause"

Ending a "pause"	Explanation
The supply voltage 1L+ of the interface module has failed	The "pause" is exited and can be re-activated by re-sending the PROFIenergy parameter assignment followed by the "Start_Pause" command.
• Controller stop[1] • Controller failure (connection interrupted)[1] • Firmware update • Reset to factory settings • Deactivation of the IO device[1]	
The I/O module is pulled and plugged	
Station stop[1] • Removal of more than one I/O module (depending on the interface module used) • Dismounting of the server module	The "pause" is exited , the PROFIenergy parameter assignment is still on the I/O module and the "pause" can be re-activated by the "Start_Pause" command.
Failure of the supply voltage L+ of the I/O module.	
Modification of the parameter settings of the I/O module during operation using data record 128	

[1] The substitute value behavior is activated.

1.3 Parameter assignment

Parameter assignment

- Parameter assignment of PROFIenergy takes place by means of the user program and parameter data record (version2), index 3. The interface module distributes the PROFIenergy parameters to the I/O modules.
- The parameter assignment of an additional pause behavior is possible immediately after the start of the previous "Pause". The required state for the following pause is activated with a new "Start_Pause" command.
- The parameter assignment can be written as often as necessary.
- The interface module checks the distribution of the parameters to the I/O modules and returns the result of the write job by means of return value. In the case of a negative return value, there are one or more I/O modules that have not accepted the parameter data record. In this case, the I/O modules respond according to their last valid PROFIenergy parameter assignment with an incoming "Start_Pause" command.
- Parameter assignment by means of the parameter data record has to be repeated in case of an I/O module failure or station failure.
- ET 200SP supports the setting for the behavior of **one** "Pause". If a different response is required for an additional "Pause", you will have to assign parameters again.

Note

Effect: The response (shutdown) of the I/O modules to PROFIenergy is related to the slot, which means that all channels of the slot show the same behavior.

Parameter data record

You specify which I/O modules (slots) are controlled with PROFIenergy commands in the parameter data record for PROFIenergy.

The content of the parameter data record for PROFIenergy, index 3 is described below; you can create it yourself and transmit it to the interface module.

Table 1- 2 Parameter data record for PROFIenergy (version 2), index 3

Byte	Element		Coding	Explanation
0	Version		02_D	Cannot be modified
1	Number of blocks		01_D to n	Slots 1 to n depending • on the number of slots supported by the interface module and • the current configuration of the ET 200SP.
2	Block 1	Slot number	00_D	Unassigned
			01_D to n	I/O module slot with PROFIenergy
3		Mode	0_D: PE_MODE_PROCEED, proceed at "Pause" 1_D: PE_MODE_SHUTDOWN, shut down at "Pause" [1] 3_D: PE_MODE_LAST_VALUE, last output or measured value is retained 4_D: PE_MODE_SUBST_VALUE, substitute value "0" [2]	
:	:	:	:	
128	Block 64	Slot number	See Block 1	
129		Mode		

[1] The specific behavior depends on the used I/O module (with a digital input module, for example, the sensor supply is turned off or the outputs of an analog output module are de-energized)

[2] An analog output module (e. g. with the output range 0 mA to 20 mA, ± 20 mA) or a digital output module issues the value "0".

Error messages

The feedback data record returns the following error messages, if needed:

Table 1- 3 Error messages

Error code	Meaning	
$80B1_H$	Impermissible length	Check the length of the data record
$80E0_H$	Error in header information	Check the data record header information
$80E1_H$	Parameter error • At least one I/O module does not support PROFIenergy • A parameter value has been incorrectly encoded	Check the content of the data record and correct the parameter assignment error before starting the "Pause". Parameter assignment errors which are not corrected can result in incorrect I/O module shutdown behavior.

1.4 PROFIenergy control data records

PROFIenergy control data records

The control data record for PROFIenergy, Index $80A0_H$, supports the following services of the Common Application Profile PROFIenergy V1.0 for the IM 155-6 PN ST, IM 155-6 PN HF:

Table 1- 4 Control data records for PROFIenergy

Service	Service ID	Meaning
Start pause [1]	01_H	Assuming the configured Pause behavior, suppressing all associated diagnostics data
End Pause	02_H	Leaving the pause
Query Modes	03_H	Reads the supported modes • Request List Energy Saving Modes • Request Get Mode (Energy Saving Mode Data)
PEM status	04_H	Reads the PROFIenergy status Status messages: • 00_H: PROFIenergy is ready for operation • 01_H: "Pause" is active • FF_H: "Pause" is not active
PE_Identify	05_H	Reads the supported PROFIenergy services

[1] The minimum (configurable) pause time for the ET 200SP is 10 s.

1.5 I/O modules

1.5.1 Digital input module

Requirements

- Digital input module DI 8x24VDC ST (6ES7131-6BF00-0BA0)
- Digital input module DI 8x24VDC HF (6ES7131-6BF00-0CA0)
- Digital input module DI 8xNAMUR HF (6ES7131-6TF00-0CA0)
- Digital input module DI 8x24VDC HS (6ES7131-6BF00-0DA0)

Display

DI 8x24VDC ST/ DI 8x24VDC HF/ DI 8x24VDC HS

- The channel LEDs are directly affected by the signal level at the terminal.
- Switching off the sensor supply also switches off the channel LED if an external sensor supply is connected.

DI 8xNAMUR

- The channel LEDs correspond to the signal state supplied by the I/O module.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

All channels which are set to "PE_MODE_PROCEED" in pause mode report errors as in productive operation.

The following applies for all channels which switch to a different pause mode:

- Sensor supply switch-off upon the start of "pause" does not result in the messages "Line break" or "Short circuit".
- "Line break" and "Short circuit" error recognition is not possible during the "pause":
  - Messages for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 1- 5 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Shut down at "Pause" [1] • Sensor supply switched off [2] • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Sensor supply switched off [2] • Pause substitute value: Last input value
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Sensor supply switched off [2] • Pause substitute value: Configured pause substitute value

1 DI 8xNAMUR HF: A channel is set to "inverted". During the "pause", the PE substitute value is read in 1:1 (as in the parameter settings and not inverted again).

2 DI 8x24VDC ST: As there is only one sensor supply for all channels, the supply can only be switched off at a "pause" if all channel parameters have been set to switch off.

1.5.2 Digital output modules

Requirements

- Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD20-0BA0)
- Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD20-0CA0)
- Digital output module DQ 4x24VDC/2A HS (6ES7132-6BD20-0DA0)
- Digital output module DQ 8x24VDC/0,5A ST (6ES7132-6BF00-0BA0)
- Digital output module DQ 8x24VDC/0,5A HF (6ES7132-6BF00-0CA0)
- Digital output module DQ 16x24VDC/0,5A ST (6ES7132-6BH00-0BA0)
- Digital output module DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)
- Digital output module RQ 4x24VUC/2A CO ST (6ES7132-6GD50-0BA0)
- Digital output module RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB0)
- Digital output module RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)

Display

The channel LEDs are directly affected by the output value at the terminal.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

Line break and short circuit error recognition continues to be possible during the "pause". All channels therefore report errors as in productive operation, regardless of their pause mode.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+ (exception: The DQ 4x24..230VAC/2A ST remains in "Pause")
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 1- 6 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Pause substitute value: Last output value is maintained[1]
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Pause substitute value: Configured pause substitute value is output

[1] DQ 4x24VDC/2A HS: In the "Pulse width modulation" mode, the last value is output as frequency.

1.5.3 Analog input modules

Requirements

- Analog input module AI 2xU ST (6ES7134-6FB00-0BA1)
- Analog input module AI 2xI 2-/4-wire ST (6ES7134-6GB00-0BA1)
- Analog input module AI 4xI 2-/4-wire ST (6ES7134-6GD00-0BA1)
- Analog input module AI 2xU/I 2-/4-wire HF (6ES7134-6HB00-0CA1)
- Analog input module AI 4xU/I 2-wire ST (6ES7134-6HD00-0BA1)
- Analog input module AI 2xU/I 2-/4-wire HS (6ES7134-6HB00-0DA0)

Display

The channel LEDs are not affected by PROFIenergy.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

All channels which are set to "PE_MODE_PROCEED" in pause mode report errors as in productive operation.

The following applies for all channels which switch to a different pause mode:

- Sensor supply switch-off upon the start of "pause" does not result in the message "Line break".
- "Line break", "Short circuit", "High limit exceeded" and "Low limit exceeded" error recognition is not possible during the "pause":
  - Messages for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 1- 7 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Sensor supply switched off [1] • Pause substitute value: $7FFF_H$
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Sensor supply switched off [1] • Pause substitute value: Last input value
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Sensor supply switched off [1] • Pause substitute value: Configured pause substitute value

[1] AI 2xI 2-/4-wire ST, AI 4xI 2-/4-wire ST, AI 4xU/I 2-wire ST, AI 2xU/I 2-/4-wire HS: As there is only one sensor supply for all channels, the supply can only be switched off at a "pause" if all channels have been configured to switch off.

1.5.4 Analog output module

Requirements

- Analog output module AQ 2xU ST (6ES7135-6FB00-0BA1)
- Analog output module AQ 2xI ST (6ES7135-6GB00-0BA1)
- Analog output module AQ 4xU/I ST (6ES7135-6HD00-0BA1)
- Analog output module AQ 2xU/I HF (6ES7135-6HB00-0CA1)
- Analog output module AQ 2xU/I HS (6ES7135-6HB00-0DA1)

Display

The channel LEDs are not affected by PROFIenergy.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

All channels which are set to "PE_MODE_PROCEED" in pause mode report errors as in productive operation.

The following applies to all channels which switch to the pause mode "PE_MODE_SHUTDOWN":

- "Line break" and "Short circuit" error recognition is not possible during the pause.
  - Messages for errors already pending before the "pause" are retained.
  - Incoming and outgoing errors are reported once the "pause" has ended.

The following applies for all channels which switch to a different pause mode:

- "Line break" and "Short circuit" error recognition continues to be possible during the pause. These errors are reported.
- The selection of an incorrect pause substitute value which does not correspond to the output range may result in the message "High limit exceeded" or "Low limit exceeded". The pause substitute output value effective at the terminal is limited to the high or low control limit for the output range.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 1- 8 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Outputs free from current and voltage
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Pause substitute value: Last output value is maintained
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Pause substitute value: Configured pause substitute value is output

1.5.5 IO-Link Master

Requirements

Communication module IO-Link Master CM 4xIO-Link (6ES7137-6BD00-0BA0)

Note

The minimum pause time (10 s) must be observed. If it is undershot, problems may occur with the restart of IO-Link communication.

1.5.5.1 DI operating mode

Display

Switching off the supply voltage USn (port) also switches off the associated channel status LED Qn if an external supply voltage is connected.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is adopted.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Re-assignment of the I/O module parameters
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 1- 9 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Supply voltage USn (port) switched off • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Supply voltage USn (port) switched off • Pause substitute value: Last input value
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Supply voltage USn (port) switched off • Pause substitute value: Configured pause substitute value

1.5.5.2 DQ operating mode

Display

The channel status LEDs Qn show the output value.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is adopted.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Re-assignment of the I/O module parameters
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 1- 10 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Pause substitute value: Last output value is maintained
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Pause substitute value: Configured pause substitute value is output

1.5.5.3 IO-Link operating mode

Display

When supply voltage USn (port) is switched off, the associated port status LED Cn and port error LED Fn are also switched off.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is adopted.

All channels which are set to "PE_MODE_PROCEED" and "PE_MODE_LAST_VALUE" in pause mode report errors as in productive operation.

The following conditions apply to all channels (ports) which switch to a different pause mode ("PE_MODE_SHUTDOWN" and "PE_MODE_SUBST_VALUE"):

- Switching off the supply voltage USn (port) at the start of "pause" does not result in the messages "Line break" or "Short circuit".
- Error detection is not possible during the "pause" (no IO-Link device communication):
  - Messages for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Re-assignment of the I/O module parameters
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 1- 11 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Supply voltage USn (port) switched off[1] • Pause substitute value (input): 0_B
	3_D: PE_MODE_LAST_VALUE[2]	• Supply voltage USn (port) switched off • Last input and output value is maintained
	4_D: PE_MODE_SUBST_VALUE	see: 1_D: PE_MODE_SHUTDOWN

1 Supply voltage USn of the assigned port is switched off. Result: The IO-Link device fails.

2 With time-based IO, the IO-Link master behaves according to 1_D: PE_MODE_SHUTDOWN

SIEMENS

SIMATIC

ET 200SP
Product Information Mixed Configuration ET 200SP / ET 200AL

Product Information

Preface

Application planning 1

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02/2016

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Scope

This product information supplements the ET 200SP system manual documentation.

Security information

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security in the Internet (http://www.siemens.com/industrialsecurity).

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Application planning

1

Mixed configuration ET 200SP and ET 200AL with ET-Connection

You have the option of integrating the I/O modules of the ET 200AL distributed I/O system (IP65/IP67) in a configuration of the ET 200SP distributed I/O system (IP20).

The figure below shows a combination of the modules of the ET 200AL and ET 200SP distributed I/O system.

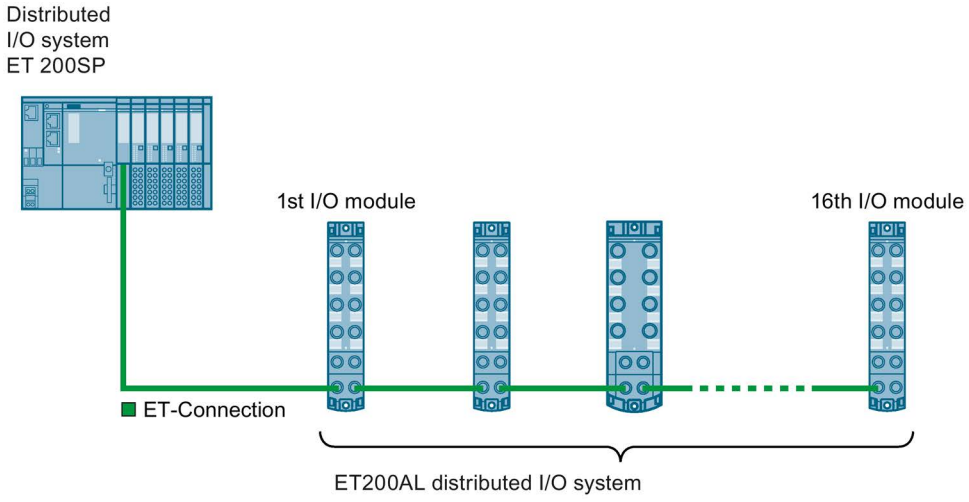


Image 1-1 Mixed configuration ET 200SP and ET 200AL with ET-Connection

Requirement

The following components support mixed configuration:

- Interface module
  - IM 155-6 PN HF (V3.0 or higher)
  - IM 155-6 PN ST (V3.1 or higher)
  - IM 155-6 DP HF (V3.0 or higher)
- CPU
  - CPU 1510SP-1 PN (V2.0 or higher)
  - CPU 1510SP F-1 PN (V2.0 or higher)
  - CPU 1512SP-1 PN (V2.0 or higher)
  - CPU 1512SP F-1 PN (V2.0 or higher)
- BaseUnit BU-Send with BusAdapter BA-Send 1xFC
- ET-Connection cable
- Power cable

Rules

You must observe the following rules when assembling a mixed configuration:

- The bus length of the ET 200SP distributed I/O system must not exceed 1 m (without interface module, including BU-Send/BA-Send 1xFC and server module)
- A maximum of 16 ET 200AL I/O modules can be connected to ET-Connection.
- The maximum length of the bus cable for ET-Connection between BA-Send and the first module or between two modules is 15 m.

The following table shows which firmware versions of your IM or CPU support which maximum bus cable length.

IM/CPU	2 m	5 m	10 m	15 m
IM 155-6 PN HF	V3.0 or higher	V3.0 or higher	V3.0 or higher	V3.3 or higher
IM 155-6 PN ST	V3.1 or higher	V3.1 or higher	V3.1 or higher	V3.3 or higher
IM 155-6 DP HF	V3.0 or higher	V3.0 or higher	V3.0 or higher	--
CPU 1510SP-1 PN	V2.0 or higher	V2.0 or higher	V2.0 or higher	V2.0 or higher
CPU 1510SP F-1 PN	V2.0 or higher	V2.0 or higher	V2.0 or higher	V2.0 or higher
CPU 1512SP-1 PN	V2.0 or higher	V2.0 or higher	V2.0 or higher	V2.0 or higher
CPU 1512SP F-1 PN	V2.0 or higher	V2.0 or higher	V2.0 or higher	V2.0 or higher

Procedure

To assemble a multi-tier configuration, follow these steps:

1. Install the BaseUnit BU-Send to the immediate right of the ET 200SP CPU/interface module.
   When the BaseUnit BU-Send is used next to the ET 200SP CPU, a CM DP and an Ethernet CP or a maximum of 2 Ethernet CPs can be inserted between the CPU and BU-Send.
2. Then mount the additional BaseUnits / I/O modules for the ET 200SP distributed I/O system and the server module.
3. Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1xFC and mount this on the BaseUnit BU-Send.
4. Screw the BusAdapter BA-Send 1×FC to the BaseUnit BU-Send (1 screw with 0.2 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade.
5. Connect the other end of the bus cable for ET-Connection (with M8 connector) to the first ET 200AL I/O module (X30 socket ET-Connection IN).
6. Connect the supply voltage (24 V DC) to the ET 200AL I/O modules (X80 connector).

Note

Firmware update of an ET 200AL I/O module

When you run a firmware update of an ET 200AL I/O module, ET-Connection is briefly interrupted by the restart of the module. All downstream ET 200AL I/O modules report a pull/plug interrupt.

Mounting

2

Introduction

For the connection of the ET 200AL I/O module via ET-Connection to the ET 200SP, you require the BaseUnit BU-Send with the BusAdapter BA-Send 1xFC.

Requirement

- The mounting rail is mounted.
- The interface module is mounted.

Required tools

3 to 3.5 mm screwdriver (only for dismantling the BusAdapter)

Mounting BaseUnit BU-Send

To mount the BaseUnit BU-Send, follow these steps:

1. Mount the BU-Send to the right of the CPU/interface module.
2. Swivel the BU-Send back until you hear the mounting rail release click into place.
3. Move the BU-Send to the left until you hear it click into place on the CPU/interface module.

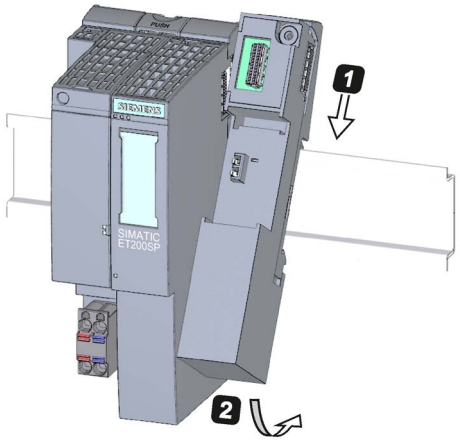


Image 2-1 Mounting BU-Send

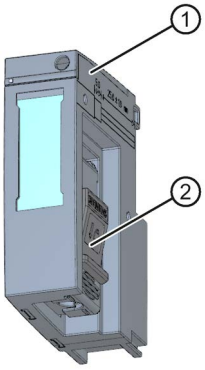
4. Mount the BusAdapter BA-Send 1xFC only after you have connected the bus cable for ET-Connection (see section Connecting (Page 9)).

Connection

3

Introduction

You connect the ET 200AL I/O modules via the BusAdapter BA-Send 1×FC using ET-Connection.



① BusAdapter BA-Send 1×FC
② Connection element for ET-Connection bus cable

Image 3-1 BusAdapter BA-Send 1xFC

Required tools

Screwdriver with 3 to 3.5 mm blade

Required accessories

Use the bus cable for ET-Connection as connecting cable between the BusAdapter BA-Send 1xFC and the ET 200AL I/O modules.

We recommend using the stripping tool for ET-Connection (6ES7194-2KA00-0AA0) with blade cassette green (6GK1901-1B...). This guarantees fast and safe stripping.

The bus cable for ET-Connection M8, prefabricated on one side with 1 x M8 connector, 4-pole, shielded, is available in the following lengths:

- Length 2 m: 6ES7194-2LH20-0AC0
- Length 5 m: 6ES7194-2LH50-0AC0
- Length 10 m: 6ES7194-2LN10-0AC0
- Length 15 m: 6ES7194-2LN15-0AB0

Procedure

To connect the BusAdapter BA-Send 1xFC, follow these steps:

1. Strip the sheath of the bus cable at the open end as follows:

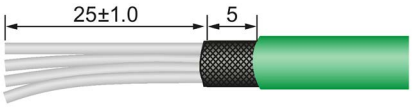
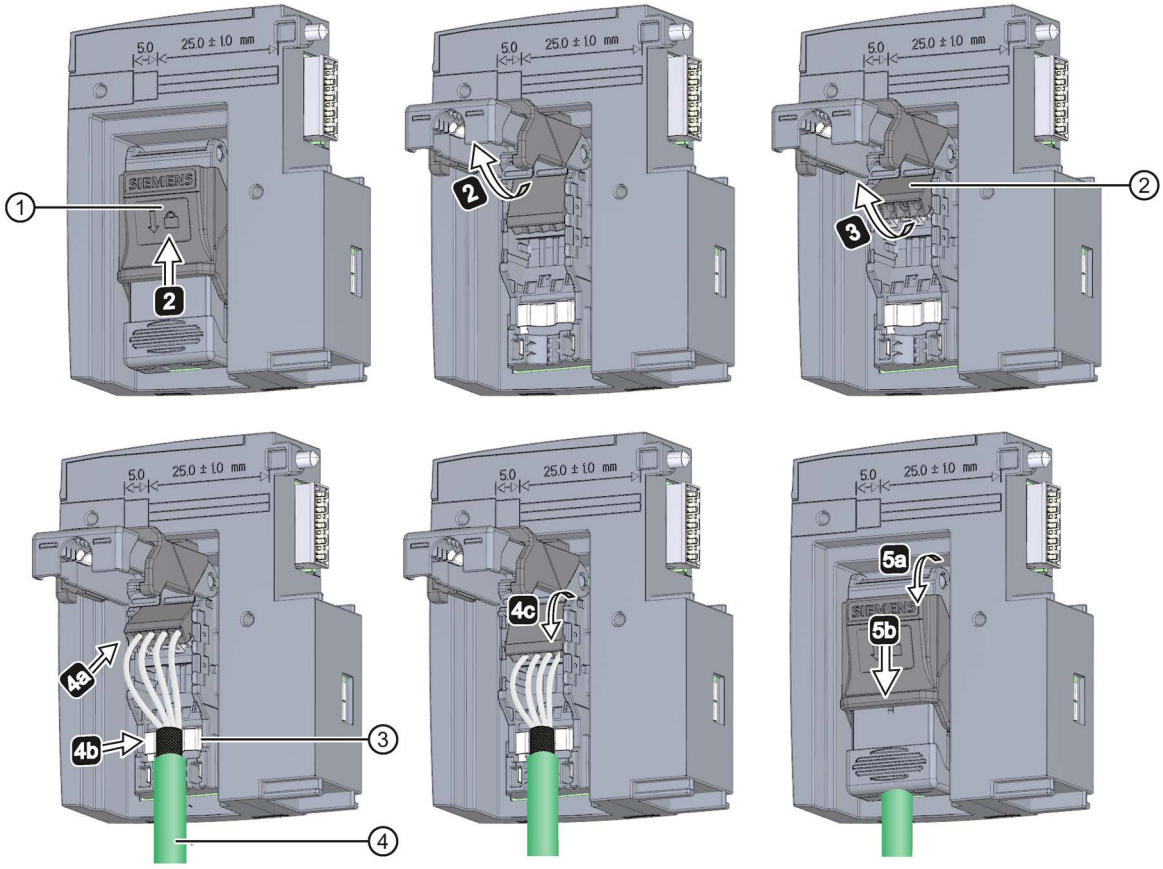


Image 3-2 Connecting cable

   Use the stripping tool for ET-Connection to do this. The relevant settings are shown on the tool.

2. Pull back the locking slide of the BusAdapter BA-Send 1×FC and open the cover of the connection element.
3. Lift the cable routing up as far as it will go.
4. Insert the unstripped single cores of the bus cable (according to the imprinted color coding) into the cable routing as far as they will go and press the cable routing down as far as it will go.
5. Close the cover of the connection element and push the locking slide forward.

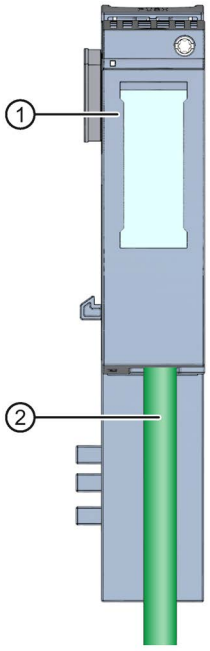
6. Connect and screw the BusAdapter BA-Send 1×FC to the BaseUnit BU-Send (1 screw with 0.2 Nm tightening torque.) To do this, use a screwdriver with a 3 to 3.5 mm blade.
7. Connect the M8 connector of the bus cable to the first ET 200AL I/O module (socket X30 ET-Connection IN). For more information about wiring the ET 200AL I/O module refer to the system manual of the ET 200AL distributed I/O system.



①	Locking slide	③	Shield contact
②	Cable routing	④	Bus cable for ET-Connection

Image 3-3 Connection of the BusAdapeter BA-Send 1xFC

BusAdapter BA-Send 1×FC mounted



① BusAdapter BA-Send 1×FC
② Bus cable for ET-Connection

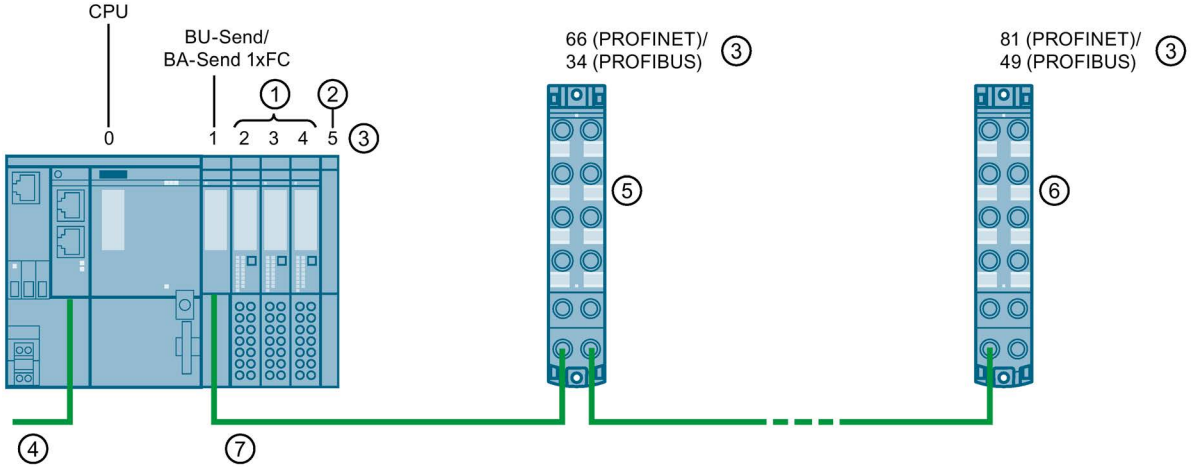
Image 3-4 BusAdapter BA-Send 1×FC mounted

Configuring

4

Introduction

The mixed configuration allows the connection of up to 16 ET 200AL I/O modules to the ET 200SP via ET-Connection. The figure below shows the configuration of the ET-Connection and the assignment of the slots.



①	ET 200SP I/O modules	⑤	1st ET 200AL I/O module
②	ET 200SP server module	⑥	16th ET 200AL I/O module
③	Slots	⑦	ET-Connection
④	PROFINET IO		

Image 4-1 Mixed configuration

For more information about connecting the ET-Connection, supply voltages, actuators and sensors, refer to the ET 200AL system manual.

Configuration with a CPU

In a configuration with a CPU, a maximum of 2 slots can be used immediately to the right of the CPU with CM DP module or Ethernet CP. Combinations are also possible, i.e. CM DP module and one Ethernet CP or two Ethernet CPs.

BU-Send and BA-Send should always be inserted to the immediate right of the CM/CP.

Rules

Observe the following rules when configuring:

- With mixed configurations, the following maximum configuration is possible:
  - 31 (IM 155-6 DP HF and IM 155-6 PN ST)/63 (IM 155-6 PN HF and CPUs) slots for ET 200SP modules
  - 16 slots for ET 200AL I/O modules
  - 1 slot for BU-Send/BA-Send 1xFC
  - 1 slot for server module.
- The mixed configuration may contain a maximum of 31 (IM 155-6 DP HF and IM 155-6 PN ST)/63 (IM 155-6 PN HF) ET 200SP I/O modules.
- The server module can also be mounted right next to the BU-Send/BA-Send 1xFC.
- Supported functions:

Function	Mixed configuration		
	ET 200SP		ET 200AL I/O modules on ET-Connection
	IM	CPU	
Isochronous mode	⑥	--	--
Configuration control	⑥	⑥	⑥
Shared device	⑥	⑥	⑥
PROFIenergy	⑥	--	⑥
System redundancy S2	--	--	--

Configuring

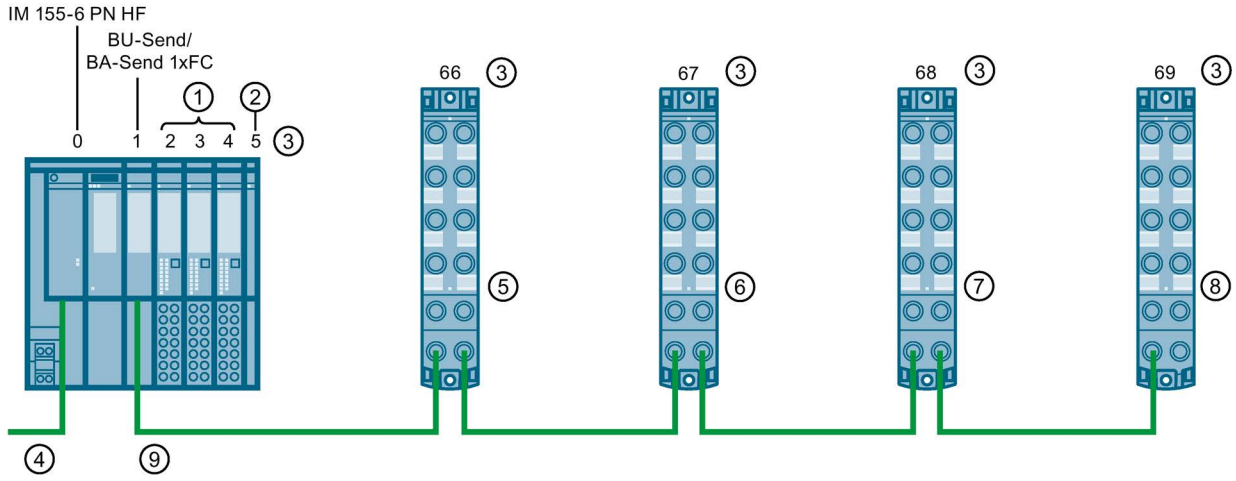
Observe the following points when configuring:

- BU-Send/BA-Send 1xFC and server module must be configured. With BU-Send/BA-Send 1xFC, no parameters are available.
- Arrangement of the modules in the configuration:
  - Configure the BU-Send/BA-Send 1xFC downstream from the interface module in slot 1. Position the ET 200SP modules behind it.
  - Configure the ET 200AL I/O modules from slot 66 (PROFINET)/67 (CPU)/34 (PROFIBUS).
- The layout of the modules represents a preset configuration and is independent of the configuration control.
- The system redundancy S2 function is not available in a mixed configuration.

Configuration example

An example of a mixed configuration is shown below:

Hardware configuration



① ET 200SP I/O modules
② ET 200SP server module
③ Slots
④ PROFINET IO
⑤ 1st ET 200AL I/O module
⑥ 2nd ET 200AL I/O module
⑦ 3rd ET 200AL I/O module
⑧ 4th ET 200AL I/O module
⑨ ET-Connection

Image 4-2 Mixed configuration

Configuring configuration example

Table 4- 1 Overview

Mixed configuration	Module	Slot
ET 200SP	IM 155-6 PN HF	0
	BA-Send 1xFC	1
	DI 16×24VDC ST	2
	DI 16×24VDC ST	3
	DI 16×24VDC ST	4
	Server module	5
ET 200AL	DI 8x24VDC 8xM8	66
	DIQ 4+DQ 4x24VDC/0.5A 8xM8	67
	AI 4xU/I/RTD 4xM12	68
	CM 4xIO-Link 4xM12	69

Note

Configuration using PROFIBUS GSD file

When you use the PROFIBUS GSD file for the configuration, you must configure the gaps between the server module and the first ET 200AL I/O module with BU-Cover.

BaseUnit BU-Send

5

5.1 Product overview

Article number

6ES7193-6BN00-0NE0

View

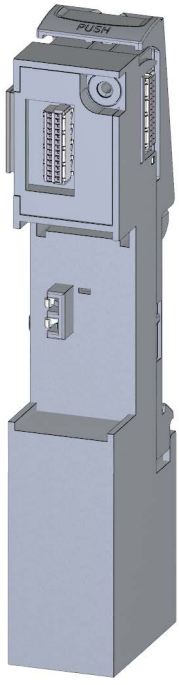


Image 5-1 BaseUnit BU-Send

Properties

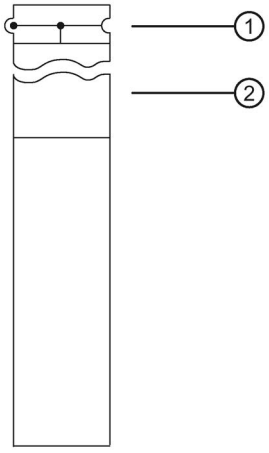
BaseUnit suitable for BusAdapter BA-Send 1xFC

5.2 Connection

Pin assignment

The BaseUnit BU-Send has only one slot for an expansion module. No other connections are available.

Schematic circuit diagram



① Backplane bus
② BA-Send 1xFC expansion module

Image 5-2 Schematic circuit diagram BU-Send

5.3 Technical specifications

Technical specifications of the BaseUnit BU-Send

	6ES7193-6BN00-0NE0
Product type designation	BaseUnit BU-Send
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Hardware configuration	
Slots	
Number of slots	1
Plug-in modules, other	Yes; BusAdapter BA-Send
Dimensions	
Width	20 mm
Height	117 mm
Depth	32 mm
Weights	
Weight, approx.	30 g

BusAdapter BA-Send 1xFC

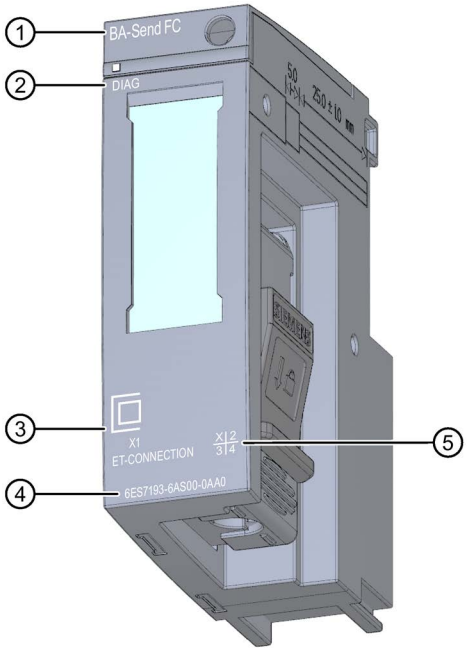
6

6.1 Properties

Article number

6ES7193-6AS00-0AA0

View of the module



① Module type and name
② LED for diagnostics
③ ((Connection for ET-CONNECTION))
④ Article number
⑤ Functional version

Image 6-1 View of the BusAdapter BA-Send 1xFC

Properties

The module has the following technical properties:

- BusAdapter for the direct connection of ET-Connection
- Connects the interface module via ET-Connection with the ET 200AL I/O modules
- Supports all ET 200AL I/O modules

The module supports the following functions:

- Identification data I&M 0 to 3. See system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

Maximum configuration

- 16 ET 200AL I/O modules
- 15 m bus cable between BusAdapter BA Send and the first ET 200AL I/O module and between two ET 200AL I/O modules.
- Supported functions:

Function	Mixed configuration		
	ET 200SP		ET 200AL I/O modules on ET-Connection
	IM	CPU	
Isochronous mode	⑥	--	--
Configuration control	⑥	⑥	⑥
Shared device	⑥	⑥	⑥
PROFIenergy	⑥	--	⑥
System redundancy S2	--	--	--

Accessories

The following components must be ordered separately:

- Labeling strips
- Reference identification label
- Stripping tool for ET-Connection
- Bus cables for ET-Connection

See also

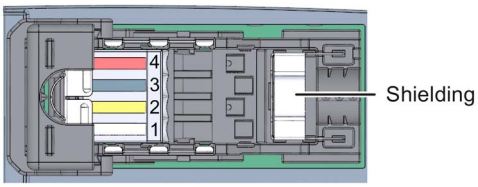
You can find more information on accessories and additional components in the Accessories/spare parts section of the ET 200AL distributed I/O system (http://support.automation.siemens.com/WW/view/en/89254965) system manual.

6.2 Pin assignment

ET-Connection with BusAdapter BA-Send 1xFC

The following table shows the signal names and the designations for the pin assignment of the BusAdapter BA-Send 1xFC.

Table 6- 1 ET-Connection pin assignment with BusAdapter BA-Send 1×FC

View	Signal name		Description
Port 1 	1	TD	Transmit data +
	2	RD	Receive data +
	3	TD_N	Transmit data –
	4	RD_N	Receive data -

6.3 Schematic circuit diagram

Schematic circuit diagram

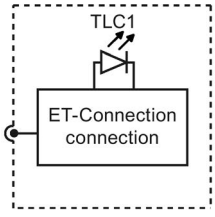
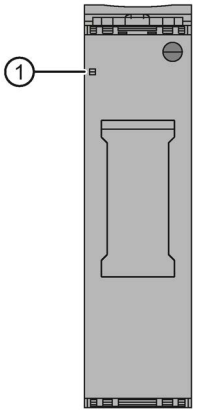


Image 6-2 Schematic circuit diagram for BusAdapter BA-Send 1xFC

6.4 Diagnostics by means of LED display

LED display

The figure below shows the LED display (status and fault display) of the BusAdapter BA-Send 1xFC.



① DIAG (green/red)

Image 6-3 LED display

Meaning of the LED display

The table below explains the meaning of the status and fault display.

DIAG LED

Table 6- 2 Status and fault display DIAG

DIAG LED	Meaning	Remedy
☐ Off	There is no connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and ET 200AL.	Check whether the bus cable is interrupted.
	The interface module does not support the BA-Send 1xFC.	Run a firmware update.
■ On	There is a connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and ET 200AL.	---
☼ Flashes	There is (at least) one diagnostics alarm of an ET-Connection device. Group error for all ET-Connection bus nodes.	Check the ET-Connection device.
	Set configuration does not match the actual configuration on the ET-Connection.	Check the configuration of the ET-Connection to see whether a module is missing or defective, or whether a non-configured module is wired.

6.5 Technical specifications

Technical specifications of the BusAdapter BA-Send 1xFC

	6ES7193-6AS00-0AA0
Interfaces	
PROFINET IO	
Cable length	
• Copper cables	15 m; as of IM firmware V3.3: Bus nodes between BA-Send and the first ET-Connection as well as between all other bus nodes.
ET-Connection	
Number of interfaces ET-Connection	1
FC (FastConnect)	Yes
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Weights	
Weight, approx.	44 g

SIEMENS

SIMATIC

ET 200SP
User calibration of analog modules

Product Information

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Example 6

Appendix A A

09/2014

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Security information

1

To ensure the secure operation of products and solutions from Siemens, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

Introduction 2

The characteristics of analog-digital/digital-analog converters in analog modules are usually offset and not uniform in their slope. This means you must calibrate the characteristics to the conditions of the analog module. A general distinction is made between factory calibration and user calibration.

Factory calibration

To ensure the accuracy of an analog module, it is calibrated during production in the factory. You cannot delete or change the factory calibration. You can only read the factory calibration values.

User calibration

You can start, delete and read back a user calibration for an analog module with error-free parameter assignment at any time. User calibration is used to increase the accuracy for specific use cases with deviations that can be compensated, for example, by sensors or wiring.

Zero-Scale/Offset calibration

Zero-Scale or Offset calibration is the calibration of the zero point. Usually "0" for bipolar ranges and the low limit of the nominal range for unipolar ranges. The characteristic of the converter is offset corrected and thus shifted into the zero point.

Full-Scale/Gain/Gain calibration

Full-Scale or Gain calibration is the calibration of the end point. It is usually the high limit of the nominal range. The slope of the converter characteristic is adjusted so that it also intersects the end point.

Converter characteristic

The figure below shows the shift of the converter characteristic into the zero point on the left. The right part of the figure shows the change in the converter characteristic slope so that the converter characteristic intersects the end point.

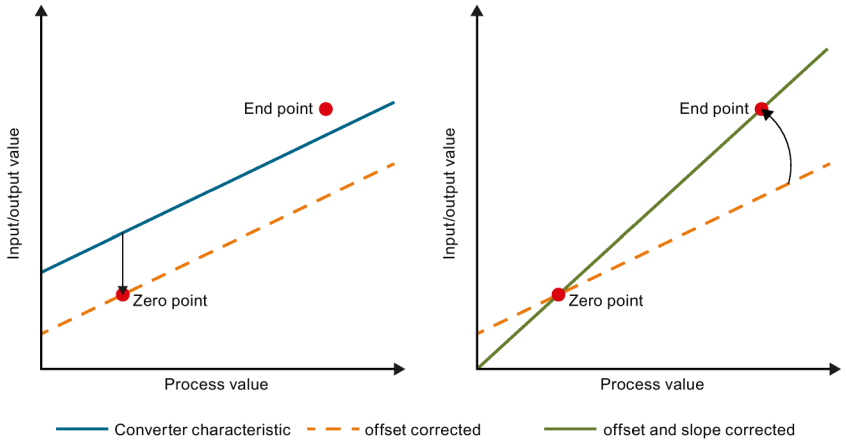

Figure 2-1 Correction of the converter characteristic

Requirement

3

The accuracy/quality of a user calibration depends on the following points:

- Stable temperature condition (e.g., 25 °C)
- The settling time of the used calibrator/measuring instrument and the analog module (e.g., for input or output modules with integrated measuring process → sigma-delta converter)
- Cables (if possible, short, shielded and grounded at one side)
- Accuracy of the used calibrator and/or measuring instrument

---

Note

Measuring accuracy

The measuring accuracy may deteriorate if the user calibration is not performed properly.

It is not immediately clear if a channel works with factory calibration values or user calibration values.

Mode of operation

4

You must perform the user calibration for each channel. To do so, always calibrate the selected channel in the set input/output range. You can start the user calibration at any time for a channel with error-free parameter assignment. After successful user calibration the newly calibrated channel works in the current input/output range with the newly determined calibration values.

4.1 Procedure

The user calibration is controlled by the data sets (DS). You must write a job data set for the analog module and receive instructions for further actions in the acknowledgment data set. This procedure is described in more detail in the section Performing user calibration (Page 21).

The figure below shows the steps required for the user calibration of an instruction to the analog module.

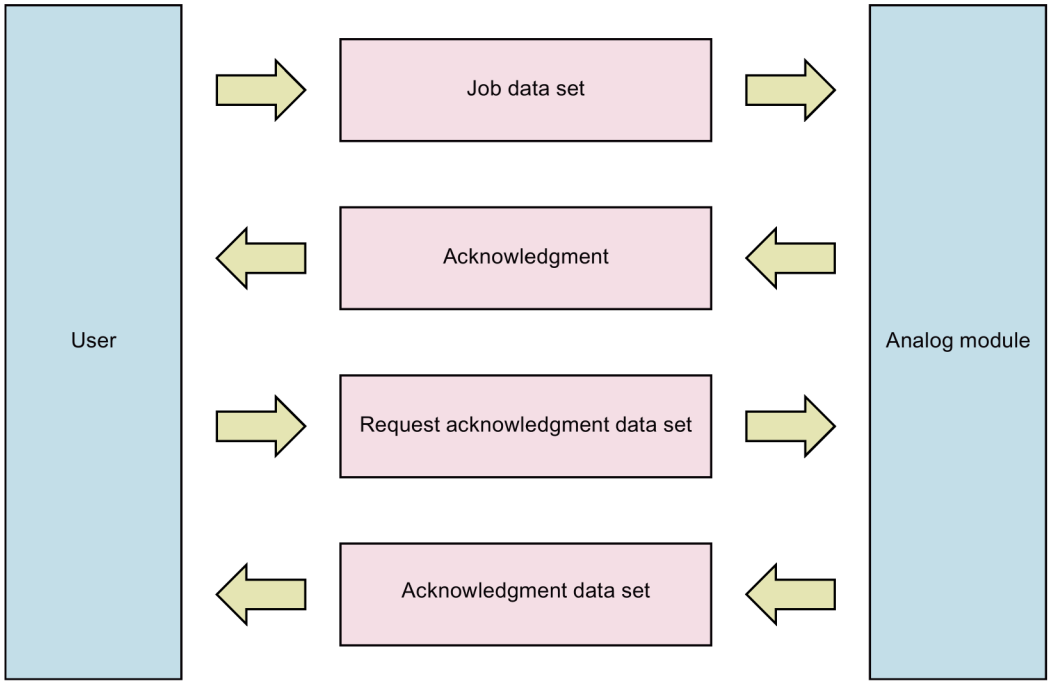

Figure 4-1 Steps in the user calibration for an instruction

The analog module saves the user calibration values. The values always apply only to the input/output range for which they were created. If the input/output range is re-parameterized, the factory calibration values are used once again. But the user calibration values still exist (see section Re-parameterization of the input/output range (Page 26)).

Each user calibration receives a time stamp (for each channel) which includes the date and time of the last user calibration of the channel. You must transfer the date and time to the analog module during calibration, because these values are not generated by the analog module.

The analog module controls the number of required calibration steps for a user calibration.

The actions which you must start or confirm during user calibration are also initiated by the analog module.

The set input/output range of a channel can only be calibrated completely during a user calibration (zero-scale and full-scale). Partial calibration is not possible (e.g., zero-scale only).

4.2 Data set structure

You can start a calibration process with the Write data set (job data set) and Read data set (acknowledgment data set) mechanisms, DS 237 for each.

The structure of the job data set and the acknowledgment data set is identical. This means the acknowledgment data set read last serves as the template for the next job data set.

Job data set and acknowledgment data set also apply to mixed modules with input and output channels. Mixed modules have an input channel and an output channel with channel number 0. To determine if you are calibrating an output channel or an input channel, the channel number for output channels generally has the offset value 40_H added to it.

4.2.1 Job data set

The following table shows the structure of the job data set.

Table 4- 1 Structure of the job data set (18 bytes long)

Byte address	Element	Value range	Format
0	Command/job ID	1: Factory calibration 2: User calibration 3: Abort, normal channel processing 4: Read calibration values 5: Restore factory calibration 6: Reset	Byte
1	Identifier	0 1	Byte
2	Channel number	00_H … $3F_H$ 40_H … $7F_H$ FF_H	Byte
3	Calibration step	FF_H FE_H … 00_H	Byte
4	Not relevant	-	Byte
5	Not relevant	-	Byte
6	Not relevant	-	Byte
7	Input/output size	0: Not relevant 1: mV 2: µA 3: - 4: Time/date 5: Ohm 6: Degrees 7: - 8: - 9: U~ (0.01 V) effective value AC 10: I~ (0.0001 A) effective value AC 11: Phi (0.01 degrees) (phase angle)	Byte
8	Substitute value behavior of inputs	0: retain last value 1: Overflow ($7FFF_H$) 2: Substitute value 3: continue to supply values*	Byte
9	Reserved	-	Byte
10 … 17	Extended Record	See section below Extended Record	

* Only for analog modules AI 4xRTD/TC 2-/3-/4-wire HF and AI 8xRTD/TC 2-wire HF

The tables below show the value ranges of the elements and description of the job data set.

Command/job ID

Table 4- 2 Command/job ID

Value range	Description
1: Factory calibration	Not relevant
2: User calibration	See section User calibration (mode = 2) (Page 28)
3: Abort, normal channel processing	See section Abort (mode = 3) (Page 46)
4: Read calibration values	See section Read calibration values (mode = 4) (Page 48)
5: Restore factory calibration	See section Restore factory calibration (mode = 5) (Page 51)
6: Reset	See section Reset (mode = 6) (Page 53)

Identifier

Table 4- 3 Identifier

Value range	Description
0	Not relevant
1	Execute

Channel number

Table 4- 4 Channel number

Value range	Description
00_H … $3F_H$	Input channels
40_H … $7F_H$	Output channels
FF_H	All channels, only permitted for command = 6 (Reset)

Calibration step

Table 4- 5 Calibration step

Value range	Description
FF_H	Start
FE_H … 00_H	Apply from last acknowledgment data set

Input/output size

Table 4- 6 Input/output size

Value range	Description
0: Not relevant	Specifies how to interpret the values as of byte 10.
1: mV	
2: µA	
3: -	
4: Time/date	
5: Ohm	
6: Degrees	
7: -	
8: -	
9: U~ (0.01 V) effective value AC	
10: I~ (0.0001 A) effective value AC	
11: Phi (0.01 degrees) (phase angle)	

Substitute value behavior of inputs

Table 4- 7 Substitute value behavior of inputs

Value range	Description
0: retain last value	Only relevant for analog input modules. Evaluated at start only.
1: Overflow ($7FFF_H$)	
2: Substitute value	
3: continue to supply values*	

* Only for analog modules AI 4xRTD/TC 2-/3-/4-wire HF and AI 8xRTD/TC 2-wire HF

Extended Record

Table 4- 8 Extended Record for input/output size = 1 (mV), 2 (µA), 5 (Ohm), 6 (Degrees)

Byte address	Element	Format	Value range	Description
10	Date1	Word	-32768 … 32767	Place before the decimal point
12	Date2	Word	-999 … 999	Places after decimal point * 1000
14	Date3	Word	Not used	
16	Substitute value	Word	Not used	

Extended Record for input/output size = 4 (Date/Time), BCD coded: See section Time stamp, date/time (Page 26)

Table 4- 9 Extended Record for input/output size = 9 (U~), 10 (I~), 11 (Phi)

Byte address	Element	Format	Value range	Description
10	Date1	Word	Not used	
12	Date2	Word	Not used	
14	Date3	Word	0 … 65535	Setpoint for calibration operating point
16	Substitute value	Word	Not used	

Table 4- 10 Extended Record for substitute value behavior of inputs = 2 (substitute value)

Byte address	Element	Format	Value range	Description
10	Date1	Word	0	Not relevant
12	Date2	Word	0	Not relevant
14	Date3	Word	0	Not relevant
16	Substitute value	Word	8000_H … $7FFF_H$	Must be within parameterized measuring range

4.2.2 Acknowledgment data set

The following table shows the structure of the acknowledgment data set.

Table 4- 11 Structure of the job or acknowledgment data set (18 bytes long)

Byte address	Element	Value range	Format
0	Command/mode	1: Factory calibration 2: User calibration 3: Abort, normal channel processing 4: Read calibration values	Byte
1	Status/error code	00_H: OK, Working 01_H: OK, Ready ≥ 10_H: Error	Byte
2	Channel number	00_H … $3F_H$ 40_H … $7F_H$ FF_H	Byte
3	Calibration step	FF_H … 00_H	Byte
4	Input/output type	00_H … $F9_H$	Byte
5	Input/output range	00_H … $F9_H$	Byte
6	User action	0: None 1: Short-circuit 2: Feed, connection 3: Measurement 4: Remove connections	Byte
7	Input/output size	0: Not relevant 1: mV 2: µA 3: Calibration values 4: Time/date 5: Ohm 6: Degrees 7: - 8: - 9: U~ (0.01 V) effective value AC 10: I~ (0.0001 A) effective value AC 11: Phi (0.01 degrees) (phase angle)	Byte
8	Calibration counter	00_H … FF_H	Byte
9	Reserved	-	Byte
10 … 17	Extended Record	See section below Extended Record	

The tables below show the value ranges of the elements and description of the acknowledgment data set.

Command/mode

Is mirrored from the command with error-free processing of the job data set.

Table 4- 12 Command/mode

Value range	Description
1: Factory calibration	Not relevant
2: User calibration	See section User calibration (mode = 2) (Page 28)
3: Abort, normal channel processing	See section Abort (mode = 3) (Page 46)
4: Read calibration values	See section Read calibration values (mode = 4) (Page 48)

Status/error code

Table 4- 13 Status/error code

Value range	Description
00_H: OK, Working	Job processing still ongoing
01_H: OK, Ready	Job processing successfully completed
≥ 10_H: Error	See section Status and error codes (Page 24)

Channel number

Table 4- 14 Channel number

Value range	Description
00_H … $3F_H$	Input channels
40_H … $7F_H$	Output channels
FF_H	All channels

Calibration step

Table 4- 15 Calibration step

Value range	Description
FF_H … 00_H	Number of calibration steps still required

Input/output type

Table 4- 16 Input/output type

Value range	Description
00_H … $F9_H$	Currently parameterized input/output type of the channel, see Parameter tables in the sections Format input type/range: Input channels (Page 55) and Format output type/range: Output channels (Page 58)

Input/output range

Table 4- 17 Input/output range

Value range	Description
00_H … $F9_H$	Currently parameterized input/output range of the channel, see Parameter tables in the sections Format input type/range: Input channels (Page 55) and Format output type/range: Output channels (Page 58)

User action

Table 4- 18 User action

Value range	Description
0: None	Indicates how to wire the terminals specified under Terminal1/Terminal2.
1: Short-circuit	
2: Feed, connection	
3: Measurement	
4: Remove connections	

Input/output size

Table 4- 19 Input/output size

Value range	Description
0: Not relevant	Specifies how to interpret the values as of byte 10. For user actions = 2 and 3 the corresponding unit is specified here.
1: mV	
2: µA	
3: Calibration values	
4: Time/date	
5: Ohm	
6: Degrees	
7: -	
8: -	
9: U~ (0.01 V) effective value AC	
10: I~ (0.0001 A) effective value AC	
11: Phi (0.01 degrees) (phase angle)	

Calibration counter

Table 4- 20 Calibration counter

Value range	Description
00_H … FF_H	Number of successful user calibrations 00_H = Factory calibration values

Extended Record

Table 4- 21 Extended Record for input/output size = 1 (mV), 2 (µA), 5 (Ω), 6 (Degrees)

Byte address	Element	Format	Value range	Description
10	Date1	Word	-32768 … 32767	Place before the decimal point
12	Date2	Word	-999 … 999	Place after decimal point * 1000
14	Date3	Word	Not used	
16	Terminal1	Byte	0 … x (0 = invalid)	Terminal at BaseUnit
17	Terminal2	Byte	0 … x (0 = invalid)	Terminal at BaseUnit

Table 4- 22 Extended Record for input/output size = 9 (U~), 10 (I~), 11 (Phi)

Byte address	Element	Format	Value range	Description
10	Date1	Double word	00_H … $FFFFFFFF_H$	Calibration register content (last calibration step executed)
14	Date2	Word	0 … 65535	Setpoint for next step
16	Terminal1	Byte	0 … x (0 = invalid)	Terminal at BaseUnit
17	Terminal2	Byte	0 … x (0 = invalid)	Terminal at BaseUnit

Extended Record for input/output size = 4 (Date/Time): See section Time stamp, date/time (Page 26)

Table 4- 23 Extended Record for input/output size = 3 (calibration values)

Byte address	Element	Format	Value range	Description
10	Date1	Word	Format 1	Offset (converter units)
12	Date2	Word	Format 2	Gain
14	Date3	Word	Module-specific Format 1 or Format 2	Add1
16	Date4	Word		Add2

The values can be output in two formats:

Format 1 (identifier = 0):

WORD, value range -32767 ... +32768

Format 2 (identifier = 1):

Value range -31.999 to +31.999

Table 4- 24 Extended Record: Places before and after the decimal point

2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
VZ	Places before the decimal point (0 … 31)					Places after decimal point * 1000 (0 … 999)									

Format Terminal1/Terminal2:

For user actions = 1, 2, 3, 4 the terminal number of the terminal at BaseUnit are displayed here (1 … x).

Performing user calibration

5

5.1 Calibration start

You must start the user calibration using the job data set with command = 2 (user calibration) and calibration step = FF_H (Start).

An active/running calibration is displayed with Mode = 2 (user calibration) in the acknowledgment data set.

A diagnostic is also reported for analog modules with diagnostic capability:

- Analog modules with channel diagnostics signal error 31 (Channel temporarily unavailable) for the affected channel, channel fault LED lights up red, the module fault LED flashes.
- Analog modules which support the value status (QI) set QI to "BAD".

The user calibration can be started at any time. The start requires that the channel was parameterized without errors and that it is not already in another calibration mode which can be recognized by command 3 and status > 00_H in the acknowledgment data set:

- After starting the user calibration and until it is completed, only command = 2 is accepted and processed for this channel.
  All other commands result in the user calibration being aborted.
- The acknowledgment data set is generated immediately by mirroring it from the job data set and entering it in the status = 00_H (OK, Working).
- After completing the calibration step, the acknowledgment data set is updated and the status > 00_H is set:
  - The command was accepted with status = 01_H (OK, Ready). The number of steps that still have to executed is specified in the calibration step. The action that you need to execute next is specified in the user action.
  - For user action = 1 (Short-circuit), 2 (Infeed), 3 (Measuring) and 4 (Remove connections), the relevant terminals are specified in the Extended Record under Terminal1 and Terminal2 whereby Terminal1 is always the positive terminal.
  - For user action = 2 (Infeed) or 3 (Measuring) the unit is specified for measured variable (e.g., µA or mV).
  - For status > 10_H, an error was detected and calibration was aborted. In Command/Mode, "Abort, normal channel processing" is signaled. The analog module resumes the same status as before calibration was started.

5.2 Calibration sequence

Each calibration step is triggered by writing the job data set with calibration step = FF_H (for start) or FE_H … 00_H, applied from the previously signaled acknowledgment data set and identifier = 01_H.

Next the analog module has to read and evaluate the acknowledgment data set.

- For status = 00_H (OK, Working), the calibration of the analog module initiated with the job data set is still in progress.
- For status = 01_H (OK, Ready), the calibration of the analog module initiated with the job data set is complete and was processed without errors.
- For status ≥ 10_H (Error), the calibration of the analog module initiated with the job data set was not processed successfully and was acknowledged with an error. The ongoing calibration is aborted and any determined calibration values are discarded.

Note

Non-relevant elements

Elements that are not relevant for a calibration step are not taken into consideration by the module. The user calibration is not aborted by these elements.

5.3 Calibration exit

You can exit the calibration in any calibration step by means of a job data set with command = 3 (Abort, normal channel processing). Any calibration values determined until then are lost. The analog module resumes the same status as before calibration was started. If user calibration values existed before the calibration, these will become effective again after the abort. If no user calibration values existed, the factory calibration values are still in effect.

Any calibration initiated previously can also be aborted with the following actions:

- POWER OFF/POWER ON of the supply voltage
- Pulling & plugging of the analog module
- Re-parameterization of the analog module
- Re-parameterization of the analog module
- Firmware update of the analog module

5.4 Calibration completion

The last calibration step is the confirmation of the calibration or of the determined calibration values. This calibration step is initialized by the analog module for a user calibration with calibration step = 1 in the acknowledgment data set. All calibration values of the current calibration process are determined and signaled back.

Confirm the calibration values with the job data set and calibration step = 1. With input/output size = 4 (Date/Time) a time stamp in S7 BCD format is entered starting with byte 10 (see section Time stamp, Date/Time (Page 26)).

As soon as the calibration values and the time stamp of the analog module have been checked and applied, mode = 3 (normal channel processing) and status = 01_H (OK, Ready) are signaled in the acknowledgment data set. The channel number, the input/output type and the input/
output range remain the same; the remaining data equals zero.

The newly determined calibration values are now valid and in effect.

The previous user calibration values are overwritten and cannot be restored.

In case of an error in the last calibration step (e.g., error in time stamp), the corresponding error code is signaled in the status. The new calibration values are discarded.

5.5 Status and error codes

Table 5- 1 Status codes

Status code	Description
00_H	OK, Working; job in progress
01_H	OK, Ready; job executed without error
02_H … $0F_H$	Reserved

Calibration is aborted with an error if an error occurs during calibration.

Table 5- 2 Error codes

Error codes	Description	Remedy/Cause
General errors of the calibration process		
10_H	Invalid command	Correct job data set; table Command/job ID (Page 12)
11_H	Invalid channel number	Correct job data set; table Identification (Page 12)
12_H	Invalid identification	Correct job data set; table Channel number (Page 12)
13_H	Invalid calibration step	Correct job data set; table Calibration step (Page 12)
14_H	Error in input/output type or input/ output range	Input/output type or input/output range cannot be scaled; see Analog Module Manual
15_H	Invalid module action	Irrelevant for user calibration
16_H	Invalid input/output size information	Extended Record, invalid content; Correct job data set (Page 11)
17_H	Reserved	–
18_H	Time stamp error (year)	Invalid time stamp; correct job data set; section Time stamp, Date/Time (Page 26)
19_H	Time stamp error (month)	
$1A_H$	Time stamp error (day)	
$1B_H$	Time stamp error (hour)	
$1C_H$	Time stamp error (minute)	
$1D_H$	Time stamp error (day of the week)	
$1E_H$	Invalid substitute value behavior of inputs	Correct job data set; table Substitute value behavior of inputs (Page 13)
$1F_H$	Substitute value out of the measuring range	

Error codes	Description	Remedy/Cause
Technology errors		
20_H	Value measured by user deviates too much from setpoint	Circuit, check measuring technique; correct job data set
21_H	Value supplied by user deviates too much from setpoint	Circuit, check infeed technique
22_H … 23_H	Reserved	–
24_H	User calibration not supported	See Analog Module Manual
25_H … $2F_H$	Reserved	–
System errors/general module errors		
30_H	Error writing to EEPROM/Flash	Replace analog module
31_H	Error in procedure	A job data set with a command other than the one active came in during the calibration process. Follow procedure; see section Example (Page 28)
32_H	Channel not parameterized	Correct configuration/parameter assignment
33_H	Reserved	–
34_H	Abort due to parameter assignment during ongoing calibration	See section Behavior with parameter assignment of analog modules during calibration (Page 27)
35_H … $3F_H$	Reserved	–
Other faults/errors		
40_H	Reserved	–
41_H	No calibration values available	No calibration values available to delete; See section Prepare factory calibration (mode = 5) (Page 51) and Reset (mode = 6) (Page 53)
42_H … FF_H	Reserved	–

5.6 Time stamp, Date/time

During user calibration, you transfer the date and time of the synchronization to the analog module in calibration step = 1 Date and time.

When reading the calibration values (command = 4), the date and time of the read calibration values are output in calibration step = 1.

Both take place with measured variable = 4 as time stamp in the acknowledgment data set as well as in the job data set as of byte 10 in S7 BCD format.

Byte address	Value	Format	Value range
10	Year	Byte	00_H = 2000, 99_H = 2099
11	Month	Byte	01_H … 12_H
12	Tag	Byte	01_H … 31_H
13	Hour	Byte	00_H … 23_H
14	Minute	Byte	00_H … 59_H
15	Second	Byte	00_H … 59_H
16	ms	Byte	00_H … 99_H
17.4 … 17.7	ms	High nibble	0_H … 9_H
17.0 … 17.3	Day of the week	Low nibble	0 = undefined 1 = Sunday 2 = Monday 3 = Tuesday 4 = Wednesday 5 = Thursday 6 = Friday 7 = Saturday

5.7 Re-parameterization of the input/output range

If you have conducted a user calibration on a channel, the user calibration values are in effect for this channel. The user calibration values always apply only to the input/output range for which they were created. If the input/output range is re-parameterized to another input/output range, the factory calibration values are used once again for this range. The user calibration values still exist.

When you start a user calibration in the new input/output range, the new calibration values are saved for this new input/output range. The user calibration values of the previous input/output range are overwritten because only one user calibration can be saved per channel.

If you do not start user calibration and switch back to the previous input/output range, the previous user calibration values will be in effect once again.

Other channel parameters (e.g., interference frequency suppression) have no effect on the validity of the calibration values.

5.8 Calibration counter

Each error-free and complete user calibration of a channel is counted. More than 255 calibration processes do not increase the calibration counter.

The current counter status (including ongoing calibration) is displayed in calibration step = 1 together with the currently determined calibration values. When you acknowledge this calibration step with the job data set, the calibration counter is saved retentively with the determined user calibration values and will be in effect.

Each command = 5 (Restore factory calibration) or 6 (Reset) deletes the calibration counter.

A re-parameterization of the input/output ranges does not delete the calibration counter.

When you start a user calibration in the new input/output range, the calibration counter is reset and starts counting from 1 again.

If you do not start user calibration and switch back to the previous input/output range, the previous user calibration values will be in effect once again.

5.9 Behavior at CPU-STOP

Reading and writing of data sets is not possible in CPU STOP.

5.10 Behavior with parameter assignment of analog modules during calibration

Each parameter data set that comes in during an ongoing user calibration results in the calibration being aborted.

The acknowledgment data set is updated with a corresponding error message.

Example

6

6.1 User calibration (mode = 2)

All processes described below are based on the initial state of the acknowledgment data set.

Byte	Element	Value
0	Mode	3: normal channel processing
1	Status/error code	> 0
2	Channel number	X
3	Calibration step	FF_H*
4	Input/output type	0
5	Input/output range	0
6	User action	0: None
7	Input/output size	0
8	Calibration counter	0
9	Reserved	0
10	Date1	0
12	Date2	0
14	Date3	0
16	Terminal1	0
17	Terminal2	0

* The calibration step can only take place immediately after run-up FF_H. After completion/abort of a calibration step, "0 = no more steps" is signaled.

Only the data necessary for the current calibration step are entered in the job/ acknowledgment data set.

- The command and the channel number must remain the same for each job data set of a calibration sequence; otherwise, the calibration is aborted.
- The calibration step must be transferred to the analog module again in each job data set according to the last acknowledgment data set. The start is an exception.
- The channel must be parameterized.
- A job data set may only be transferred to the analog module with status > 00_H.
- The current calibration step is to be executed with identifier = 1 in the job data set.

6.1.1 Example: Analog input module RTD (resistance thermometer)

6.1.1.1 Step A: Start

Job data set:

Start the user calibration with channel X. The specified substitute value behavior of the inputs and the substitute value apply to the triggered calibration and are evaluated and applied by the analog module during the initial call only.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H: Start
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	0: retain last value
9	Reserved	
10	Date1	
12	Date2	
14	Datem3	
16	Substitute value	

Acknowledgment data set:

The analog module acknowledges the change to user calibration (mode = 2) with channel = X and status = 00_H (OK, Working). As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data. The input/output range currently set on this channel as well as the number of required calibration steps is signaled. The analog module requests channel X in the next calibration step; short-circuit at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**4 more steps**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			1: Short-circuit
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

6.1.1.2 Step B: Zero-Scale calibration

Job data set:

Acknowledge calibration step 4. The requested action (short-circuit terminals Y, Z) is finished.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	4
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented. The analog module requests channel X in the next calibration step; infeed; remove connections.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	4		**3 more steps**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			4: Remove connections
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

6.1.1.3 Step C: Intermediate step

Job data set:

Acknowledge calibration step 3. The requested action (remove connections at terminals Y, Z) is finished.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	3
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented. The analog module requests channel X in the next calibration step; infeed 390.5 Ω at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	3		**2 more steps**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			2: Infeed
7	Input/output size			5: Ohm
8	Calibration counter			
9	Reserved			
10	Date1			390
12	Date2			500
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

6.1.1.4 Step D: Full-Scale calibration positive

Job data set:

Acknowledge calibration step 2. The requested action (infeed 390.5 Ω at terminals Y, Z) is finished.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	2
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented. The calibration values determined by the analog module are signaled (identified by measured variable = 3). The offset is in Date1, the gain in Date2, Add1 in Date3 (if present) and Add2 in Date4 (if present).

The number of successful calibration processes is signaled for this input/output range in the calibration counter.

1 is not signaled back in calibration step, which means the last calibration step.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	2		**1 more step**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			0: None
7	Input/output size			3: Calibration values
8	Calibration counter			X: 1 … 255
9	Reserved			
10	Date1			Offset
12	Date2			Gain
14	Date3			Add1
16	Date4			Add2

6.1.1.5 Step E: Closure

Job data set:

Acknowledge calibration step 1. The synchronization values signaled by the analog module are accepted. You must enter the date and the time with measured variable = 4 in S7 BCD format as of byte 10.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	1
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	4: Date/time
8	Substitute value behavior	
9	Reserved	
10	Date/time	Date and time in S7 BCD format

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), the determined calibration values and date/time are applied and saved.

0 is not signaled back in calibration step, which means no more calibration steps. Calibration complete.

Byte	Element	Value		Value
0	Mode	2: User calibration		3: normal channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	1		**0 (ready now)**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			0
7	Input/output size			0
8	Calibration counter			0
9	Reserved			0
10	Date1			0
12	Date2			0
14	Date3			0
16	Terminal1			0
17	Terminal2			0

6.1.2 Example: Analog output module +/-10 V

6.1.2.1 Step A: Start

Job data set:

Start the user calibration with channel X.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H: Start
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

The analog module acknowledges the change to user calibration (mode = 2) with channel = X and status = 00_H (OK, Working). As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The input/output range currently set on this channel as well as the number of required calibration steps is signaled.

The analog module requests channel X in the first calibration step; measuring at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**3 more steps**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			3: Measurement
7	Input/output size			1: mV
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

6.1.2.2 Step B: Zero-Scale calibration

Job data set:

Acknowledge calibration step 3. The requested action (voltage measuring at terminals Y, Z) is finished. The measured voltage is transferred to the analog module in Date1 in the unit specified under measured variable. The place in front of the decimal point of the voltage in mV is entered in Date1, and the value after the decimal point of the voltage in mV multiplied by 1000 is entered in Date2. Example: 15.6 mV.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	3
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	1: mV
8	Substitute value behavior	
9	Reserved	
10	Date1	15
12	Date2	600
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented.

The analog module requests channel X in the next calibration step; measuring at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	3		**2 more steps**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			3: Measurement
7	Input/output size			1: mV
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

6.1.2.3 Step C: Intermediate step

Job data set:

Acknowledge calibration step 2. The requested action (voltage measuring at terminals Y, Z) is finished. The measured voltage is transferred to the analog module in Date1 in the unit specified under measured variable. The place in front of the decimal point of the voltage in mV is entered in Date1, and the value after the decimal point of the voltage in mV multiplied by 1000 is entered in Date2. Example: 9986.3 mV.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	2
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	1: mV
8	Substitute value behavior	
9	Reserved	
10	Date1	9986
12	Date2	300
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented. The calibration values determined by the analog module are signaled (identified by measured variable = 3). The offset is in Date1, the gain in Date2, Add1 in Date3 (if present) and Add2 in Date4 (if present). The number of successful calibration processes is signaled for this input/output range in the calibration counter.

1 is not signaled back in calibration step, which means the last calibration step.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	2		**1 more step**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			0: None
7	Input/output size			3: Calibration values
8	Calibration counter			X: 1 … 255
9	Reserved			
10	Date1			Offset
12	Date2			Gain
14	Date3			Add1
16	Date4			Add2

6.1.2.4 Step D: Full-Scale calibration positive

Job data set:

Acknowledge calibration step 1. The synchronization values signaled by the analog module are accepted.

You must enter the date and the time with measured variable = 4 in S7 BCD format as of Date1.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	1
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	4: Date/time
8	Substitute value behavior	
9	Reserved	
10	Date1	Date and time in S7 BCD format

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), the determined calibration values and date/time are applied and saved.

0 is not signaled back in calibration step, which means no more calibration steps. Calibration complete.

Byte	Element	Value		Value
0	Mode	2: User calibration		3: normal channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	1		**0 (ready now)**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			0
7	Input/output size			0
8	Calibration counter			0
9	Reserved			0
10	Date1			0
12	Date2			0
14	Date3			0
16	Terminal1			0
17	Terminal2			0

6.2 Abort (mode = 3)

6.2.1 User abort

Job data set:

An ongoing calibration can be aborted in any calibration step and in any state, even with status = 00_H (OK, Working), with the command = 3 (Abort, channel processing).

Byte	Element	Value
0	Command	3: Abort, channel processing
1	Identifier	
2	Channel number	X
3	Calibration step	
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (abort, normal channel processing), the calibration of channel X is aborted. The channel has the same state as before the calibration. The input/output range currently set on the channel is signaled.

Byte	Element	Value		Value
0	Mode	3: Abort, channel processing		3: Abort, channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step			0
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			0
7	Input/output size			0
8	Calibration counter			0
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			
17	Terminal2			

6.2.2 Module abort

If the analog module detects an error during a calibration process, this error aborts the calibration. The error code is signaled in the status.

See also

Calibration exit (Page 22)

6.3 Read calibration values (mode = 4)

All current calibration values of an analog module channel are read with command = 4 (Read calibration values); these are either the values from the factory calibration or the user calibration.

The command is only permitted in status > 00_H. The channel number must be specified and the calibration step must be set to FF_H (Start).

6.3.1 Step A: Start

Job data set:

Byte	Element	Value
0	Command	4: Read calibration values
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H: Start
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data. Measured variable = 3 identifies the data as of Date1 as calibration values. Only the current calibration values of the specified channel are read with command = 4; these are the calibration values associated with the parameterized input/output range.

Byte	Element	Value		Value
0	Mode	4: Read calibration values		4: Read calibration values
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		1 more step
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			0: None
7	Input/output size			3: Calibration values
8	Calibration counter			X: 0 … 255
9	Reserved			0
10	Date1			Offset
12	Date2			Gain
14	Date3			Add1
16	Date4			Add2

The input/output range currently set on the channel is signaled.

The offset is in Date1, the gain in Date2, Add1 in Date3 (if present) and Add2 in Date4 (if present).

The calibration counter specifies if the values are factory calibration values (calibration counter = 0) or user calibration values (calibration counter > 0). For user calibration values, the value of the calibration counter is equal to the number of successful calibration processes for this input/output range (since the last user calibration of a different input/output range).

Calibration step = 1 indicates that one more step is necessary.

6.3.2 Step B: Closure

Job data set:

Acknowledge calibration step 1.

Byte	Element	Value
0	Command	4: Read calibration values
1	Identifier	
2	Channel number	X
3	Calibration step	1
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data. Measured variable = 4 identifies the data as of Date1 Time stamp. A time stamp that matches the previously read calibration values is signaled.

Byte	Element	Value		Value
0	Mode	4: Read calibration values		3: normal channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	1		0
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			0: None
7	Input/output size			4: Date/time
8	Calibration counter			X: 0 … 255
9	Reserved			
10	Date/time			Date and time in S7 BCD format

6.4 Restore factory calibration (mode = 5)

Use command = 5 (Restore factory calibration) to undo the executed user calibration of the specified channel for the set input/output range. The analog module applies the calibration values determined at the factory which will be in effect again. Delete saved user calibration values.

If user calibration values of the channel exist which do not belong to the set input/output range, these are not deleted.

The command is only permitted in status > 00_H.

Specify the channel number and set the calibration step to FF_H (Start).

The calibration counter is set to 0 again with this command.

Job data set:

Byte	Element	Value
0	Command	5: Restore factory calibration
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), restoration is complete. The user calibration was deleted and the channel continues operating in the previous state with factory calibration values.

Byte	Element	Value		Value
0	Mode	5: Restore factory calibration		3: normal channel processing
1	Status/error code	00: OK, Working		01: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**0 (ready now)**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 … 10 V
6	User action			
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			
17	Terminal2			

6.5 Reset (mode = 6)

Use the command = 6 (Reset) to restore the factory calibration for a channel or the entire analog module regardless of the parameter assignment of the channels.

The factory calibration of a channel is restored according to the channel number, and any saved user calibration values are deleted (even if the saved user calibration values do not belong to the currently set input/output range). With channel number FF_H, restoration takes place for all channels of the analog module.

The command is only permitted in status > 00_H. Set the calibration step to FF_H (Start). The channel or the analog module must not be parameterized.

The involved calibration counters are set to 0 again with this command.

Job data set:

Byte	Element	Value
0	Command	6: Reset
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), reset is complete. The user calibration values were deleted. All channels involved continue operating in their previous state with factory calibration values.

Byte	Element	Value		Value
0	Mode	6: Reset		3: normal channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**0 (ready now)**
4	Input/output type			
5	Input/output range			
6	User action			
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			
17	Terminal2			

Appendix A

A

A.1 Input type/range format: Input channels

Input type format: Input channels

$Value_D$	Input type
00	Deactivated
01	Voltage
02	Current (4-wire transducer)
03	Current (2-wire transducer)
04	resistance (4-wire connection)
05	resistance (3-wire connection)
06	resistance (2-wire connection)
07	Thermal resistance (linear, 4-conductor connection)
08	Thermal resistance (linear, 3-conductor connection)
09	Thermal resistance (linear, 2-conductor connection)
10	Thermocouple

Input range format: Input channels

An input type that is not as listed in this table can also be used for specific modules. You must note, however, that the input type in the acknowledgment data set no longer matches the general definition.

$Value_D$	Input type
For input type = 01 (voltage)	
00	± 25 mV
01	± 50 mV
02	± 80 mV
03	± 250 mV
04	± 500 mV
05	± 1 V
06	± 1.25 V
07	± 2.5 V
08	± 5 V
09	± 10 V
10	1 … 5 V
11	0 … 10 V

Value$_D$	Input type
For input type = 02, 03 (current)	
00	± 3.2 mA
01	± 10 mA
02	0 … 20 mA
03	4 … 20 mA
04	± 20 mA
05	± 5 mA
For input type = 04, 05, 06 (resistor: 4-wire, 3-wire , 2-wire connection)	
00	48 Ω
01	150 Ω
02	300 Ω
03	600 Ω
04	3000 Ω
05	6000 Ω
06	10000 Ω
15	PTC (DIN VDE 0660 Part 303 Type A)
For input type = 07, 08, 09 (thermistor: 4-wire, 3-wire , 2-wire connection)	
00	Pt100 climatic range
01	Ni100 climatic range
02	Pt100 Standard range
03	Ni100 standard range
04	Pt500 standard range
05	Pt1000 standard range
06	Ni1000 standard range
07	Pt200 climatic range
08	Pt500 climatic range
09	Pt1000 climatic range
10	Ni1000 climatic range
11	Pt200 standard range
12	Ni120 standard range
13	Ni120 climatic range
14	Cu10 climatic range
15	Cu10 standard range
16	Ni200 standard range
17	Ni200 climatic range
18	Ni500 standard range
19	Ni500 climatic range
20	Pt10 standard range
21	Pt10 climatic range
22	Pt50 standard range
23	Pt50 climatic range
24	Cu50 standard range

Value$_D$	Input type
25	Cu50 climatic range
26	Cu100 standard range
27	Cu100 climatic range
28	LG Ni1000 standard range
29	LG Ni1000 climatic range
For input type = 10 (thermocouple)	
00	Type B [PtRh-PtRh]
01	Type N [NiCrSi-NiSi]
02	Type E [NiCr-CuNi]
03	Type R [PtRh-Pt]
04	Type S [PtRh-Pt]
05	Type J [Fe-CuNi]
06	Type L [Fe-CuNi] recalled since 1994 standard (DIN 43710)
07	Type T [Cu-CuNi]
08	Type K [NiCr-Ni]
09	Type U [Cu-CuNi] recalled since 1994 standard (DIN 43710)
10	Type C [W5Re-W26Re]
11	TXK/XK(L) [TXK/XK(L)]

A.2 Output type/range format: Output channels

Output type format: Output channels

An output type that is not as listed in this table can also be used for specific modules. You must note, however, that the output type in the acknowledgment data set no longer matches the general definition.

$Value_D$	Output type
00	Deactivated
01	Voltage
02	Current (4-wire transducer)
03	Current (2-wire transducer)

Output range format: Output channels

$Value_D$	Output range
For output type = 01 (voltage)	
00	± 10 V
01	± 5 V
02	0 … 10 V
03	1 … 5 V
04	± 2.5 V
05	± 1 V
For output type = 02, 03 (current)	
00	± 20 mA
01	0 … 20 mA
02	4 … 20 mA

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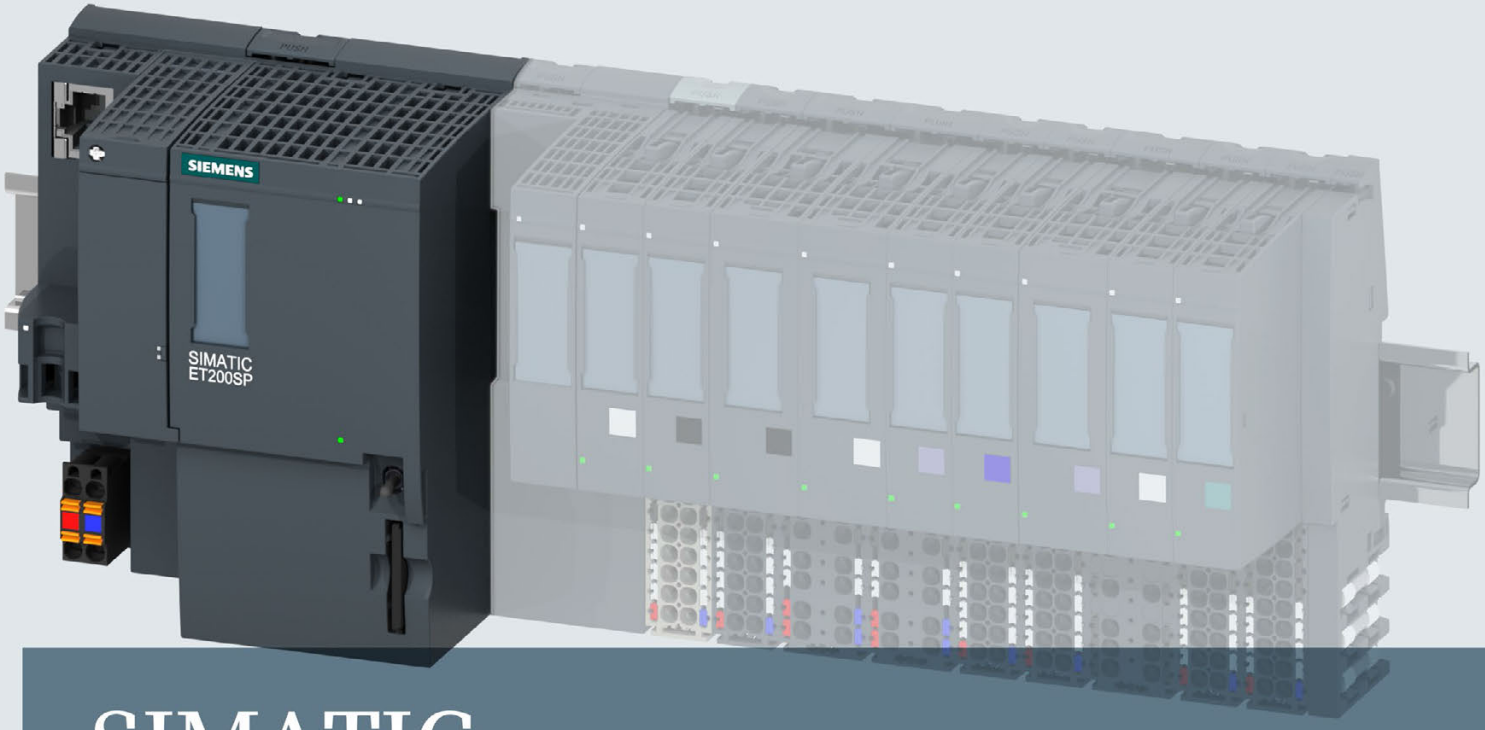

SIMATIC

ET 200SP

CPU 1510SP-1 PN (6ES7510-1DJ01-0AB0)

Manual

Edition 09/2016

siemens.com

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SIMATIC

ET 200SP
CPU 1510SP-1 PN
(6ES7510-1DJ01-0AB0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual as well as the function manuals. This manual contains a description of the module-specific information. The system-related functions are described in the system manual. All system-spanning functions are described in the function manuals.

The information provided in this manual and the system manual allows you to commission the CPU 1510SP-1 PN.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe the notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

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Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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- **Product support**

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- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

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- **Forums**

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Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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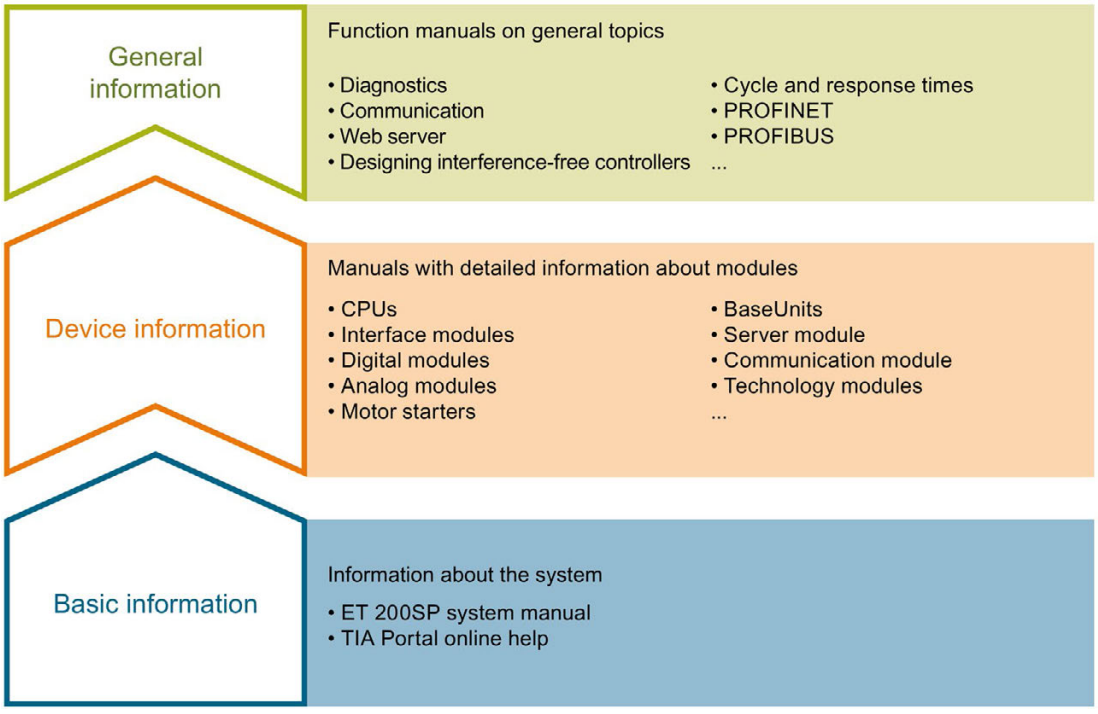
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

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You need to register once to use the full functionality of "mySupport".

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You can export the manual in PDF format or in an editable format.

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"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 New functions in firmware version V2.0

New functions of the CPU in firmware version V2.0

This section lists the new features of the CPU with firmware version V2.0.

You can find additional information in the sections of this manual.

Table 2- 1 New functions of the CPU with firmware version 2.0 compared with firmware version V1.8

New functions	Applications	Customer benefits
OPC UA server	You realize the data communication between different systems, both within the process level and on the control and enterprise levels: • To embedded systems with controllers • To controllers with MES systems and systems of the enterprise level (ERP, asset systems) • To Siemens controllers with controllers from other manufacturers • To intelligent sensors with controllers Supported standard: OPC Data Access, DA.	OPC UA is a unified standard for data communication and is independent of any particular operating system platforms. You have integrated security mechanisms on different automation systems, for example, for data exchange, on the application level, for authentication of the user. OPC UA servers provide a large amount of data: • Values of PLC tags that clients can access • Data types of these PLC tags • Information about the OPC UA server itself and the CPU In this way, clients can gain an overview and can read and write values.
PROFINET IO		
MRPD: Media Redundancy for Planned Duplication for IRT	PROFINET IO IRT enables you to realize applications that place particularly high demands on failure safety and accuracy (isochronous).	By sending the cyclic IO data in both directions in the ring, the communication to the IO devices is maintained even when the ring is interrupted and does not result in device failure even with fast update times. You achieve higher failure safety than with MRP.
PROFINET performance upgrade	You can develop applications with high demands on speed and clock cycles. This is interesting for applications with high demands on performance.	Better utilization of the bandwidth results in short reaction times.
Limitation of the data infeed into the network	You limit the network load for standard Ethernet communication to a maximum value.	You smooth peaks in the data infeed. You share the remaining bandwidth based on requirements.

New functions	Applications	Customer benefits
Web server		
Backing up and restoring via the Web server	You can, for example, backup and restore the configuration of the CPU to the PG/PC on which the Web server is running.	You can make a backup copy of an operational project without STEP 7. In an "emergency", you can simply use an existing configuration without STEP 7, for example, during commissioning or after a program download.
Web server provides up to three project languages for comments and alarm texts	When you export your plants worldwide, for example, comments or alarm texts can be stored on the card in up to 3 languages. For example, German - author's language, English - internationally usable, Portuguese - end user's language.	You provide customers with better service.
Trace via Web server	When you enable trace functions via the Web server, you have better service support. You can send your trace recordings via Web service, for example, to your service partner.	You get plant/project information for diagnostics and maintenance requirements without STEP 7. You can provide trace recordings for each Web server. You save time in troubleshooting.
Monitoring of configured technology objects via a Web server	You can monitor statuses, errors, technology alarms and the current values of technology objects (TOs) with the Web server.	
Motion control		
Greater number of axes for Motion Control applications and new technology objects: Output cam, cam track and measuring input	Speed specification, e.g. for: • Pumps, fans, mixers • Conveyor belts • Auxiliary drives Positioning tasks, e.g.: • Lifting and vertical conveyors • Feeding and gate control • Palletizing equipment Output cams and cam tracks make other applications possible, e.g.: • Applying glue tracks • Triggering switching operations with precise positioning • Very precise processing of products on a conveyor belt Measuring inputs are used, for example: • For measuring products • For detecting the position of the product on a conveyor belt	You can implement additional Motion Control applications with a CPU. The scalable configuration limits allow you to handle all types of application. High machine speeds result in greater productivity with better accuracy.

New functions	Applications	Customer benefits
ET 200SP		
Support for ET 200AL in a central configuration	You can set up a simple connection of IP 65/67 I/O to the CPU. You can connect up to 16 ET 200AL I/O modules via a BA send module on the central bus of the ET 200SP CPU. The distance between two ET 200AL modules can be up to 15 m. You can realize the use of ET 200AL in assembly and handling engineering directly at moving parts, for example in linear axes or drag chains.	You do not have to individually run sensors or actuators at the central control cabinet to the different sections of a machine or assembly line. You save time and costs: • Through lightweight construction • Reduction of wear and exposure to vibration • Increased productivity
Increasing the address space in the station	For example, you can use up to 49 ET 200SP energy meter modules behind an ET 200SP CPU.	A larger address space of 2560 bytes (2048 bytes for ET 200SP module + 512 bytes for ET 200AL modules) is available in the station. The address space has been increased to 288 bytes per module.
Support for communications processors		
CP 1542SP-1	Flexible expansion of the ET 200SP system with an additional Ethernet interface; network separation.	
CP 1542SP-1 IRC	Seamless data recording with time stamping, support for standardized telecontrol protocols DNP3 and IEC.	
CP 1543SP-1 ISEC	With the integrated security functions firewall (Stateful Inspection) and VPN protocol (IPSec), the communications processor protects ET200SP stations and subordinate networks against unauthorized access, and employs encryption to protect data transmission against manipulation and espionage.	

2.2 Operating principle

The CPU contains the operating system and executes the user program. The user program is located on the SIMATIC memory card and is processed in the work memory of the CPU.

The PROFINET interfaces on the CPU allow simultaneous communication with PROFINET devices, PROFINET controllers, HMI devices, programming devices, other controllers and other systems. The CPU 1510SP-1 PN supports operation as an IO controller, I-device or standalone CPU.

With its optional PROFIBUS interface, CM DP, CPU 1510SP-1 PN supports the configuration of PROFIBUS networks in addition to PROFINET IO. When you use the interface as a PROFIBUS DP interface, you can configure the CPU 1510SP-1 PN as a DP master or as an intelligent DP slave (I-slave).

IO controller

CPU 1510SP-1 PN sends and receives data from the connected IO devices within a PROFINET IO system. You can operate the CPU with a maximum of 64 connected IO devices, a maximum of 64 of which use IRT (Isochronous Real Time).

I-device

The "I-device" (intelligent IO device) functionality allows you to exchange data with an IOcontroller. CPU 1510SP-1 PN thus fulfills the role of an intelligent distributed pre-processing unit for sub-processes. The I-device is connected as an IO device to a higher-level IO controller for this purpose.

Advantages:

- Interference-resistant configuration due to short signal and encoder wiring
- Reduced wiring requirements for transmission of the data via PROFINET

Standalone CPU

You can also use the CPU 1510SP-1 PN in the ET 200SP distributed I/O system as a "central system" without a higher-level controller.

DP master

To use the ET 200SP as a DP master, you need the CPU and the optional communication module, CM DP. When used as a DP master, ET 200SP exchanges data with the connected DP slaves via PROFIBUS DP.

Intelligent DP slave (I-slave)

To use the ET 200SP as an intelligent DP slave (I-slave), you need the CPU and the optional communication module, CM DP. As an I-slave, the ET 200SP CPU is connected via PROFIBUS DP to a higher-level DP master and exchanges data with it.

2.3 Properties

Article number

6ES7510-1DJ01-0AB0

View of the module

The following figure shows the CPU 1510SP-1 PN.

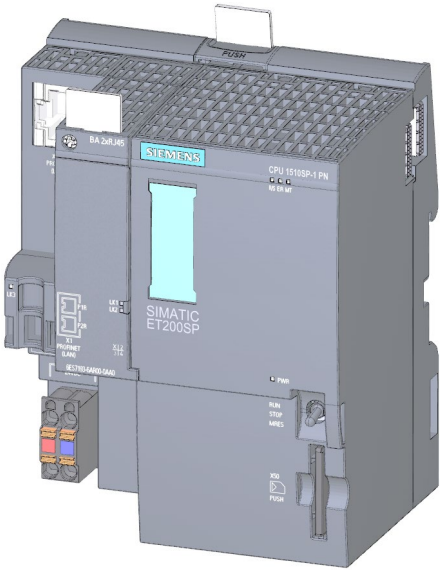


Figure 2-1 CPU 1510SP-1 PN

Properties

The CPU 1510SP-1 PN has the following technical properties:

- Communication:
  - Interfaces

    The CPU 1510SP-1 PN has a PROFINET interface (X1 P3) with an integrated 3-port switch. Port 1 and port 2 are located on the optionally pluggable BusAdapter. Port 3 is integrated in the housing of the CPU. The CPU supports the BusAdapters BA 2xRJ45 and BA 2xFC. You connect the PROFINET IO to the CPU via the BusAdapter.

    In addition to PROFINET basic functionality, the interface also supports PROFINET IO RT (real-time) and IRT (isochronous real-time). PROFINET IO communication or real-time settings can be configured. The basic functionality of PROFINET supports HMI communication, communication with the configuration system, communication with a higher-level network (backbone, router, Internet) and communication with another machine or automation cell.

    Port 1 and port 2 can also be used as ring ports for the configuration of redundant ring structures in Ethernet.

    Note

    The CPU is delivered without a BusAdapter. You can find the article numbers of the supported BusAdapters in the "Accessories/spare parts" section of the ET 200SP distributed automation system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

    The CM DP is optionally available with a PROFIBUS interface (X2). You can find additional information about this expansion module in the manual Communication module CM DP (http://support.automation.siemens.com/WW/view/en/90156526).

    You can find information about connecting the PROFINET IO BusAdapter to the CPU as well as connecting the optional PROFIBUS interface to the interface module in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

  - OPC UA
    With OPC UA, data is exchanged via an open and vendor-neutral communication protocol. The CPU, as OPC UA server, can communicate with OPC UA clients such as HMI panels, SCADA systems, etc.

- Integrated Web server:

  A Web server is integrated in the CPU. You can read out the following information with the Web server:

  – Start page with general CPU information
  – Identification information
  – Contents of the diagnostics buffer
  – Query of module states
  – Firmware update
  – Alarms (without acknowledgment option)
  – Information about communication
  – PROFINET topology
  – Tag status, writing tags
  – Watch tables
  – Memory usage
  – User pages
  – Data logs (if used)
  – Online backup and restoration of the configuration.
  – Diagnostic information for the motion control technology objects
  – Display of trace recordings stored on the SIMATIC memory card
  – Readout service data
  – Basic Web pages
  – Display of the Web server in 3 project languages, for example, comments and message texts
  – Recipes
  – User-defined Web pages

- Integrated technology:
  - Motion Control

    The Motion Control functionality uses technology objects to support speed-controlled axes, positioning axes, synchronous axes, external encoders, cams, cam tracks and measuring inputs, as well as PLCopen blocks for programming the motion control functionality.
    You can find a detailed description of the use of Motion Control and its configuration in the S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/109739589) function manual.
    You can also use the TIA Selection Tool (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool) or the SIZER (http://w3.siemens.com/mcms/mc-solutions/en/engineering-software/drive-design-tool-sizer/Pages/drive-design-tool-sizer.aspx) to create or configure axes.
  - Integrated closed-loop control functionality

    - PID Compact (continuous PID controller)

    - PID 3Step (step controller for integrating actuators)

    - PID Temp (temperature controller for heating and cooling with two separate actuators)
- Trace functionality:
  - Trace functionality supports you in troubleshooting and optimizing the user program, especially for motion control or closed-loop control applications. Trace only supports saves measurements on a SIMATIC memory card. You will find additional information on "Trace" in the Using the trace and logic analyzer function (http://support.automation.siemens.com/WW/view/en/64897128) function manual.
- Integrated system diagnostics:
  - The alarms for the system diagnostics are automatically created by the system and displayed on a PG/PC, HMI device or the Web server. System diagnostics information is also available when the CPU is in STOP mode.

- Integrated security:
  - Know-how protection

    The assignment of passwords protects user blocks against unauthorized access and modifications.
  - Copy protection

    Copy protection links user blocks to the serial number of the SIMATIC memory card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC memory card or CPU.
  - Access protection

    Extended access protection provides high-quality protection against unauthorized configuration changes. You can use authorization levels to assign separate rights to different user groups.
  - Integrity protection

    The system protects the data transferred to the CPU against manipulation. The CPU detects erroneous or manipulated engineering data.

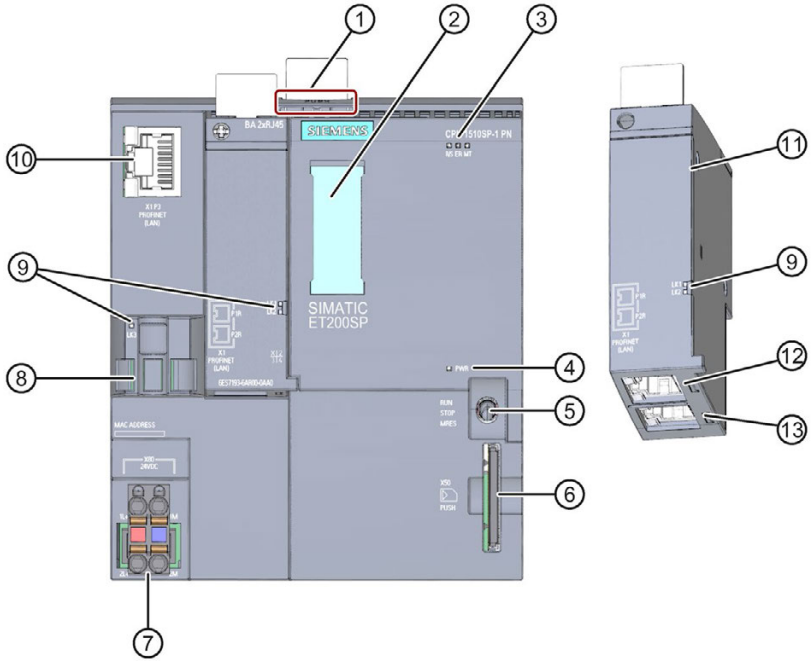
    You can find additional information on the topic of "Protection" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).
- Support for ET 200AL
  - Simple connection of IP 65/67 I/O modules to the CPU.
- Communication CPs
  - CP 1542SP-1: Flexible expansion of the ET 200SP system with an additional Ethernet interface; network separation.
  - CP 1542SP-1 IRC: Seamless data recording with time stamping, support for standardized telecontrol protocols DNP3 and IEC.
  - CP 1543SP-1 ISEC: With the integrated security functions firewall (Stateful Inspection) and VPN protocol (IPSec), the communications processor protects ET200SP stations and subordinate networks against unauthorized access, and employs encryption to protect data transmission against manipulation and espionage.
- Address space
  - A larger address space of 2560 bytes (2048 bytes for ET 200SP module + 512 bytes for ET 200AL modules) is available within the station.

- CPU 1510SP-1 PN supports the following additional functions:
  - PROFIenergy
    You can find information on the topic of "PROFIenergy" in the PROFINET function manual (https://support.industry.siemens.com/cs/ww/en/view/49948856) and in the PROFINET specification on the Internet (http://www.profibus.com).
  - Shared device
    You can find information on the topic of "Shared device" in the PROFINET function manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).
  - Configuration control
    You can find information on the topic of "Configuration control" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).
  - Isochronous mode
    You can find information about the "Isochronous mode" topic in the PROFINET (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

2.4 Operating and display elements

2.4.1 Front view of the module with BusAdapter

The figure on the left shows the CPU 1510SP-1 PN including a plugged BA 2xRJ45 BusAdapter. The figure on the right shows a separate view of the BA 2xRJ45 BusAdapter.



① Mounting rail release
② Labeling strips
③ LEDs for status and error displays
④ LED for display of the supply voltage
⑤ Mode switch
⑥ Slot for the SIMATIC memory card
⑦ Connection for supply voltage (included in product package)
⑧ Cable support and attachment for port P3 of the PROFINET interface
⑨ LEDs for status displays of the PROFINET interface: LK1 and LK2 on BusAdapter, LK3 on CPU
⑩ Port P3 of the PROFINET interface: RJ45 socket
⑪ Separate view of the BusAdapter
⑫ Port P1 R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy
⑬ Port P2 R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

Figure 2-2 Front view of the CPU 1510SP-1 PN with BusAdapter

2.5 Mode switch

Use the mode switch to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2- 2 Mode switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU is executing the user program.
STOP	STOP mode	The user program is not being executed.
MRES	Memory reset	Position for CPU memory reset.

Wiring

3

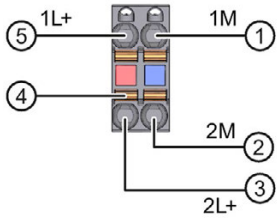
3.1 Pin assignment

This section provides information on the pin assignment of the individual interfaces and the block diagram of the CPU 1510SP-1 PN.

24 V DC supply voltage (X80)

The connector for the supply voltage is plugged in when the CPU ships from the factory.

The figure below shows the pin assignment for 24 V DC supply voltage.



① Ground of the supply voltage
② Ground of the supply voltage for loop-through (maximum of 10 A permitted)
③ +24 V DC of the supply voltage for loop-through (maximum of 10 A permitted)
④ Spring NC contacts
⑤ + 24 V DC of the supply voltage

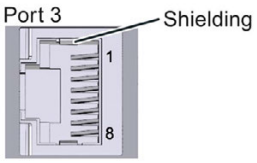
Internally jumpered:
① and ②
③ and ⑤

Figure 3-1 Supply voltage connection

PROFINET IO interface on the CPU (X1 P3)

The assignment corresponds to the Ethernet standard for an RJ45 connector.

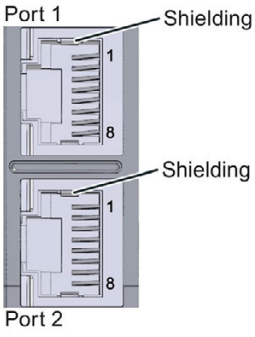
- When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X).
- If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).



PROFINET IO interface on the BusAdapter BA 2xRJ45 (X1 P1 R and X1 P2 R)

The assignment at the BA 2xRJ45 BusAdapter corresponds to the Ethernet standard for an RJ45 connector.

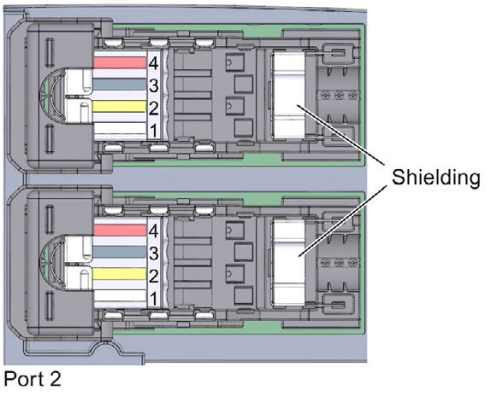
Table 3- 1 Pin assignment PROFINET IO interface on the BusAdapter BA 2xRJ45

View	Designation
	• When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X). • If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).

PROFINET IO interface on the BusAdapter BA 2xFC (X1 P1 R and X1 P2 R)

The following table shows the pin assignment for the PROFINET IO interface on the BusAdapter BA 2xFC.

Table 3- 2 Pin assignment PROFINET IO interface on the BusAdapter BA 2xFC

View	Signal name		Designation
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	RD_N	Receive data -

Reference

You can find additional information on the topics of "Connecting the CPU" and "Accessories/spare parts" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Assignment of the MAC addresses

The MAC address is a globally unique device identifier that is assigned to each PROFINET device in the factory. Its 6 bytes are divided into 3 bytes for the manufacturer ID and 3 bytes for the device ID (serial number). The front of the CPU 1510SP-1 PN is lasered with the MAC address of the PROFINET interface.

The PROFINET interface (X1) of the CPU 1510SP-1 PN has three ports. Port 3 is located on the CPU. Ports 1 and 2 are located on the optional BusAdapter. In addition to the PROFINET interface, each PROFINET port also has a separate MAC address. There is therefore a total of four MAC addresses for the CPU 1510SP-1 PN.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

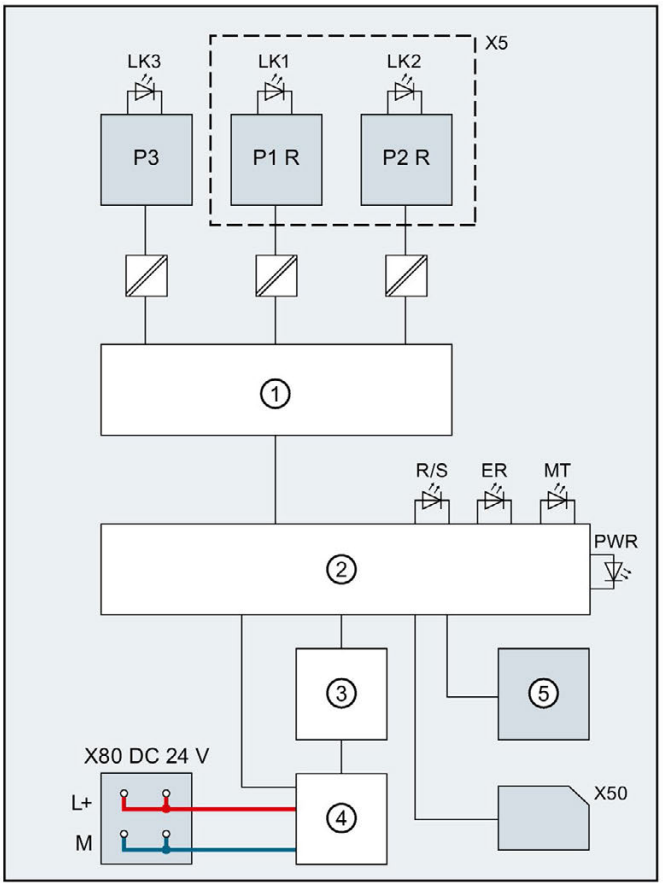
The table below shows how the MAC addresses are assigned.

Table 3- 3 Assignment of the MAC addresses

	Assignment
MAC address 1	PROFINET interface X1 • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	Port X1 P1 R (required for LLDP, for example)
MAC address 3	Port X1 P2 R (required for LLDP, for example)
MAC address 4	Port X1 P3 (required for LLDP, for example)

Block diagram

The following figure shows the block diagram of the CPU 1510SP-1 PN.



①	PROFINET switch	P1 R	PROFINET interface X1 Port 1
②	Electronics	P2 R	PROFINET interface X1 Port 2
③	Backplane bus interface	P3	PROFINET interface X1 Port 3
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	RUN/STOP/MRES mode selector	M	Ground
X5	BusAdapter	LK1, 2, 3	LED Link TX/RX
X50	SIMATIC memory card	R/S	RUN/STOP LED (yellow/green)
X80 24 V DC	Infeed of supply voltage	ER	ERROR LED (red)
		MT	MAINT LED (yellow)
		PWR	POWER LED (green)

Figure 3-2 Block diagram of the CPU 1510SP-1 PN

Interrupts, error messages, diagnostics and system alarms

4

The status and error displays of the CPU 1510SP-1 PN are described below.

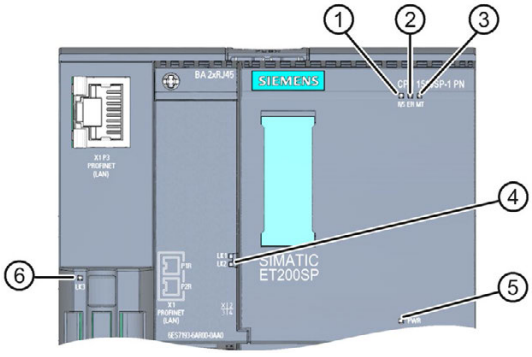
You will find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on the topics of "Diagnostics" and "System alarms" in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

4.1 Status and error display of the CPU

LED displays

The figure below shows the LED displays of the CPU 1510SP-1 PN and the BA 2xRJ45 BusAdapter.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ LINK RX/TX LED for ports X1 P1 and X1 P2 (green LEDs on BusAdapter)
⑤ POWER LED (green LED)
⑥ LINK RX/TX LED for port X1 P3 (green LED on CPU)

Figure 4-1 LED displays on the CPU and BusAdapter

Meaning of the POWER, RUN/STOP, ERROR and MAINT LEDs

CPU 1510SP-1 PN features an LED for monitoring the supply voltage of the electronics (PWR) and three LEDs for displaying the current operating and diagnostics status. The following table shows the meaning of the various combinations of colors for the POWER, RUN/STOP, ERROR and MAINT LEDs.

Table 4- 1 Meaning of the LEDs

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	LED off	Missing or insufficient power supply on the CPU.
LED lit green	LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED lit green	LED flashes red	LED off	A diagnostics event is pending.
LED lit green	LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. The affected hardware must be checked/replaced within a short period of time.
				Active Force job
				PROFIenergy pause
LED lit green	LED lit green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be checked/replaced within a foreseeable period of time.
				Bad configuration
LED lit green	LED lit yellow	LED off	LED flashes yellow	Firmware update successfully completed.
LED lit green	LED lit yellow	LED off	LED off	CPU is in STOP mode.
LED lit green	LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC memory card is causing an error.
				CPU defective
LED lit green	LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. startup after STOP.
				Download of the user program from the SIMATIC memory card
LED lit green	LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED lit green	LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
				Test of LEDs during startup, inserting a module.
				LED flashing test

Meaning of the LINK LED

Each port has a LINK LED (LK1, LK2, LK3). The table below shows the various "LED scenarios" of the ports of the CPU 1510SP-1 PN.

Table 4- 2 Meaning of the LEDs

LINK LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The "LED flashing test" is being performed.
LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.

Technical specifications

5

	6ES7510-1DJ01-0AB0
General information	
Product type designation	CPU 1510SP-1 PN
Hardware function version	FS03
Firmware version	V2.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14
Configuration control	
Via data record	Yes
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure buffering	
Power/voltage failure buffer time	5 ms
Input current	
Current consumption (rated value)	0.6 A
Inrush current, max.	4.7 A; rated value
I^2t	0.14 A^2s
Power	
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	5.6 W
Memory	
Number of slots for SIMATIC memory card	1
SIMATIC memory card required	Yes
Work memory	
Integrated (for program)	100 KB
Integrated (for data)	750 KB
Load memory	
Plug-in (SIMATIC memory card), max.	32 GB
Buffering	
Maintenance-free	Yes

	6ES7510-1DJ01-0AB0
CPU processing times	
For bit operations, typ.	72 ns
For word operations, typ.	86 ns
For fixed-point arithmetic, typ.	115 ns
For floating-point arithmetic, typ.	461 ns
CPU blocks	
Number of elements (total)	2000; blocks (OB/FB/FC/DB) and UDTs
DB	
Number range	1 ... 60 999; divided into: Number range that can be used by user: 1 ... 59 999 and number range for DBs generated by SFC 86: 60 000 ... 60 999
Size, max.	750 KB; for absolutely addressed DBs, the max. size is 64 KB
FB	
Number range	0 ... 65 535
Size, max.	100 KB
FC	
Number range	0 ... 65 535
Size, max.	100 KB
OB	
Size, max.	100 KB
Number of free-cycle OBs	100
Number of time-of-day interrupt OBs	20
Number of time-delay interrupt OBs	20
Number of cyclic interrupt OBs	20
Number of hardware interrupt OBs	50
Number of DPV1 interrupt OBs	3
Number of isochronous mode OBs	1
Number of technology synchronous interrupt OBs	2
Number of startup OBs	100
Number of asynchronous error OBs	4
Number of synchronous error OBs	2
Number of diagnostic interrupt OBs	1
Nesting depth	
Per priority class	24
Counters, timers and their retentivity	
S7 counters	
Quantity	2048
Retentivity	
• can be set	Yes

	6ES7510-1DJ01-0AB0
IEC counters	
Quantity	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
S7 timers	
Quantity	2048
Retentivity	
• can be set	Yes
IEC timers	
Quantity	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
Data areas and their retentivity	
Total retentive data area (including timers, counters, bit memories), max.	128 KB; for bit memories, timers, counters, DBs and technological data (axes), usable retentive memory: 88 KB
Bit memory	
Number, max.	16 KB
Number of clock memories	8; there are 8 clock memory bits, grouped in one clock memory byte
Data blocks	
Retentivity can be set	Yes
Retentivity preset	No
Local data	
Per priority class, max.	64 KB; max. 16 KB per block
Address area	
Number of IO modules	1024; max. number of modules/submodules
I/O address area	
Inputs	32 KB; all inputs are in the process image
Outputs	32 KB; all outputs are in the process image
Of which per integrated IO subsystem	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Of which per CM/CP	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Process image partitions	
Number of process image partitions, max.	32
Address space per module	
Address space per module, max.	288 bytes; for both input and output data

	6ES7510-1DJ01-0AB0
Address space per station	
Address space per station, max.	2560 bytes; for central inputs and outputs; depending on configuration; 2048 bytes for ET 200SP modules + 512 bytes for ET 200AL modules
Hardware configuration	
Number of distributed IO systems	32; a distributed IO system is understood to mean the integration of distributed I/O via PROFINET or PROFIBUS communication modules as well as the connection of I/O via AS-i master modules or links (e.g. IE/PB link)
Number of DP masters	
Via CM	1
Number of IO controllers	
Integrated	1
Via CM	0
Rack	
Modules per rack, max.	80; CPU + 64 modules + server module (configuration width max. 1 m) + 16 ET 200AL modules
Number of rows, max.	1
PtP CM	
Number of PtP CMs	The number of PtP CMs that can be connected is only limited by the available slots
Time	
Clock	
Type	Hardware clock
Backup duration	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Operating hours counter	
Quantity	16
Time-of-day synchronization	
Supported	Yes
On DP, master	Yes; via CM DP module
On DP, slave	Yes; via CM DP module
In AS, master	Yes
In AS, slave	Yes
On Ethernet via NTP	Yes
Interfaces	
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; via CM DP module
With optical interface	No

	6ES7510-1DJ01-0AB0
1st interface	
Interface hardware	
Number of ports	3; 1st integrated + 2nd via BusAdapter
Integrated switch	Yes
RJ45 (Ethernet)	Yes; X1 P3; opt. X1 P1 and X1 P2 via BusAdapter BA 2xRJ45
BusAdapter (PROFINET)	Yes; usable BusAdapters: BA 2x RJ45, BA 2x FC
Protocols	
PROFINET IO controller	Yes
PROFINET IO device	Yes
SIMATIC communication	Yes
Open IE communication	Yes
Web server	Yes
Media redundancy	Yes
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50
• MRPD	Yes; requirement: IRT
• PROFIenergy	Yes
• Prioritized startup	Yes; max. 32 PROFINET devices
• Number of connectable IO devices, max.	64; a total of up to 256 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
• of these, IO devices with IRT, max.	64
• Number of connectable IO devices for RT, max.	64
• of these, in a line topology, max.	64
• Number of IO devices that can be activated/deactivated simultaneously, max.	8; in total over all interfaces
• Number of IO devices per tool, max.	8
• Update times	The minimum value of the update time also depends on the communication allocation setting for PROFINET IO, the number of IO devices and the amount of configured user data

	6ES7510-1DJ01-0AB0
Update time with IRT	
• With send clock of 250 µs	250 µs to 4 ms; note: with IRT with isochronous mode, the minimum update time of 625 µs of the isochronous OB is crucial
• With send clock of 500 µs	500 µs to 8 ms; note: with IRT with isochronous mode, the minimum update time of 625 µs of the isochronous OB is crucial
• With send clock of 1 ms	1 ms to 16 ms
• with send clock of 2 ms	2 ms to 32 ms
• with send clock of 4 ms	4 ms to 64 ms
• with IRT and "odd" send clock parameter assignment	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs to 3 875 µs)
Update time with RT	
• With send clock of 250 µs	250 µs to 128 ms
• With send clock of 500 µs	500 µs to 256 ms
• With send clock of 1 ms	1 ms to 512 ms
• with send clock of 2 ms	2 ms to 512 ms
• with send clock of 4 ms	4 ms to 512 ms
PROFINET IO device	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	No
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes
• MRPD	Yes; requirement: IRT
• PROFIenergy	Yes
• Shared device	Yes
• Number of IO controllers with shared device, max.	4
2nd interface	
Interface hardware	
Number of ports	1
RS 485	Yes; via CM DP module
Protocols	
PROFIBUS DP master	Yes
PROFIBUS DP slave	Yes
SIMATIC communication	Yes

	6ES7510-1DJ01-0AB0
Interface hardware	
RJ45 (Ethernet)	
100 Mbps	Yes
Autonegotiation	Yes
Autocrossing	Yes
Industrial Ethernet status LED	Yes
RS 485	
Transmission rate, max.	12 Mbps
Protocols	
Number of connections	
Number of connections, max.	96
Number of connections reserved for ES/HMI/Web	10
Number of connections via integrated interfaces	64
Number of connections per CP/CM	32
Number of S7 routing connections	16
SIMATIC communication	
S7 communication, as server	Yes
S7 communication, as client	Yes
User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
TCP/IP	Yes
• Data length, max.	64 KB
• Multiple passive connections per port, supported	Yes
ISO-on-TCP (RFC1006)	Yes
• Data length, max.	64 KB
UDP	Yes
• Data length, max.	1472 bytes
DHCP	No
SNMP	Yes
DCP	Yes
LLDP	Yes
Web server	
HTTP	Yes; standard and user-defined pages
HTTPS	Yes; standard and user-defined pages

	6ES7510-1DJ01-0AB0
PROFIBUS DP master	
Number of connections, max.	48
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Data record routing	Yes
• Isochronous mode	No
• Constant bus cycle time	No
• Number of DP slaves	125; a total of up to 256 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
• Activation/deactivation of DP slaves	Yes
OPC UA	
OPC UA server	Yes; Data Access (Read, Write, Subscribe), Runtime license required
• Application authentication	Yes
• Security Policies	Available Security Policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256
• User authentication	"Anonymous" or with user name and password
Additional protocols	
MODBUS	Yes; MODBUS TCP
Media redundancy	
Switchover time in the case of cable break, typ.	200 ms; with MRP; bumpless with MRPD
Number of devices in the ring, max.	50
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes; only with PROFINET; with a minimum OB 6x cycle of 625 µs
S7 signaling functions	
Number of stations that can be logged in for signaling functions, max.	32
Block-related alarms	Yes
Number of configurable interrupts, max.	5000
Number of simultaneously active interrupts in interrupt pool	
• Number of reserved user interrupts	300
• Number of reserved interrupts for system diagnostics	100
• Number of reserved interrupts for motion control technology objects	80

	6ES7510-1DJ01-0AB0
Test/commissioning functions	
Shared commissioning (Team Engineering)	Yes; parallel online access possible for up to 3 engineering systems
Status block	Yes; up to 8 simultaneously (in total over all ES clients)
Single-step	No
Status/modify	
Status/modify tag	Yes
Tags	Inputs/outputs, bit memory, DB, peripheral inputs/outputs, timers, counters
Number of tags, max.	
• Of which are status tags, max.	200; per job
• Of which are modify tags, max.	200; per job
Forcing	
Forcing	Yes
Forcing, tags	Peripheral inputs/outputs
Number of tags, max.	200
Diagnostics buffer	
Available	Yes
Number of entries, max.	1000
• Of which are power failure-proof	500
Traces	
Number of configurable traces	4; up to 512 KB data possible per trace
Interrupts/diagnostics/status information	
Diagnostics display LED	
RUN/STOP LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Monitoring of the supply voltage (PWR LED)	Yes
Connection display LINK TX/RX	Yes
Supported technology objects	
Motion control	Yes; note: the number of axes affects the cycle time of the PLC program; selection guide via the TIA Selection Tool or SIZER
• Number of available motion control resources for technology objects (except cams)	800
• Required Motion Control resources	
– per speed-controlled axis	40
– per positioning axis	80
– per synchronous axis	160
– per external encoder	80
– per output cam	20
– per cam track	160
– per measuring input	40

	6ES7510-1DJ01-0AB0
Controller	
• PID_Compact	Yes; universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves
• PID temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
Standards, approvals, certificates	
Suitable for safety functions	No
Highest safety class achievable in safety mode	
Performance level according to EN ISO 13849-1:2008	None
SIL according to IEC 61508	No
Ambient conditions	
Ambient temperature during operation	
Horizontal mounting position, min.	0 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, min.	0 °C
Vertical mounting position, max.	50 °C
Ambient temperature during storage/transport	
Min.	-40 °C
Max.	70 °C
Configuring	
Programming	
Programming language	
• LAD	Yes
• FBD	Yes
• STL	Yes
• SCL	Yes
• GRAPH	Yes
Know-how protection	
User program protection	Yes
Copy protection	Yes
Block protection	Yes
Access protection	
Protection level: Write protection	Yes
Protection level: Read/write protection	Yes
Protection level: Complete protection	Yes

	6ES7510-1DJ01-0AB0
Cycle time monitoring	
Low limit	Configurable minimum cycle time
High limit	Configurable maximum cycle time
Dimensions	
Width	100 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	310 g

Technical specifications of the BusAdapter BA 2×RJ45

Table 5- 1 Technical specifications of the BusAdapter BA 2×RJ45

	6ES7193-6AR00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
RJ45	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	46 g

Technical specifications of the BusAdapter BA 2×FC

Table 5- 2 Technical specifications of the BusAdapter BA 2×FC

	6ES7193-6AF00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
FC (FastConnect)	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	53 g

General technical specifications

You can find information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc., in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Dimension drawing

A

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimension drawing of the CPU 1510SP-1 PN

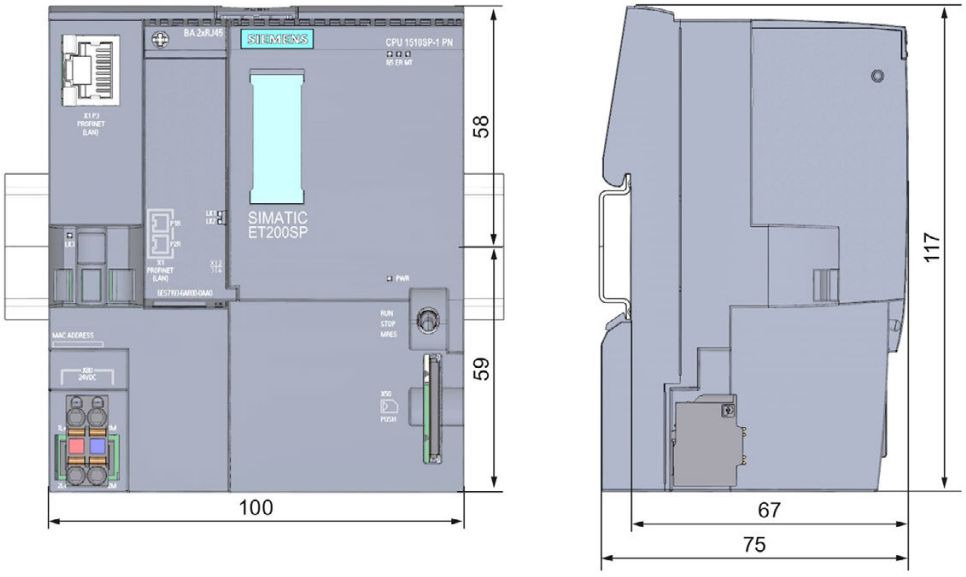


Figure A-1 Dimensional drawing CPU 1510SP-1 PN

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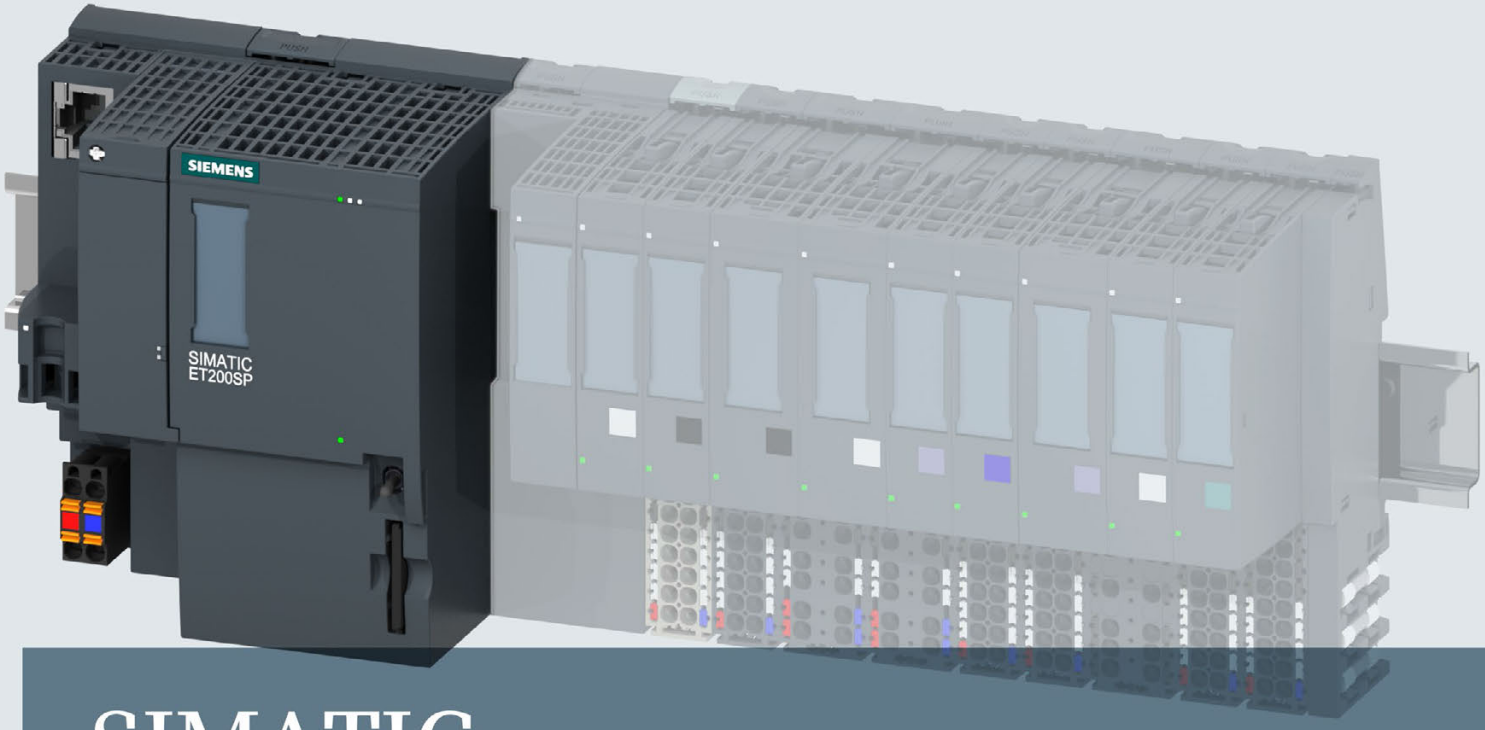

SIMATIC

ET 200SP

CPU 1512SP-1 PN (6ES7512-1DK01-0AB0)

Manual

Edition 09/2016

siemens.com

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ET 200SP
CPU 1512SP-1 PN
(6ES7512-1DK01-0AB0)

Manual

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09/2016

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 08/2016 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual as well as the function manuals. This manual contains a description of the module-specific information. The system-related functions are described in the system manual. All system-spanning functions are described in the function manuals.

The information provided in this manual and the system manual allows you to commission the CPU 1512SP-1 PN.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

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- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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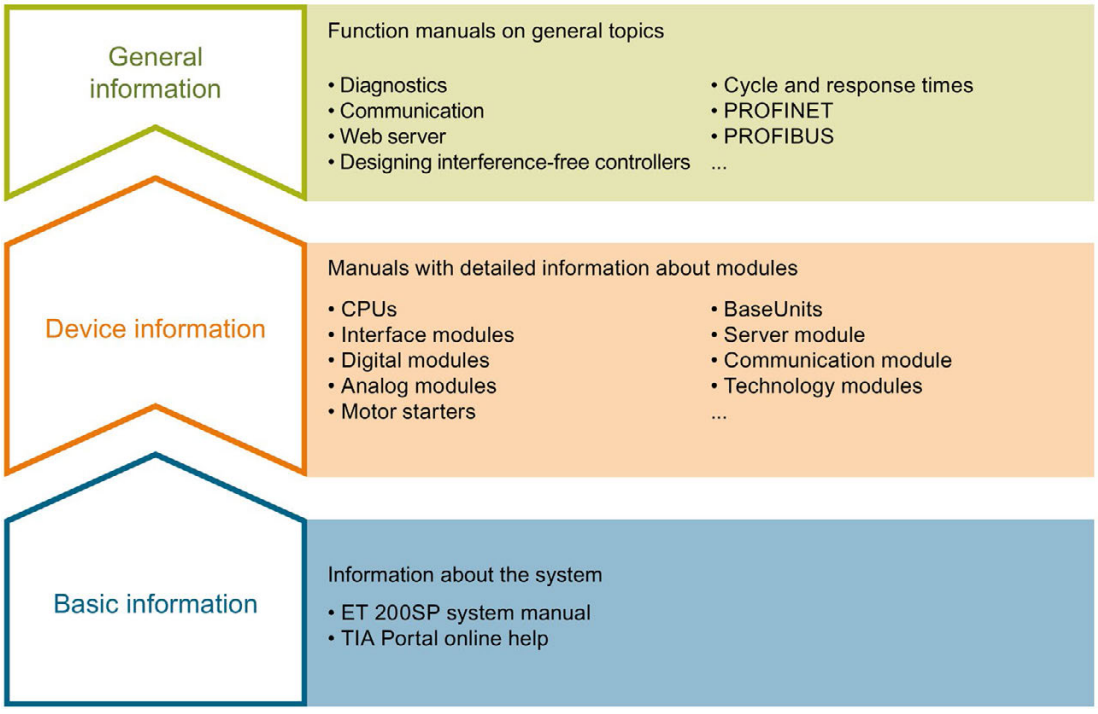
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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"mySupport" - Documentation

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You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 New functions in firmware version V2.0

New functions of the CPU in firmware version V2.0

This section lists the new features of the CPU with firmware version V2.0.

You can find additional information in the sections of this manual.

Table 2- 1 New functions of the CPU with firmware version 2.0 compared with firmware version V1.8

New functions	Applications	Customer benefits
OPC UA server	You realize the data communication between different systems, both within the process level and on the control and enterprise levels: • To embedded systems with controllers • To controllers with MES systems and systems of the enterprise level (ERP, asset systems) • To Siemens controllers with controllers from other manufacturers • To intelligent sensors with controllers Supported standard: OPC Data Access, DA.	OPC UA is a unified standard for data communication and is independent of any particular operating system platforms. You have integrated security mechanisms on different automation systems, for example, for data exchange, on the application level, for authentication of the user. OPC UA servers provide a large amount of data: • Values of PLC tags that clients can access • Data types of these PLC tags • Information about the OPC UA server itself and the CPU In this way, clients can gain an overview and can read and write values.
PROFINET IO		
MRPD: Media Redundancy for Planned Duplication for IRT	PROFINET IO IRT enables you to realize applications that place particularly high demands on failure safety and accuracy (isochronous).	By sending the cyclic IO data in both directions in the ring, the communication to the IO devices is maintained even when the ring is interrupted and does not result in device failure even with fast update times. You achieve higher failure safety than with MRP.
PROFINET performance upgrade	You can develop applications with high demands on speed and clock cycles. This is interesting for applications with high demands on performance.	Better utilization of the bandwidth results in short reaction times.
Limitation of the data infeed into the network	You limit the network load for standard Ethernet communication to a maximum value.	You smooth peaks in the data infeed. You share the remaining bandwidth based on requirements.

New functions	Applications	Customer benefits
Web server		
Backing up and restoring via the Web server	You can, for example, backup and restore the configuration of the CPU to the PG/PC on which the Web server is running.	You can make a backup copy of an operational project without STEP 7. In an "emergency", you can simply use an existing configuration without STEP 7, for example, during commissioning or after a program download.
Web server provides up to three project languages for comments and alarm texts	When you export your plants worldwide, for example, comments or alarm texts can be stored on the card in up to 3 languages. For example, German - author's language, English - internationally usable, Portuguese - end user's language.	You provide customers with better service.
Trace via Web server	When you enable trace functions via the Web server, you have better service support. You can send your trace recordings via Web service, for example, to your service partner.	You get plant/project information for diagnostics and maintenance requirements without STEP 7. You can provide trace recordings for each Web server. You save time in troubleshooting.
Monitoring of configured technology objects via a Web server	You can monitor statuses, errors, technology alarms and the current values of technology objects (TOs) with the Web server.	
Motion control		
Greater number of axes for Motion Control applications and new technology objects: Output cam, cam track and measuring input	Speed specification, e.g. for: • Pumps, fans, mixers • Conveyor belts • Auxiliary drives Positioning tasks, e.g.: • Lifting and vertical conveyors • Feeding and gate control • Palletizing equipment Output cams and cam tracks make other applications possible, e.g.: • Applying glue tracks • Triggering switching operations with precise positioning • Very precise processing of products on a conveyor belt Measuring inputs are used, for example: • For measuring products • For detecting the position of the product on a conveyor belt	You can implement additional Motion Control applications with a CPU. The scalable configuration limits allow you to handle all types of application. High machine speeds result in greater productivity with better accuracy.

New functions	Applications	Customer benefits
ET 200SP		
Support for ET 200AL in a central configuration	You can set up a simple connection of IP 65/67 I/O to the CPU. You can connect up to 16 ET 200AL I/O modules via a BA send module on the central bus of the ET 200SP CPU. The distance between two ET 200AL modules can be up to 15 m. You can realize the use of ET 200AL in assembly and handling engineering directly at moving parts, for example in linear axes or drag chains.	You do not have to individually run sensors or actuators at the central control cabinet to the different sections of a machine or assembly line. You save time and costs: • Through lightweight construction • Reduction of wear and exposure to vibration • Increased productivity
Increasing the address space in the station	For example, you can use up to 49 ET 200SP energy meter modules behind an ET 200SP CPU.	A larger address space of 2560 bytes (2048 bytes for ET 200SP module + 512 bytes for ET 200AL modules) is available in the station. The address space has been increased to 288 bytes per module.
BusAdapter with glass-fiber interface	You can achieve long distances (up to 3 km) between the PROFINET devices.	
Support for communications processors		
CP 1542SP-1	Flexible expansion of the ET 200SP system with an additional Ethernet interface; network separation.	
CP 1542SP-1 IRC	Seamless data recording with time stamping, support for standardized telecontrol protocols DNP3 and IEC.	
CP 1543SP-1 ISEC	With the integrated security functions firewall (Stateful Inspection) and VPN protocol (IPSec), the communications processor protects ET200SP stations and subordinate networks against unauthorized access, and employs encryption to protect data transmission against manipulation and espionage.	

2.2 Operating principle

The CPU contains the operating system and executes the user program. The user program is located on the SIMATIC memory card and is processed in the work memory of the CPU.

The PROFINET interfaces on the CPU allow simultaneous communication with PROFINET devices, PROFINET controllers, HMI devices, programming devices, other controllers and other systems. The CPU 1512SP-1 PN supports operation as an IO controller, I-device or standalone CPU.

With its optional PROFIBUS interface, CM DP, CPU 1512SP-1 PN supports the configuration of PROFIBUS networks in addition to PROFINET IO. When you use the interface as a PROFIBUS DP interface, you can configure the CPU 1512SP-1 PN as a DP master or as an intelligent DP slave (I-slave).

IO controller

CPU 1512SP-1 PN sends and receives data from the connected IO devices within a PROFINET IO system. You can operate the CPU with a maximum of 128 connected IO devices, a maximum of 64 of which use IRT (Isochronous Realtime).

I-device

The "I-device" (intelligent IO device) functionality allows you to exchange data with an IO controller. CPU 1512SP-1 PN thus fulfills the role of an intelligent distributed pre-processing unit for sub-processes. The I-device is connected as an IO device to a higher-level IO controller for this purpose.

Advantages:

- Interference-resistant configuration due to short signal and encoder wiring
- Reduced wiring requirements for transmission of the data via PROFINET

Standalone CPU

You can also use the CPU 1512SP-1 PN in the ET 200SP distributed I/O system as a "central system" without a higher-level controller.

DP master

To use the ET 200SP as a DP master, you need the CPU and the optional communication module, CM DP. When used as a DP master, ET 200SP exchanges data with the connected DP slaves via PROFIBUS DP.

Intelligent DP slave (I-slave)

To use the ET 200SP as an intelligent DP slave (I-slave), you need the CPU and the optional communication module, CM DP. As an I-slave, the ET 200SP CPU is connected via PROFIBUS DP to a higher-level DP master and exchanges data with it.

2.3 Properties

Article number

6ES7512-1DK01-0AB0

View of the module

The following figure shows the CPU 1512SP-1 PN.

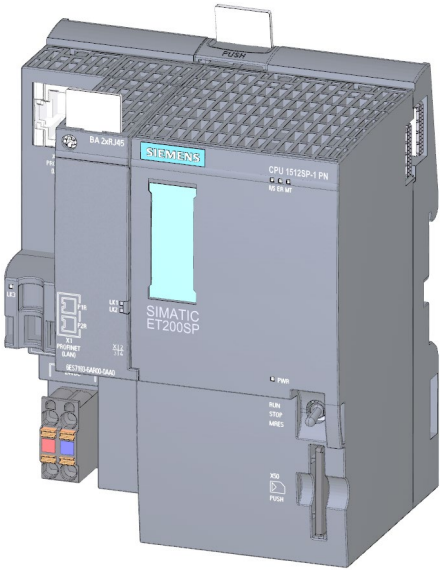


Figure 2-1 CPU 1512SP-1 PN

Properties

The CPU 1512SP-1 PN has the following technical properties:

1. Communication:
   - Interfaces

     The CPU 1512SP-1 PN has a PROFINET interface (X1 P3) with an integrated 3-port switch. Port 1 and port 2 are located on the optionally pluggable BusAdapter. Port 3 is integrated in the housing of the CPU. You connect the PROFINET IO to the CPU via the BusAdapter. You will find information on the BusAdapters supported by the CPU in section Wiring (Page 22).

     In addition to PROFINET basic functionality, the interface also supports PROFINET IO RT (real-time) and IRT (isochronous real-time). PROFINET IO communication or real-time settings can be configured. The basic functionality of PROFINET supports HMI communication, communication with the configuration system, communication with a higher-level network (backbone, router, Internet) and communication with another machine or automation cell.

     Port 1 and port 2 can also be used as ring ports for the configuration of redundant ring structures in Ethernet.

     Note

     The CPU is delivered without a BusAdapter. You can find the article numbers of the supported BusAdapters in the "Accessories/spare parts" section of the ET 200SP distributed automation system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

     The CM DP is optionally available with a PROFIBUS interface (X2). You can find additional information about this expansion module in the manual Communication module CM DP (http://support.automation.siemens.com/WW/view/en/90156526).

     You can find information about connecting the PROFINET IO BusAdapter to the CPU as well as connecting the optional PROFIBUS interface to the interface module in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

   - OPC UA
     With OPC UA, data is exchanged via an open and vendor-neutral communication protocol. The CPU, as OPC UA server, can communicate with OPC UA clients such as HMI panels, SCADA systems, etc.

- Integrated Web server:

  A Web server is integrated in the CPU. You can read out the following information with the Web server:
  - Start page with general CPU information
  - Identification information
  - Contents of the diagnostics buffer
  - Query of module states
  - Firmware update
  - Alarms (without acknowledgment option)
  - Information about communication
  - PROFINET topology
  - Tag status, writing tags
  - Watch tables
  - Memory usage
  - User pages
  - Data logs (if used)
  - Online backup and restoration of the configuration.
  - Diagnostic information for the motion control technology objects
  - Display of trace recordings stored on the SIMATIC memory card
  - Readout service data
  - Basic Web pages
  - Display of the Web server in 3 project languages, for example, comments and message texts
  - Recipes
  - User-defined Web pages
- Integrated technology:
  - Motion Control

    The Motion Control functionality uses technology objects to support speed-controlled axes, positioning axes, synchronous axes, external encoders, cams, cam tracks and measuring inputs, as well as PLCopen blocks for programming the motion control functionality.
    You can find a detailed description of the use of Motion Control and its configuration in the S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/109739589) function manual.
    You can also use the TIA Selection Tool (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool) or the SIZER (http://w3.siemens.com/mcms/mc-solutions/en/engineering-software/drive-design-tool-sizer/Pages/drive-design-tool-sizer.aspx) to create or configure axes.
  - Integrated closed-loop control functionality

    - PID Compact (continuous PID controller)

    - PID 3Step (step controller for integrating actuators)

    - PID Temp (temperature controller for heating and cooling with two separate actuators)

- Trace functionality:
  - Trace functionality supports you in troubleshooting and optimizing the user program, especially for motion control or closed-loop control applications. Trace only supports saves measurements on a SIMATIC memory card.
    You will find additional information on "Trace" in the Using the trace and logic analyzer function (http://support.automation.siemens.com/WW/view/en/64897128) function manual.
- Integrated system diagnostics:
  - The alarms for the system diagnostics are automatically created by the system and displayed on a PG/PC, HMI device or the Web server. System diagnostics information is also available when the CPU is in STOP mode.
- Integrated security:
  - Know-how protection

    The assignment of passwords protects user blocks against unauthorized access and modifications.
  - Copy protection

    Copy protection links user blocks to the serial number of the SIMATIC memory card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC memory card or CPU.
  - Access protection

    Extended access protection provides high-quality protection against unauthorized configuration changes. You can use authorization levels to assign separate rights to different user groups.
  - Integrity protection

    The system protects the data transferred to the CPU against manipulation. The CPU detects erroneous or manipulated engineering data.

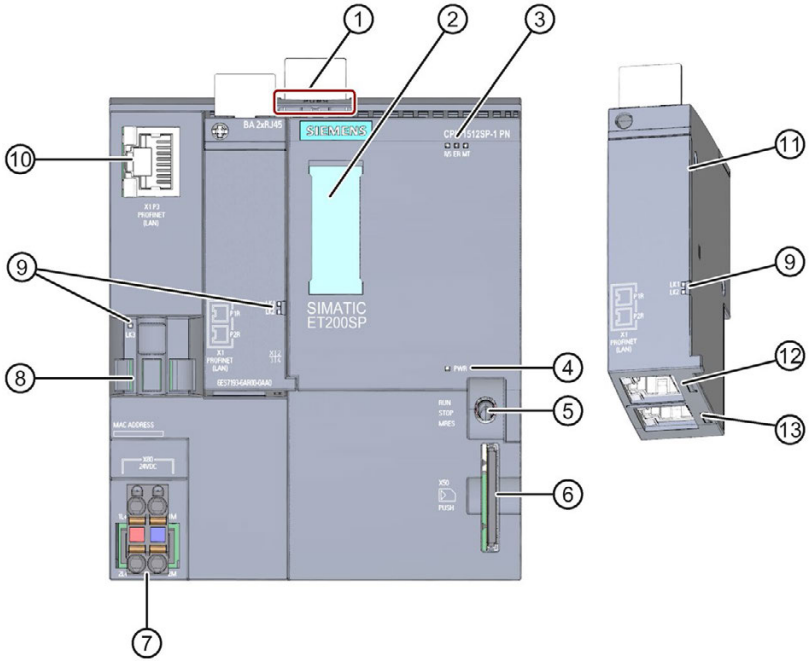
    You can find additional information on the topic of "Protection" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).
- Support for ET 200AL
  - Simple connection of IP 65/67 I/O modules to the CPU.
- Communication CPs
  - CP 1542SP-1: Flexible expansion of the ET 200SP system with an additional Ethernet interface; network separation.
  - CP 1542SP-1 IRC: Seamless data recording with time stamping, support for standardized telecontrol protocols DNP3 and IEC.
  - CP 1543SP-1 ISEC: With the integrated security functions firewall (Stateful Inspection) and VPN protocol (IPSec), the communications processor protects ET200SP stations and subordinate networks against unauthorized access, and employs encryption to protect data transmission against manipulation and espionage.

- Address space
  - A larger address space of 2560 bytes (2048 bytes for ET 200SP module + 512 bytes for ET 200AL modules) is available within the station.
- CPU 1512SP-1 PN supports the following additional functions:
  - PROFIenergy
    You can find information on the topic of "PROFIenergy" in the PROFINET function manual (https://support.industry.siemens.com/cs/ww/en/view/49948856) and in the PROFINET specification on the Internet (http://www.profibus.com).
  - Shared device
    You can find information on the topic of "Shared device" in the PROFINET function manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).
  - Configuration control
    You can find information on the topic of "Configuration control" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).
  - Isochronous mode
    You can find information about the "Isochronous mode" topic in the PROFINET (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

2.4 Operating and display elements

2.4.1 Front view of the module with BusAdapter

The figure on the left shows the CPU 1512SP-1 PN including a plugged BA 2xRJ45 BusAdapter. The figure on the right shows a separate view of the BA 2xRJ45 BusAdapter.



① Mounting rail release
② Labeling strips
③ LEDs for status and error displays
④ LED for display of the supply voltage
⑤ Mode switch
⑥ Slot for the SIMATIC memory card
⑦ Connection for supply voltage (included in product package)
⑧ Cable support and attachment for port P3 of the PROFINET interface
⑨ LEDs for status displays of the PROFINET interface: LK1 and LK2 on BusAdapter, LK3 on CPU
⑩ Port P3 of the PROFINET interface: RJ45 socket
⑪ Separate view of the BusAdapter
⑫ Port P1 R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy
⑬ Port P2 R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

Figure 2-2 Front view of the CPU 1512SP-1 PN with BusAdapter

2.5 Mode switch

Use the mode switch to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2- 2 Mode switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU is executing the user program.
STOP	STOP mode	The user program is not being executed.
MRES	Memory reset	Position for CPU memory reset.

Wiring

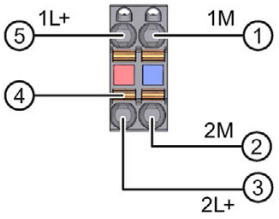
3

This section provides information on the pin assignment of the individual interfaces and the block diagram of the CPU 1512SP-1 PN.

24 V DC supply voltage (X80)

The connector for the supply voltage is plugged in when the CPU ships from the factory.

The figure below shows the pin assignment for 24 V DC supply voltage.



① Ground of the supply voltage
② Ground of the supply voltage for loop-through (maximum of 10 A permitted)
③ +24 V DC of the supply voltage for loop-through (maximum of 10 A permitted)
④ Spring NC contacts
⑤ + 24 V DC of the supply voltage

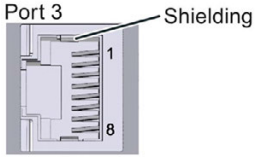
Internally jumpered:
① and ②
③ and ⑤

Figure 3-1 Supply voltage connection

PROFINET IO interface on the CPU (X1 P3)

The assignment corresponds to the Ethernet standard for an RJ45 connector.

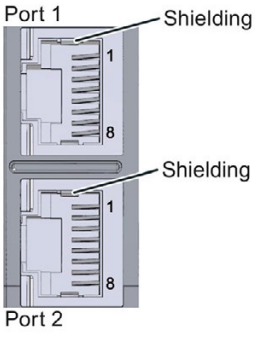
- When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X).
- If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).



PROFINET IO interface on the BusAdapter BA 2xRJ45 (X1 P1 R and X1 P2 R)

The assignment at the BA 2xRJ45 BusAdapter corresponds to the Ethernet standard for an RJ45 connector.

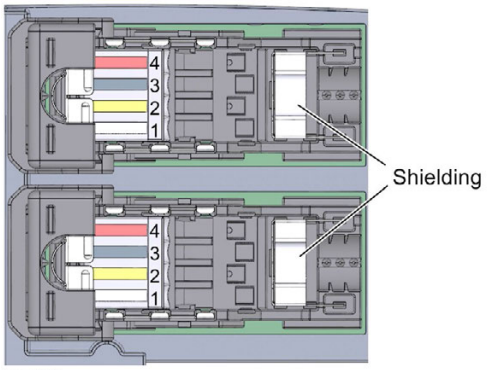
Table 3- 1 Pin assignment PROFINET IO interface on the BusAdapter BA 2xRJ45

View	Designation
	• When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X). • If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).

PROFINET IO interface on the BusAdapter BA 2xFC (X1 P1 R and X1 P2 R)

The following table shows the pin assignment for the PROFINET IO interface on the BusAdapter BA 2xFC.

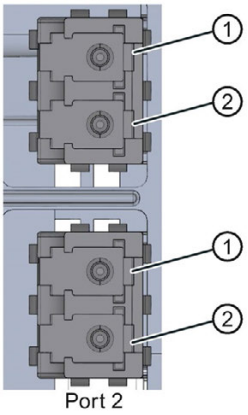
Table 3- 2 Pin assignment PROFINET IO interface on the BusAdapter BA 2xFC

View	Signal name		Designation
Port 1  Port 2	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO interface with BusAdapter BA 2×LC (X1 P1 R and X1 P2 R) (as of V2.0)

The following table shows the signal names and description of the pin assignment for the BA 2×LC BusAdapter.

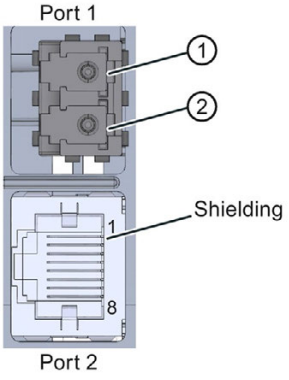
Table 3- 3 Pin assignment PROFINET IO with BusAdapter BA 2×LC

View	Signal name	Designation
Port 1  Port 2	①	Receiver/Receive data
	②	Sender/Transmit data

PROFINET IO interface with BusAdapter BA LC/RJ45 (X1 P1 R and X1 P2 R) (as of V2.0)

The following table shows the signal names and description of the pin assignment for the BA LC/RJ45 BusAdapter.

Table 3- 4 Pin assignment PROFINET IO with BusAdapter BA LC/RJ45

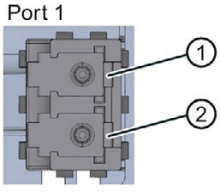
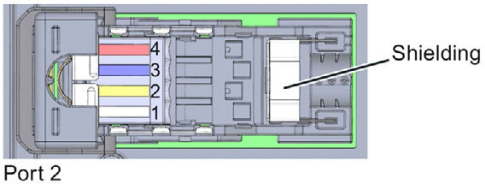
View	Signal name	Designation
	①	Receiver/Receive data
	②	Sender/Transmit data
	RJ45, Port2 • When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X). • If autonegotiation is activated, then auto-crossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).	

PROFINET IO interface with BusAdapter BA LC/FC (X1 P1 R and X1 P2 R) (as of V2.0)

The following table shows the signal names and description of the pin assignment for the BA LC/FC BusAdapter.

The I/Os of the BA LC/FCBusAdapter are shown individually for a clearer overview.

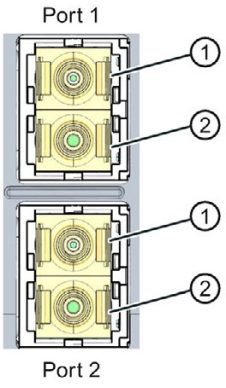
Table 3- 5 PROFINET IO pin assignment with BusAdapter BA LC/FC

View	Signal name		Designation
	①		Receiver/Receive data
	②		Sender/Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO interface with BusAdapter BA 2×SCRJ (X1 P1 R and X1 P2 R)

The following table shows the signal names and description of the pin assignment for the BA 2×SCRJ BusAdapter.

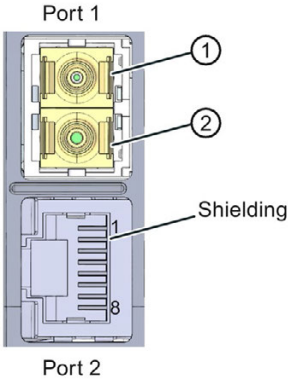
Table 3- 6 PROFINET IO pin assignment with BusAdapter BA 2×SCRJ

View	Signal name	Designation
	①	Receiver/Receive data
	②	Sender/Transmit data

PROFINET IO interface with BusAdapter BA SCRJ/RJ45 (X1 P1 R and X1 P2 R)

The following table shows the signal names and description of the pin assignment for the BA SCRJ/RJ45 BusAdapter.

Table 3- 7 Pin assignment PROFINET IO with BusAdapter BA SCRJ/RJ45

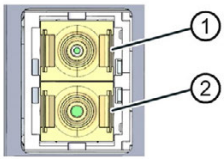
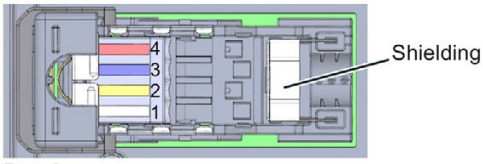
View	Signal name	Designation
	①	Receiver/Receive data
	②	Sender/Transmit data
	RJ45, Port2 • When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X). • If autonegotiation is activated, then auto-crossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).	

PROFINET IO with BusAdapter BA SCRJ/FC (X1 P1 R and X1 P2 R)

The following table shows the signal names and description of the pin assignment for the BA SCRJ/FC BusAdapter.

The pin assignment for the BA SCRJ/FC BusAdapter is shown individually for a clearer overview.

Table 3- 8 PROFINET IO pin assignment with BusAdapter BA SCRJ/FC

View	Signal name		Designation
Port 1  	①		Receiver/Receive data
	②		Sender/Transmit data
 Port 2	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

Reference

You can find additional information on the topics of "Connecting the CPU" and "Accessories/spare parts" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Assignment of the MAC addresses

The MAC address is a globally unique device identifier that is assigned to each PROFINET device in the factory. Its 6 bytes are divided into 3 bytes for the manufacturer ID and 3 bytes for the device ID (serial number). The front of the CPU 1512SP-1 PN is lasered with the MAC address of the PROFINET interface.

The PROFINET interface (X1) of the CPU 1512SP-1 PN has three ports. Port 3 is located on the CPU. Ports 1 and 2 are located on the optional BusAdapter. In addition to the PROFINET interface, each PROFINET port also has a separate MAC address. There is therefore a total of four MAC addresses for the CPU 1512SP-1 PN.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

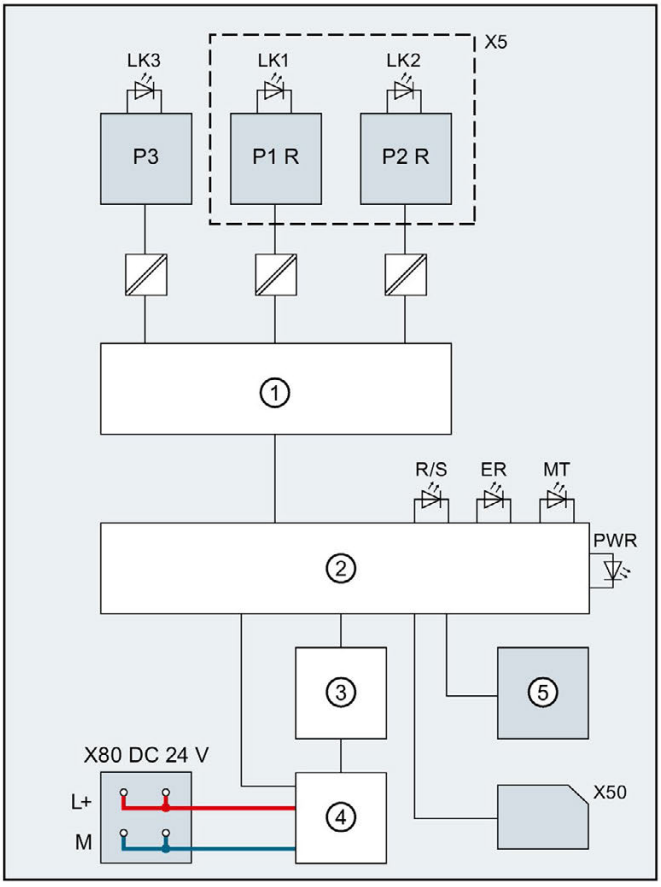
The table below shows how the MAC addresses are assigned.

Table 3- 9 Assignment of the MAC addresses

	Assignment
MAC address 1	PROFINET interface X1 • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	Port X1 P1 R (required for LLDP, for example)
MAC address 3	Port X1 P2 R (required for LLDP, for example)
MAC address 4	Port X1 P3 (required for LLDP, for example)

Block diagram

The following figure shows the block diagram of the CPU 1512SP-1 PN.



①	PROFINET switch	P1 R	PROFINET interface X1 Port 1
②	Electronics	P2 R	PROFINET interface X1 Port 2
③	Backplane bus interface	P3	PROFINET interface X1 Port 3
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	RUN/STOP/MRES mode selector	M	Ground
X5	BusAdapter	LK1, 2, 3	LED Link TX/RX
X50	SIMATIC memory card	R/S	RUN/STOP LED (yellow/green)
X80 24 V DC	Infeed of supply voltage	ER	ERROR LED (red)
		MT	MAINT LED (yellow)
		PWR	POWER LED (green)

Figure 3-2 Block diagram of the CPU 1512SP-1 PN

Interrupts, error messages, diagnostics and system alarms

4

The status and error displays of the CPU 1512SP-1 PN are described below.

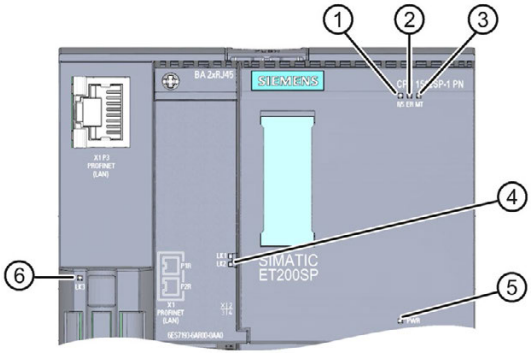
You will find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on the topics of "Diagnostics" and "System alarms" in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

4.1 Status and error display of the CPU

LED displays

The figure below shows the LED displays of the CPU 1512SP-1 PN and the BA 2xRJ45 BusAdapter.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ LINK RX/TX LED for ports X1 P1 and X1 P2 (green LEDs on BusAdapter)
⑤ POWER LED (green LED)
⑥ LINK RX/TX LED for port X1 P3 (green LED on CPU)

Figure 4-1 LED displays on the CPU and BusAdapter

Meaning of the POWER, RUN/STOP, ERROR and MAINT LEDs

CPU 1512SP-1 PN features an LED for monitoring the supply voltage of the electronics (PWR) and three LEDs for displaying the current operating and diagnostics status. The following table shows the meaning of the various combinations of colors for the POWER, RUN/STOP, ERROR and MAINT LEDs.

Table 4- 1 Meaning of the LEDs

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	LED off	Missing or insufficient supply voltage on the CPU.
LED lit green	LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED lit green	LED flashes red	LED off	A diagnostics event is pending.
LED lit green	LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. The affected hardware must be checked/replaced within a short period of time.
				Active Force job
				PROFIenergy pause
LED lit green	LED lit green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be checked/replaced within a foreseeable period of time.
				Bad configuration
LED lit green	LED lit yellow	LED off	LED flashes yellow	Firmware update successfully completed.
LED lit green	LED lit yellow	LED off	LED off	CPU is in STOP mode.
LED lit green	LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC memory card is causing an error.
				CPU defective
LED lit green	LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. startup after STOP.
				Download of the user program from the SIMATIC memory card
LED lit green	LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED lit green	LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
				Test of LEDs during startup, inserting a module.
				LED flashing test

Meaning of the LINK LED

Each port has a LINK LED (LK1, LK2, LK3). The table below shows the various "LED scenarios" of ports for the CPU 1512SP-1 PN.

Table 4- 2 Meaning of the LEDs

LINK LED	Meaning
▫ LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
☼ LED flashes green	The "LED flashing test" is being performed.
■ LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.

Technical specifications

5

	6ES7512-1DK01-0AB0
General information	
Product type designation	CPU 1512SP-1 PN
Hardware function version	FS03
Firmware version	V2.0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14
Configuration control	
Via data record	Yes
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure buffering	
Power/voltage failure buffer time	5 ms
Input current	
Current consumption (rated value)	0.6 A
Inrush current, max.	4.7 A; rated value
I^2t	0.14 A^2s
Power	
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	5.6 W
Memory	
Number of slots for SIMATIC memory card	1
SIMATIC memory card required	Yes
Work memory	
Integrated (for program)	200 KB
Integrated (for data)	1 MB
Load memory	
Plug-in (SIMATIC memory card), max.	32 GB
Buffering	
Maintenance-free	Yes

	6ES7512-1DK01-0AB0
CPU processing times	
For bit operations, typ.	48 ns
For word operations, typ.	58 ns
For fixed-point arithmetic, typ.	77 ns
For floating-point arithmetic, typ.	307 ns
CPU blocks	
Number of elements (total)	2000; blocks (OB/FB/FC/DB) and UDTs
DB	
Number range	1 ... 60 999; divided into: Number range that can be used by user: 1 ... 59 999 and number range for DBs generated by SFC 86: 60 000 ... 60 999
Size, max.	1 MB; for absolutely addressed DBs, the max. size is 64 KB
FB	
Number range	0 ... 65 535
Size, max.	200 KB
FC	
Number range	0 ... 65 535
Size, max.	200 KB
OB	
Size, max.	200 KB
Number of free-cycle OBs	100
Number of time-of-day interrupt OBs	20
Number of time-delay interrupt OBs	20
Number of cyclic interrupt OBs	20
Number of hardware interrupt OBs	50
Number of DPV1 interrupt OBs	3
Number of isochronous mode OBs	1
Number of technology synchronous interrupt OBs	2
Number of startup OBs	100
Number of asynchronous error OBs	4
Number of synchronous error OBs	2
Number of diagnostic interrupt OBs	1
Nesting depth	
Per priority class	24
Counters, timers and their retentivity	
S7 counters	
Quantity	2048
Retentivity	
• can be set	Yes

	6ES7512-1DK01-0AB0
IEC counters	
Quantity	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
S7 timers	
Quantity	2048
Retentivity	
• can be set	Yes
IEC timers	
Quantity	Any (only limited by the work memory)
Retentivity	
• can be set	Yes
Data areas and their retentivity	
Total retentive data area (including timers, counters, bit memories), max.	128 KB; for bit memories, timers, counters, DBs and technological data (axes), usable retentive memory: 88 KB
Bit memory	
Number, max.	16 KB
Number of clock memories	8; there are 8 clock memory bits, grouped in one clock memory byte
Data blocks	
Retentivity can be set	Yes
Retentivity preset	No
Local data	
Per priority class, max.	64 KB; max. 16 KB per block
Address area	
Number of IO modules	2048; max. number of modules/submodules
I/O address area	
Inputs	32 KB; all inputs are in the process image
Outputs	32 KB; all outputs are in the process image
Of which per integrated IO subsystem	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Of which per CM/CP	
• Inputs (volume)	8 KB
• Outputs (volume)	8 KB
Process image partitions	
Number of process image partitions, max.	32
Address space per module	
Address space per module, max.	288 bytes; for both input and output data

	6ES7512-1DK01-0AB0
Address space per station	
Address space per station, max.	2560 bytes; for central inputs and outputs; depending on configuration; 2048 bytes for ET 200SP modules + 512 bytes for ET 200AL modules
Hardware configuration	
Number of distributed IO systems	32; a distributed IO system is understood to mean the integration of distributed I/O via PROFINET or PROFIBUS communication modules as well as the connection of I/O via AS-i master modules or links (e.g. IE/PB link)
Number of DP masters	
Via CM	1
Number of IO controllers	
Integrated	1
Via CM	0
Rack	
Modules per rack, max.	80; CPU + 64 modules + server module (configuration width max. 1 m) + 16 ET 200AL modules
Number of rows, max.	1
PtP CM	
Number of PtP CMs	The number of PtP CMs that can be connected is only limited by the available slots
Time	
Clock	
Type	Hardware clock
Backup duration	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Operating hours counter	
Quantity	16
Time-of-day synchronization	
Supported	Yes
On DP, master	Yes; via CM DP module
On DP, slave	Yes; via CM DP module
In AS, master	Yes
In AS, slave	Yes
On Ethernet via NTP	Yes
Interfaces	
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; via CM DP module
With optical interface	Yes; via BusAdapter
1st interface	

	6ES7512-1DK01-0AB0
Interface hardware	
Number of ports	3; 1st integrated + 2nd via BusAdapter
Integrated switch	Yes
RJ45 (Ethernet)	Yes; X1 P3; opt. X1 P1 and X1 P2 via BusAdapter BA 2xRJ45
BusAdapter (PROFINET)	Yes; usable BusAdapters: BA 2x RJ45, BA 2x FC, BA 2x SCRJ, BA SCRJ / RJ45, BA SCRJ / FC, BA 2x LC, BA LC / RJ45, BA LC / FC
Protocols	
PROFINET IO controller	Yes
PROFINET IO device	Yes
SIMATIC communication	Yes
Open IE communication	Yes
Web server	Yes
Media redundancy	Yes
PROFINET IO controller	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	Yes
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes; as MRP redundancy manager and/or MRP client; max. number of devices in the ring: 50
• MRPD	Requirement: IRT
• PROFIenergy	Yes
• Prioritized startup	Yes; max. 32 PROFINET devices
• Number of connectable IO devices, max.	128; a total of up to 512 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
• of these, IO devices with IRT, max.	64
• Number of connectable IO devices for RT, max.	128
• of these, in a line topology, max.	128
• Number of IO devices that can be activated/deactivated simultaneously, max.	8; in total over all interfaces
• Number of IO devices per tool, max.	8
• Update times	The minimum value of the update time also depends on the communication allocation setting for PROFINET IO, the number of IO devices and the amount of configured user data

	6ES7512-1DK01-0AB0
Update time with IRT	
• With send clock of 250 µs	250 µs to 4 ms; note: with IRT with isochronous mode, the minimum update time of 500 µs of the isochronous OB is decisive
• With send clock of 500 µs	500 µs to 8 ms
• With send clock of 1 ms	1 ms to 16 ms
• with send clock of 2 ms	2 ms to 32 ms
• with send clock of 4 ms	4 ms to 64 ms
• with IRT and "odd" send clock parameter assignment	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs to 3 875 µs)
Update time with RT	
• With send clock of 250 µs	250 µs to 128 ms
• With send clock of 500 µs	500 µs to 256 ms
• With send clock of 1 ms	1 ms to 512 ms
• with send clock of 2 ms	2 ms to 512 ms
• with send clock of 4 ms	4 ms to 512 ms
PROFINET IO device	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Isochronous mode	No
• Open IE communication	Yes
• IRT	Yes
• MRP	Yes
• MRPD	Yes; requirement: IRT
• PROFIenergy	Yes
• Shared device	Yes
• Number of IO controllers with shared device, max.	4
2nd interface	
Interface hardware	
Number of ports	1
RS 485	Yes; via CM DP module
Protocols	
PROFIBUS DP master	Yes
PROFIBUS DP slave	Yes
SIMATIC communication	Yes

	6ES7512-1DK01-0AB0
Interface hardware	
RJ45 (Ethernet)	
100 Mbps	Yes
Autonegotiation	Yes
Autocrossing	Yes
Industrial Ethernet status LED	Yes
RS 485	
Transmission rate, max.	12 Mbps
Protocols	
Number of connections	
Number of connections, max.	128
Number of connections reserved for ES/HMI/Web	10
Number of connections via integrated interfaces	88
Number of connections per CP/CM	32
Number of S7 routing connections	16
SIMATIC communication	
S7 communication, as server	Yes
S7 communication, as client	Yes
User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
TCP/IP	Yes
• Data length, max.	64 KB
• Multiple passive connections per port, supported	Yes
ISO-on-TCP (RFC1006)	Yes
• Data length, max.	64 KB
UDP	Yes
• Data length, max.	1472 bytes
DHCP	No
SNMP	Yes
DCP	Yes
LLDP	Yes
Web server	
HTTP	Yes; standard and user-defined pages
HTTPS	Yes; standard and user-defined pages

	6ES7512-1DK01-0AB0
PROFIBUS DP master	
Number of connections, max.	48
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Data record routing	Yes
• Isochronous mode	No
• Constant bus cycle time	No
• Number of DP slaves	125; a total of up to 512 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
• Activation/deactivation of DP slaves	Yes
OPC UA	
OPC UA server	Yes; Data Access (Read, Write, Subscribe), Runtime license required
• Application authentication	Yes
• Security Policies	Available Security Policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256
• User authentication	"Anonymous" or with user name and password
Additional protocols	
MODBUS	Yes; MODBUS TCP
Media redundancy	
Switchover time in the case of cable break, typ.	200 ms; with MRP; bumpless with MRPD
Number of devices in the ring, max.	50
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes; only with PROFINET; with a minimum OB 6x cycle of 625 µs
S7 signaling functions	
Number of stations that can be logged in for signaling functions, max.	32
Block-related alarms	Yes
Number of configurable interrupts, max.	5000
Number of simultaneously active interrupts in interrupt pool	
• Number of reserved user interrupts	300
• Number of reserved interrupts for system diagnostics	100
• Number of reserved interrupts for motion control technology objects	80

	6ES7512-1DK01-0AB0
Test/commissioning functions	
Shared commissioning (Team Engineering)	Yes; parallel online access possible for up to 3 engineering systems
Status block	Yes; up to 8 simultaneously (in total over all ES clients)
Single-step	No
Status/modify	
Status/modify tag	Yes
Tags	Inputs/outputs, bit memory, DB, peripheral inputs/outputs, timers, counters
Number of tags, max.	
• Of which are status tags, max.	200; per job
• Of which are modify tags, max.	200; per job
Forcing	
Forcing	Yes
Forcing, tags	Peripheral inputs/outputs
Number of tags, max.	200
Diagnostics buffer	
Available	Yes
Number of entries, max.	1000
• Of which are power failure-proof	500
Traces	
Number of configurable traces	4; up to 512 KB data possible per trace
Interrupts/diagnostics/status information	
Diagnostics display LED	
RUN/STOP LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Monitoring of the supply voltage (PWR LED)	Yes
Connection display LINK TX/RX	Yes
Supported technology objects	
Motion control	Yes; note: the number of axes affects the cycle time of the PLC program; selection guide via the TIA Selection Tool or SIZER
• Number of available motion control resources for technology objects (except cams)	800
• Required Motion Control resources	
– per speed-controlled axis	40
– per positioning axis	80
– per synchronous axis	160
– per external encoder	80
– per output cam	20
– per cam track	160
– per measuring input	40

	6ES7512-1DK01-0AB0
Controller	
• PID_Compact	Yes; universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves
• PID temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
Standards, approvals, certificates	
Suitable for safety functions	No
Highest safety class achievable in safety mode	
Performance level according to EN ISO 13849-1:2008	None
SIL according to IEC 61508	No
Ambient conditions	
Ambient temperature during operation	
Horizontal mounting position, min.	0 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, min.	0 °C
Vertical mounting position, max.	50 °C
Ambient temperature during storage/transport	
Min.	-40 °C
Max.	70 °C
Configuring	
Programming	
Programming language	
• LAD	Yes
• FBD	Yes
• STL	Yes
• SCL	Yes
• GRAPH	Yes
Know-how protection	
User program protection	Yes
Copy protection	Yes
Block protection	Yes
Access protection	
Protection level: Write protection	Yes
Protection level: Read/write protection	Yes
Protection level: Complete protection	Yes

	6ES7512-1DK01-0AB0
Cycle time monitoring	
Low limit	Configurable minimum cycle time
High limit	Configurable maximum cycle time
Dimensions	
Width	100 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	310 g

Technical specifications of the BusAdapter BA 2×RJ45

Table 5- 1 Technical specifications of the BusAdapter BA 2×RJ45

	6ES7193-6AR00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
RJ45	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	46 g

Technical specifications of the BusAdapter BA 2×FC

Table 5- 2 Technical specifications of the BusAdapter BA 2×FC

	6ES7193-6AF00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
FC (FastConnect)	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	53 g

Technical specifications of the BusAdapter BA 2×LC

Table 5- 3 Technical specifications of the BusAdapter BA 2×LC

	6ES7193-6AG00-0AA0
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC multimode glass-fiber
PROFINET IO	
RJ45	No
FC (FastConnect)	No
SCRJ	0
LC	2
Cable length	
• Multimode gradient-index fiber 50/125 µm	3 km
• Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	40 g

Technical specifications of the BusAdapter BA 2×SCRJ

Table 5- 4 Technical specifications of the BusAdapter BA 2×SCRJ

	6ES7193-6AP00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (switch) SCRJ FO
SCRJ	2
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA LC/RJ45

Table 5- 5 Technical specifications of the BusAdapter BA LC/RJ45

	6ES7193-6AG20-0AA0
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC / RJ45
PROFINET IO	
RJ45	Yes; 1x
FC (FastConnect)	No
SCRJ	0
LC	1
Cable length	
• Copper cables	100 m
• Multimode gradient-index fiber 50/125 µm	3 km
• Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	32 g

Technical specifications of the BusAdapter BA LC/FC

Table 5- 6 Technical specifications of the BusAdapter BA LC/FC

	6ES7193-6AG40-0AA0
Interfaces	
Number of PROFINET interfaces	1
PROFINET IO	
RJ45	No
FC (FastConnect)	Yes; 1x
SCRJ	0
LC	1
Cable length	
• Copper cables	100 m
• Multimode gradient-index fiber 50/125 µm	3 km
• Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/RJ45

Table 5- 7 Technical specifications of the BusAdapter BA SCRJ/RJ45

	6ES7193-6AP20-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + RJ45)
RJ45	Yes; 1 x
SCRJ	1
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/FC

Table 5- 8 Technical specifications of the BusAdapter BA SCRJ/FC

	6ES7193-6AP40-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + FC)
FC (FastConnect)	Yes; 1 x
SCRJ	1
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

General technical specifications

You can find information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc., in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Dimension drawing

A

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimension drawing of the CPU 1512SP-1 PN

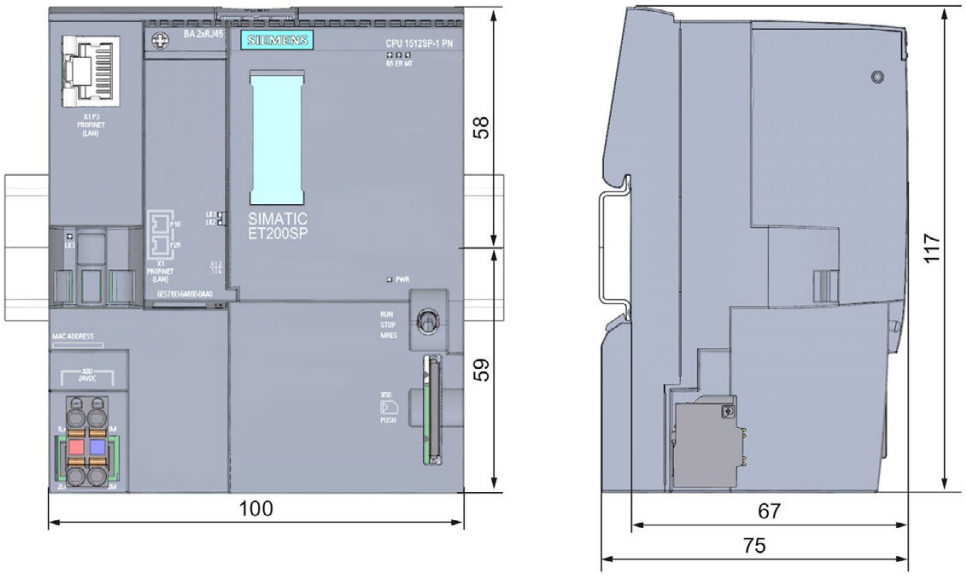


Figure A-1 Dimension drawing CPU 1512SP-1 PN

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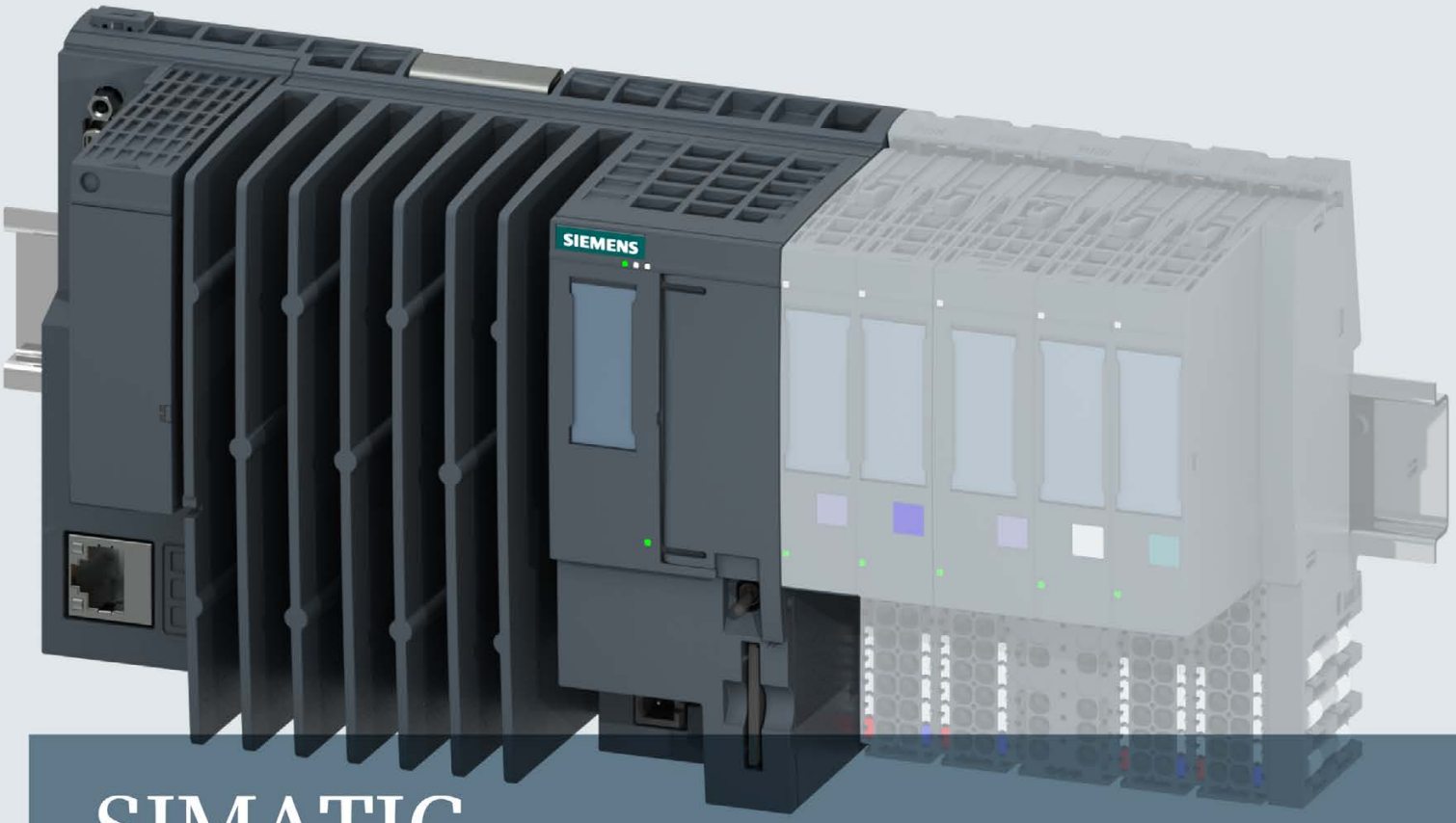

SIMATIC

ET 200SP Open Controller

CPU 1515SP PC (6ES7677-2AAxx-0xx0)

Manual

Edition 12/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP Open Controller CPU 1515SP PC

Manual

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12/2014

A5E32701806-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the system manual for the ET 200SP distributed I/O system. Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the CPU 1515SP PC.

Basic knowledge required

The system must be operated and used by qualified staff only.
The following knowledge is required:

- Installation guidelines for SIMATIC ET 200SP
- Programming with STEP 7
- PC-based automation using an S7-1500 software controller and WinCC Runtime Advanced
- Basic knowledge of PC technology
- Windows Embedded Standard 7 operating system

Scope of validity of the documentation

This documentation is valid for the following devices:

ET 200SP Open Controller	Article number	
	Hardware variant WES7 E 32Bit 2GB RAM	Hardware variant WES7 P 64Bit 4GB RAM
CPU 1515SP PC	6ES7677-2AA31-0EB0	6ES7677-2AA41-0FB0
CPU 1515SP PC + HMI 128PT	6ES7677-2AA31-0EK0	6ES7677-2AA41-0FK0
CPU 1515SP PC + HMI 512PT	6ES7677-2AA31-0EL0	6ES7677-2AA41-0FL0
CPU 1515SP PC + HMI 2048PT	6ES7677-2AA31-0EM0	6ES7677-2AA41-0FM0
CPU 1515SP PC, spare part, without CFast card	6ES7677-2AA30-0AA0	6ES7677-2AA40-0AA0

Conventions

Conventions STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. For more information about industrial security, visit (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. For more information, visit (http://support.automation.siemens.com).

Information about third-party software updates

This product contains third-party software. Siemens accepts liability with respect to updates/patches for the third-party software only when these are distributed by Siemens in the context of a Software Update Service contract or officially approved by Siemens. Otherwise, updates/patches are installed at the user's own risk. You can find more information about our software update service offer under (http://www.automation.siemens.com/mcms/automation-software/en/software-update-service/Pages/Default.aspx).

Notes on protecting administrator accounts

A user with administrator rights has extensive access and manipulation possibilities.

Therefore, make sure that the administrator account is adequately protected to prevent unauthorized changes. To do this, set secure passwords and use a standard user account for regular operation. Other measures, such as the use of security policies, should be applied as required.

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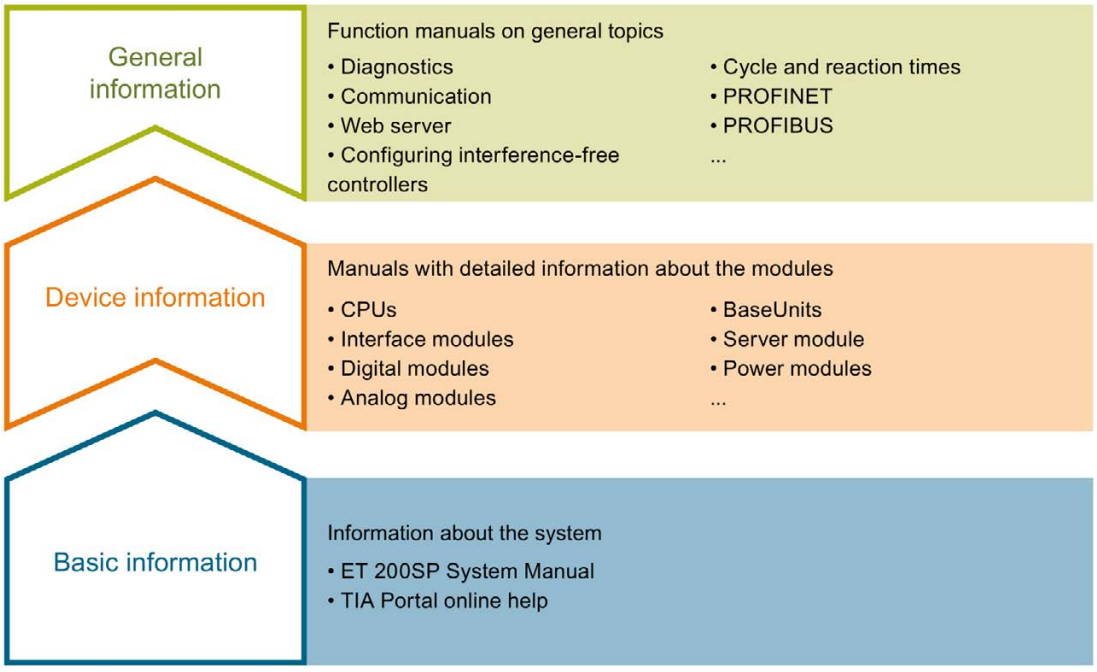
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

1.1 Documentation on CPU 1515SP PC

The following additional documentation is required to use the CPU 1515SP PC:

- Operating manual S7-1500 software controller (http://support.automation.siemens.com/WW/view/en/10805639/133300)
- System manual WinCC Advanced V13 (http://support.automation.siemens.com/WW/view/en/68075405)
- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- Manual Server module (http://support.automation.siemens.com/WW/view/en/63257531)

Safety notes

2

WARNING

Life-endangering voltage when control cabinet is open

If the device is installed in a control cabinet, areas or components can be under life-endangering voltage when the control cabinet is open.

Contact with these areas or components may lead to death through electric shock.

Switch off the power before opening the control cabinet.

If the device is operated in a machine in accordance with the machinery directive, the provisions of the guideline 2006/42/EC apply.

Safe operation of a plant

WARNING

Risk of fire

The device is classified for use in the area of Industrial Control Equipment as "Open Type" according to UL508. If overheating occurs, burning material may leak and cause a fire.

For this reason, observe the following information:

- For approval and operation in accordance with UL508, the device must be installed in a housing complying with UL508.
- Install the device in a housing complying with the requirements of Sections 4.6 and 4.7.3 of the standards EN 60950-1:2006 and IEC/UL/EN/DIN-EN 60950-1.

If you have questions about the validity of installation in the planned environment, please contact our service representatives.

NOTICE

Protective measures

To ensure safe operation of a plant, you have to take suitable IT security measures, for example, network segmentation.

Seal the cover to protect the CFast card with the operating system of the CPU 1515SP PC from unauthorized access.

For more information on Industrial Security, refer to the Internet (http://www.siemens.com/industrialsecurity).

Repairs

⚠ WARNING
Damage caused by opening the device
Unauthorized opening of and improper repairs to the device may result in substantial damage to equipment or endanger the user.
Only authorized personnel are permitted to repair the device.

For additional information on repairs, see section Sending the device to customer service (Page 80).

ESD guidelines

Modules containing electrostatic sensitive devices (ESDs) can be identified by the following label:

Strictly follow the guidelines mentioned below when handling modules which are sensitive to ESD:

- Always discharge yourself of static electricity before handling modules which are sensitive to ESD (for example, by touching a grounded object).
- All devices and tools must be free of static charge.
- Always pull the mains connector and disconnect the battery before installing or removing modules which are sensitive to ESD.
- Handle modules fitted with ESDs only by their edges.
- Do not touch any connector pins or conductors on modules containing ESDs.

See also

Electromagnetic compatibility (Page 87)

2.1 Notes on use

⚠ WARNING

Hazards at an unprotected machine or plant

According to the results of a risk analysis, hazards can occur at an unprotected machine. The hazards may lead to personal injury.

According to the risk analysis, the risk of injury to persons can be countered with the following measures:

- Additional protective equipment at the machine or plant. In this case, the programming, parameter assignment and wiring of the I/O used, in particular, must be performed in accordance with the safety criteria (SIL, PL or Cat.) ascertained by means of an appropriate risk analysis.
- Use of the device for its intended purpose, which can be established by performing a functional test on the plant. This allows errors in programming, parameter assignment and wiring to be detected.
- Documentation of the test results which can be entered, if required, into the relevant safety certificates.

NOTICE

Ambient conditions

Ambient conditions for which the device is not suitable can lead to faults or damage the device.

Note the following:

- Only operate the device in enclosed areas. If you do not comply with this instruction, the warranty becomes void.
- Only operate the device in accordance with the ambient conditions given in the technical specifications.
- Protect the device from dust, moisture and heat.
- Do not expose the device to direct sunlight or other strong sources of light.
- The device must not be used in places with more difficult operating conditions through corrosive vapors or gases without taking additional protective measures, for example, supply of clean air.

Product overview

3

3.1 Properties

Article number

6ES7677-2AAxx-0xx0

The complete article number depends on the hardware version and the order option.

View of the module

The figure below shows the CPU 1515SP PC.

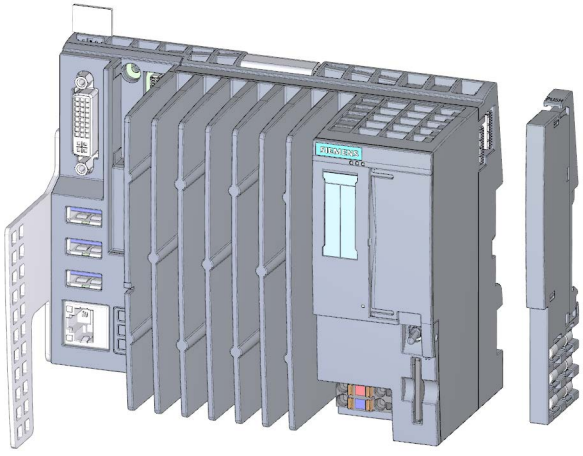


Figure 3-1 CPU 1515SP PC with supplied accessories

Properties

The CPU 1515SP PC is a PC-based automation device in the design of the ET 200SP. It is used for control and visualization purposes. The supplied IPC DiagBase software provides basic diagnostics functions and supports you in handling the BIOS.

The CPU 1515SP PC has the following technical properties:

- A removable CFast card with the following pre-installations is used as storage medium:
  - Windows Embedded Standard 7 operating system
  - S7 1500 software controller: CPU 1505S
  - Optionally with HMI: WinCC Runtime Advanced V13 SP1
- Interfaces
  - An interface for the exchangeable ET 200SP BusAdapters for connection of PROFINET IO (2 ports)
  - An interface for connecting devices using Industrial Ethernet (Gigabit Ethernet)
  - 3 interfaces for USB devices
  - A DVI-I interface for a monitor
  - A sealable slot for the CFast card
  - A slot for an SD/MMC card as additional optional drive
- Supply voltage 1L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery.
- The CPU 1515SP PC is suitable for use in industrial environments:
  - Compact design
  - Fan-less operation
  - High robustness
- The CPU 1515SP PC complies with IP 20 degree of protection and is intended for installation in a control cabinet.

Hardware variants and ordering options

The following hardware variants are available for the **CPU 1515SP PC**:

- WES7 E 32-bit 2GB RAM, 8 GB CFast card
- WES7 P 64-bit 4GB RAM, 16 GB CFast card, suitable for Multitouch panels

The following order options are available:

- CPU 1515SP PC with preinstalled software controller
- CPU 1515SP PC + HMI (128PT, 512PT, 2040PT) with preinstalled software controller and WinCC Runtime Advanced V13 SP1

3.2 Sample configuration

Configuration

The CPU 1515SP PC is mounted on a mounting rail according to EN 60715. A modular system is formed with ET 200SP modules in the central rack.

The CPU 1515SP PC can be used as PROFINET IO controller. The PROFINET IO devices are connected via the ports of the X1 PN (LAN) interface using the SIMATIC BusAdapter BA 2xRJ45.

Devices can be connected via Industrial Ethernet using the integrated interface X2 PN/IE (LAN).

The connection to PROFIBUS can be made using the DP master module.

Sample configuration

The figure below shows a sample configuration with the CPU 1515SP PC.

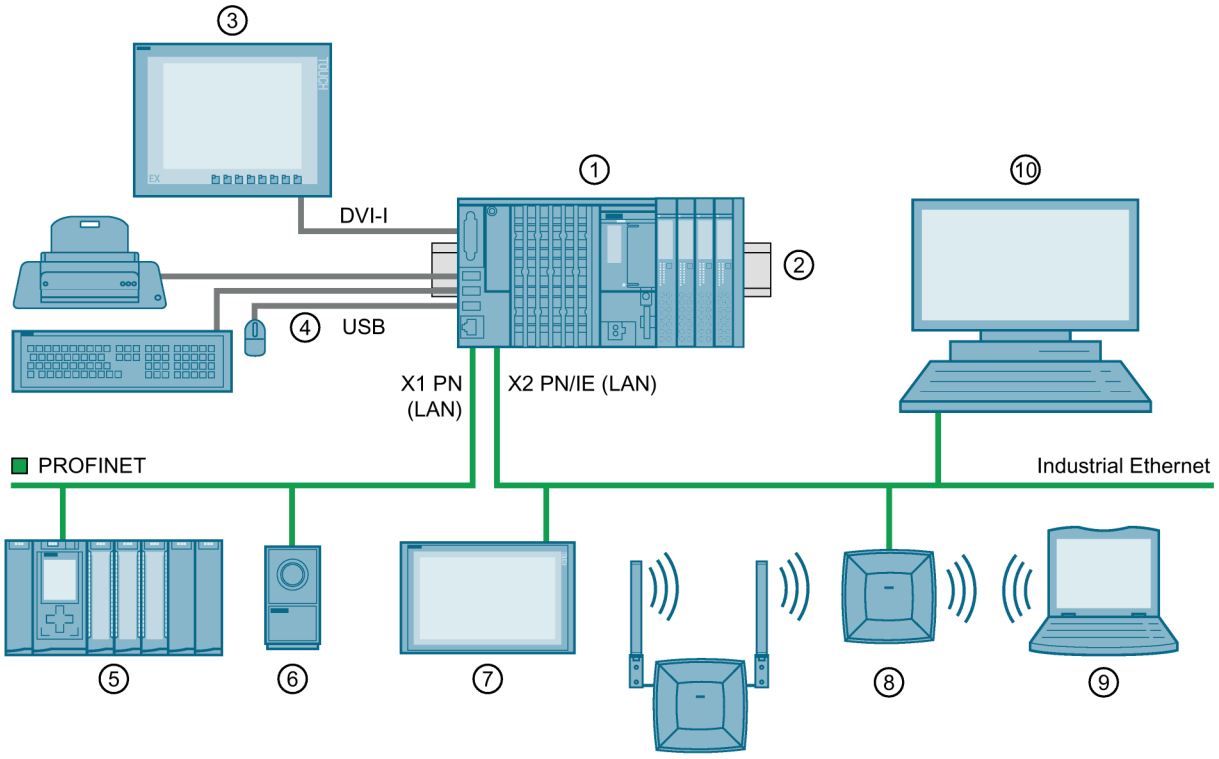


Figure 3-2 Sample configuration with the CPU 1515SP PC

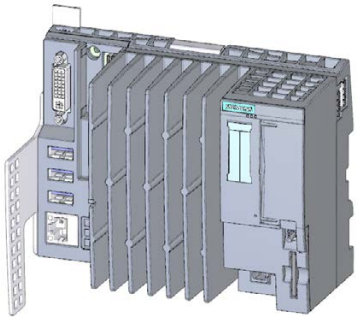
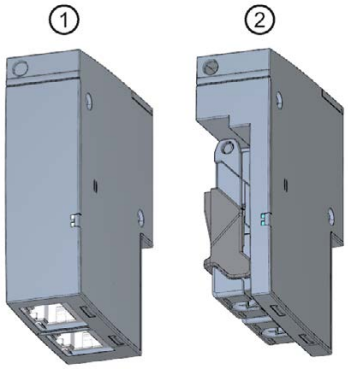
① CPU 1515SP PC, I/O modules, server module
② Mounting rail
③ Flat Panel - Wide Screen Display
④ USB devices: Keyboard, mouse, printer ...
⑤ PROFINET IO device
⑥ Camera
⑦ Industrial Thin Client ITC
⑧ SCALANCE W786
⑨ Field programming device
⑩ PC/Programming device

3.3 Components

Components of the CPU 1515SP PC

The following table provides an overview of the components of the CPU 1515SP PC:

Table 3- 1 Components of the CPU 1515SP PC

Component	Function	Figure
Mounting rail in accordance with EN 60715	The mounting rail is the rack for the CPU 1515SP PC.	
CPU 1515SP PC	CPU with strain relief and white reference labels	
BusAdapter	The BusAdapter allows free selection of the connection technology for PROFINET IO. The following variants are available for the CPU 1515SP PC: • For standard RJ45 plug (BA 2×RJ45) ① • For direct connection of the bus cable (BA 2×FC) ②	
Server module	The server module completes the configuration of the CPU 1515SP PC with I/O modules. The server module is included in the CPU's scope of delivery.	

3.4 Configuration of the devices

Front view

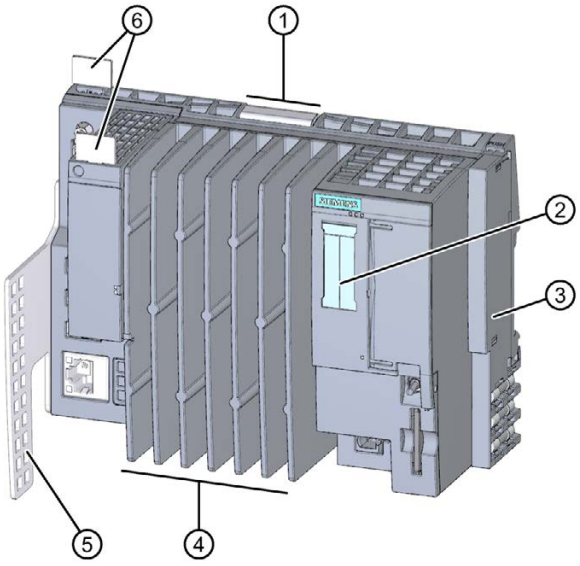


Figure 3-3 Front view of CPU 1515SP PC

① Mounting rail release mechanism
② Labeling strips
③ Server module
④ Cooling fins
⑤ Strain relief
⑥ Reference labels

3.5 Operator controls and display elements

Front view of the module

The following figure shows the operator controls and connection elements of the CPU 1515SP PC.

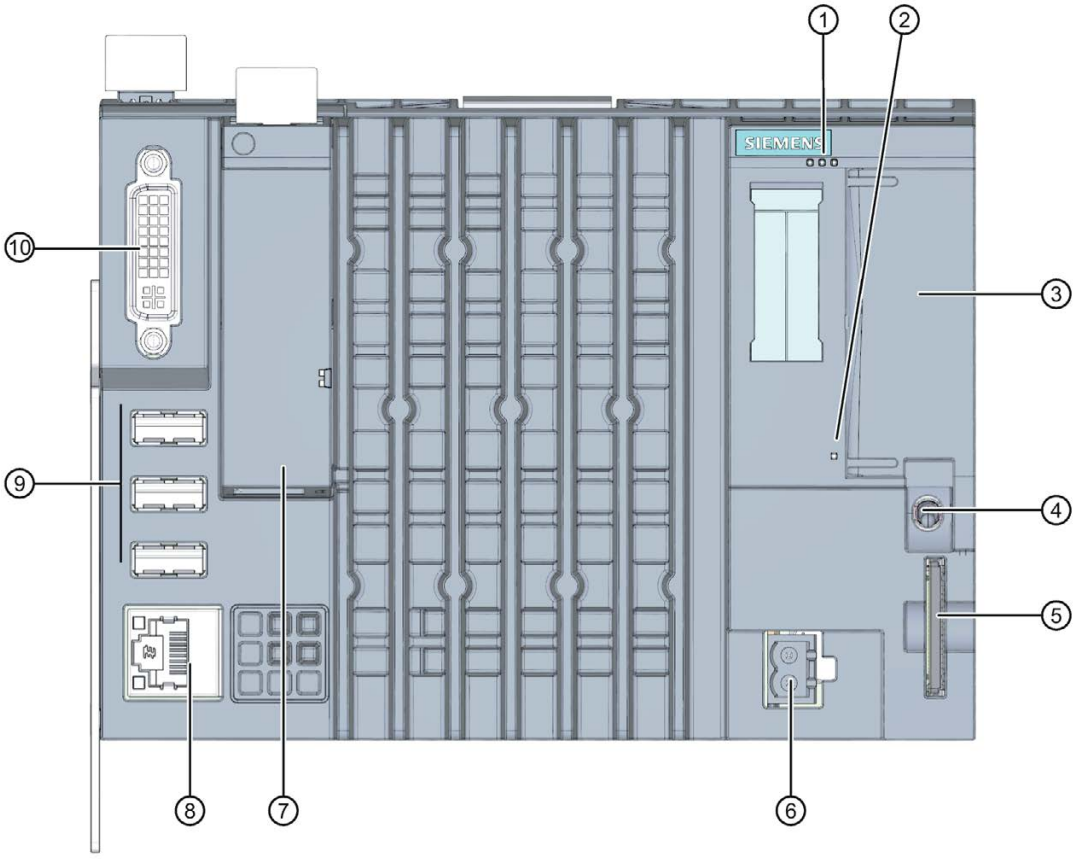


Figure 3-4 View of the CPU 1515SP PC

① LED displays for the current operating mode and diagnostic status of the CPU
② Power LED
③ **X50:** Slot for the CFast card (flash memory), sealable
④ Mode selector
⑤ **X51:** Slot for an optional SD/MMC card
⑥ **X80:** Connector for 24 V DC supply voltage
⑦ **X1 PROFINET (LAN):** Slot for BusAdapter for connection of PROFINET IO; status display for PROFINET
⑧ **X2 PN/IE (LAN):** GbE Ethernet connection with integrated display
⑨ **X60, X61, X62:** 3 USB connections
⑩ **X70 DVI-I:** Connection for monitor

Slot for CFast card

The operating system, Runtime software and project are installed on the supplied SIMATIC CFast card. The CFast card is the only mass storage device of the CPU 1515SP PC.

Note

Unauthorized access

Seal the cover of the slot to protect the CFast card with the operating system of the CPU 1515SP PC from unauthorized access and manipulation.

Slot for SD/MMC card

A SIMATIC SD or MMC card can be used as additional storage drive. This drive can be used to store data via Windows, for example a backup, but not the operating system, the Runtime software or the project.

Permitted SD cards: SDHC up to 32 GB, SDXC up to 2 TB.

USB connections

Two USB high-current (500 mA) interfaces and one low-current (100 mA) interface can be used at the same time.

MAC addresses

The MAC address consists of a 3-byte manufacturer ID and a 3-byte device ID (consecutive number).

Each device is already assigned four MAC addresses in the factory. The front of the CPU 1515SP PC is lasered with the MAC address 1 and 4. With the MAC addresses 2 and 3, the consecutive numbers are incremented. If, for example, the first MAC address is 08-00-06-6B-80-C0, the second MAC address is 08-00-06-6B-80-C1.

Table 3- 2 Assignment of the MAC addresses

	Assignment
MAC address 1	X2 PN/IE (LAN) • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	X1 PROFINET (LAN) • Visible in STEP 7 for accessible devices
MAC address 3	Port X1 P1 (required for LLDP, for example)
MAC address 4	Port X1 P2 R (required for LLDP, for example) • Lasered on the front of the CPU (end of the number range)

Connector for supply voltage

The CPU 1515SP PC is equipped with a 2-pin connection terminal for the power supply.

The connection plug for the supply voltage is plugged in when the CPU is shipped from the factory.

Mode selector

Use the mode selector to set the CPU operating mode.

Table 3- 3 Mode selector positions

Position	Meaning	Description
RUN	Operating mode RUN[1]	The CPU is processing the user program.
STOP	Operating mode STOP[1]	The CPU is not processing the user program. The outputs are set to a "safe" state.
MRES	Memory reset	**For active S7-1500 software controller**[2] only: CPU memory reset

1 RUN and STOP indicate the **selected** operating state. The RUN and STOP LEDs indicate the **actual** operating mode of the CPU 1515SP PC.

2 See the S7-1500 software controller manual

3.6 Scope of delivery

3.6.1 Unpacking the device

When unpacking

When unpacking, make sure to check the following:

- Check packaging and contents for visible damage from transport.
- Check the delivery for completeness.
  Please inform your Siemens contact partner should you determine damages from transport or any irregularities.
- Keep the supplied documentation and licenses. They belong to the device and are the proof that you have purchased the software preinstalled on the CFast card.
  Documentation and licenses are required for initial commissioning and for any questions that arise.
- Keep the original packaging in case the device needs to be transported again.

NOTICE
Damage to the device during transport and storage If a device is transported or stored without packaging, it is unprotected from shocks, vibrations, pressure and moisture. Damaged packaging indicates that environmental conditions have already had a significant impact on the device. The device might be damaged. Do not dispose of the original packaging. Pack the device for transport and storage.

NOTICE
Damage to the device caused by condensation If the device was exposed to low temperatures or extreme variations in temperature during transport, this may cause moisture to build up on or in the device (condensation). Moisture may cause a short-circuit and damage the device. Proceed as follows to avoid damage: • Store the device in dry conditions. • Make sure it adapts to room temperature before commissioning. • Do not expose the device to direct heat radiation from a heater. • If condensation has developed, wait for approximately 12 hours or until the device is completely dry before you switch it on.

⚠ WARNING

Electric shock and fire hazard from damaged device

A damaged device can carry dangerous voltage and trigger a fire in the machine or plant. A damaged device has unpredictable properties and states.

Death or severe injury could occur.

Make sure that the damaged device is not installed and commissioned accidentally. Label the damaged device correspondingly and keep it locked up. Have the device repaired without delay.

Identification data

The identification data can be used to clearly identify the device when a repair is necessary.

Make a note of the following data for your devices:

- The article number of the CPU 1515SP PC can be found on the order slip.
- Depending on the scope of delivery, the "Certificate of License" is provided as proof of license for the S7-1500 software controller and for WinCC Runtime Advanced V13 SP1.
- The "Microsoft Windows Product Key" can be found on the "Certificate of Authenticity" label.
- The first and the last MAC address are provided on the device.

3.6.2 Scope of delivery - Hardware variant WES7 E 32Bit 2GB RAM

Note

The device always comes with the **CPU 1515SP PC** label with article number 6ES7677-**2AA30-0AA0**, regardless of the order options.

The following components are included in the scope of delivery of the CPU 1515SP PC:

Table 3- 4 Scope of delivery - Hardware variant WES7 E 32Bit 2GB RAM

Order option	**CPU 1515SP PC**	**CPU 1515SP PC + HMI**	**CPU 1515SP PC (spare part)**
Article number	6ES7677-2AA**31**-**0EB0**	6ES7677-2AA**31**- • **0EK0** HMI 128PT • **0EL0** HMI 512PT • **0EM0** HMI 2048PT	6ES7677-2AA**30**-**0AA0**
CPU	X	X	X
Strain relief with fixing screws	X	X	X
Server module	X	X	X
8 GB CFast card with the following pre-installations:			
• Windows Embedded Standard 7 E operating system	X	X	–
• S7-1500 software controller CPU 1505S	X	X	–
• WinCC RT Advanced V13 SP1	–	X	–
Restore DVD for image restore	X	X	–
"Documentation and Drivers" DVD	X	X	–
Windows Certificate of Authenticity (CoA)	X	X	–
Certificate of License (CoL)	X	X	–
USB stick with SIMATIC license keys	X	X	–
Product information	X	X	–

3.6.3 Scope of delivery - Hardware variant WES7 P 64Bit 4GB RAM

Note

The device always comes with the **CPU 1515SP PC** label with article number 6ES7677-**2AA40-0AA0**, regardless of the order options.

The following components are included in the scope of delivery of the CPU 1515SP PC:

Table 3- 5 Scope of delivery - Hardware variant WES7 P 64Bit 4GB RAM

Order option	**CPU 1515SP PC**	**CPU 1515SP PC + HMI**	**CPU 1515SP PC (spare part)**
Article number	6ES7677-2AA**41-0FB0**	6ES7677-2AA**41**- • **0FK0** HMI 128PT • **0FL0** HMI 512PT • **0FM0** HMI 2048PT	6ES7677-2AA**40-0AA0**
CPU	X	X	X
Strain relief with fixing screws	X	X	X
Server module	X	X	X
16 GB CFast card with the following pre-installations:			
• Windows Embedded Standard 7 P operating system	X	X	–
• S7-1500 software controller CPU 1505S	X	X	–
• WinCC RT Advanced V13 SP1	–	X	–
Restore DVD for image restore	X	X	–
"Documentation and Drivers" DVD	X	X	–
Windows Certificate of Authenticity (CoA)	X	X	–
Certificate of License (CoL)	X	X	–
USB stick with SIMATIC license keys	X	X	–
Product Information	X	X	–

Installing

4

4.1 Basics

Introduction

The CPU 1515SP PC is an open resource. This means that you may only install it in enclosures, cabinets or electrical operating areas. These housings, cabinets or electrical operating areas must only be accessible with a key or tool. Access may only be possible for instructed or authorized personnel.

Installation location

Install the CPU 1515SP PC in a suitable enclosure/control cabinet with at least IP54 degree of protection according to EN 60529 and take into consideration the ambient conditions for operating the devices.

Installation position

You can install the ET 200SP distributed I/O system in any position. The preferred mounting position is horizontal mounting on a vertical wall.

Depending on the mounting position, restrictions on ambient temperature and maximum configuration apply to the CPU 1515SP PC.

NOTICE
Damage to the modules Modules can be damaged if exposed to ambient temperatures higher than permitted. The following ambient temperatures must not be exceeded during operation: • Horizontal mounting – 60 °C for an installation with up to 32 I/O modules. – 55 °C for an installation with up to 64 I/O modules. • Vertical mounting – 50 °C for an installation with up to 32 I/O modules.

For more detailed information, refer to section Mechanical and climatic ambient conditions (Page 89)

Mounting rail

The CPU 1515SP PC is mounted on a mounting rail according to EN 60715 (35 × 7.5 mm or 35 × 15 mm).

The mounting rail must be grounded separately in the control cabinet. Exception: If you install the rail on grounded, zinc-plated mounting plates, there is no need to ground the rail separately.

Note

If the ET 200SP distributed I/O system is exposed to vibration and shock loads, both ends of the ET 200SP system assembly must be mechanically fixed to the mounting rail (e.g using 8WA1010-1PH01 ground terminals). This measure prevents the ET 200SP from shifting to the side.

Note

If the ET 200SP distributed I/O system is exposed to high vibration and shock load, we recommend that you screw the mounting rail to the mounting surface at intervals of approx. 200 mm.

Suitable surface finishes are:

- Steel strip in accordance with Appendix A of EN 60715 or
- Tinned steel strip. We recommend the use of the mounting rails in section Accessories/spare parts (Page 103).

Note

Mounting rails of other manufacturers

If you use mounting rails from other manufacturers, ensure that they have the properties required for your climatic and mechanical ambient conditions.

Check whether the mounting rails meet the requirements for a protective conductor.

Minimum clearances

Make sure to maintain the following minimum clearances when installing or dismantling the CPU 1515SP PC.

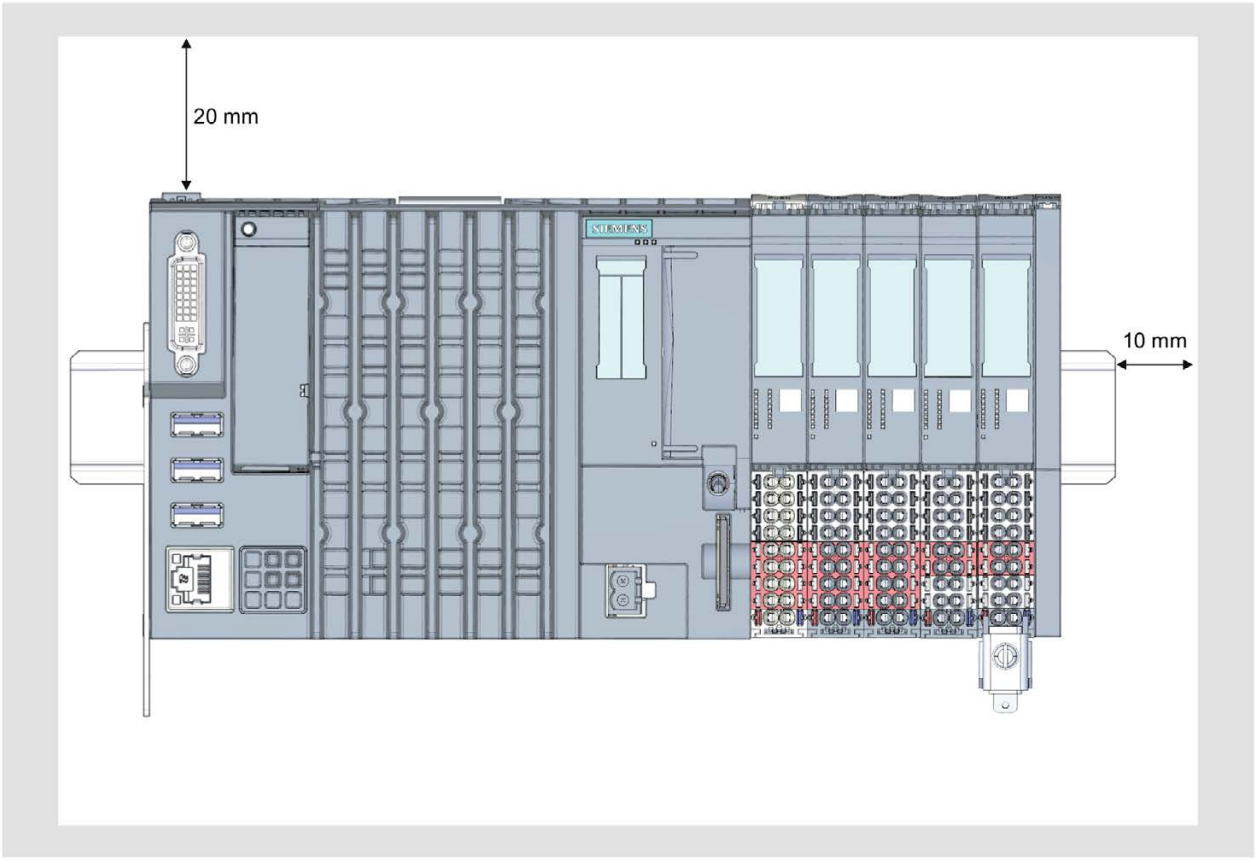


Figure 4-1 Minimum clearances

Installation rules

- After the CPU 1515SP PC, there is a BaseUnit BU..D with incoming supply voltage L+ (light-colored terminal box).
- This is followed by BaseUnits BU..B (with dark-colored terminal box).
- The respective corresponding I/O modules can be connected to the BaseUnits. Refer to the "Selection of a suitable BaseUnit" section in the ET 200SP manual for appropriate combinations of BaseUnits and I/O modules.
- The server module completes the installation.

Note

Install the CPU 1515SP PC only with disconnected supply voltage.

4.2 Hardware configuration

Maximum mechanical configuration

As soon as one of the following rules applies, the maximum configuration has been reached:

Table 4- 1 Maximum mechanical configuration

Properties	Rule
Number of modules	• Horizontal mounting – 0 to 60 °C ambient temperature: a maximum of 32 I/O modules **and** USB load – 0 to 55 °C ambient temperature: a maximum of 64 I/O modules **and** USB load • Vertical mounting – 0 to 50 °C ambient temperature: a maximum of 32 I/O modules **and** USB load
Backplane bus length	A maximum mounting width of 1 m (without CPU 1515SP PC, including server module)

Electrical maximum configuration

The number of operable I/O modules of a potential group is limited by the

- Power consumption of the I/O modules
- Power consumption of the components supplied via these I/O modules

The maximum current-carrying capability of the terminals on the BaseUnit L+/ground is 10 A.

USB load

When using the CPU 1515SP PC with the maximum configuration, the USB load must also be considered:

- Horizontal mounting
  - Ambient temperature of 0 to 60 °C with maximum 32 I/O modules **and** 3 x 100 mA USB load
  - Ambient temperature of 0 to 55 °C with maximum 64 I/O modules **and** 2 x 500 mA + 1 x 100 mA USB load
- Vertical mounting
  - Ambient temperature of 0 to 50 °C with maximum 32 I/O modules **and** 3 x 100 mA USB load

Address space

The address space is preset and can be adjusted in the user program.

4.3 Installing the CPU 1515SP PC

Requirements

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only to fix the strain relief and dismantle the BusAdapter)

Fixing strain relief

Fix the strain relief on the top and the bottom of the left-hand side of the CPU 1515SP PC with the supplied screws.

Installing the CPU 1515SP PC

1. Install the CPU on the mounting rail.
2. Swivel the CPU back until you hear the mounting rail release click into place
3. To check that the CPU has correctly clicked into place, pull on the underside of the enclosure.

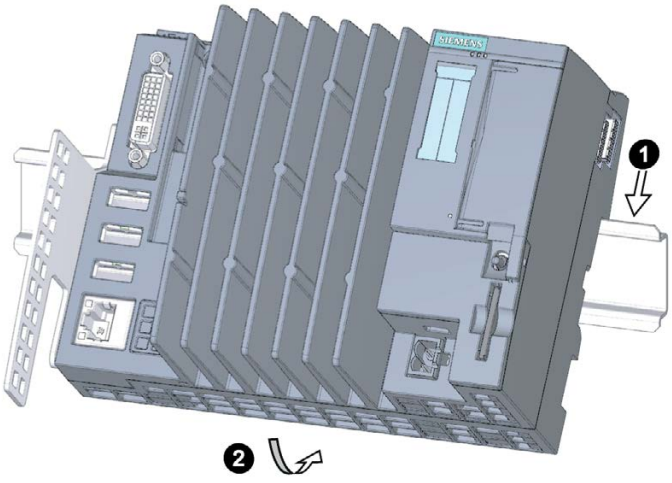


Figure 4-2 Installing the CPU 1515SP PC

Dismantling the CPU 1515SP PC

The BaseUnits with the I/O modules are located to the right of the CPU 1515SP PC:

1. Switch off the supply voltage on the CPU.
2. Press the mounting rail release button on the first BaseUnit and, at the same time, move the CPU parallel to the left until it comes off the rest of the module group.

   Note: The mounting rail release button is located above the CPU.
3. While pressing the mounting rail release button on the CPU, swivel the CPU out of the mounting rail.

Note

It is not necessary to remove the BusAdapter from the CPU 1515SP PC.

Connection

5

5.1 Notes on connection

Note

Rules and regulations for operation

Observe the information contained in the *Wiring* section in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and in the function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

NOTICE

Fault caused by I/O devices

The connection of I/O devices can lead to faults on the device.

Injury to persons and damage to the machine or plant could result.

Note the following when connecting I/O devices:

- Read the documentation related to the I/O devices. Follow all instructions given in the documentation.
- Only connect I/O devices which are suitable for use in industrial environments according to EN 61000-6-2/EC 61000-6-2.
- I/O devices which are not hot-plug capable may only be connected when the power supply of the device is switched off.

Note

Feedback through USB devices

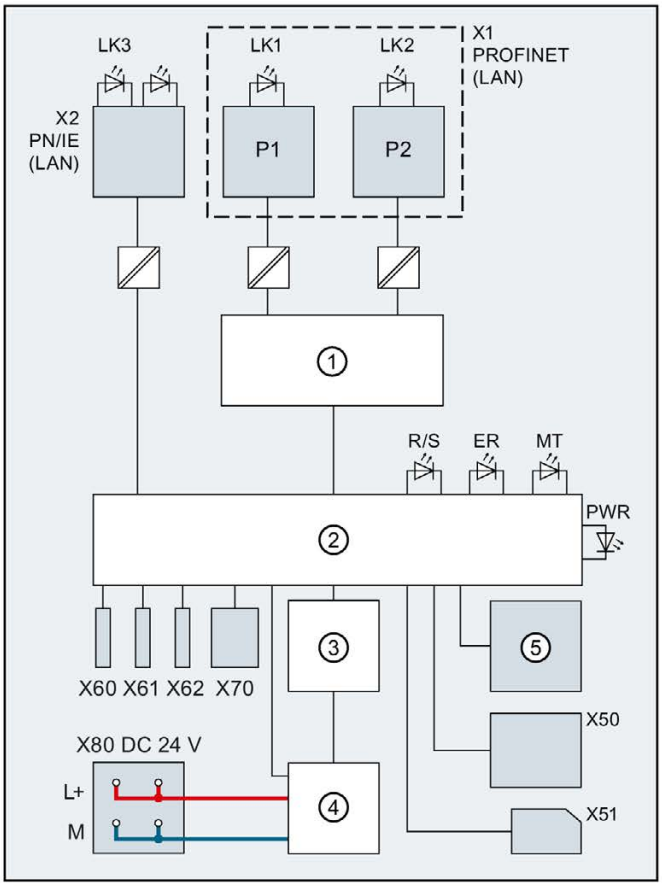
The startup of the CPU 1515SP PC at power on is not guaranteed for USB devices which - contrary to the USB 2.0 specification - feed back voltage to the host interface.

Regenerative feedback is generally not permitted.

5.2 Terminal and block diagram

Block diagram

The figure below shows the block diagram for the CPU 1515SP PC.



①	Switch	X1 PN (LAN)	PROFINET interface X1
②	Electronics	P1	PROFINET interface X1 Port 1
③	Backplane bus interface	P2	PROFINET interface X1 Port 2
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	Mode selector	M	Ground
X50	CFast card	LK1, LK2	LED Link TX/RX
X51	SD/MMC card	LK3	LED Link
X60	USB interface 2.0, 0.5 A	R/S	RUN/STOP LED (yellow/green)
X61, X62	USB interface 2.0, 0.5 A	ER	ERROR LED (red)
X70	DVI-I interface	MT	MAINT LED (yellow)
X80 24 V DC	Infeed of supply voltage	PWR	POWER LED (yellow/green)
X2 PN/IE (LAN)	Ethernet interface X2		

Figure 5-1 Block diagram for the CPU 1515SP PC

5.3 Electrical configuration

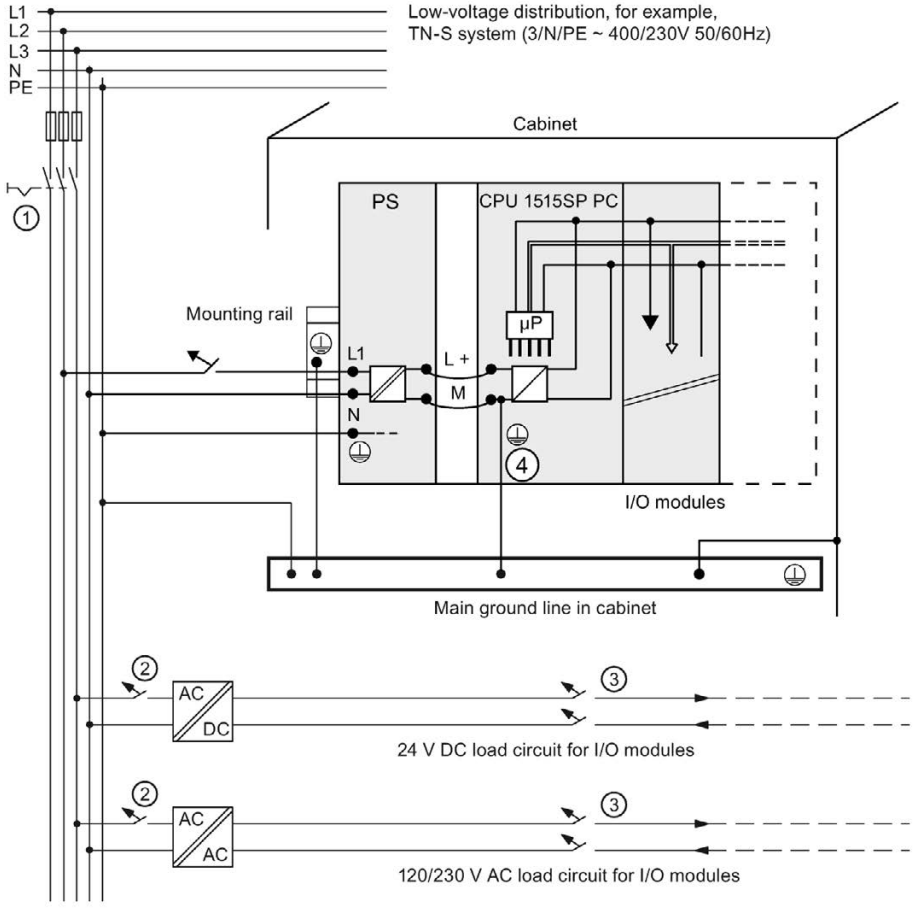
Non-isolated configuration

Note

Unlike the ET 200SP distributed I/O system, the CPU 1515SP PC can only be operated with a non-isolated configuration.

The following figure shows the overall configuration of a CPU 1515SP PC when supplied from a TN-S system. The power supply supplies the CPU 1515SP PC and the load circuit for the 24 V DC modules.

For the CPU 1515SP PC, there is a fixed connection between the ground infeed terminal and the contact springs to the mounting rail. The mounting rail must be grounded separately in the control cabinet.



① Master switch
② Short-circuit and overload protection
③ Load current supply (galvanic isolation)
④ This connection is established automatically with the CPU 1515SP PC.
The represented layout of the power connections does not correspond to the actual layout; it was chosen for demonstration purposes only.

Figure 5-2 Connecting the load voltage reference potential

5.4 Connecting devices to networks

The following options are available for integrating devices into existing or planned system environments and networks.

Ethernet

You can use the integrated Ethernet interface X2 PN/IE (LAN) (10/100/1000 Mbps) for communication and data exchange with automation devices, for example, SIMATIC S7.

You need suitable software to do this: STEP 7, WinCC, SIMATIC NET.

Note

Use a Category 5e Ethernet cable (Cat-5e cable) for operation with 1000 Mbps.

PROFINET

PROFINET operation is possible via the X1 PN (LAN) interface and permitted BusAdapter.

PROFIBUS

The connection to PROFIBUS can be made using the DP master module.

5.5 Securing cables

The strain relief for connecting cables prevents the USB cables and PROFINET connectors detaching from the CPU 1515SP PC. The strain relief is included in the scope of delivery.

⚠ WARNING

Flying sparks due to loose cables

Risk of explosion in hazardous areas.

USB cables and PROFINET connectors may detach from the device in the case of strong oscillation and high vibrating loads.

Attach these cables to the strain relief of the device using cable ties.

Requirements

- The strain relief is fixed to the CPU.
- The CPU is installed.

Procedure

Secure the USB and PROFINET cables to the strain relief using cable ties.

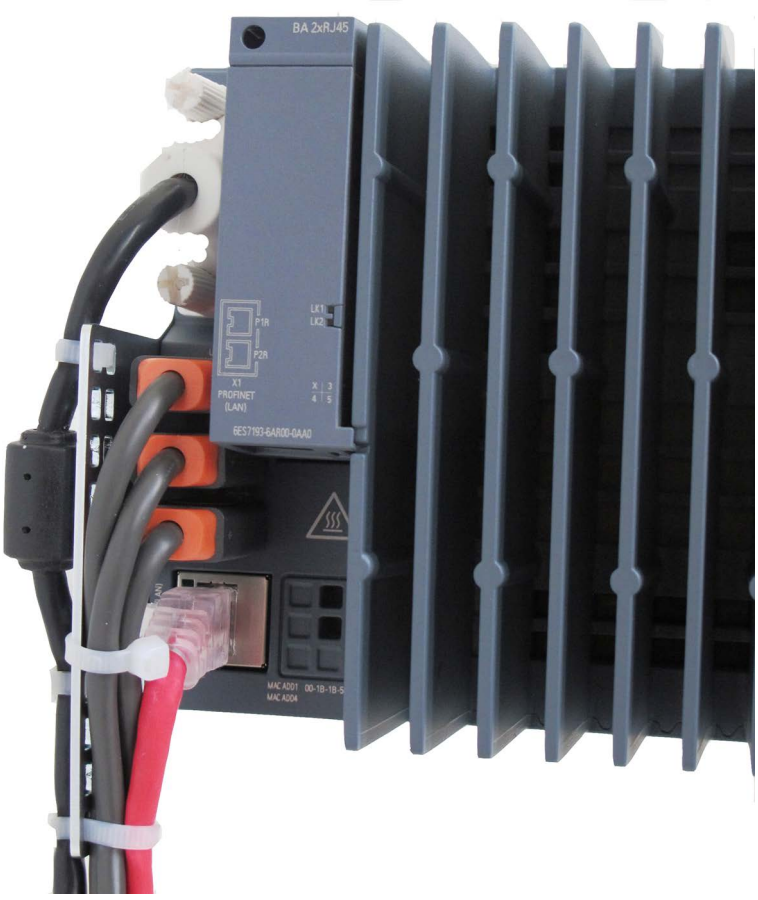


Figure 5-3 Secured cables

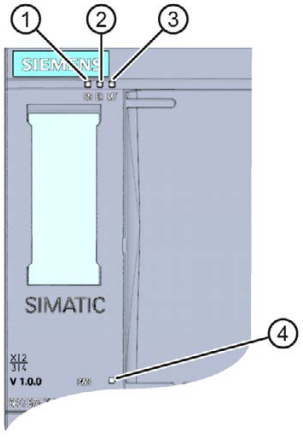
Diagnostics, error and system alarm

6

6.1 Status and error display

LED display

The following figure shows the LEDs of the CPU 1515SP PC.



① RUN/STOP LED (yellow/green LED)
② ERROR LED (red LED)
③ MAINT LED (yellow LED)
④ POWER LED (yellow/green LED)

Figure 6-1 LEDs of the CPU 1515SP PC

Meaning of the LED displays with active software controller

The CPU 1515SP PC has three LED displays to indicate the current operating status and the diagnostic status.

The following table shows the meaning of the color combinations of the LED displays in connection with the software controller.

Table 6- 1 Meaning of the LED displays

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	POWER OFF Missing or insufficient supply voltage on the CPU 1515SP PC.
LED off	LED flashes red	LED off	An error has occurred.
LED green	LED off	LED off	Software controller of the CPU 1515SP PC is in the operating state RUN.
LED green	LED flashes red	LED off	A diagnostics event is pending.
LED green	LED off	LED lights up yellow	Maintenance demanded for the plant. The affected hardware must be replaced within a short period of time.
LED green	LED off	LED flashes yellow	Maintenance required for the plant. The affected hardware must be replaced within a reasonable time period.
			Firmware update successfully completed
LED lights up yellow	LED off	LED off	Software controller of the CPU is in the operating state STOP.
LED lights up yellow	LED flashes red	LED flashes yellow	The user program is causing an error.
			CPU defective
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Loading the user program
LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
			Test of LEDs during startup, inserting a module.
			LED flashing test

POWER LED

Table 6- 2 POWER LED

POWER LED	Meaning
LED off	No supply voltage or supply voltage too low
LED lights up yellow	Supply voltage present; running through BIOS phase; operating system is shut down
LED green	Supply voltage present; Booting or operation of the operating system

Commissioning 7

7.1 Notes on commissioning

⚠ WARNING

Improper commissioning in hazardous areas

Device failure or risk of explosion in hazardous areas.

- Do not commission the device unless it is fully mounted and connected according to the specifications in the section Enhanced Write Filter (EWF) (Page 67).
- Before commissioning, please consider the effects on other devices in the plant.

⚠ CAUTION

Hot surfaces

Risk of burns due to hot surfaces.

During operation, only touch the device with appropriate protective gloves.

NOTICE

Condensation in the device

Damage to the device due to condensation if the temperature between transport or storage and the installation site differs by more than 20 °C (36 °F).

Before commissioning the device, leave it to stand for several hours in the new environment.

NOTICE

Data loss

Data loss may occur if write filters are used incorrectly.

Therefore, note the information on write filters.

Two write filters are available for configuration under Windows Embedded:

- Enhanced Write Filter (Page 67)
- File Based Write Filter (Page 71)

7.2 Initial commissioning

When first starting up your CPU 1515SP PC, passwords, IP addresses and some basic settings are queried.

Then, the operating system which is pre-installed on the CFast card is set up automatically on the device.

Note

Initial commissioning is not possible with a Multitouch panel, because the Multitouch drivers are not available until after the installation of the operating system.

Requirements

- The CPU 1515SP PC is installed.
- The CFast card is inserted.
- No data carriers are connected via USB.
- The following hardware is available: A monitor, a USB keyboard, a USB mouse

Procedure

NOTICE

Faulty installation

If you change the default values in the BIOS setup or switch off the device during the installation process, the installation is faulty and the operating system is not installed properly. The operational reliability of the device and the plant is compromised.

Do not switch off the device at any time during the installation process. Do not change the default values in the BIOS setup.

1. Connect a monitor using a DVI-I cable.
2. Connect a keyboard and a mouse to the CPU via USB.
3. Connect the power supply.

   → The PWR LED lights up yellow first, then green.

   → The device carries out the hardware initialization.
4. Wait until the Siemens logo disappears from the screen.
5. Follow the instructions on the screen to configure the device

Note

Restart the device after the operating system has been set up.

Result

- The WES7 operating system is installed.
- WES7 P: The Multitouch functions are available.
- The operating system's start screen is displayed after each startup.
- A login window appears if a password was entered during the initial commissioning.

Screen resolution

Under Windows Embedded Standard 7, the values transmitted from the monitor are set for the screen resolution.

7.3 Installing license keys

Licensing the software

The S7-1500 software controller and WinCC RT Advanced require product-specific license keys. These can be found on the supplied USB stick.

Before commissioning, the license keys must be installed using the *Automation License Manager (ALM)*.

Perform the licensing directly via the CPU 1515SP PC.

Requirements

- Initial commissioning was successfully completed.
- Windows Embedded Standard 7 has started.
- The extended write filter **EWF must be deactivated** on the CPU 1515SP PC.

Installing License keys with local configuration

The *Automation License Manager* is pre-installed on the CPU 1515SP PC.

The software can be opened using the desktop icon or a menu command.

1. In the Windows Start bar, select **Start > Programs > Siemens Automation > Automation License Manager**.
2. Follow the instructions of the *Automation License Manager*.

Using a programming device/PC to install the license keys

The *Automation License Manager* is pre-installed on a programming device/PC with STEP 7 and the CPU 1515SP PC.

1. Connect the CPU 1515SP PC to a programming device/PC.
2. Connect the supplied USB stick to the programming device/PC.
3. Select the menu command **Start > SIMATIC > License Management > Automation License Manager**.
4. Select the **Edit > Connect Computer** menu command and type in the IP address of the CPU 1515SP PC (default 192.168.1.1).
5. Drag the license keys from the USB stick to the system partition C: of the CPU 1515SP PC.

Saving and securing license keys in the case of restore and repair

Note

Loss of license keys

A SIMATIC license key cannot be copied or duplicated. No more license key copies exist on the USB stick once you have dragged the license keys from the USB stick to the CPU 1515SP PC.

Secure your purchased license keys **before** restoring the delivery state (Restore) or in the case of repair. To do this, move the license keys to a USB stick and keep this stick in a safe place.

If an error occurs on your license keys on the CPU 1515SP PC, contact your Siemens representative. Make sure to have the "Certificate of License" (CoL) to hand.

Note

The EWF (Page 67) write filter serves to protect your license keys and your configuration.

Reference

For additional information on licenses, refer to the *Automation License Manager* manual. This can be found on the CPU 1515SP PC under **Start > All Programs > Siemens Automation > Documentation** and on the Internet (http://support.automation.siemens.com/WW/view/fr/56956174).

7.4 Windows Security Center

Warning from the Windows Security Center

A warning from the Windows Security Center appears when you first switch on your device. The Security Center checks the status of the device regarding the three important security aspects listed below. If a problem is detected, the Security Center provides recommendations on how you can better protect the device.

- Firewall: The Windows firewall contributes to protecting the device by preventing non-authorized users from accessing the device via a network or the Internet. Windows checks whether the device is protected by a software firewall.
  In the delivery state, the firewall is enabled.
- Antivirus software: Antivirus programs contribute to protecting the device against viruses and other security threats. Windows checks whether a comprehensive, up-to-date antivirus program is used on the device.
  In the delivery state, no antivirus software is installed.
- Automatic updates: With the help of automatic updates, Windows can routinely check for the latest major updates for the device and install these automatically. In the delivery state, this option is disabled.

Configure the Security Center to suit your requirements.

7.5 Switching on/off the CPU 1515SP PC

Requirements

Initial commissioning was successfully completed.

Switching on the CPU 1515SP PC

1. Switch on the power supply of the CPU.

   → The Boot Manager GRUB4DOS opens.

2. Select the mode in which the CPU 1515SP PC is to start:
   - Only with the Windows operating system.
   - With the Windows operating system and the S7-1500 software controller (default).

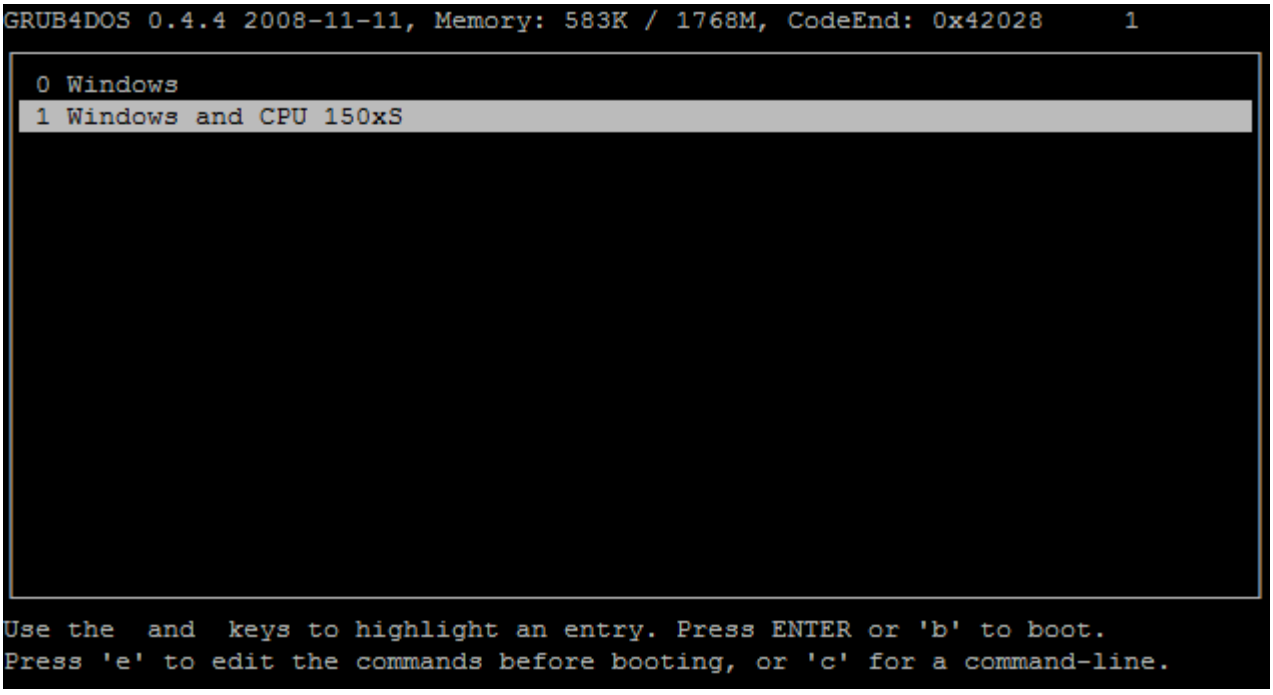


Figure 7-1 Boot Manager GRUB4DOS

Switching off the CPU 1515SP PC

Use the **Start > Shut down** Windows function to switch off.

→ The PWR LED changes from green to yellow.

→ The Windows function shuts down the Windows operating system and the S7-1500 software controller.

If you do not intend to use the device for a long period after the shutdown, disconnect it from the power supply.

Functions

8

8.1 Monitoring functions

Introduction

The CPU 1515SP PC features monitoring functions that can be used with the corresponding software. The following display, monitoring and control functions are available.

- Temperature monitoring
- Monitoring of drives with SMART functionality
- Operating hours counter (information on the total runtime)

SIMATIC IPC DiagBase

The SIMATIC IPC DiagBase software is included in the scope of delivery of the CPU 1515SP PC.

With the SIMATIC IPC DiagBase software, you use the functions for local monitoring. Use the DiagBase Management Explorer application to obtain a clearer overview for monitoring. The DiagBase Alarm Manager notifies you of individual alarms.

Note

For additional information, refer to the online help for the SIMATIC IPC DiagBase software.

SIMATIC IPC DiagMonitor

The SIMATIC IPC DiagMonitor software is provided on a CD.

The diagnostics and alarm software is used for early detection and reporting of potential system failures. The software is also used for remote diagnostics.

The software contains:

- The software for the stations to be monitored
- A library for creating your own applications

Temperature monitoring

Three temperature sensors monitor the temperature at different locations of the CPU 1515SP PC:

- Processor temperature
- Temperature in the vicinity of the RAM ICs/blocks
- Temperature of the basic module

If one of the temperature values exceeds the set temperature threshold, a temperature error is triggered which activates the IPC DiagBase or IPC DiagMonitor software.

The temperature error remains stored until the temperatures fall below the temperature threshold again and it is reset using one of the following measures:

- Acknowledgment of the error message by the monitoring software
- Restart of the device

8.2 Retentive memory NVRAM

Retentive memory is non-volatile memory for saving a limited quantity of data in the event of power failure.

The data defined as retentive is stored in retentive memory. This data is retained beyond a power-off or power failure.

A corresponding function is implemented in the S7-1500 software controller to allow NVRAM to be used there. This saves up to 183.5 KB of data in non-volatile data memory in the case of power failure. This function can be set on the engineering station in the TIA Portal.

8.3 BIOS description

8.3.1 Introduction

BIOS setup

The BIOS setup is located in the BIOS ROM. The information on the system configuration is stored in the memory of the CPU 1515SP PC.

Using the Setup, you can set the following:

- The hardware configuration, for example, drive type
- The system properties
- time and date

Note

The American keyboard layout applies in the BIOS.

Changing the device configuration

The device configuration is preset for working with the supplied software.

Only change the set values if you have made technical changes to your device.

8.3.2 Starting BIOS setup

Start the setup program as follows:

1. Disconnect the device from the power supply and switch it on again (cold restart).

   With the CPU 1515SP PC default settings, the following screen appears after the device has been switched on:

Figure 8-1 BIOS setup

After completion of the startup test, you have the option of starting the SETUP program.

The following BIOS message appears:

```
Press F2 go to Setup Utility

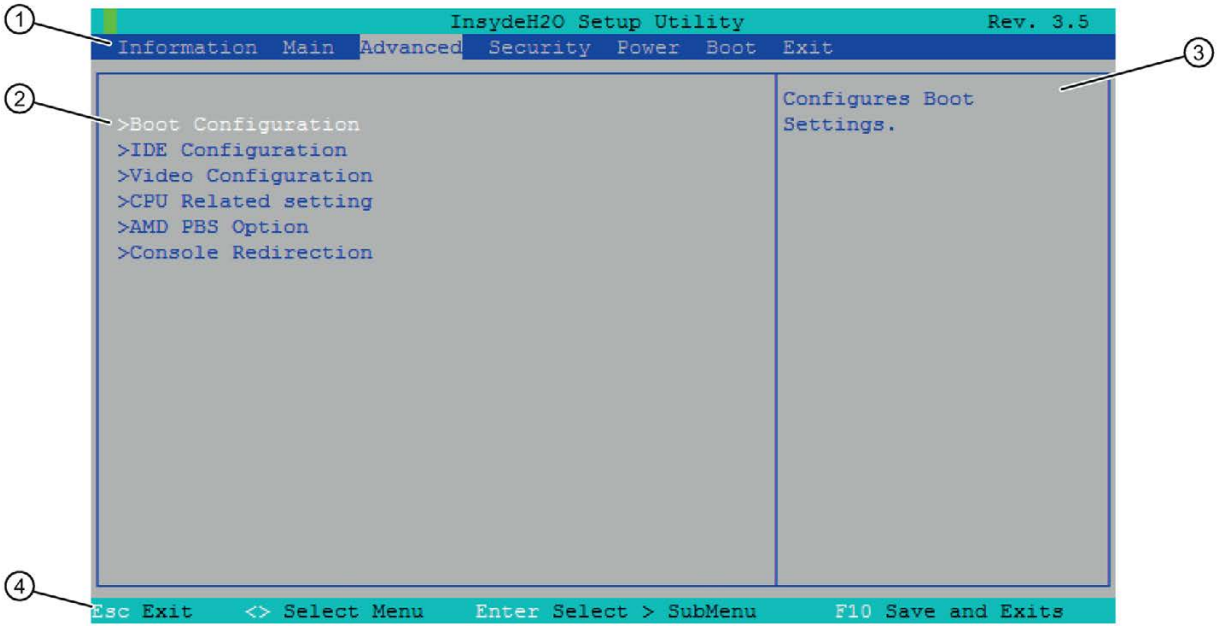
Press F12 go to Boot Manager
```

2. Press the <F2> button while the message is on the screen.

8.3.3 BIOS setup menus

Overview of BIOS setup

The menus and submenus are shown on the following pages.



① Menu bar
② Selectable submenu
③ Help window
④ Operating line

Figure 8-2 Structure of the BIOS setup menus

Menu structure

In the menu bar ①, you can select between the following menu forms:
[Information] [Main] [Advanced] [Security] [Power] [Boot] [Exit].

In the main window ②, various settings are displayed or submenus selected.

In the Help window ③ of the respective menu, you can find information on the selected setup entry.

The operating line ④ contains notes on operation.

You can use the cursor keys [←] left and [→] right to switch between the menu forms.

Menu	Meaning
Information	Device-specific information, for example, product version
Main	Setting system functions
Advanced	Advanced system configuration
Security	Safety functions, for example, setting a password
Power	Determining the switch-on behavior of the device
Boot	Determining boot options, such as boot priority
Exit	Exiting and saving

8.3.3.1 Information menu

This menu shows the versions of the device-specific functions.

Keep this information at hand for Customer Support when you have technical questions regarding your system.

Example

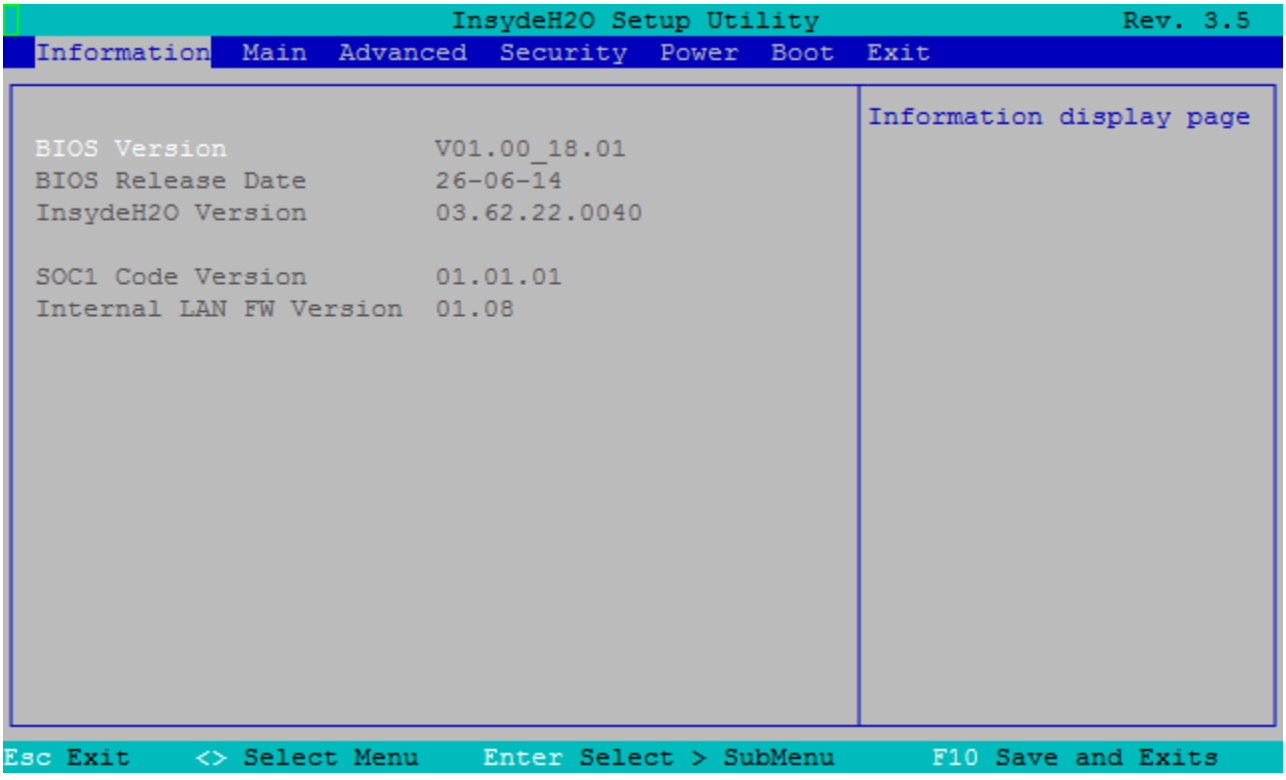


Figure 8-3 Information menu

8.3.3.2 Main menu

Settings in the Main menu

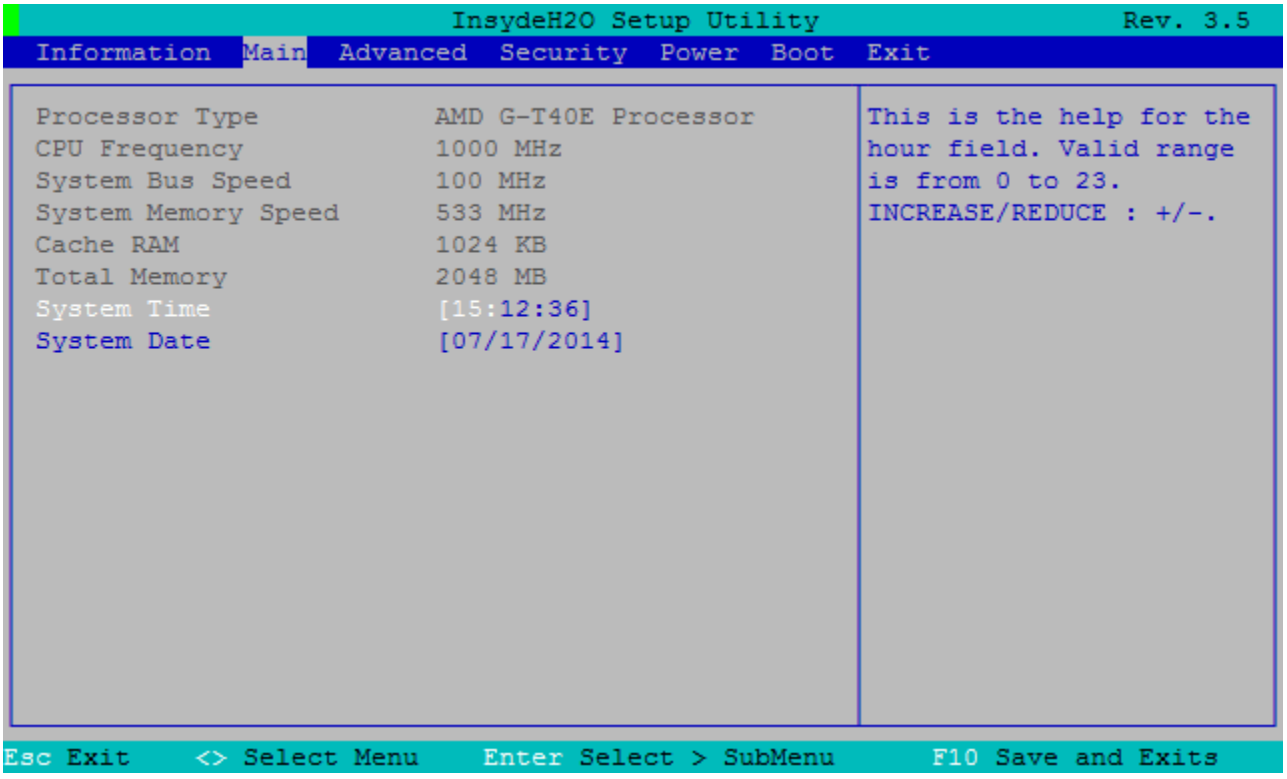


Figure 8-4 Main menu

In the Main menu, you can use the [↑] up and [↓] down arrow keys to select between the following system setting fields:

Array	Meaning
System Time	Displaying and setting the current time
System Date	Displaying and setting the current calendar date

System Time and System Date

System Time and System Date show the current values. After you have selected the corresponding field, you can change the following settings, one after the other, using the [+] and [–] keys:

- For the time of day: Hour: Minute: Second
- For the date: Month/day/year.

You can use the <ENTER> key to switch between the entries within the Date and Time fields (e.g., from hour to minute).

8.3.3.3 Advanced menu

Settings in the Advanced menu

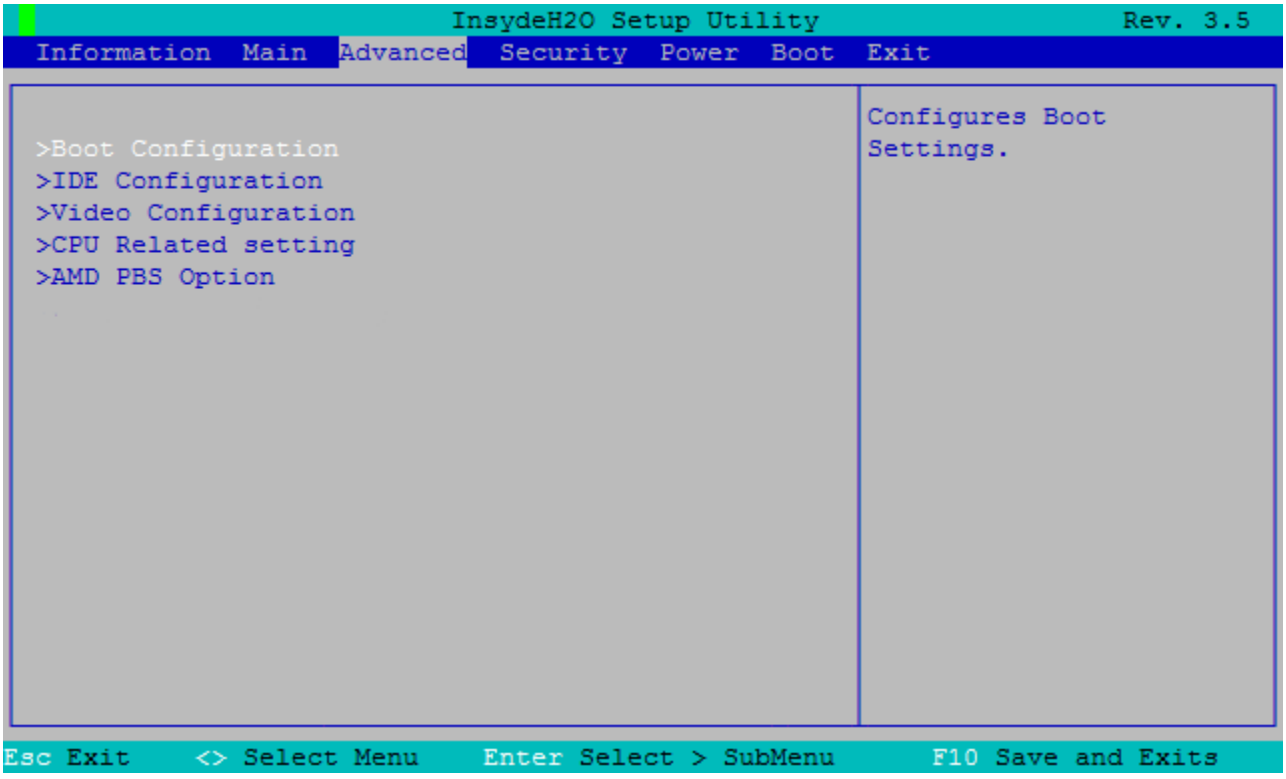


Figure 8-5 Advanced menu

Entry	Meaning
Boot Configuration	Configuring the boot settings
IDE Configuration	Configuring the devices
Video Configuration	Configuring the graphics parameters
CPU Related setting	Configuring CPU parameters
AMD PBS Option	Configuring interfaces

"IDE Configuration" submenu

Entry	Meaning
SATA configure as	Setting the SATA configuration type: IDE, LEGACY IDE, AHCI
Serial ATA Port 0	Serial ATA Port 0 device configuration

"Video Configuration" submenu

Entry	Meaning
UMA Sharing Memory Size (256 MB)	Setting the size of the work memory for the graphics processor. (Unified Memory Architecture; also Shared Memory)

"CPU Related setting" submenu

Entry	Meaning
SVM support	Enabling (Enabled) or disabling (Disabled) Secure Virtual Machine functionality .

"AMD PBS Option" submenu

Entry	Meaning
Internal LAN Controller	Integrated Ethernet interface (10/100/1000 Mbps) X2 PN/IE (LAN)
PXE Boot to INT_LAN	Enabling (Enabled) or disabling (Disabled) internal Southbridge Network Controller.

8.3.3.4 Security menu

Settings in the Security menu

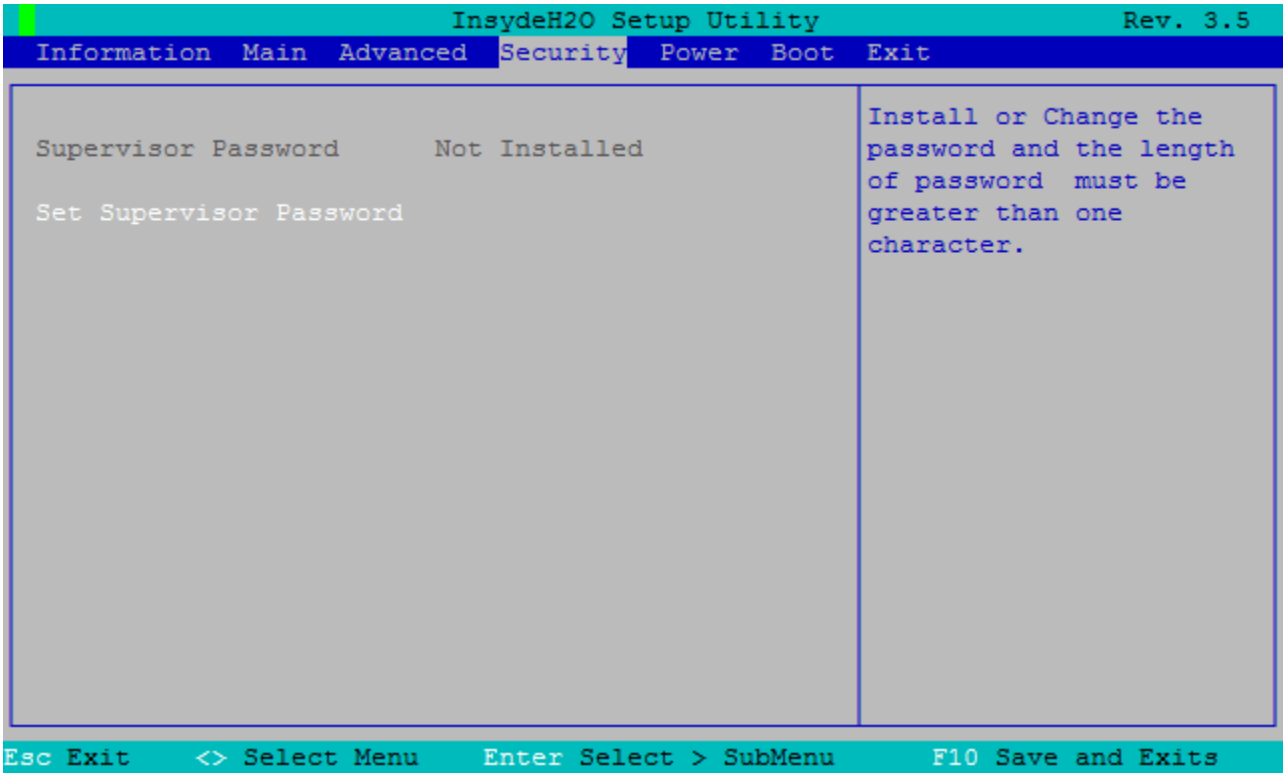


Figure 8-6 Security menu

You can assign a password to protect the CPU 1515SP PC against unauthorized access.

Supervisor Password	Installed	Specific setup fields, including the Supervisor password, can be modified by the user.
	Not installed	Password is disabled.
Set Supervisor Password	This field opens the password entry dialog box. Once a password has been entered, it can be changed by entering a new password or deleted and thereby disabled using the <Return> key.	

Note

Overwriting of the Supervisor password during a BIOS update

A BIOS update overwrites the password.

After a BIOS update, set up the password again.

8.3.3.5 Power menu

Settings in the Power menu

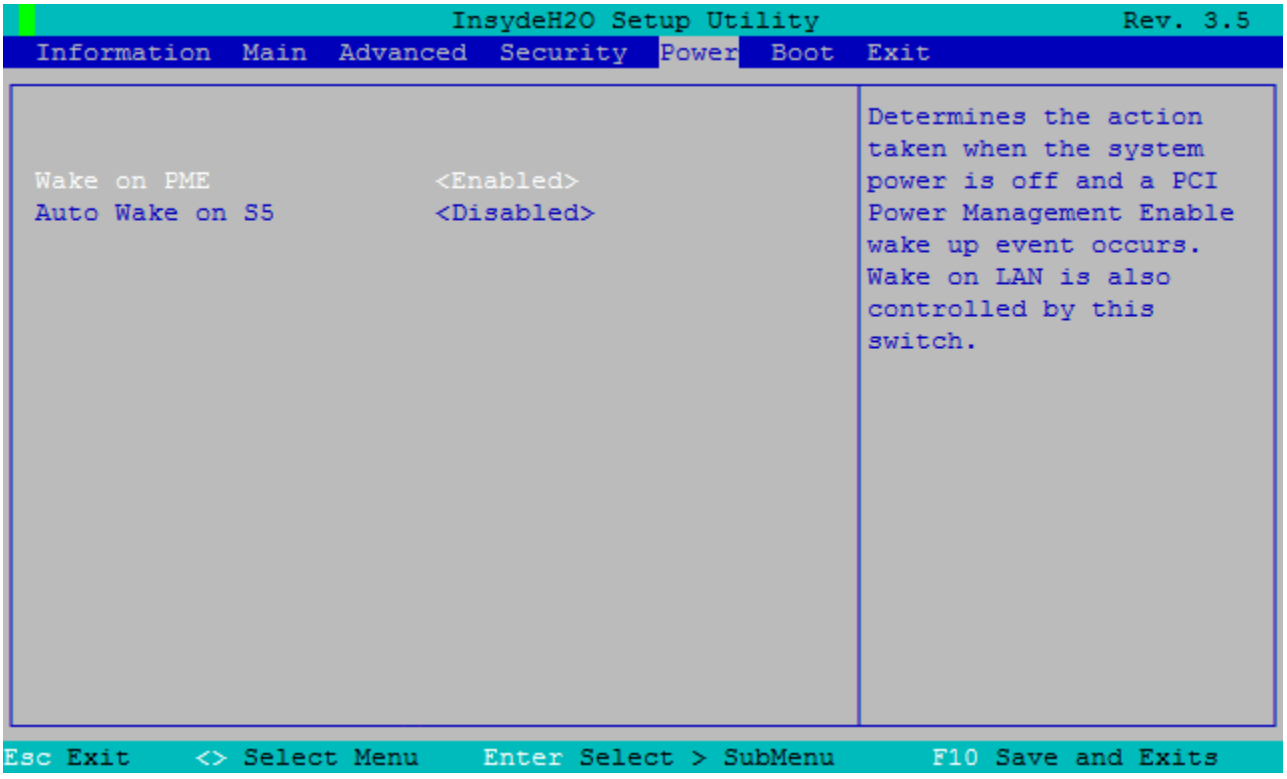


Figure 8-7 Power menu

The device response after a power failure and after a Wake Event is determined in the Power menu.

Entry	Meaning
Wake on PME	When activated (Enabled), the device switches itself on when a Power Management Event occurs. Otherwise, the device remains switched off.
Auto Wake on S5	When activated (Enabled), the device switches itself on when a Wake Event occurs. Otherwise, the device remains switched off.

8.3.3.6 Boot menu

Entries in the Boot menu

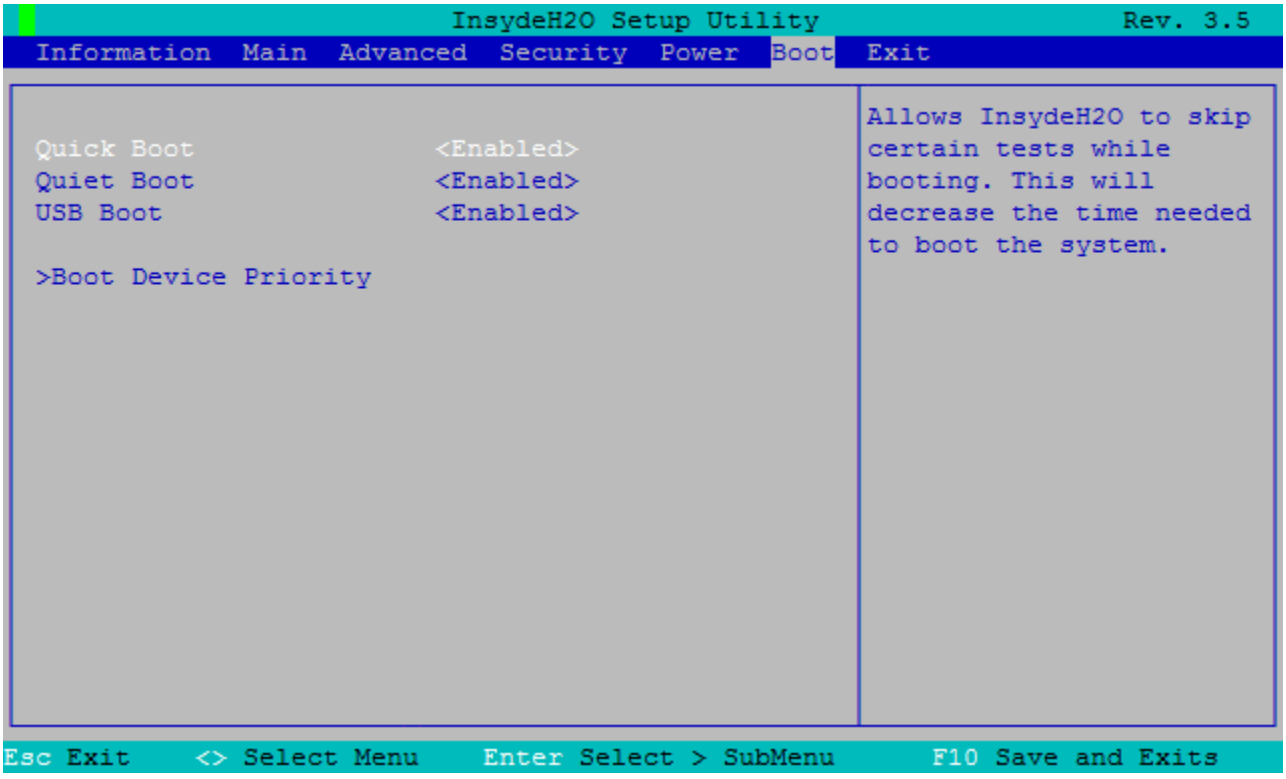


Figure 8-8 Boot menu

In this menu, you define the boot behavior of the device.

Entry	Meaning
Quick Boot	Enabling (Enabled) or disabling (Disabled). The device starts up faster when this option is enabled, because various hardware function tests are skipped.
Quiet Boot	When this option is disabled, the device boots in text mode. When it is enabled, a start screen with logo appears.
USB Boot	Booting from connected USB devices permitted/not permitted.

Boot menu > submenu "Boot Device Priority"

In this menu, you define the sequence of the boot media.

Entry	Meaning
Normal Boot Menu	Normal = boot sequence by component type Advance = individual boot sequence of all components

Boot Device Priority > submenu "Boot Type Order"

Entry	Meaning
Hard Disk Drive	Setting the boot sequence of the group of drives
USB	Setting the boot sequence of the group of USB drives
Others	Setting the boot sequence of the group Others,, e.g. Remote Boot Device

All connected boot-capable components and their boot position are displayed in this menu. The boot position of the components can be moved freely.

The component at the top (highest boot priority) is used for booting. If the component is not available, the system boots from the next component in the list.

You change the boot sequence as follows:

- Select the boot components using the keys <↑>, <↓>
- Move to the required position using the keys <+>, <–>

Note

During the boot operation, you can start the Boot Manager with the <F12> key.
The Boot Manager displays all available boot components and boots from the device selected by the user.

"Normal Boot Menu > Advance" setting

In the "Advance" setting, boot-capable components that are disconnected and reconnected by the CPU 1515SP PC between the boot processes are set to the top position by the BIOS.

Boot Device Priority > submenu "Hard Disk Drive"

The size of the CFast card is displayed in this menu.

8.3.3.7 Exit menu

Settings in the Exit menu

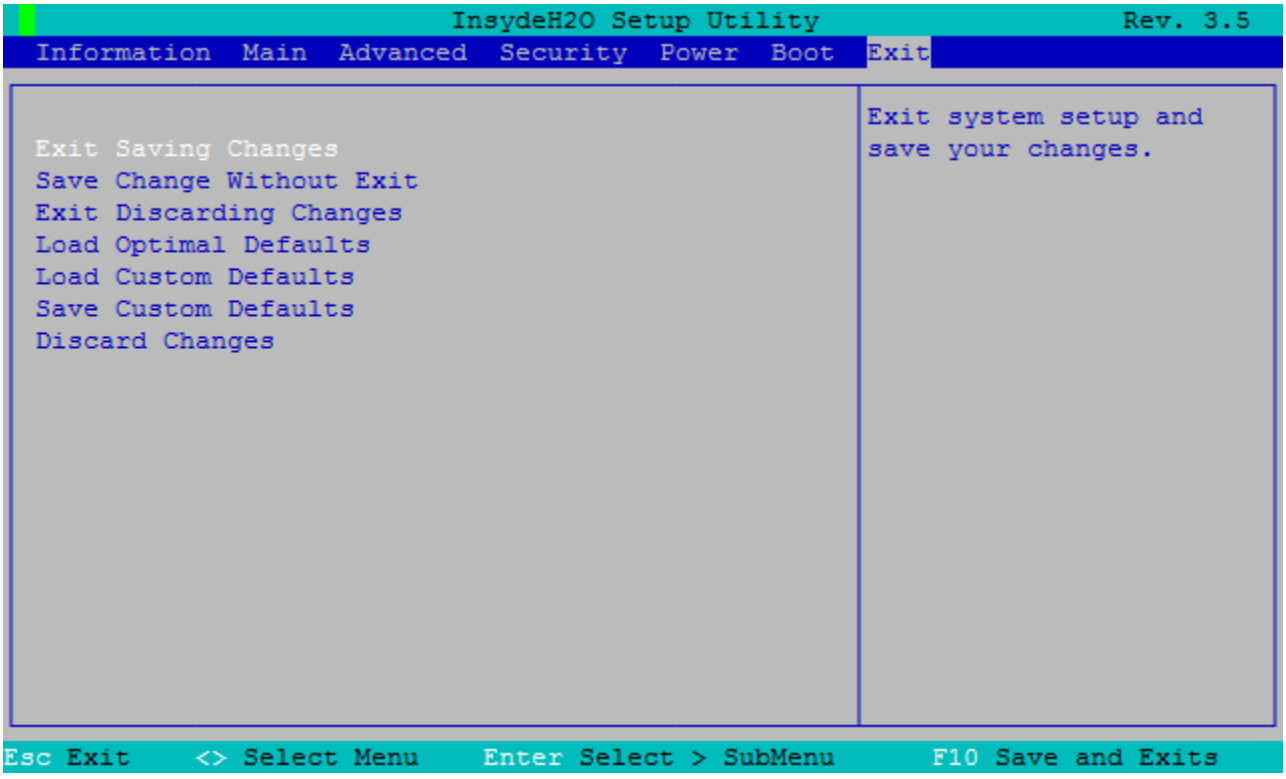


Figure 8-9 Exit menu

The setup program is always terminated via the Exit menu.

The menu is used to save or discard the changes made.

Entry	Meaning
Exit Saving Changes	All changes are saved; then, the system is restarted with the new parameters.
Save Change Without Exit	All changes are saved.
Exit Discarding Changes	All changes are discarded and then executed with the old parameters when the system is restarted.
Load Optimal Defaults	Loading optimum default values
Load Custom Defaults	Loading default values
Safe Custom Defaults	Saving default values
Discard Changes	All changes are discarded.

8.3.4 BIOS setup default settings

Documenting the device configuration

If you make changes to the default setting of the BIOS setup, enter these in the table below. This will ensure that values you set will be readily available if hardware changes are made later.

We recommend that you print out the table below and keep it in a safe place after you have made your entries.

Note

The default settings in the BIOS setup depend on the ordered device configuration.

BIOS setup default settings

Menu	System parameters	Default settings	User settings
Main	System Time	hh:mm:ss	
	System Date	MM/TT/JJJJ	
Advanced > IDE Configuration	SATA configure as	LEGACY IDE	
	Serial ATA Port 0	SIMATIC IPC CFast 8/16	
Advanced > Video Configuration	UMA Sharing Memory Size	256 MB	
Advanced > CPU Related setting	SVM Support	Enabled	
Advanced > AMD PBS Option	Internal LAN Controller	Auto	
	PXE Boot to INT_LAN	Disabled	
Security	Supervisor Password	Not installed	
	Set Supervisor Password	Inactive (no password assigned)	
Power	Wake on PME	Enabled	
	Auto Wake on S5	Disabled	
Boot	Quick Boot	Enabled	
	Quiet Boot	Disabled	
	USB Boot	Disabled	
Boot > Boot Device Priority > Normal Boot Menu	Normal Advance	Normal	
Boot > Boot Device Priority	Boot Type Order	Hard Disk Drive	
		USB	
		Others	
	Hard Disk Drive	SIMATIC IPC CFast 8/16 GByte	

Menu	System parameters	Default settings	User settings
Exit	Exit Saving Change	Standard	
	Save Change Without Exit		
	Exit Discarding Changes		
	Load Optimal Defaults		
	Load Custom Defaults		
	Safe Custom Defaults		
	Discard Changes		

8.3.5 BIOS update

With the SIMATIC IPC DiagBase software (included in scope of delivery), you can perform the following actions:

- Perform a BIOS update.
- Saving and updating the current BIOS version.
- Saving the BIOS settings or loading them from another backup.

For additional information, refer to the online help for the SIMATIC IPC DiagBase software.

Requirements

- The S7-1500 software controller CPU 1505S must be in STOP mode.
- The CPU 1515SP PC must be started in Windows mode.

NOTICE
Malfunctions in the software controllers due to critical actions If a BIOS update is performed during CPU 1505S operation, malfunctions may occur in the software controller, such as communication breakdowns and failures. During operation of the CPU 1505S, do not perform a BIOS update or other actions that place an extremely high demand on the hardware. **Before** a BIOS update, switch the CPU 1505S to STOP.

Performing a BIOS update

1. Start the CPU 1515SP PC in the GRUB menu in **Windows mode** (see figure (Page 47)).

   → The PWR LED lights up yellow first, then green.

   → The device carries out the hardware initialization.
2. Follow the BIOS update steps described in the help for SIMATIC IPC DiagBase.

   → The update is performed.

   → You are prompted to restart the device.
3. Use the **Start > Shut down** Windows function to switch off the CPU 1515SP PC.

   → The PWR LED lights up green first, then yellow.

   → The Windows function closes the Windows operating system and the software controller.
4. Switch off the supply voltage on the CPU 1515SP PC.
5. Connect the power supply.
6. Wait until the Siemens logo disappears.

   → The CPU 1515SP PC restarts.

NOTICE
Overwriting of the Supervisor password during a BIOS update A BIOS update overwrites the password. After a BIOS update, set up the password again in the Security menu under "Set Supervisor Password".

8.4 Power options

A power plan with the name SIMATIC is set as default on the CPU 1515SP PC. This ensures that the CPU does not deviate from its maximum clock rate in order not to endanger the real-time capability of the software controller.

8.5 Protective functions for data carriers

NOTICE
Data loss The number of write cycles on CFast cards is limited due to technical reasons. To prevent data loss, the CFast card must therefore be provided with special protection. Use a write filter to extend the life of the CFast card and to avoid a possible failure of the CPU 1515SP PC.

Write filters

Two write filters are available for Windows Embedded:

- To protect an entire partition of the CFast card, use the Enhanced Write Filter EWF (Page 67).
  Unlike the FBWF, the EWF can also be used for compressed NTFS file system.
- Use the File-Based Write Filter FBWF (Page 71) to update specific files dynamically.
  The FBWF can be configured more flexibly and allows direct write access without restart.

NOTICE
Data loss If both write filters are activated, the EWF blocks direct write access of the FBWF. Data is lost after a restart of the CPU 1515SP PC. Activate **only one** of the two write filters per partition.

8.5.1 Enhanced Write Filter (EWF)

Purpose and function

The Enhanced Write Filter (EWF) allows you to write-protect individual partitions.

EWF is activated by default on the CPU 1515SP PC.

The EWF is activated by means of the pre-installed SIMATIC IPC EWF Manager or the Windows console application ewfmgr.exe.

SIMATIC IPC EWF Manager

Start the software via **Start > All Programs > Siemens Automation > SIMATIC > EWF Manager**.

In the status bar, you can use the SIMATIC IPC EWF Manager icon to check whether the EWF is active.

Table 8- 1 Meaning of the icons

Icons	Meaning
	The partition is protected by the EWF.
	The EWF is deactivated for this partition.
	The EWF is currently switched off, but will be activated after the restart.
	The EWF is currently active, but will be deactivated after the restart.
	The filter is active. A Commit command is executed before the next reboot.
	The filter is currently active, but will be deactivated after the restart. A Commit command will also be executed before the next reboot.

The operating instructions for the SIMATIC Industrial PC: IPC EWF Manager (http://support.automation.siemens.com/WW/view/en/50867677) is located on the CPU 1515SP PC in **Start > All Programs > Siemens Automation > Documents > Manuals.**

Console application ewfmgr.exe

The application is called via the Windows command line (Command Prompt).

The following functions are available, among others, for setting, switching on and switching off the EWF:

Table 8- 2 Enhanced Write Filter functions

Function	Command
Write-protect drive C: Switching on	`ewfmgr c: -enable`
Write-protect drive C: disable (modified data is accepted)	`ewfmgr c: -commitanddisable`
Modified files on drive C: Accept	`ewfmgr c: -commit`
Display information about the EWF drive	`ewfmgr c:`
Display help	`ewfmgr /h`

Note

The EWF commands for write protection become effective only after a restart.

Note

The EWF command `ewfmgr c: -commitanddisable` must not be used with the option `-Live`.

Special features when using the EWF

NOTICE
Data loss upon power failure and upon shutdown/restart If the EWF is active, all changes made on the C drive are lost after power failure and on shutdown/restart. Use an UPS to prevent data losses after power failure.

Back up the data in the EWF RAM Overlay to the CFast card before shutting down the CPU 1515SP PC. In the command line, enter the following commands:

```
ewfmgr c: -commit
```

Restart the device

Or

```
ewfmgr c: -commitanddisable
```

Restart the device

```
ewfmgr c: -enable
```

Restart the device

Note

Data loss

If EWF is active and you decline a restart after having set the `-commitanddisable` or `-commit` option, your data is lost after a power failure!

Note

Disabling automatic daylight saving changes

In systems without central time management and with activated EWF, the time is advanced or set back by one hour in the daylight saving time or standard time period each time the system performs a cold or warm restart, due to the system-specific function for automatic daylight saving changes.

Reason for this behavior: Windows Embedded Standard 7 sets a flag in a registry entry that indicates completion of the conversion to daylight saving time. Since this file is also protected against modification by the EWF, the marker is lost during the boot sequence and the adjustment is made again.

We therefore recommend that you deactivate the automatic adjustment and change the clock manually.

Proceed as follows:

1. Disable the EWF filter (`ewfmgr c: -commitanddisable`) and reboot the system.
2. Deactivate automatic adjustment in the Control Panel:
   Remove the check mark under Start > Control Panel > Date and Time > "Time Zone" tab at "Automatically adjust clock for daylight saving changes".
3. Save the change (`ewfmgr c: -commit`).
4. Switch on the EWF again (`ewfmgr c: -commitanddisable`) and reboot the system.

8.5.2 File-Based Write Filter (FBWF)

Purpose and function

The FBWF allows you to write-protect specific files and folders of a partition.

FBWF is deactivated by default on the CPU 1515SP PC.

The FBWF is activated by means of the Windows console application fbwfmgr.exe.

NOTICE
Data loss If both write filters are activated, the EWF blocks direct write access of the FBWF. Data is lost after a restart of the CPU 1515SP PC. Activate **only one** of the two write filters.

Console application fbwfmgr.exe

The application is called via the Windows command line (Command Prompt).

The following functions, among others, are available for setting, switching on and switching off the FBWF:

Table 8- 3 File-Based Write Filter

Function	Command
Show FBWF status	`fbwfmgr /displayconfig`
Activate FBWF after the next restart	`fbwfmgr /enable`
Write to protected files	`fbwfmgr /commit c: \<path>\<file name>`
Display help	`fbwfmgr /?`
Defining exclusions:	
• Add file	`fbwfmgr /addexclusion c: \<path>\<filename.ext>`
• Add folder	`fbwfmgr /addexclusion c: \<path>`
• Remove file	`fbwfmgr /removeexclusion c: \<path>\<filename.ext>`
• Remove folder	`fbwfmgr /removeexclusion c: \<path>`

Note

Note:

- The correct notation is as follows:
  Drive letter: space character "\" relative file path
- The write protection commands become effective only after a restart.

Rule for exclusion list

The following sequence applies if you define exclusions for files and folders that do not yet exist:

- Defining exclusions
- Restart CPU 1515SP PC
- Create file/folder

Display of the partition size with activated FBWF

The partition size displayed in the Explorer does not correspond with the actual size when the FBWF is active. The size displayed is derived from the amount of memory occupied on the partition and from memory released by the FBWF. After the maximum size of the overlay was reached, a message is output warning of insufficient space on the partition.

Reference

Additional information on the FBWF can be found on the Internet (http://msdn.microsoft.com/en-us/library/ff794219(v=winembedded.60).aspx).

Maintenance

9

9.1 Backing up and restoring data

Introduction

The operating system and the Runtime software are located on the supplied Restore DVD. You can use this to restore the original software of the CPU 1515SP PC.

You can also create your own image of your CFast card. This includes the operating system, the Runtime software, and the complete project loaded from the TIA Portal.

Save your project to partition D: of the CFast card.

SIMATIC IPC Image & Partition Creator

To back up data in Windows Embedded Standard 7, we recommend the software tool SIMATIC IPC Image & Partition Creator (V3.3 or later). It provides for easy backup and fast restore of the contents of the CFAST card and of individual partitions (images).

Note

The SIMATIC Image & Partition Creator supports the X2 PN/IE (LAN) interface.

You can procure the SIMATIC IPC Image & Partition Creator:

- via the Siemens online ordering system (http://www.siemens.de/automation/mall).
- Pre-installed on the SIMATIC IPC Service USB flash drives.

For additional information, please refer to the corresponding product documentation.

SIMATIC IPC Service USB flash drive

You can use the SIMATIC IPC Service USB flash drives for data backup and restore.

You obtain these through the Siemens online ordering system (http://www.siemens.de/automation/mall).

9.2 Partitioning data carriers

Partitioning the CFast card

The following partitions are set up on the CFast card by default:

Partition	Name	8 GB CFast card (WES7 E 32Bit)	16 GB CFast card (WES7 P 64Bit)	File system
C:	SYSTEM	6150 MB	10240 MB	NTFS
D:	DATA	Rest	Rest	NTFS
-	-	400 MB	400 MB	RAW

Note

Partitions in Windows Embedded Standard 7

The partitions need to be set again if they are faulty or if the partitioning is to be changed.

NOTICE

CPU volume for software controller (400 MB RAW)

Do not change the CPU volume for software controllers.

This is the only way to ensure that the software controller continues to operate without error.

9.3 Restoring the delivery state

Introduction

The entire image of your operating system and your Runtime software are located on the supplied Restore DVD. You can use the SIMATIC restore menu to restore the original software of the CPU 1515SP PC.

Alternatively, you can use the Restore menu to create a bootable USB stick in order to restore the original software without a DVD-ROM drive. Refer to the section Restoring delivery state using USB stick (Page 78).

Note

Restoring existing system partition

If your projects are stored on partition D: you can use the option "Restore existing system partition" to restore partition C: with the operating system and the Runtime software, without your project data being affected.

Note

Using Multitouch panels

The restoration of the original software is not possible with a Multitouch panel, because the Multitouch driver is not available until after the installation of the operating system.

Requirements

To restore the original software of the CPU 1515SP PC, the following is required:

- A CFast card. Minimum size of the CFast card for the CPU 1515SP PC:
  - WES7 E 32Bit 2GB RAM: 8 GB
  - WES7 P 64Bit 4GB RAM: 16 GB
- A DVD drive with external power supply
- The supplied Restore DVD. Alternatively, a bootable USB stick
- A data backup

NOTICE
Data loss
During restoration of the system to delivery state, the CFast card is completely erased and re-formatted, and is then loaded with the original software. All subsequently modified or added data, programs, license keys and partitions on the CFast card will be lost.
Back up the data of the CPU 1515SP PC after you have assigned the parameters for the modules and if you are making changes to the configuration.

NOTICE
Loss of license keys
Back up the license keys before the restore by dragging these to your USB stick via *Automation License Manager*.
After the restart of the CPU 1515SP PC, re-install the license keys on the device via *Automation License Manager*.

Restoring the delivery state of the CPU 1515SP PC using the Restore DVD

Before the restore

1. Switch off the power supply of the CPU.
2. Remove all USB devices from the CPU.
3. Connect a DVD drive with restore DVD to a USB interface of the CPU.
4. Switch on the power supply of the CPU.
   → The CPU is started.
5. Press <F12> to start the Boot Manager.
6. Select the list entry for the DVD drive in the Boot Manager.
7. After the prompt, confirm the start by pressing any key.
   → The loading process is displayed (Windows logo).
   → The SIMATIC Restore menu opens.
   – Select a language.
   – Select "CPU1515SP PC" or "CPU1515SP PC + HMI".
   – Select the option "Completely restore system drive".
     → The original software is restored on Partition C:, Partition D: is deleted.

After the restore

1. Exit the Restore menu.
2. Remove all USB devices.
3. Proceed as described in Initial commissioning (Page 43).

Further procedure

- Reconnect the USB devices.
- Install the license keys.

9.4 Restoring delivery state using USB stick

Introduction

Alternatively, you can use the Restore menu to create a bootable USB stick in order to restore the original software of the CPU 1515SP PC without a DVD-ROM drive.

Minimum size of the USB sticks for the CPU 1515SP PC:

- WES7 E 32Bit 2GB RAM: 8 GB
- WES7 P 64Bit 4GB RAM: 16 GB

Preparing bootable USB stick using PC

NOTICE
Data loss If you transfer the data from the Restore-DVD to the USB stick, all existing data on the USB stick is deleted. You should back up the data on the USB stick before you create the Restore USB stick.

Transferring Restore DVD data to the USB stick

1. Place the Restore DVD into the DVD drive of a PC.
2. Double-click the file CD_Menu.exe in the root directory of the DVD.
   - Select a language.
   - Select "CPU1515SP PC" or "CPU1515SP PC + HMI".
   - Select the option " Create USB flash drive".
3. When all the data has been transferred, remove the Restore USB stick safely from the PC.

Restoring delivery state using USB stick

Before the restore

1. Switch off the power supply of the CPU.
2. Remove all USB devices from the CPU.
3. Connect the Restore USB stick directly to the CPU.
4. Switch on the power supply of the CPU.
   → The CPU is started.
   → The restore process starts.
5. Press <F12> to start the Boot Manager.
6. Select the list entry for the USB stick as boot medium in the Boot Manager.
7. After the prompt, confirm the start by pressing any key.
   → The loading process is displayed (Windows logo).
   → The SIMATIC Restore menu opens.
   – Select a language.
   – Select "CPU1515SP PC" or "CPU1515SP PC + HMI".
   – Select the option "Restore delivery state".
     → The original software is restored.

After the restore

1. Exit the Restore menu.
2. Remove all USB devices.
3. Proceed as described in Initial commissioning.

9.5 Updating software

Note

When you update software, start the CPU 1515SP PC in the GRUB menu in Windows mode (see figure (Page 47)).

Information on updating software can be found on the Internet (http://www.siemens.com/automation/service&support).

HMI devices

During the installation, make sure that you always use the latest drivers for the HMI devices used (SIMATIC Flat Panels).
Before you install a new driver version, you must uninstall the old driver version in order to ensure proper operation.

You can download the current driver software from SIMATIC Product Support.

9.6 Windows Embedded Standard 7

The Windows Embedded Standard 7 operating system is pre-installed on the CPU 1515SP PC. WES7 E 32 Bit and WES7 P 64 Bit are offered, depending on the order option.

The WES7 P version supports multi-touch functionality (gesture control).

You can install additional updates at a later time. Current information on the operating system is available at www.windows.com.

9.7 Sending the device to customer service

Before sending

Note

Back up data and remove memory cards

Before you send in the CPU 1515SP PC for repair:

- Create a backup of your data.
- Back up your SIMATIC license keys on a USB stick.
- Remove your SD/MMC cards.
- Remove your **CFast card**.

9.8 Removing and inserting the CFast card

Introduction

The CPU 1515SP PC has a slot for a CFast card. On this card, you will find the operating system, your Runtime software and, after configuration, the project.

Seal the cover for the CFast card to protect the system against unauthorized access.

You must remove the CFast card before you send in the CPU, for example, for repair.

Requirements

- The CPU 1515SP PC is disconnected from the power supply.

Procedure – Removing the CFast card

1. Remove the seal.
2. Open the cover, using a screwdriver if necessary.
3. Press onto the CFast card.
   The card is pressed out of the slot.
4. Pull the card out of the slot.
   To do this, grip the rib on the underside of the memory card.

Procedure – Inserting the CFast card

1. Open the cover of the slot, using a screwdriver if necessary.
2. Insert the CFast card into the slot.
3. Press the CFast card into the slot.

   The CFast card is properly inserted if the cover can be closed without any resistance.
4. Close the cover.

NOTICE
Unauthorized access Seal the cover to protect the CFast card with the operating system of the CPU 1515SP PC from unauthorized access.

Technical data

10

10.1 Standards and approvals

Introduction

The general technical specifications cover the following:

- The standards and test values that the CPU 1515SP PC complies with and fulfills.
- The test criteria according to which the CPU 1515SP PC was tested.

Currently valid markings and approvals

Note

The currently valid markings and approvals are printed on the CPU 1515SP PC.

Safety information

WARNING

Risk of personal injury and damage to property.

In hazardous atmospheres, injury to persons and material damage may occur if you disconnect plug-in connections during operation of an ET 200SP.

Always switch off the power to the ET 200SP when disconnecting plug-in connections in hazardous atmospheres.

WARNING

Flying sparks due to loose cables

Risk of explosion in hazardous areas.

USB cables and PROFINET connectors may detach from the device in the case of strong oscillation and high vibrating loads.

Attach these cables to the strain relief of the device using cable ties.

⚠ WARNING
Explosion hazard
If you replace components, compliance with Class I, DIV. 2 could be compromised.

⚠ WARNING
Area of application
This device is only suitable for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

CE marking

The CPU 1515SP PC meets the requirements and safety objectives of the following EC guidelines and complies with the harmonized European standards (EN) for programmable logic controllers published in the official journals of the European Community:

- 2006/95/EC "Electrical equipment designed for use within certain voltage limits" (Low-Voltage Directive)
- 2004/108/EC "Electromagnetic Compatibility" (EMC Directive)
- 94/9/EC "Equipment and protective systems intended for use in potentially explosive atmospheres" (Explosion Protection Directive)

The EC declarations of conformity are available for the responsible authorities at:

Siemens Aktiengesellschaft
Sektor Industry
I IA AS FA DH AMB
Postfach 1963
D-92209 Amberg, Germany

These are also available for download on the Customer Support Internet pages, keyword "Declaration of Conformity".

cULus approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)

OR

cULus HAZ. LOC. approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Installation Instructions for cULus haz.loc.

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

FM approval

Factory Mutual Research (FM) according to
Approval Standard Class Number 3611, 3600, 3810 (ANSI/ISA 82.02.01)
CSA C22.2 No. 213
CSA C22.2 No. 61010-1
APPROVED for use in Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

ATEX approval

in accordance with EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC Tx Gc
DEKRA 12ATEX0038X

IECEx approval

According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements)

IECEx Ex nA IIC Tx Gc
IECEx DEK 13.0011X

Marking for Australia and New Zealand

The ET 200SP distributed I/O system meets the requirements of the standard AS/NZS CISPR 16.

Korea Certificate KCC-REM-S49-ET200SP

Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

IEC 61131

The CPU 1515SP PC with the S7-1500 software controller CPU 1505S fulfills the requirements and criteria of the IEC 61131-2 standard (programmable logic controllers, Part 2: Equipment requirements and tests).

PROFINET standard

The ET 200SP distributed I/O system is based on IEC 61158 Type 10..

PROFIBUS standard

The ET 200SP distributed I/O system is based on IEC 61158 Type 3.

IO-Link standard

The ET 200SP distributed I/O system is based on IEC 61131-9.

Marine approval (available soon)

Classification societies:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- DNV (Det Norske Veritas)
- GL (Germanischer Lloyd)
- LRS (Lloyds Register of Shipping)
- Class NK (Nippon Kaiji Kyokai)

Use in industrial environments

SIMATIC products are designed for use in industry.

Table 10- 1 Use in industrial environments

Area of application	Interference emission requirements	Interference immunity requirements
Industry	EN 61000-6-4: 2011	EN 61000-6-2: 2005

Use in residential areas

Note

The ET 200SP is intended for use in industrial areas; use in residential areas may have an impact on radio/TV reception.

If you want to use the ET 200SP in residential areas, you must ensure that its radio frequency interference emission complies with limit class B in accordance with EN 55011.

Suitable measures for achieving RF interference level Class B include, for example:

- Installation of the CPU 1515SP PC in grounded control cabinets/control boxes
- Use of filters in the supply lines

Reference

The certificates for the markings and approvals can be found on the Internet under Service&Support (http://www.siemens.com/automation/service&support).

10.2 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Among other things, the CPU 1515SP PC also meets the requirements of the EMC legislation for the European single market. The prerequisite for this is that the CPU 1515SP PC complies with the requirements and guidelines relating to electrical configuration.

EMC according to NE 21

The CPU 1515SP PC meets the EMC specifications of the NAMUR guideline NE 21.

Pulse-shaped disturbance

The following table shows the electromagnetic compatibility of the CPU 1515SP PC with regard to pulse-shaped disturbances.

Table 10- 2 Pulse-shaped disturbance

Pulse-shaped disturbance	Test voltage	corresponds to degree of severity
Electrostatic discharge according to IEC 61000-4-2.	Air discharge: ± 8 kV Contact discharge: ± 6 kV	3 3
Burst pulses (high-speed transient disturbance) according to IEC 61000-4-4.	2 kV (power supply cable) 2 kV (signal cable > 30 m) 1 kV (signal cable < 30 m)	3 3
High-energy single pulse (surge) according to IEC 61000-4-5 External protective circuit required (see function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566))		3
• asymmetric coupling	2 kV (power supply cable) DC with protective elements 2 kV (signal cable/data cable only > 30 m), possibly with protective elements	
• symmetric coupling	1 kV (power supply cables) DC with protective elements 1 kV (signal cable/data cable only > 30 m), possibly with protective elements	

Sinusoidal disturbance

The following table shows the electromagnetic compatibility of the CPU 1515SP PC with regard to sinusoidal disturbance variables.

- RF radiation

Table 10- 3 Sinusoidal disturbance variables with RF radiation

RF radiation according to IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		**corresponds to degree of severity**
80 to 1000 MHz; 1.0 to 2.0 GHz	2.0 GHz to 2.7 GHz	3
10 V/m	3 V/m	
80% AM (1 kHz)		

- RF coupling

Table 10- 4 Sinusoidal disturbance variables with RF coupling

RF coupling according to IEC 61000-4-6	**corresponds to degree of severity**
(10 kHz) 150 kHz to 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

Emission of radio interference

Interference emission of electromagnetic fields according to EN 55016: Limit class A, group 1 (measured at a distance of 10 m).

Table 10- 5 Interference emission of electromagnetic fields according to EN 55016

Frequency	**Emitted interference**
30 MHz to 230 MHz	< 40 dB (µV/m)Q
230 MHz to 1000 MHz	< 47 dB (µV/m)Q

Interference emission via the AC power supply according to EN 55016: Limit value class A, Group 1.

Table 10- 6 Interference emission via the AC power supply according to EN 55016

Frequency	**Emitted interference**
0.15 to 0.5 MHz	<79 dB (µV) Q <66 dB (µV) M
0.5 to 30 MHz	<73 dB (µV) Q <60 dB (µV) M

10.3 Shipping and storage conditions

Introduction

With respect to shipping and storage conditions, the CPU 1515SP PC exceeds the requirements according to IEC 61131-2. The following statements apply to modules that are transported and/or stored in the original packaging.

Table 10- 7 Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤1 m
Temperature	From -40 °C to +70 °C
Barometric pressure	1080 hPa to 660 hPa (corresponds to an altitude of -1000 m to 3500 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal vibrations according to IEC 60068-2-6	5 - 8.4 Hz: 3.5 mm 8.4 - 500 Hz: 9.8 m/s^2
Shock according to IEC 60068-2-27	250 m/s^2, 6 ms, 1000 shocks

10.4 Mechanical and climatic ambient conditions

Note

Restrictions

In contrast to the ambient conditions for the ET 200SP distributed I/O system, the following restrictions apply to the CPU 1515SP PC:

- Mechanical ambient conditions:
  - 2 g constant acceleration when BusAdapter BA 2×FC is used
- Ambient temperature:
  - 0 to 60 °C for horizontal installation with maximum 32 I/O modules
  - 0 to 55 °C for horizontal installation with maximum 64 I/O modules
  - 0 to 50 °C for vertical installation with maximum 32 I/O modules

Operating conditions

The CPU 1515SP PC is suitable for use in weather-proof, fixed locations. The operating conditions exceed the requirements according to DIN IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (climatic requirements)

Mechanical ambient conditions

The table below shows the mechanical ambient conditions in the form of sinusoidal oscillations.

Table 10- 8 Mechanical ambient conditions

Frequency band	CPU 1515SP PC
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration
10 ≤ f ≤ 60 Hz	0.35 mm amplitude
60 ≤ f ≤ 1000 Hz	• 1 g constant acceleration (with BusAdapter BA 2×RJ45) • **2 g** constant acceleration (with BusAdapter BA 2×FC)

Test of mechanical ambient conditions

The table below provides important information with respect to the type and scope of the test of ambient mechanical conditions.

Table 10- 9 Test of mechanical ambient conditions

Condition tested	Test Standard	Comment
Vibration	Vibration test according to IEC 60068-2-6 (sine)	Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute. BA 2×RJ45 • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration BA 2×FC • 10 Hz ≤ f ≤ 60 Hz, 0.35 mm constant amplitude • 60 Hz ≤ f ≤ 1000 Hz, **2 g** constant acceleration Duration of vibration: 10 frequency sweeps per axis in each of 3 vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of 3 vertically aligned axes

Climatic ambient conditions

You may use the CPU 1515SP PC under the following climatic ambient conditions:

Table 10- 10 Climatic ambient conditions

Ambient conditions	Permissible range	Comments
Temperature: Horizontal mounting position:	• from 0 to 60 °C	For configuration with 32 I/O modules and 3 x 100 mA USB load
	• from 0 to 55 °C	For configuration with 64 I/O modules and 2 x 500 mA + 1 x 100 mA USB load
Vertical installation:	• 0 to 50 °C	For configuration with 32 I/O modules and 3 x 100 mA USB load
Permitted temperature change	10 K/h	-
Relative humidity	from 10 to 95%	Without condensation, corresponds to relative humidity (RH) class 2 according to IEC 61131 part 2
Barometric pressure	1080 hPa to 795 hPa	Corresponds to an altitude of -1000 m to 2000 m
Concentration of pollutants	SO_2: < 0.5 ppm; RH < 60%, no condensation H_2S: < 0.1 ppm; RH < 60 %, no condensation	-
	ISA-S71.04 severity level G1; G2; G3	-

10.5 Information on insulation, protection class, degree of protection and rated voltage

Insulation

The insulation is designed according to the requirements of EN 61131-2: 2007.

Note

For modules with 24 V DC supply voltage, the electrical isolation is designed for max. 60 V AC/75 V DC and basic insulation is designed according to EN 61131-2: 2007.

Pollution degree/overvoltage category according to IEC 61131

- Pollution degree 2
- Overvoltage category: II

Protection class according to IEC 61131-2:2007

The CPU 1515SP PC meets protection class I and includes parts of protection classes II and III.

The grounding of the mounting rail must meet the requirements for functional earth FE.

The installation location (e.g. enclosure, control cabinet) must have a protective conductor connection that meets the standard to maintain protection class I.

Degree of protection IP20

Degree of protection IP20 according to IEC 60529, i.e.:

- Protection against contact with standard probe
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Rated voltage for operation

The CPU 1515SP PC works with the rated voltage and corresponding tolerances listed in the following table.

Table 10- 11 Rated voltage for operation

Rated voltage	Tolerance range
24 V	19.2 to 28.8 V DC [1]
	18.5 to 30.2 V DC [2]

[1] Static value: Creation as functional extra-low voltage with safe electrical isolation in accordance with IEC 60364-4-41

[2] Dynamic value: including ripple, e.g. with three-phase bridge rectification

10.6 Use of the ET 200SP in zone 2 potentially explosive atmospheres

See product information Use of subassemblies/modules in a Zone 2 Hazardous Area (http://support.automation.siemens.com/WW/view/en/19692172).

10.7 Technical specifications

10.7.1 CPU 1515SP PC (6ES7677-2AA30-0AA0)

CPU 1515SP PC (spare part)

	6ES7677-2AA30-0AA0
Product type designation	CPU 1515SP PC
General information	
Hardware version	FS01
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
PC configuration	
Computer platform	ET 200SP Open Controller
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	2 GB RAM
Installed SW	
Visualization	No
Controller	No
Operator controls	
Mode selector	1
Installation type/mounting	
Rack mounting possible	No
Front installation possible	No
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W

	6ES7677-2AA30-0AA0
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use
Memory	
Type of memory	DDR3-SDRAM work memory
CFast card	No
Work memory	
Integrated	2 GB
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	
Modules per rack, max.	64; CPU + 64 modules + server module (configuration width max. 1 m)
Rack, number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Deviation per day, max.	10 s; typ.: 2 s
Buffered period	6 wk; at 40 °C ambient temperature, typ.
Interfaces	
Number of Industrial Ethernet interfaces	2
Number of PROFINET interfaces	1; X1 via BusAdapter BA 2x RJ45
Number of PROFIBUS interfaces	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of RS 485 interfaces	1; via CM DP module
Graphic interface	1 X DVI-I
1st interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
• Transmission rate, max.	100 Mbps
• Industrial Ethernet status LED	Yes

	6ES7677-2AA30-0AA0
2nd interface	
Interface hardware	
• Number of ports	1
• RJ 45 (Ethernet)	Yes; integrated
• Transmission rate, max.	1000 Mbps
• Industrial Ethernet status LED	No
3rd interface	
Interface hardware	
• RS 485	Yes; via CM DP module
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st interface X1
1000 Mbps	Yes; for 2nd interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60 °C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55 °C with max. 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Storage/transport temperature	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
• SD card	Optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.2 CPU 1515SP PC (6ES7677-2AA40-0AA0)

CPU 1515SP PC (spare part)

	6ES7677-2AA40-0AA0
Product type designation	CPU 1515SP PC
General information	
Hardware version	FS01
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
PC configuration	
Computer platform	ET 200SP Open Controller
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	4 GB RAM
Installed SW	
Visualization	No
Controller	No
Operator controls	
Mode selector	1
Installation type/mounting	
Rack mounting possible	No
Front installation possible	No
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use

	6ES7677-2AA40-0AA0
Memory	
Type of memory	DDR3-SDRAM work memory
CFast card	No
Work memory	
Integrated	4 GB
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	
Modules per rack, max.	64; CPU + 64 modules + server module (configuration width max. 1 m)
Rack, number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Deviation per day, max.	10 s; typ.: 2 s
Buffered period	6 wk; at 40 °C ambient temperature, typ.
Interfaces	
Number of Industrial Ethernet interfaces	2
Number of PROFINET interfaces	1; X1 via BusAdapter BA 2x RJ45
Number of PROFIBUS interfaces	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of RS 485 interfaces	1; via CM DP module
Graphic interface	1 X DVI-I
1st interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
• Transmission rate, max.	100 Mbps
• Industrial Ethernet status LED	Yes
2nd interface	
Interface hardware	
• Number of ports	1
• RJ 45 (Ethernet)	Yes; integrated
• Transmission rate, max.	1000 Mbps
• Industrial Ethernet status LED	No

	6ES7677-2AA40-0AA0
3rd interface	
Interface hardware	
• RS 485	Yes; via CM DP module
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st interface X1
1000 Mbps	Yes; for 2nd interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60°C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55°C with max. 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Storage/transport temperature	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
• SD card	Optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.3 CPU 1515SP PC, CPU 1515SP PC + HMI

The technical specifications of the following devices modules can be found in the product information under (http://support.automation.siemens.com/WW/view/en/104117388).

ET 200SP Open Controller	Article number	
	Hardware variant WES7 E 32Bit 2GB RAM	Hardware variant WES7 P 64Bit 4GB RAM
CPU 1515SP PC	6ES7677-2AA31-0EB0	6ES7677-2AA41-0FB0
CPU 1515SP PC + HMI 128PT	6ES7677-2AA31-0EK0	6ES7677-2AA41-0FK0
CPU 1515SP PC + HMI 512PT	6ES7677-2AA31-0EL0	6ES7677-2AA41-0FL0
CPU 1515SP PC + HMI 2048PT	6ES7677-2AA31-0EM0	6ES7677-2AA41-0FM0

10.7.4 S7-1500 Software Controller CPU 1505S

The CPU 1505S is a PC-based controller from the range of SIMATIC S7-1500 software controllers.

Technical specifications

All technical specifications for CPU 1505S with the article number 6ES7672-5AC00-0YA0 can be found under (http://support.automation.siemens.com/WW/view/en/6ES7672-5AC00-0YA0).

10.8 Dimension drawings

10.8.1 CPU 1515SP PC

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets.

Dimension drawings of the CPU 1515SP PC

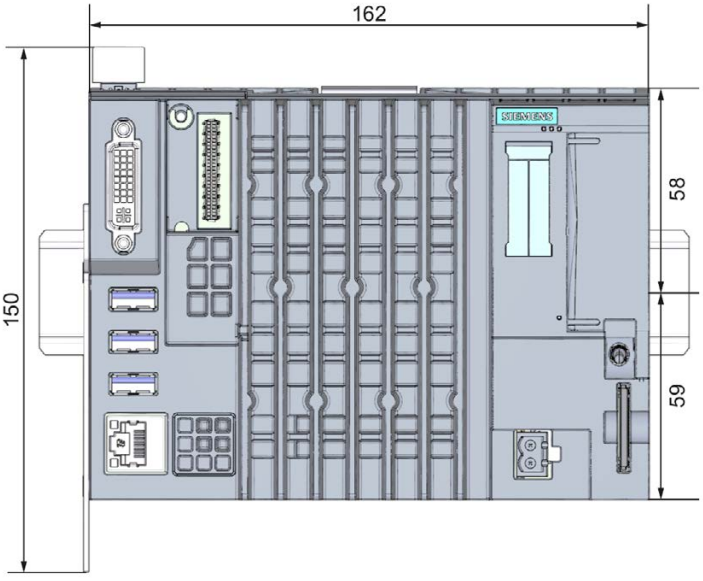


Figure 10-1 Dimension drawing of CPU 1515SP PC, front view

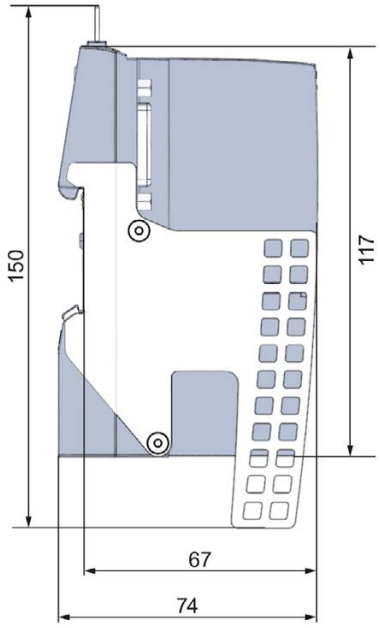


Figure 10-2 Dimension drawing of CPU 1515SP PC, side view

Accessories/spare parts

A

Order options and accessories for CPU 1515SP PC

Table A- 1 Order options for CPU 1515SP PC

Description	Article number
Hardware variant **WES7 E 32Bit 2GB RAM** [1]	
CPU 1515SP PC, spare part (without CFast card)	6ES7677-2AA30-0AA0
CPU 1515SP PC, 8 GB CFast card, with pre-installed S7-1500 software controller CPU 1505S	6ES7677-2AA31-0EB0
CPU 1515SP PC, 8 GB CFast card, with pre-installed S7-1500 software controller CPU 1505S and WinCC Runtime Advanced V13 SP1	
• CPU 1515SP PC + HMI 128PT	6ES7677-2AA31-0EK0
• CPU 1515SP PC + HMI 512PT	6ES7677-2AA31-0EL0
• CPU 1515SP PC + HMI 2048PT	6ES7677-2AA31-0EM0
Hardware variant **WES7 P 64Bit 4GB RAM** [1]	
CPU 1515SP PC, spare part (without CFast card)	6ES7677-2AA40-0AA0
CPU 1515SP PC, 16 GB CFast card, with pre-installed S7-1500 software controller CPU 1505S	6ES7677-2AA41-0FB0
CPU 1515SP PC, 16 GB CFast card, with pre-installed S7-1500 software controller CPU 1505S and WinCC Runtime Advanced V13 SP1	
• CPU 1515SP PC + HMI 128PT	6ES7677-2AA41-0FK0
• CPU 1515SP PC + HMI 512PT	6ES7677-2AA41-0FL0
• CPU 1515SP PC + HMI 2048PT	6ES7677-2AA41-0FM0

[1] Windows Embedded Standard 7

Table A- 2 Accessories for CPU 1515SP PC

Description	Article number
BusAdapter, 1 unit	
• BA 2×RJ45 (PROFINET BusAdapter with standard Ethernet socket)	6ES7193-6AR00-0AA0
• BA 2×FC (PROFINET BusAdapter with Fast Connect Ethernet connection)	6ES7193-6AF00-0AA0
Server module; 1 unit	6ES7193-6PA00-0AA0
Strain relief for CPU 1515SP PC	A5E32291462
SIMATIC IPC Service USB flash drive 8 GB (SLC), pre-installed BIOS-MANAGER V3.3, Image/Partition Creator V3.3 and installation CD	6AV7672-8JD01-0AA0
SIMATIC IPC Service USB flash drive 16 GB, USB3.0, pre-installed BIOS-MANAGER V3.3, Image/Partition Creator V3.3 and installation CD	6AV7672-8JD02-0AA0
SIMATIC IPC DiagMonitor Software V4.4.1	6ES7648-6CA04-4YX0
SIMATIC PC, adapter cable, DVI-I compliant with VGA, 250 mm long	6ES7648-3AB00-0XA0
Reference identification label, sheet with 16 labels, 10 units	6ES7193-6LF30-0AW0
Mounting rails, tin-plated steel strip	
• Length: 483 mm	6ES5710-8MA11
• Length: 430 mm	6ES5710-8MA21
• Length: 830 mm	6ES5710-8MA31
• Length: 2000 mm	6ES5710-8MA41
SIMATIC IPC CFast cards	
• CFast 2 GB Industrial Grade	6ES7648-2BF10-0XF10
• CFast 4 GB Industrial Grade	6ES7648-2BF10-0XG10
• CFast 8 GB Industrial Grade	6ES7648-2BF10-0XH10
• CFast 16 GB Industrial Grade	6ES7648-2BF10-0XJ10
• CFast 32 GB Industrial Grade	6ES7648-2BF10-0XK10

Online catalog

Additional article numbers can be found on the Internet in the online catalog and online ordering system (http://www.siemens.de/automation/mall).

Abbreviations

B

Abbreviation	Term	Meaning
AC	Alternating current	Alternating current
ALM	Automation License Manager	Tool for managing license keys in STEP 7
BIOS	Basic Input Output System	Basic Input Output System. A set of important software routines used after the startup of the CPU to load the operating system and to provide the routines for data exchange between hardware components.
CE	Communauté Européenne	CE label
CFast	CompactFlash ATA Serial Transfer	Memory card
CoA	Certificate of Authenticity	Certificate of Authenticity, label with Microsoft Windows "Product Key"
CoL	Certificate of License	Certificate of License for the SIMATIC software loaded
DC	Direct Current	DC current
DVD	Digital Versatile Disc	Digital storage medium with high memory capacity.
DVI-I	Digital Visual Interface	Interface for transfer of image and video data for DVI-I monitors.
ESD	Components sensitive to electrostatic charge	
EN	European standard	
EWF	Enhanced Write Filter	Enhanced write filter
FBWF	File Based Write Filter	File based write filter
GbE	Gigabit Ethernet	
GRUB / GRUB4DOS	GRand Unified Bootloader	Boot Manager
HMI	Human Machine Interface	User interface
IEC	International Electronical Commission	
IM	Interface module	The interface module connects the ET 200SP distributed I/O system with the IO controller and exchanges data with the I/O modules via the backplane bus.
LAN	Local Area Network	Computer network that is limited to a local area.
LED	Light Emitting Diode	Light emitting diode
LLDP	Link Layer Discovery Protocol	Protocol that enables the exchange of information between adjacent devices.
MMC	Multi Media Card	Memory card
NTFS	New Technology File System	File system that offers targeted access protection at the file level.
NVRAM	Non-Volatile Random-Access Memory	Non-volatile data memory that is RAM-based, the data content of which is retained without external power supply.
PC	Personal Computer	

Abbreviation	Term	Meaning
PELV	Protective Extra Low Voltage	PELV, previously called "extra low voltage with safe isolation", is a protective measure against electrical shock. See EN 50178.
PN	PROFINET	
PG	Programming device	Compact programming device which meets the special requirements of industry. The PG is fully equipped for programming SIMATIC PLCs.
PS	Power supply	Power supply
PT	Power Tags	Process tags; tags enable data exchange between the components of an automation process, for example, between the HMI device and the controller.
RAM	Random Access Memory	Main or work memory of a computer with direct access, allowing read access to data and editing.
RT	Runtime	
SD	Secure Digital card	Memory card
SELV	Safety Extra Low Voltage	Safety extra-low voltage; protective measure in which circuits with a rated voltage of up to 50 V AC or 120 V DC are operated ungrounded and feeds from circuits with a higher voltage are separated from these by, for example, a safety transformer.
UL	Underwriters Laboratories Inc.	
USB	Universal Serial Bus	Serial bus system for connecting a computer to external devices.

Troubleshooting

C

Problem	Possible cause	Remedy
CPU 1515SP PC is not working.	CPU 1515SP PC is not supplied with current.	Check the power supply.
CPU 1515SP PC does not start.	Feedback through USB devices.	Use USB devices that comply with the USB 2.0 specification.
Windows no longer boots.	Settings in the BIOS setup are not correct.	Check the settings in the BIOS setup menu Boot.
Time and/or date of the CPU 1515SP PC not correct.	CPU 1515SP PC was not connected for more than 6 weeks.	Correct the settings in the BIOS setup menu Main or in Windows.
USB device is not working.	USB power supply is overloaded.	Use an external power supply for the USB device (see section Application planning (Page 31).

Glossary

Cold restart

A startup procedure commencing when the CPU is switched on. Upon a cold restart, the system typically performs some basic hardware checks and then loads the operating system from the hard disk into the work memory.

Controller

Integrated hardware and software controlling the operation of a specific internal or I/O device (e.g. keyboard controller).

Device configuration

The device configuration of a PC/programming device includes information on the features and options of the PC/programming device such as memory configuration, drive types, monitor, network address etc. The data is stored in a configuration file and is used by the operating system to load the corresponding device drivers or assign device parameters.

Drivers

Program sections of the operating system. They convert data from the user programs to the specific formats required by the I/O devices (e.g. hard disks, monitors, printers).

Enhanced Write Filter (EWF)

Configurable write filter making it possible to boot Windows Embedded Standard from write-protected media (e.g. from CD-ROM), to write-protect individual partitions and to adapt file system performance to the user's requirements (e.g. when using CFast cards).

Ethernet

Local network (bus structure) for text and data communication with a data transmission rate of 10/100/1000 Mbps.

File-Based Write Filter (FBWF)

Configurable write filter making it possible to write-protect individual files.

Image

An image is a copy of hard-disk partitions, for example, which is stored as backup in a file so that it can be restored if necessary.

Interface

- Connection between individual hardware elements such as PCs, programming device, printer or screen by means of physical plug-in connections (cables).
- Connection between different programs to allow them to be used together.

LAN

Local Area Network: LAN refers to a local network consisting of a group of computers and other devices which are distributed over a relatively restricted area and connected through communication lines. The devices connected to a LAN are referred to as nodes. The purpose of networks is the shared use of files, printers or other resources.

License key

The license key is the electronic license stamp of a license. Siemens AG provides a license key for software that is protected by licensing laws.

Operating system

Generic term which describes all functions for controlling and monitoring user program execution and distribution of system resources to the user programs as well as maintenance of the operating mode in cooperation with the hardware.

Power options

The power options can be used to reduce the power consumption of the computer while still keeping it ready for immediate use. Can be configured in Windows via **Settings** > **Control Panel** > **Power Options**.

Restart

Restart of an already running computer which is performed without switching off the power supply, for example using the key combination <Ctrl + Alt + Del>.

Restore DVD

You use the Restore DVD to reset your system partition or the entire hard disk to the delivery state in the event of an error. The DVD contains all the image files required and is bootable.

ROM

Read Only Memory. ROM refers to a read-only memory where each memory location can be addressed individually. The stored programs or data are hard-coded and are preserved even in the event of a power failure.

S.M.A.R.T

Self-Monitoring, Analysis and Reporting Technology (SMART or S.M.A.R.T.) is an industry standard for storage media. It provides for permanent monitoring of relevant parameters and thus early recognition of pending defects.

SATA

Serial ATA. An interface for hard disk drives and optical drives with serial data transmission up to 300 Mbps.

SETUP (BIOS setup)

A program used to determine information on the device configuration. The device configuration of the CPU 1515SP PC is preset. Changes must be made whenever a memory expansion, new modules or drives are to be activated.

SIEMENS

SIMATIC S7-1200/S7-1500 F-CPUs

Product Information

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

Content

Introduction

This Product Information contains important information on the F-CPUs specified in the section "Scope of validity". The Product Information is part of the product supplied. The information in this Product Information should be considered more up-to-date than other documentation if uncertainties arise.

Scope of validity

The statements in this product information apply to the F-CPUs listed below:

S7-1200 F-CPUs	S7-1500 F-CPUs		
• CPU 1212FC DC/DC/DC • CPU 1212FC DC/DC/Rly • CPU 1214FC DC/DC/DC • CPU 1214FC DC/DC/Rly • CPU 1215FC DC/DC/DC • CPU 1215FC DC/DC/Rly	• CPU 1511F-1 PN • CPU 1513F-1 PN • CPU 1515F-2 PN • CPU 1516F-3 PN/DP • CPU 1517F-3 PN/DP • CPU 1517TF-3 PN/DP • CPU 1518F-4 PN/DP • CPU 1518F-4 PN/DP ODK	• CPU 1510SP F-1 PN • CPU 1512SP F-1 PN • CPU 1516proF-2 PN	S7-1500 F-Software Controller • CPU 1505SP F • CPU 1507S F

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Areas of application

Main areas of application of the S7-1200/1500 F-CPUs are personal and machine safety and burner controls. In addition to the safety program, you can also program standard applications.

You can operate the S7-1200/1500 F-CPUs in safety or standard mode.

The installed *STEP 7 Safety* optional package is required for safety mode. If the *STEP 7 Safety* optional package is not installed, you can use the S7-1200/S7-1500 F-CPUs in standard mode. In standard mode, S7-1200/1500 F-CPUs behave like standard S7-1200/1500 CPUs.

Additional information on using the S7-1200/1500 F-CPUs in safety mode is available in the programming and operating manual "SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)".

Additional information on using the S7-1200 F-CPUs in standard mode is available in the "S7-1200 Programmable controller (https://support.industry.siemens.com/cs/ww/en/view/109478121)" system manual.

Additional information on using the S7-1500 F-CPUs in standard mode is available in the relevant manuals for the S7-1500 standard CPUs at the following links:

- CPUs 151x (http://support.automation.siemens.com/WW/view/en/67295862/133300)
- CPUs 151xSP (http://support.automation.siemens.com/WW/view/en/90466439/133300)
- CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/ps/13906/man)
- S7-1500 Software Controller (http://support.automation.siemens.com/WW/view/en/109740725)

You can find the latest firmware for the relevant F-CPU by searching for downloads with the respective article number in the Industry Online Support (https://support.industry.siemens.com).

Note

Observe any application-specific requirements, for example on mains buffering for power supplies/power packs.

PFD_{avg} and PFH values for F-CPUs

Below are the probability of failure on demand values (PFD_{avg}, PFH values) for the above-named F-CPUs with a service life of 20 years and an MTTR of 100 hours:

Operation in low demand mode low demand mode **According to IEC 61508:2010:** **PFD_{avg} = Average probability of a dangerous failure on demand**	**Operation in high demand or continuous mode** high demand/continuous mode **According to IEC 61508:2010:** **PFH = Average frequency of a dangerous failure [h^{-1}]**
< 2E-05	< 1E-09

Overview of the work memory of F-CPUs compared with standard CPUs

CPU	Work memory	F-CPU	Work memory
CPU 1212C DC/DC/DC CPU 1212C DC/DC/Rly	75 KB	CPU 1212FC DC/DC/DC CPU 1212FC DC/DC/Rly	100 KB
CPU 1214C DC/DC/DC CPU 1214C DC/DC/Rly	100 KB	CPU 1214FC DC/DC/DC CPU 1214FC DC/DC/Rly	125 KB
CPU 1215C DC/DC/DC CPU 1215C DC/DC/Rly	125 KB	CPU 1215FC DC/DC/DC CPU 1215FC DC/DC/Rly	150 KB
CPU 1511-1 PN	150 KB	CPU 1511F-1 PN	225 KB
CPU 1513-1 PN	300 KB	CPU 1513F-1 PN	450 KB
CPU 1515-1 PN	500 KB	CPU 1515F-1 PN	750 KB
CPU 1516-3 PN/DP	1 MB	CPU 1516F-3 PN/DP	1.5 MB
CPU 1517-3 PN/DP	2 MB	CPU 1517F-3 PN/DP	3 MB
CPU 1517T-3 PN/DP	3 MB	CPU 1517FT-3 PN/DP	3 MB
CPU 1518-4 PN/DP (ODK)	4 MB	CPU 1518F-4 PN/DP (ODK)	6 MB

CPU	Work memory	F-CPU	Work memory
CPU 1510SP-1 PN	100 KB	CPU 1510SP F-1 PN	150 KB
CPU 1512SP-1 PN	200 KB	CPU 1512SP F-1 PN	300 KB
CPU 1516pro-2 PN	1 MB	CPU 1516proF-2 PN	1.5 MB
CPU 1505SP	1 MB	CPU 1505SP F	1.5 MB
CPU 1507S	5 MB	CPU 1507S F	7.5 MB

Support of PROFIsafe V2

Interfaces that support PROFINET IO also support PROFIsafe V2.

Restriction with "CREAT_DB" and "DELETE_DB" instructions

F-DBs can neither be created nor deleted.

Restriction with "READ_DBL" and "WRIT_DBL" instructions

The destination address must not point to an F-DB.

Restrictions when configuring the retentive behavior of data blocks

The configuration of the retentive behavior of data blocks is not supported for F-DBs. This means that the actual values of the F-DBs will not be retentive in the event of Power OFF/ON and Restart (STOP-RUN) of the F-CPU. The F-DBs retain the initial values from the load memory.

The "Retain" check box is grayed-out for all tags in F-DBs.

Configuration control (option handling) on an S7-1200 F-CPU

Configuration control (option handling) on an S7-1200 F-CPU is possible with central F-modules subject to the following limitation:

- The fail-safe S7-1200 modules cannot be swapped and must also always be physically inserted into their configured slot.

Procedure for loading a configuration for firmware < V2.0 for S7-1500 F-CPUs

If you have loaded an S7-1500 F-CPU with a configuration for firmware V2.0 with configured protection level "Full access with. fail-safe (no protection)" and you now want to load a configuration for firmware <= V1.8 to this F-CPU, you must observe the following:

When the configuration with firmware <= V1.8 is loaded to the F-CPU, you will be prompted to enter the password and the entered password will be identified as invalid.

As a remedy, format the SIMATIC Memory Card as described in the online help for STEP 7 under "Formatting an S7-1500 memory card". You can then load the configuration for firmware <= V1.8 to the F-CPU.

Display (for S7-1500 F-CPUs with display or panel)

S7-1500 F-CPUs with display show you the following in the "Overview" menu under "Fail-safe":

- Safety mode activated/deactivated
- Collective F-signature
- Last fail-safe change
- Version of *STEP 7 Safety* with which the safety program was compiled.
- Information on the F-runtime groups
  - Name of F-runtime group
  - Collective F-signature
  - Current cycle time
  - Max. cycle time
  - Current runtime
  - Max. runtime

The following is displayed for each F-I/O under "Fail-safe parameters":

- F-parameter signature (with address)
- Safety mode
- F-monitoring time
- F-source address
- F-destination address

The following additional menu command is displayed in the "Settings" menu under "Protection":

- Enable/disable F-password

Write access to F-blocks is not permitted. For the S7-1500 F-Software Controller, no distinction is made between standard and fail-safe tags with regard to the alarm when modifying tags. Fail-safe tags are not written.

Web server

S7-1200/1500 F-CPUs show you the following on the start page of the Web server:

- Safety mode activated/deactivated
- Collective F-signature
- Last fail-safe change
- Version of *STEP 7 Safety* with which the safety program was compiled.
- Information on the F-runtime groups
  - Name of F-runtime group
  - Collective F-signature
  - Current cycle time
  - Max. cycle time
  - Current runtime
  - Max. runtime

The following is displayed for each F-I/O on the "Module information" web page in the "Fail-safe" tab:

- F-parameter signature (with address)
- Safety mode
- F-monitoring time
- F-source address
- F-destination address

Write access to F-blocks is not permitted.

The following points relate to the S7-1500 F-Software Controller

The S7-1500 F-Software Controller is a fail-safe software CPU that is used on the following devices.

S7-1500 F-Software Controller	Device
CPU 1505SP F	• CPU 1515SP PC
CPU 1507S F	• IPC 4x7D* • IPC 2x7E*

* Can only be used when NVRAM is present (to be automatically allocated)

The devices specified in the table above react in a fail-safe manner when the S7-1500 F-Software Controller and *STEP 7 Safety* are used, even in the case of elevated electromagnetic interference. Special type tests for functional safety are therefore not required for these devices – in contrast to F-I/O. With regard to availability, however, you must observe the application-specific requirements, especially the standards for burner control.

The yellow adhesive label with the TÜV SÜD test mark for functional safety included in the scope of delivery is exclusively intended for use in connection with S7-1500 F-Software Controllers. You can use the adhesive label to mark the hardware on which the S7-1500 F-Software Controller is installed. You must remove the adhesive label when you uninstall the S7-1500 F-Software Controller.

Backup and restore

Backup and restoration of project data is not supported.

Passwords for protection levels

The PC station does not distinguish between the two passwords of protection levels "Full access with fail-safe (no protection)" and "Full access (no protection)". The S7-1500 F-Software Controller distinguishes between the two passwords of protection levels "Full access with fail-safe (no protection)" and "Full access (no protection)".

ENDIS_PW instruction

When the ENDIS_PW instruction is used on an IPC, you can be locked out of your system because an IPC has no mode selector. As a remedy, you can follow a procedure similar to that described in the online help for the ENDIS_PW instruction under "Preventing unintentional lockout of an S7-1200 CPU". If an unintentional lockout occurs, you can remedy this only by uninstalling and installing the S7-1500 F-Software Controller.

TPM functionality

The TPM functionality cannot be used for S7-1500 F-Software Controllers because it could result in a STOP.

Other particularities

⚠ WARNING

You must limit access for the S7-1500 F-Software Controller through access protection to persons who are authorized to install or uninstall the software of the S7-1500 F-Software Controller.

Note

With an S7-1500 F-Software Controller, the "Delete Configuration" function is only offered on the panel when no access protection (no protection) is set up on the F-CPU.

Note

Required BIOS version for CPU 1505SP F

For use of the CPU 1505SP F, you require BIOS version V2.00_02.01 or higher.

Note

The CPU clock must not be changed in RUN because this would result in a STOP. You can prevent this by disabling the energy-saving function.

Note

Assignment of PROFIsafe addresses for F-modules via PROFIBUS on IPCs

If you want to assign PROFIsafe addresses for F-modules that are being operated via PROFIBUS on an IPC with an S7-1500 F-Software Controller, assign the PROFIsafe addresses to the F-modules and then perform a power on/power off of the PROFIBUS station.

Note

Loading the safety program or activating safety mode

After loading the safety program or activating safety mode, close the panel and then open it again to update the display on the panel.

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F-CPUs
A5E35635424-AB, 09/2016

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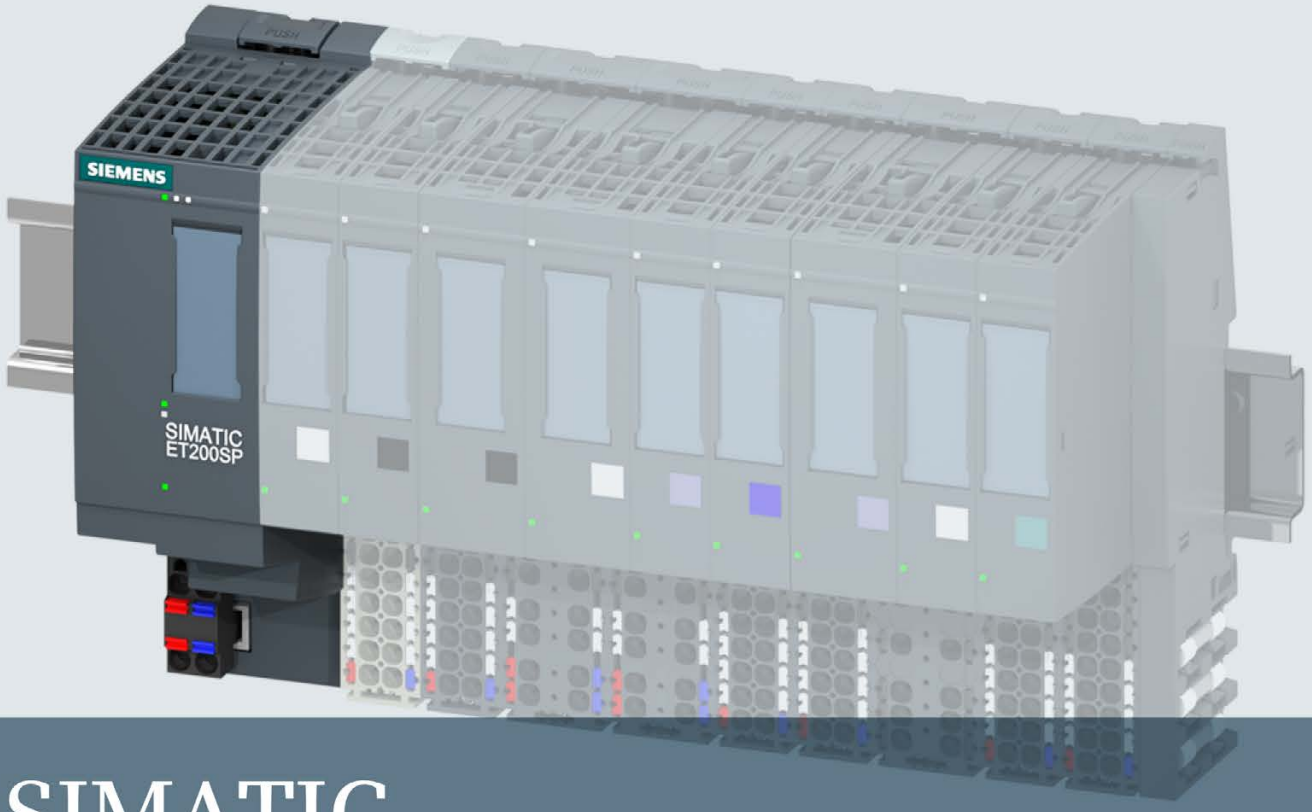

SIMATIC

ET 200SP

Interface module IM 155-6 PN BA (6ES7155-6AR00-0AN0)

Manual

Edition 03/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
IM 155-6 PN BA interface module (6ES7155-6AR00-0AN0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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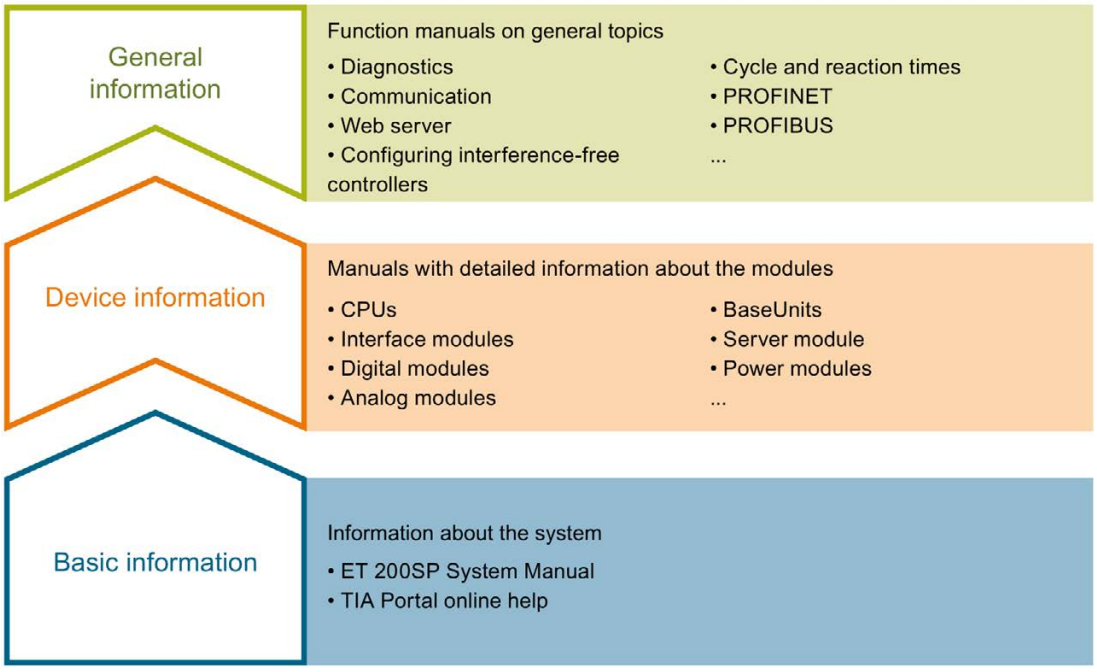
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://www.automation.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-controllers/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7155-6AR00-0AN0 (IM 155-6 PN BA interface module and server module)

View of the module

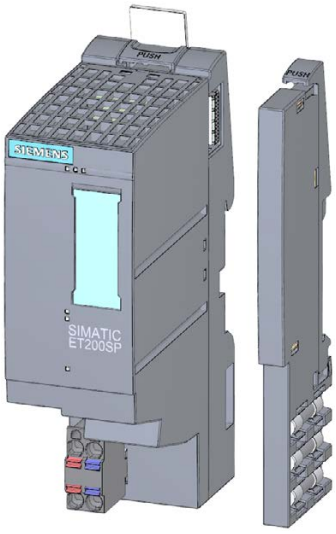


Figure 2-1 View of the IM 155-6 PN BA interface module and the server module

Properties

The module has the following properties:

- Technical properties
  - Connects the ET 200SP distributed I/O system with PROFINET IO
  - Supply voltage 1L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery of the interface module.
- Supported functions (Page 10)

Maximum configuration

- 12 I/O modules

Maximum amount of I/O data

The maximum amount of I/O data is 32 bytes input/output data.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Server module

The server module (V1.1.1 and higher) is included in the scope of delivery of the interface module and also available separately as an accessory. The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Identification data I&M 0 to 3
- Retentive storage of the device name for device replacement without topological configuration

Note

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module in the last configuration slot and enable the parameter Group diagnostics: No supply voltage L+. If there are 12 I/O modules, the server module is plugged in slot 13.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

2.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ping, arp, network diagnostics (SNMP: MIB2, LLDP-MIP and MRP-MIB)
- Port diagnostics
- Deactivating of ports
- Minimum update time 1 ms
- Media redundancy MRP
- Device replacement without programming device
- Reset to factory settings via PROFINET IO
- Firmware update via PROFINET IO

The interface module supports additional functions:

- Identification data I&M 0 to 3
- Device replacement with and without topological configuration
- Configuration control (option handling)

Requirements

Configuration takes place with GSDML or STEP 7 V13/HSPxyz.

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you must also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/de/49948856/0/en)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Device replacement without topological configuration

In addition to the interface module, the device name is also saved on the server module (V1.1.1 and higher). A device name saved on the server module is the requirement for device replacement without topological configuration.

Storing the name on the server module and the interface module produces a range of scenarios for using the device name when the interface module is replaced.

Table 2- 1 Scenarios for using the device name

	Interface module empty	**Interface module with device name**
Server module empty	No device name available.	The device name from the interface module is used and copied to the server module.
Server module with device name	The device name from the server module is used and copied to the interface module.	The device name from the server module is used and copied to the interface module if this has a different device name.

Be aware of the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the server module. To prevent the device name from being deleted in the server module, you can remove the server module from the interface module before resetting to factory settings.
- When a server module is replaced, a device name stored in the server module is applied to the interface module after a POWER ON.
- Do not pull/plug the server module while under voltage. If you pull/plug the server module while under voltage, the interface module restarts.
- If you use a server module with an invalid firmware version (< V1.1.1), channel-specific diagnostics is generated with the error number 27 (general error). To correct this error, you need to replace the server module or update the server module firmware.

IO devices that have already been used in another configuration should be reset to their factory settings before reuse (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/de/49948856/0/en)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Replacement of an IM 155-6 PN BA

If a spare part is required, any IO devices in operation must be reset to their delivery state via "Reset to factory settings" (see the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Media redundancy (MRP)

Function for safeguarding communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/de/49948856/0/en)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.1 Configuration control (option handling)

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or changes. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

Wiring

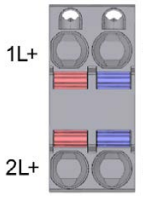
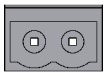
3

3.1 Terminal assignment

24 V DC supply voltage

The following table shows the signal names and the descriptions of the terminal assignment for a 24 V DC supply voltage.

Table 3- 1 Terminal assignment 24 V DC supply voltage

View		Signal name[1]	Description
Connector	IM connection		
		1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

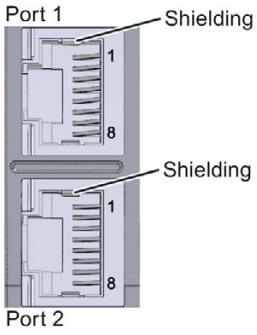
[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally.

[2] Maximum 10 A permitted.

PROFINET IO

The following table shows the signal name and description of the terminal assignment.

Table 3- 2 PROFINET IO terminal assignment

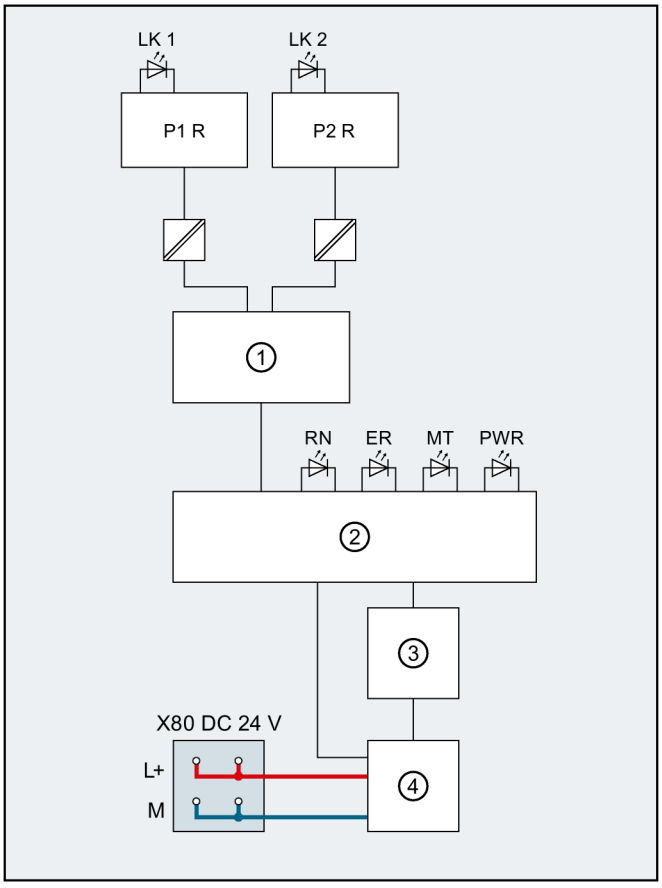
View		Signal name	Description
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

Reference

You can find more information on accessories and how to connect the interface module in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

3.2 Block diagram

The following figure shows the block diagram of the interface module IM 155-6 PN BA.



①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1,2	LED Link TX/RX
④	Internal power supply	RN	LED RUN/STOP (green/yellow)
X80 24 V DC	Infeed of supply voltage	ER	ERROR LED (red)
P1 R	PROFINET interface X1 Port 1	MT	MAINT LED (yellow)
P2 R	PROFINET interface X1 Port 2	PWR	POWER LED (red)

Figure 3-1 Block diagram of IM 155-6 PN BA interface module

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 PN BA interface module

The following table shows the parameters for the IM 155-6 BA interface module.

Table 4- 1 Parameters for interface module IM 155-6 PN BA (GSD file)

Parameters	Range of values	Default	Efficiency range
Configuration control	Disable/enable	Disable	ET 200SP

4.2 Explanation of the parameters

4.2.1 Enabling configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

Note

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information on the control data record in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.3 Substitute value behavior

The substitute value behavior in the ET 200SP distributed I/O system is executed by the IO controller for each slot.

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Station stop, for example, due to:
  - Missing server module
  - Removing more than one I/O module at a time
  - At least one I/O module installed on an incorrect BaseUnit
- Deactivating the IO device

Note

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

The "current-free/voltage-free" behavior takes effect in the following cases:

- Firmware update
- Reset to factory settings
- Configuration control: receipt of a new control data record
- Incorrectly configured module
- Module with incorrect parameter assignment

4.4 Status of the supply voltage L+ of the I/O modules

Configurations

The "Status of supply voltage L+ of the I/O modules" is configured in the IM 155-6 PN BA on the server module. The input data can then be read out on the server module. You will find the relevant description in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

Interrupts, error messages, diagnostics and system alarms

5

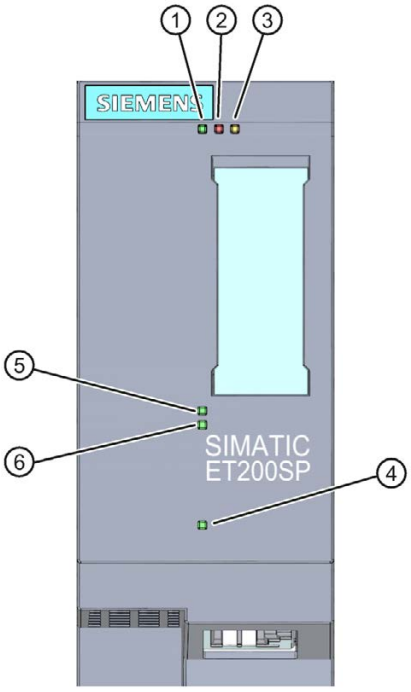
5.1 Status and error displays

Introduction

Diagnostics by means of LEDs is an initial tool for error localization. In order to localize errors still further, you usually evaluate the display of the module status in STEP 7 or the diagnostics buffer of the CPU. The buffer contains plain text information on the error that has occurred. For example, you will find the number of the relevant error OB in the plain text information.

LED display

The following diagram shows the LED display on the interface module and the BusAdapter.



① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ LK1 (green)
⑥ LK2 (green)

Figure 5-1 LED display on the interface module

Meaning of the LEDs

The following tables describe the meanings of the status and error displays.

RN/ER/MT LED on the interface module

Table 5- 1 RN/ER/MT status and error displays

LEDs			Meaning	Solution
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	No or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module. *
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
Flashes	Off	Off	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
			ET 200SP is being reset to factory settings.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not correspond to the actual configuration of the ET 200SP .	Check the structure of the ET 200SP to see whether a module is missing or defective, or whether a non-configured module is plugged.
			Invalid configuration states.	Refer to section Invalid configuration states of the ET 200SP on PROFINET IO (Page 27)
			Parameter error in the I/O module.	Evaluate the display of the module status in STEP 7 and eliminate the error in the respective I/O module.
Flashes	Flashes	Flashes	The "Node flash test" is running (the LEDs LK1 and LK2 of the PROFINET interface also flash).	-
			Hardware or firmware defective (the LEDs LK1 and LK2 of the PROFINET interface do not flash).	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

* PWR LED on (on the interface module): Check the backplane bus for a short circuit.

PWR LED on the interface module

Table 5- 2 PWR status display on the interface module

PWR LED	Meaning	Solution
□ Off	No or insufficient supply voltage	Check the supply voltage.
■ On	Supply voltage present	-

LK1/LK2 LED on the interface module

Table 5- 3 LK1/LK2 status display on the interface module

LEDs LK1/LK2	Meaning	Solution
□ Off	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted.
■ On	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	-
☼ Flashes	The "Node flash test" is running (the RN/ER/MT LEDs also flash).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interfacemodule by the ERROR (red) and MAINT (yellow) LEDs.

The following configuration errors are indicated by the LEDs:

- More than one I/O module pulled
- Missing server module
- Interruptions or short circuit on the backplane bus

Operating principle

You determine the information for cause of the error with the LED error display. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display

- is active during POWER ON as well as during operation.
- has priority before all other states displayed by the ERROR and MAINT LED.
- remains turned on until the cause of the error has been corrected.

Table 5- 4 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Signaling of error type
2	MAINT LED flashes at 1 Hz	Display of the error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Signaling of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location/error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repeat steps 1 to 5 until the cause of the error has been corrected.	

Error display

The following table shows the possible causes of error that can occur.

Table 5- 5 Error display

Error type (MAINT)	Error location (ERROR/MAINT)	Cause of error	Remedy
1	02 to 12*	The number of pulled I/O modules is displayed. The diagnostics data is generated starting with two pulled I/O modules.	Check the configuration of the ET 200SP.
	65*	• Missing server module • Interruptions at the backplane bus • Short circuit of communication on the backplane bus	

* Slot

Note

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN, ER and MT LED: Off

5.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Pull/plug module interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

STEP 7 (TIA portal) offers innovative system diagnostics for the devices of the S7-1500 (IO controller CPU S7-1500) and the ET 200SP (IO device) automation system. Independent of the cyclic user program, alarms are made available on the display of the CPU S7-1500, the CPU web server and the HMI device.

For more information on system diagnostics, refer to the System Diagnostics function manual. (http://support.automation.siemens.com/WW/view/en/59192926).

5.2.1 Triggering a diagnostics interrupt

Triggering a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts the user program and processes the diagnostics block OB 82. The interrupt triggering event is logged in the start information of OB 82.

5.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

If there is a hardware interrupt, the CPU interrupts user program execution and processes the hardware interrupt block OB 40. The result that triggered the interrupt is added to the start information of the hardware interrupt block.

Note

Diagnostics "Hardware interrupt lost" (from I/O module)

Avoid creating hardware interrupts cyclically.

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.3 Triggering a pull/plug interrupt

Triggering a pull/plug interrupt

If there is a pull/plug interrupt, the CPU interrupts user program execution and processes the hardware interrupt block OB 83. The result that triggered the interrupt is added to the start information of OB 83.

5.3 Alarms

Actions after a diagnostics alarm

There can be more than one diagnostic alarm at a given time. Actions initiated by diagnostics alarms:

- The ERROR LED of the interface module flashes.
- Diagnostic data is reported as diagnostic interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- OB 82 is called.

You can find more information on this topic in the STEP 7 online help.

Reading out the diagnostics data

Table 5- 6 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See...
SIMATIC S7	Diagnostics as plain text in STEP 7 in online and diagnostics view	STEP 7 online help • As of STEP 7 V13, function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/de/49948856/0/en) • As of STEP 7 V5.5 system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

Additional information on the data records for PROFINET IO

The structure of the diagnostic data records and programming examples are available in the programming manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) and in Application example (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and corrective measures

The causes of error and corrective measures for the diagnostics alarms are described in the manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the chapter, "Interrupts/diagnostics alarms".

See also

Channel diagnostics (Page 26)

PROFINET with STEP 7 V11
(http://support.automation.siemens.com/WW/view/en/49948856)

5.3.1 Channel diagnostics

Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read using the instruction "RDREC".

Structure of the diagnostics data records

The data records supported by the ET 200SP distributed I/O system are based on the PROFINET IO standard - Application Layer Service Definition V2.2 or higher.

You can download the standard PROFIBUS user organization (http://www.profibus.com) from the homepage of the PROFIBUS User Organization free of charge.

5.3.2 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent the exchange of user data with the I/O modules.

- Number of modules exceeds maximum configuration
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- Missing server module
- At least one I/O module is installed in a different BaseUnit than the one configured in the parameters.

Note

If you remove more than one I/O module or the server module, this results in a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module is still exchanging data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

See also

Status and error displays (Page 18)

Channel diagnostics (Page 26)

5.3.3 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull interrupt is generated.
- If an I/O module is installed during failure of the supply voltage, a plug interrupt is generated.

5.3.4 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics frames received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. You must read the data record $E00C_H$ with the "RDREC" instruction in OB 100. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO device

If you want to read the diagnostics of a station after its return, you have to read the $E00C_H$ data record with the "RDREC" instruction in OB 86. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility

6

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "No supply voltage L+" is signaled for this potential group.

Module	Order number
DI 8x24VDC ST	6ES7132-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7132-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0,5A HF	6ES7131-6BF00-0CA0

Technical specifications

7

Technical specifications of the IM 155-6 PN BA

Table 7- 1 Technical specifications of the IM 155-6 PN BA

	6ES7155-6AR00-0AN0
Product type designation	IM 155-6 PN BA with 2xRJ45 ports and server module
General information	
Hardware version	FS01
Firmware version	V3.2
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	STEP 7 V13 SP1 or higher
STEP 7 can be configured/integrated as of version	V5.5 SP4 or higher
PROFINET as of GSD version/GSD revision	V2.3 / -
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	0.1 A
Current consumption, max.	300 mA
I^2t	0.09 A^2s
Power	
Incoming power to the backplane bus	1.7 W
Power loss	
Power loss, typ.	1.7 W
Address area	
Address space per module	
Address space per module, max.	32 byte; per input/output
Address space per station	
Address space per station, max.	32 byte; per input/output

	6ES7155-6AR00-0AN0
Hardware configuration	
Rack	
Modules per rack, max.	12
Interfaces	
Number of PROFINET interfaces	1
1st interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• RJ45 (Ethernet)	Yes; 2 integrated RJ45 ports
• BusAdapter (PROFINET)	No
Protocols	
• PROFINET IO device	Yes
• Open IE communication	Yes
Interface hardware	
RJ45 (Ethernet)	
100 Mbps	Yes; PROFINET with 100 Mbps full duplex (100BASE-TX)
Transmission method	PROFINET with 100 Mbps full duplex (100BASE-TX)
Autonegotiation	Yes
Autocrossing	Yes
Protocols	
PROFINET IO	
PROFINET IO	Yes
PROFINET IO device	
Services	
• Isochronous mode	No
• Open IE communication	Yes
• IRT	No
• PROFIenergy	No
• Prioritized startup	No
• Shared Device	No

	6ES7155-6AR00-0AN0
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	
Interrupts	Yes
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
MAINT LED	Yes; yellow LED
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Connection display LINK TX/RX	Yes; 2x green LED
Electrical isolation	
Between backplane bus and electronics	No
Between PROFINET and all other circuits	Yes
Between supply and all other circuits	No
Ambient conditions	
Ambient temperature during operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	55 °C
Vertical installation, min.	0 °C
Vertical installation, max.	60 °C
Connection technology	
ET-Connection	
Via BU/BA-Send	No
Dimensions	
Width	35 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	125 g; IM 155-6 PN BA with 2xRJ45 ports and server module

Dimension drawing

A

This appendix contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

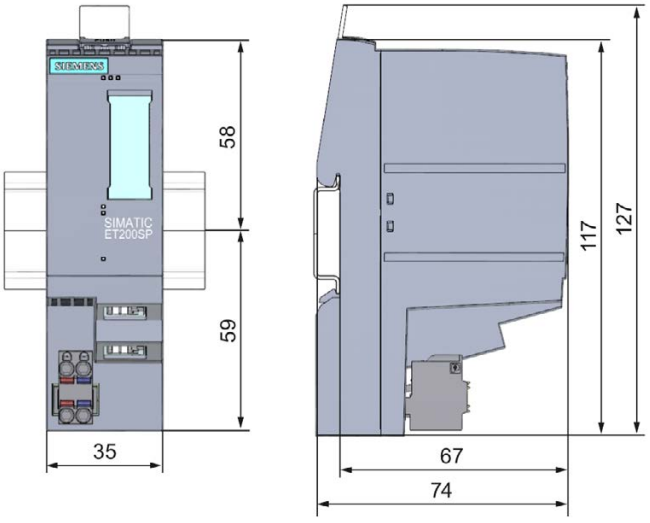


Figure A-1 Dimension drawing of the IM 155-6 PN BA interface module (front and side view)

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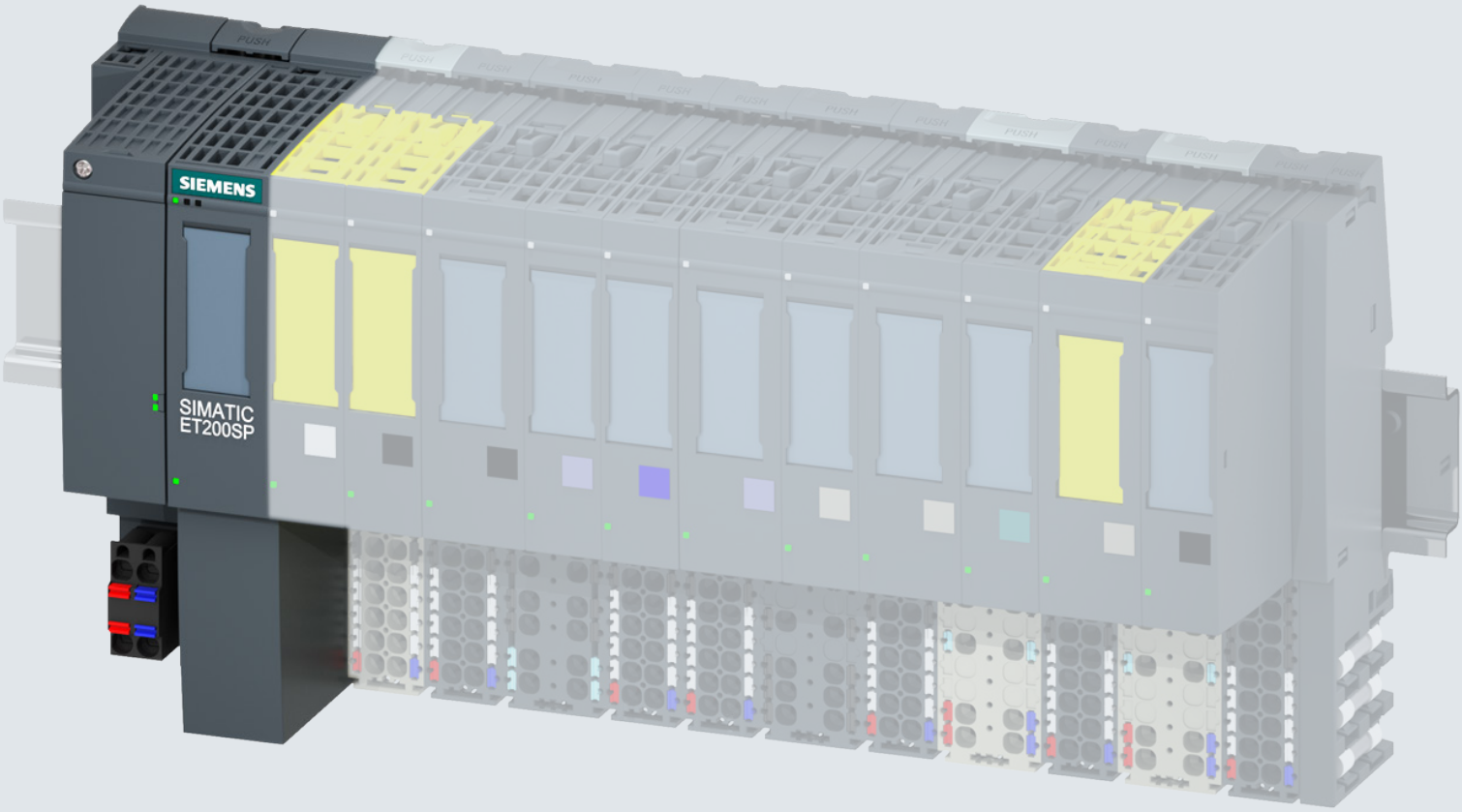

Manual

SIMATIC

ET 200SP

IM 155-6 PN ST interface module
(6ES7155-6AU01-0BN0)

Edition 04/2017

support.industry.siemens.com

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SIMATIC

ET 200SP
IM 155-6 PN ST interface module (6ES7155-6AU01-0BN0)

Manual

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Wiring 3

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Interrupts, diagnostics, error, and system messages 5

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Dimension drawing A

04/2017

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 04/2017 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

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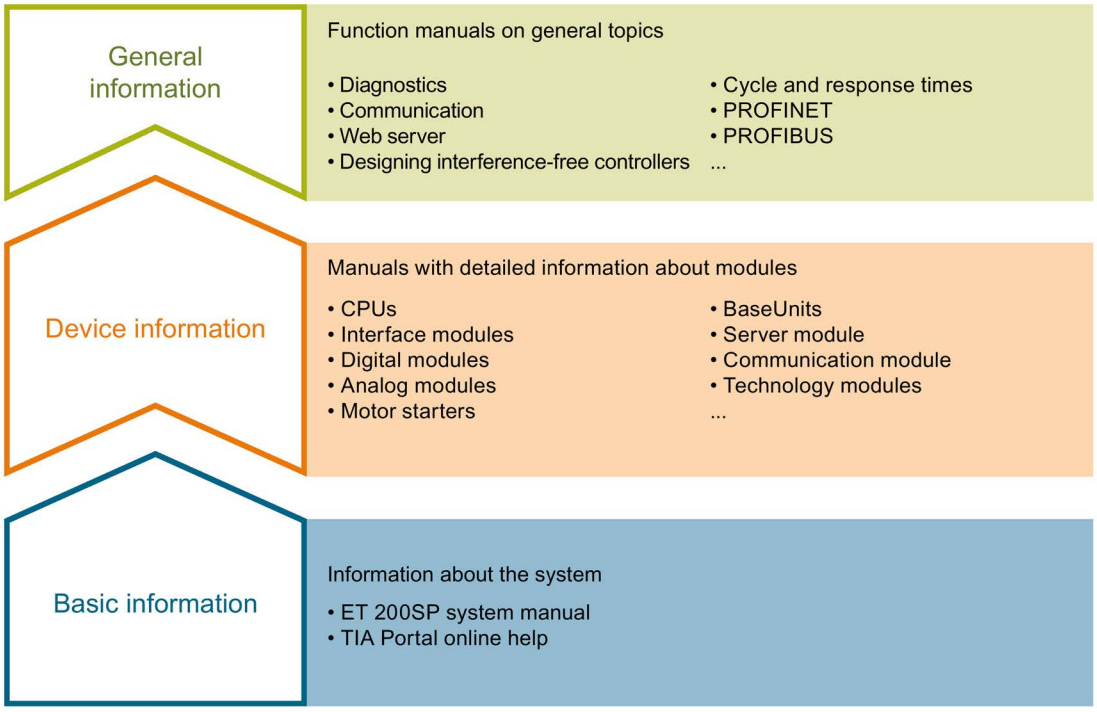
Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 Properties

Article number

6ES7155-6AU01-0BN0 (IM 155-6 PN ST interface module and server module)

6ES7155-6AA01-0BN0 (IM 155-6 PN ST interface module with BusAdapter BA 2×RJ45 and server module)

View of the module

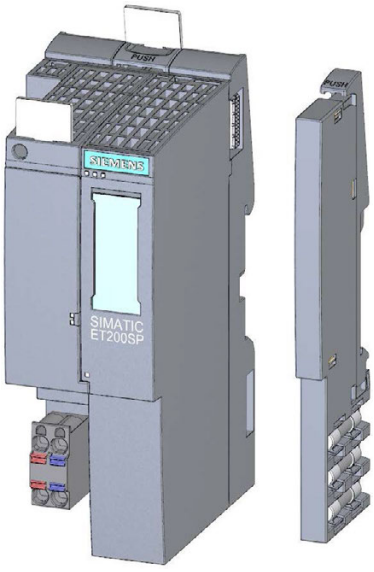


Figure 2-1 View of the IM 155-6 PN ST interface module and the server module

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO
- Supply voltage 1L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery of the interface module.
- PROFINET IO connection via selectable BusAdapter for RJ45 bus connector (BA 2×RJ45) or for direct connection of the bus cable (BA 2×FC)
- Use of fail-safe modules
- As of firmware version V 3.0, you can plug a light-colored or a dark-colored BaseUnit into slot 1.

The module supports the following functions (Page 13)

Maximum configuration

- 32 I/O modules
- 512 bytes I/O data
- 1 m backplane bus (without interface module)

Accessories

The following accessories can be ordered separately:

- BA 2xRJ45 BusAdapter
- BA 2xFC BusAdapter
- 24 V DC connector
- Labeling strips
- Reference identification label

Note

The interface module is also available as a bundle with the BusAdapter BA 2xRJ45 (and the server module). The article number is 6ES7155-6AA01-0BN0.

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Server module

The server module is included in the scope of delivery of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a holder for 3 spare fuses (5 × 20 mm)
- Identification data I&M 0 to 3

Note

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module in the last configuration slot and enable the parameter Group diagnostics: Missing supply voltage L+. When there are 32 I/O modules, the server module is inserted in slot 33.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration (as of V3.0)

Note

First BaseUnit of an ET 200SP in the configuration

The first BaseUnit of an ET 200SP station may be a dark-colored one if an AC I/O module or AI Energy Meter ST is plugged. Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

A light-colored BaseUnit must be plugged into the slot of the first 24 V DC I/O module in order to route the 24 V DC supply voltage via a fuse.

Pay attention to the type of the BaseUnits during the configuration.

As of firmware V3.x, the interface modules support plugging dark-colored BaseUnits in slot 1. This means that modules without a connection to the integrated voltage buses P1 and P2 can now also be configured starting with slot 1. Currently, this applies to the following modules:

- AI EnergyMeter
- DI 4x120..230VAC ST (6ES7131-6FD00-0BB1)
- DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)

Requirement for configuration of these modules in slot 1:

- Configuration via GSD or GSDML
- Configuration as of STEP 7 V5.5 SP4 with
  - HSP0241 V2.0 for IM155-6 PN ST
  - HSP0242 V2.0 for IM155-6 DP HF
  - HSP0255 V3.0 for IM155-6 PN HF
- Configuration as of STEP 7 V13 SP1

2.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ping, arp, network diagnostics (SNMP)/MIB-2, LLDP-MIB and MRP-MIB
- Port diagnostics
- Disabling ports
- Isochronous real-time communication
- Minimum update time 1 ms
- Prioritized startup
- Media redundancy (MRP)
- Shared device
- Support of submodules on suitable I/O modules
- Module-internal Shared Input/Shared Output (MSI/MSO)
- Device replacement without PG and without topological configuration
- Reset to factory settings via PROFINET IO
- Firmware update via PROFINET IO
- Station extension via ET-Connection
- The BusAdapter provides the connection system for PROFINET IO. The following versions are available for the IM 155-6 PN ST interface module:
  - For standard RJ45 connector: BA 2×RJ45
  - For direct connection of the bus cable: BA 2×FC

The interface module supports additional functions:

- Identification data I&M 0 to 3
- PROFIenergy
- Use of fail-safe modules
- Configuration control (option handling)
- Value status (quality information, QI) of I/O modules

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN ST interface module:

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)/software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP3 with HSP241	STEP 7 (TIA Portal), as of V11 SP2
Real-time communication	1	V1.0.0	X	X	X
Isochronous real-time communication	1	V1.0.0	X	X	X
Prioritized startup	1	V1.0.0	X	X	X
Device replacement without programming device	1	V1.0.0	X	X	X
Media redundancy (MRP)	1	V1.0.0	X	X	X
Shared device	1	V1.0.0	X	X	X (as of V13 SP1)
PROFIenergy	1	V1.0.0	---	X	X
Use of fail-safe modules	1	V1.0.1	X	X	X (as of V13 SP1)
Module-internal Shared Input/Shared Output (MSI/MSO)	1	V3.1.0	X	X	X (as of V13 SP1)
Station extension via ET-Connection	5	V3.1.0	X	X	X (as of V13 SP1)
User data 512 bytes	1	V3.1.0	X	X	X (as of V13 SP1)
Distribution of module channels to multiple submodules	1	V3.3.0	X	X (as of V5.5 SP4, HSP0241 V3)	X (as of V13 SP1, Update 6)
Interface module; article number: 6ES7155-6AU01-0BN0	1	V4.1	X	X (as of V5.5 SP4, HSP241 V4)	X (as of V14 HSP205)

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you should also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)

Isochronous real-time communication

Synchronized transmission method for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data can also be transferred without being affected by another high network load (e.g. TCP/IP communication or additional real time communication) at reserved, chronologically synchronized intervals.

A topological configuration is required for IRT.

Note

IO controller as sync master with IRT communication

We recommend also operating the IO controller as a sync master when configuring the IRT communication.

Otherwise, IO devices with IRT and RT configuration could fail as a result of sync master failure.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and:

- As of STEP 7 V12, in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)

Prioritized startup

Prioritized startup describes the PROFINET IO functionality for accelerating the startup of IO devices in a PROFINET IO system with IRT and RT communication.

The function reduces the time that the appropriately configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the supply voltage has returned
- After a station has returned
- After IO devices have been activated

Note

Dependency of the startup time

The interface module permits startup times from 0.9 s.

The startup time depends on the number and type of modules.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)

Device replacement

Device replacement without topological configuration

The device name is also stored on the BusAdapter in addition to the interface module. A device name saved on the BusAdapter is the requirement for device replacement without topological configuration.

Storing the name on the BusAdapter and the interface module produces a range of scenarios for using the device name when the interface module is replaced.

Table 2- 2 Scenarios for using the device name

	Interface module empty	**Interface module with device name**
BusAdapter empty	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Be aware of the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the BusAdapter. To prevent the device name from being deleted in the BusAdapter, you can remove the BusAdapter from the interface module before resetting to factory settings.
- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Do not pull/plug the BusAdapter while under voltage. If you pull/plug the BusAdapter while under voltage, the interface module restarts.

Device replacement with topological configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not have to be assigned with the programming device.

The replacement IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

IO devices that have already been used in another configuration should be reset to their factory settings before reuse (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)

Replacement of an IM 155-6 PN ST

In a replacement scenario, any IO devices in operation must be reset to their as-delivered state via "Reset to factory settings" (see the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Media redundancy (MRP)

Function for safeguarding communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)

Shared device

IO device which makes its data available to multiple IO controllers.

The interface module supports shared device at submodule level.

If **there is no validity check of the shared device projects by the Engineering System**, note the following:

- Make sure the configurations are consistent. In particular, modules or submodules may only be assigned to one controller. Multiple assignment will result in an error; the module or submodule will only be available in the first controller.
- If you reconfigure the shared device configurations without the validity check mentioned above, you must commission the ET 200SP once again. This means that you have to reload the projects of all involved IO controllers to the specific CPU after reconfiguration and, if necessary, switch the interface module POWER OFF/POWER ON.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856)
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Note

In the case of a shared device application, make sure that all controllers work with the same send clock. If controllers do not have the same send clock, the differing send clock can result in communication relationships that are not set up.

If you set up all controllers in one project, the same send clock is ensured. Set the same send clock for engineering in separate projects.

Submodules

The IM 155-6 PN ST interface module supports the division of I/O modules into up to 4 submodules. This allows parts of an I/O module to be separately configured and parameterized.

It is possible to assign each of these submodules to different IO controllers.

The functions:

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

can only be executed if you have configured submodule 1 during configuration.

Module-internal Shared Input/Shared Output (MSI/MSO)

The Module-internal Shared Input function allows an input module to make its input data available to up to two IO controllers (for ET 200SP PN ST). Each controller has read access to the same channels.

The Module-internal Shared Output function allows an output module to make its output data available to up to two IO controllers. One IO controller has write access. A second IO controller can have read access to the same channels.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856)

Value status

The IM 155-6 PN ST interface module supports I/O modules with value status.

Additional information on the value status can be found in the manuals for the I/O modules.

2.2.1 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You can find more information on PROFIenergy in the:

- Product manual I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300)
- PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual.
- System manual PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127)
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information.
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.

2.2.2 Use of fail-safe modules

Properties

The IM 155-6 PN ST interface module as of firmware V1.0.1 supports the use of fail-safe modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2.3 Use of technology modules

Technology modules

As of firmware version V3.1, the interface module IM 155-6 PN ST supports the "Position input for Motion Control" mode of the technology modules TM Count 1x24V (6ES7138-6AA00-0BA0) and TM PosInput 1 (6ES7138-6BA00-0BA0).

2.2.4 Configuration control (option handling)

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or changes. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

Wiring

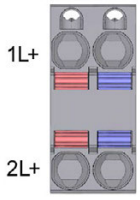
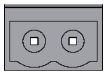
3

3.1 Pin assignment

24 V DC supply voltage

The following table shows the signal names and the descriptions of the pin assignment for a 24 V DC supply voltage.

Table 3- 1 Pin assignment 24 V DC supply voltage

View		Signal name[1]	Description
Connector	IM connection		
		1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

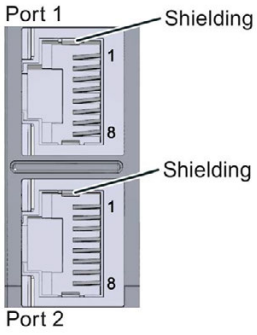
1 1L+ and 2L+ as well as 1M and 2M are bridged internally.

2 Maximum 10 A permitted.

PROFINET IO with BusAdapter BA 2×RJ45

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×RJ45.

Table 3- 2 PROFINET IO pin assignment with BusAdapter BA 2×RJ45

View	Signal name		Description
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

Note

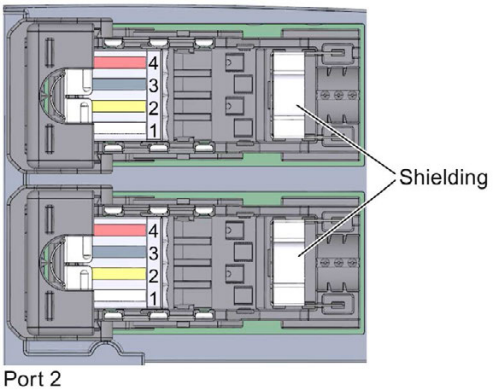
PROFINET interface X1 Port 2

If autonegotiation is disabled, the RJ-45 socket (X1 Port 2) has the switch assignment (MDI-X).

PROFINET IO with BusAdapter BA 2×FC

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×FC.

Table 3- 3 PROFINET IO pin assignment with BusAdapter BA 2×FC

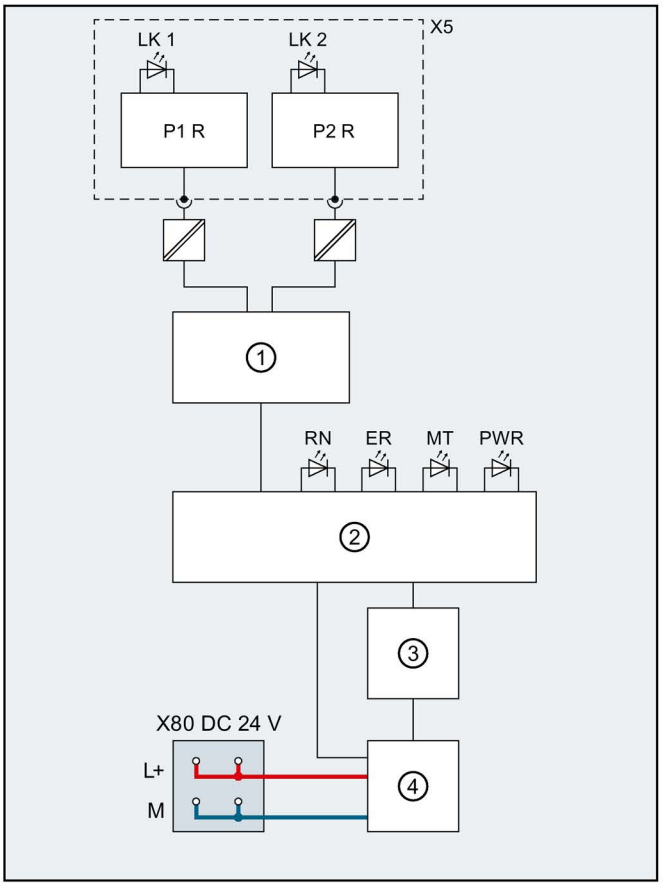
View	Signal name		Description
Port 1  Port 2	1	TD	Transmit data +
	2	RD	Receive data +
	3	TD_N	Transmit data -
	4	RD_N	Receive data -

Reference

You can find more information on accessories and how to connect the interface module in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Schematic circuit diagram

The following figure shows a block diagram of the IM 155-6 PN ST interface module.



①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Mass
③	Backplane bus	LK 1,2	TX/RX Link LED
④	Internal power supply	RN	RUN LED (green)
X80 24 V DC	Supply voltage infeed	ER	ERROR LED (red)
X5	BusAdapter	MT	MAINT LED (yellow)
P1 R	PROFINET interface X1 Port 1	PWR	POWER LED (green)
P2 R	PROFINET interface X1 Port 2		

Figure 3-1 Block diagram of the IM 155-6 PN ST interface module

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 PN ST interface module

The following table shows the parameters for the IM 155-6 PN ST interface module.

Table 4- 1 Parameters for interface module IM 155-6 PN ST (GSD file)

Parameters	Value range	Default	Efficiency range
Configuration control	Disable/enable	Disable	ET 200SP

4.2 Explanation of parameters

4.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

Note

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.3 Substitute value behavior

The substitute value behavior in the ET 200SP distributed I/O system is executed by the IO controller for each slot.

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Firmware update
- Reset to factory settings
- Station stop, for example, due to:
  - Missing server module
  - Removing more than one I/O module at a time.
  - At least one I/O module installed on an incorrect BaseUnit
- Deactivating the IO device

Note

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

The "current-free/voltage-free" behavior takes effect in the following cases:

- Firmware update
- Reset to factory settings
- Configuration control: The IM has not received a valid control data record 196 yet.
- Incorrectly configured module
- Module with incorrect parameter assignment

4.4 Status of the supply voltage L+ of the I/O modules

Introduction

The "Status of the supply voltage L+ of the I/O modules" is configured on the server module as of IM 155-6 PN ST V1.1.x and GSD file 04/2013. The input data can then be read out on the server module. You will find the relevant description in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) device manual.

Configurations

You can select two configurations for the IM 155-6 PN ST or the server module of the IM 155-6 PN ST in the configuration software:

- Configuration without input data
- Configuration with input data

Input data

You can read out the status of the supply voltage L+ for each I/O module of the ET 200SP in the input data (byte 0 to 3).

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25

Slots of the I/O modules

Bit = 0: Supply voltage L+ missing or I/O module not installed

Bit = 1: Supply voltage L+ and I/O module available

Figure 4-1 Status of the supply voltage L+

Note

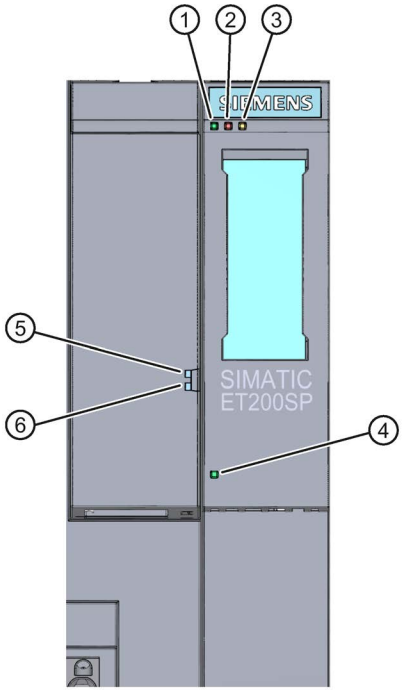
An inserted or missing server module always signals "bit = 0" for the slot.

Interrupts, diagnostics, error, and system messages 5

5.1 Status and error displays

LED display

The following diagram shows the LED display on the interface module and the BusAdapter.



① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ LK1 (green)
⑥ LK2 (green)

Figure 5-1 LED display on the interface module and BusAdapter

Meaning of the LEDs

The meaning of the status and error messages is described in the following tables.

RN/ER/MT LED on the interface module

Table 5- 1 RN/ER/MT status and error displays

LEDs			Meaning	Remedy
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn in on at the interface module. *
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
Flashes	Off	Off	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is configured.	
			ET 200SP is reset to factory settings.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics data and remedy the error.
			The configured structure does not correspond to the actual structure of the ET 200SP .	Check the structure of the ET 200SP to see whether a module is missing or defective, or whether a non-configured module is plugged.
			Invalid configuration states.	See section Invalid configuration states of the ET 200SP on PROFINET IO (Page 41)
			Parameter error in the I/O module.	Evaluate the display of the module status in STEP 7 and eliminate the error in the respective I/O module.
Not relevant	Not relevant	On	Maintenance	See section Maintenance events (Page 36)
Flashes	Flashes	Flashes	The "Node flash test" is run (the LEDs LK1 and LK2 of the PROFINET interface also flash).	-
			Hardware or firmware defective (the LEDs LK1 and LK2 of the PROFINET interface do not flash).	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

* PWR LED on (on the interface module): Check the backplane bus for a short circuit.

PWR LED on the interface module

Table 5- 2 PWR status display on the interface module

PWR LED	Meaning	Remedy
☐ Off	Supply voltage not present or too small	Check the supply voltage.
■ On	Supply voltage present	-

LK1/LK2 LED on the BusAdapter

Table 5- 3 LK1/LK2status display on the BusAdapter

LEDs LK1/LK2	Meaning	Remedy
☐ Off	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted.
■ On	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	-
☼ Flashes	The "Node flash test" is run (the RN/ER/MT LEDs also flash).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interfacemodule by the ERROR (red) and MAINT (yellow) LEDs.

The following configuration errors are indicated by the LEDs:

- More than one I/O module pulled
- Missing server module
- Interruptions or short circuit on the backplane bus

Principle of operation

You determine the information for cause of the error with the LED error display. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display

- is active during POWER ON as well as during operation.
- has priority before all other states displayed by the ERROR and MAINT LED.
- remains turned on until the cause of the error has been corrected.

Table 5- 4 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Signaling of error type
2	MAINT LED flashes at 1 Hz	Display of the error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Signaling of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location/error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repeat steps 1 to 5 until the cause of the error has been corrected.	

Error display

The following table shows the possible causes of error that can occur.

Table 5- 5 Error display

Error type (MAINT)	Error location (ERROR/MAINT)	Cause of error	Remedy
1	02 to 32*	The number of pulled I/O modules is displayed. The diagnostics data is generated starting with two pulled I/O modules.	Check the configuration of the ET 200SP.
	65*	• Missing server module • Interruptions at the backplane bus • Short circuit of communication on the backplane bus	

* Slot

Note

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN-, ER and MT LED: Off

5.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Swapping interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the updated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, messages are made available on the display of the CPU S7-1500, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

5.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts the user program and processes the diagnostics block OB 82. The interrupt triggering event is logged in the start information of OB 82.

5.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

If there is a process interrupt, the CPU interrupts user program execution and processes the process interrupt block OB 40. The result that triggered the interrupt is added to the start information of the hardware interrupt block.

Note

Diagnostics "Hardware interrupt lost" (from I/O module)

Avoid creating hardware interrupts cyclically.

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.3 Triggering a swapping interrupt

Triggering a swapping interrupt

If there is a swapping interrupt, the CPU interrupts user program execution and processes the process interrupt block OB 83. The result that triggered the interrupt is added to the start information of OB 83.

5.3 Alarms

5.3.1 Diagnostics alarms

Actions after a diagnostics alarm

There can be more than one diagnostic alarm at a given time. Each diagnostics alarm initiates the following actions:

- The ERROR LED of the interface module flashes.
- Diagnostics are reported as diagnostic error interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- OB 82 is called. If OB 82 is not available, the I/O controller goes into STOP mode.

You can find more information in the STEP 7 online help.

Reading the diagnostics

Table 5- 6 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See...
SIMATIC S7	Diagnostics as plain text in STEP 7 using Online and Diagnostics view	STEP 7 online help • as of STEP 7 V12 function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) • as of STEP 7 V5.5 system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

Additional information on the data records for PROFINET IO

The structure of the diagnostic data records and programming examples are available in the programming manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) and in Example application (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostics alarms are described in the Product Manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section, "Interrupts/diagnostics alarms".

See also

Channel diagnostics (Page 37)

5.3.2 Maintenance events

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158-6-10 standard. The goal is to detect and remove potential problems as soon as possible.

For the interface module, maintenance events signal to the user when a network component must be checked or replaced.

The CPU interrupts user program execution and processes the diagnostic block OB 82. The event that triggered the maintenance event is entered in the start information of the OB 82.

The interface module signals a maintenance event to the higher-level diagnostic system in the case of the following events:

Table 5- 7 Triggering of a maintenance event

Maintenance alarm	Event	Meaning
Maintenance demanded (*maintenance demanded*) LED MAINT is lit.	Synchronization loss	• No synchronization frame received No synchronization frame was received by the sync master within the timeout period after parameter assignment or during operation. • Successive synchronization frames are located outside permitted limits (jitter)

System events in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 with the following system events:

- Maintenance demanded - indicated for each port by a yellow wrench icon in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

5.3.3 Channel diagnostics

Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read using the instruction "RDREC".

Structure of the diagnostics data records

The data records supported by the ET 200SP distributed I/O system are based on the standard PROFINET IO - Application Layer Service Definition V2.3.

You can purchase the standard from the PROFIBUS User Organization on the Internet (http://www.profibus.com).

Coding of the extended channel diagnostics (as of firmware version V3.3.0)

With the IM 155-6 PN ST interface module, the following extended channel diagnostics are reported:

Slot number	ChannelError-Type (CET)	ExtendedChannel-ErrorType (ECET)	Associated value AddValue	Diagnostics
Module slot	0x0602	0x0691	Slot	Station stop - module parameter "Potential group" faulty or incorrect BaseUnit in actual slot (AddValue)
Slot 0	0x0602	0x0693	0x00	Diagnostics with missing server module
	0x0602	0x0698	0x00	Diagnostics backplane bus too long
	0x0602	0x0699	Slot	Diagnostics with incorrect bus configuration
	0x0602	0x069C	0x00	Diagnostics with incorrectly plugged BusAdapter
Server module slot	0x0610	0x06B0	0x00	Group diagnostics: Missing supply voltage L+ for the potential groups Note: The slot in which the light-colored BaseUnit of the respective load module is located is coded in the "ChannelNumber" element.

Structure of the manufacturer-specific diagnostics data records (firmware version < V3.3.0)

The structure of the diagnostics data records is differentiated by the BlockVersion. The following BlockVersion applies to the IM 155-6 PN ST interface modules:

Table 5- 8 Structure of the manufacturer-specific diagnostics data records

IM 155-6 PN ST interface module	BlockVersion
6ES7155-6AU00-0BN0	W#16#0101

Manufacturer-specific diagnostics in the User Structure Identifier (USI)

The following manufacturer-specific diagnostics are signaled in the USI with the IM 155-6 PN ST interface module:

Table 5- 9 Manufacturer-specific diagnostics in the USI

USI no. W#16#...	Diagnostics
0003	Group diagnostics: Missing supply voltage L+ for the potential groups *
0004	Diagnostics with missing server module
0005	Diagnostics when more than one I/O module has been pulled
0006	Diagnostics with incorrect BaseUnit
0007	Diagnostics with incorrect bus configuration

* As of IM 155-6 PN ST V1.1.x and GSD file 04/2013, this diagnostics is only signaled if the "Group diagnostics: Missing supply voltage L+" parameter has been activated.

USI structure = W#16#0003

Table 5- 10 USI structure = W#16#0003

Data block name		Content	Comment	Bytes
USI		W#16#0003	Manufacturer-specific diagnostics with failure of supply voltage L+ as of slot x	2
Followed by the slot as of which the supply voltage L+ has failed.				
	Slot	W#16#0001 to W#16#0020	Bit 8 to 15	1
			Bit 0 to 7	1
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

USI structure = W#16#0004

Table 5- 11 USI structure = W#16#0004

Data block name		Content	Comment	Bytes
USI		W#16#0004	Manufacturer-specific diagnostics with missing server module Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller.	2
Followed by 4 reserved bytes:				
	Reserved			1
	Reserved			1
	Reserved			1
	Reserved			1

USI structure = W#16#0005

Table 5- 12 USI structure = W#16#0005

Data block name		Content	Comment	Bytes
USI		W#16#0005	Manufacturer-specific diagnostics if more than one I/O module has been pulled. The number of pulled I/O modules is displayed. Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller.	2
The number of pulled I/O modules follows				
	Quantity	W#16#0002 to W#16#0020	Bit 8 to 15	1
			Bit 0 to 7	1
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

USI structure = W#16#0006

Table 5- 13 USI structure = W#16#0006

Data block name		Content	Comment	Bytes
USI		W#16#0006	Manufacturer-specific diagnostics if an I/O module is installed on an incorrect BaseUnit. Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller.	2
Followed by the slot for the I/O module:				
	Slot	W#16#0001 to W#16#0020	Bit 8 to 15	1
			Bit 0 to 7	1
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

USI structure = W#16#0007

Table 5- 14 USI structure = W#16#0007

Data block name		Content	Comment	Bytes
USI		W#16#0007	Manufacturer-specific diagnostics if operation is not possible with existing bus configuration Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller	2
Followed by the slot for the I/O module:				
	Slot	W#16#0001 to W#16#0040	Bit 8 to 15	1
			Bit 0 to 7	1
If slot 0 is specified, check the width of the station configuration (maximum 1 m).				
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

5.3.4 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent the exchange of user data with the I/O modules.

- Number of modules exceeds maximum configuration
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is installed in a different BaseUnit than the one configured in the parameters.
- Missing server module
- Invalid or incorrectly configured BusAdapter

Note

If you drag more than one I/O module or the server module the node will stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module is still exchanging data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

See also

Status and error displays (Page 28)

Channel diagnostics (Page 37)

5.3.5 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull alarm is generated.
- If an I/O module is installed during failure of the supply voltage, an insert alarm is generated.

5.3.6 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics frames received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. You must read the data record $E00C_H$ with the "RDREC" instruction in OB 100. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the diagnostics of a station after its return, you have to read the $E00C_H$ data record with the "RDREC" instruction in OB 86. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility

6

Compatibility between the versions of the IM 155-6 PN ST

The table below describes which version you can use in the configuration for which actually plugged version of the IM 155-6 PN ST interface module. The table also describes the functional differences of the versions of the IM 155-6 PN ST interface module.

IM 155-6 PN ST configured	IM 155-6 PN ST plugged					Changes compared to previous version
	V1.0.x	V1.1.x	V3.1.x	V3.3.x	V4.1.x	
V1.0	✓	✓	✓	✓	✓	---
V1.1	---	✓	✓	✓	✓	• The "Group diagnostics: Missing supply voltage L+" parameter can be set on the server module • "Status of supply voltage L+ of the I/O modules" can be configured on the server module
V3.1	---	---	✓	✓	✓	• User data 512 bytes • Station extension via ET-Connection
V3.3	---	---	---	✓	✓	• Support of submodules
V4.1	---	---	---	---	✓	---

Note

IM 155-6 PN ST (6ES7155-6AU00-0BN0) with firmware version V4.1

You can upgrade the previous version of the IM 155-6 PN ST interface module (6ES7155-6AU**00**-0BN0) to the firmware version V4.1. In this case configure the module as IM 155-6 PN ST interface module (6ES7155-6AU**01**-0BN0) with firmware version V4.1.

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7132-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7132-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0,5A HF	6ES7131-6BF00-0CA0

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules:
maximum reaction time = configured update time + 400 µs (but at least 1.4 ms)

Technical specifications

7

Technical specifications of the IM 155-6 PN ST

Article number	6ES7155-6AU01-0BN0
General information	
Product type designation	IM 155-6 PN ST with server module
HW functional status	FS01
Firmware version	V4.1
Vendor identification (VendorID)	002AH
Device identifier (DeviceID)	0313H
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V13 SP1
• STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
• PROFINET as of GSD version/GSD revision	V2.3 / -
Configuration control	
via dataset	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Short-circuit protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption (rated value)	450 mA
Current consumption, max.	550 mA
Inrush current, max.	3.7 A
I^2t	0.09 $A^2 \cdot s$
Power	
Infeed power to the backplane bus	4.5 W
Power loss	
Power loss, typ.	1.9 W

Article number	6ES7155-6AU01-0BN0
Address area	
Address space per module	
• Address space per module, max.	256 byte; per input / output
Address space per station	
• Address space per station, max.	512 byte; Dependent on configuration
Hardware configuration	
Rack	
• Modules per rack, max.	32; + 16 ET 200AL modules
Submodules	
• Number of submodules per station, max.	256
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1. Interface	
Interface types	
• Number of ports	2
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; Applicable BusAdapter: BA 2x RJ45, BA 2x FC
Functionality	
• PROFINET IO Device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; PROFINET MRP
Interface types	
RJ 45 (Ethernet)	
• Transmission procedure	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• 10 Mbps	Yes; for Ethernet services
• 100 Mbps	Yes; PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• Autonegotiation	Yes
• Autocrossing	Yes

Article number	6ES7155-6AU01-0BN0
PROFINET IO Device	
Services	
– Isochronous mode	No
– Open IE communication	Yes
– IRT	Yes; with send cycles of between 250 µs and 4 ms in increments of 125 µs
– MRP	Yes
– MRPD	No
– PROFINET system redundancy	No
– PROFIenergy	Yes
– Prioritized startup	Yes
– Shared device	Yes
– Number of IO Controllers with shared device, max.	2
Open IE communication	
• TCP/IP	Yes
• SNMP	Yes
• LLDP	Yes
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostic functions	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; Red LED
• MAINT LED	Yes; yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Connection display LINK TX/RX	Yes; 2x green link LEDs on BusAdapter
Potential separation	
between backplane bus and electronics	No
between PROFINET and all other circuits	Yes; 1500 V AC
between supply and all other circuits	No
Permissible potential difference	
between different circuits	Safety extra low voltage SELV
Isolation	
Isolation tested with	707 V DC (type test)

Article number	6ES7155-6AU01-0BN0
Standards, approvals, certificates	
Network loading class	2
Security level	According to Security Level 1 Test Cases V1.1.1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Connection method	
ET-Connection	
• via BU/BA Send	Yes; + 16 ET 200AL modules
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	147 g; without BusAdapter

Technical specifications of the BusAdapter BA 2×RJ45

Table 7- 1 Technical specifications of the BusAdapter BA 2×RJ45

	6ES7193-6AR00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
RJ45	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	46 g

Technical specifications of the BusAdapter BA 2×FC

Table 7- 2 Technical specifications of the BusAdapter BA 2×FC

	6ES7193-6AF00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
FC (FastConnect)	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	53 g

Dimension drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Figure A-1 Dimension drawing of the IM 155-6 PN ST interface module (front and side view)

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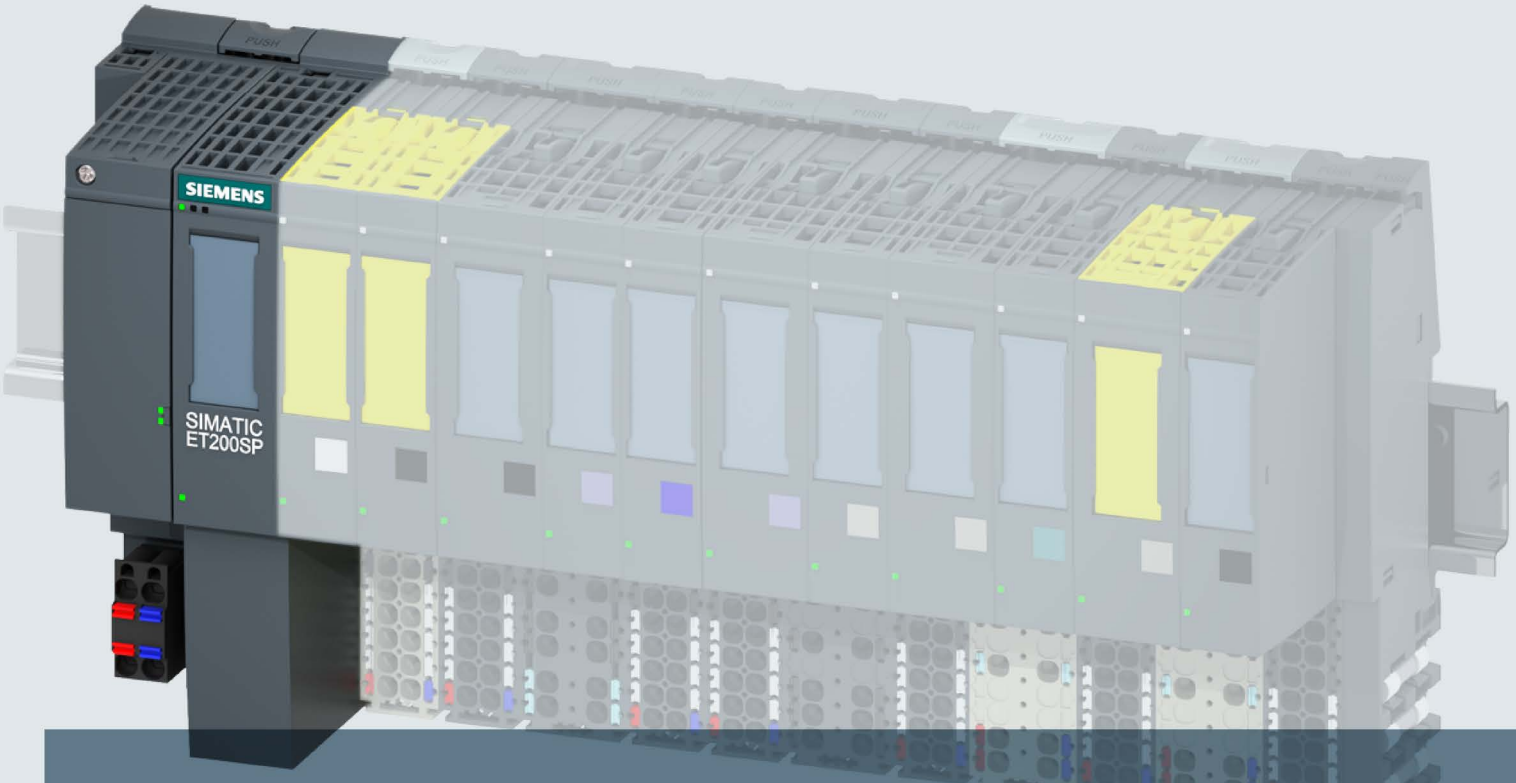

SIMATIC

ET 200SP

Interface module IM 155-6 PN HF (6ES7155-6AU00-0CN0)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
IM 155-6 PN HF interface module (6ES7155-6AU00-0CN0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes labeled as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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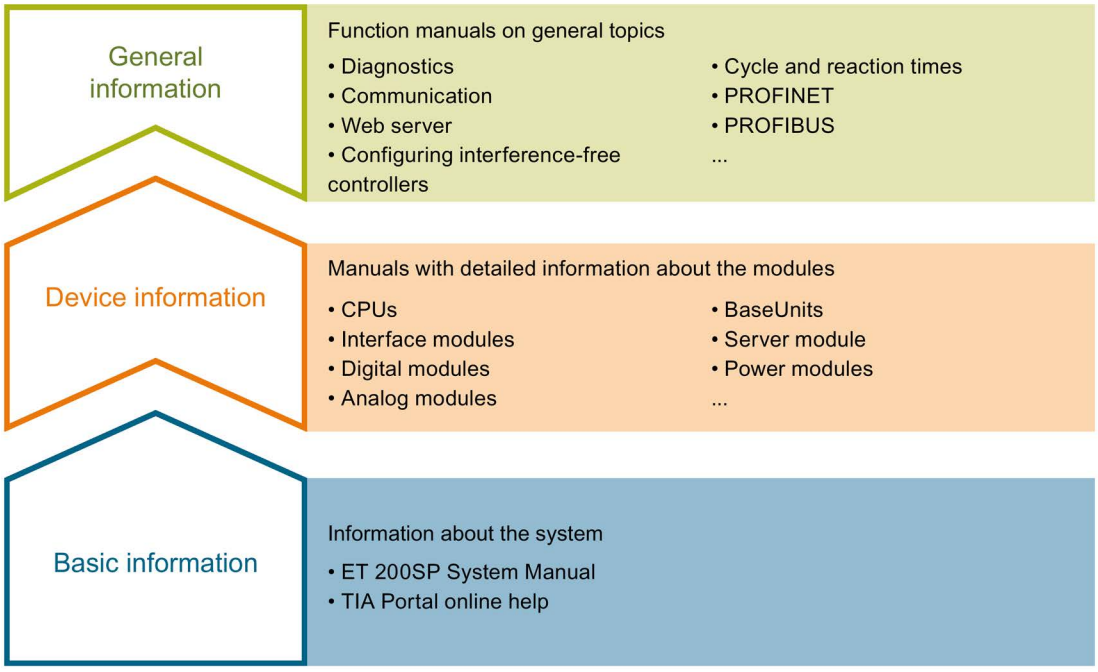
ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7155-6AU00-0CN0

View of the module

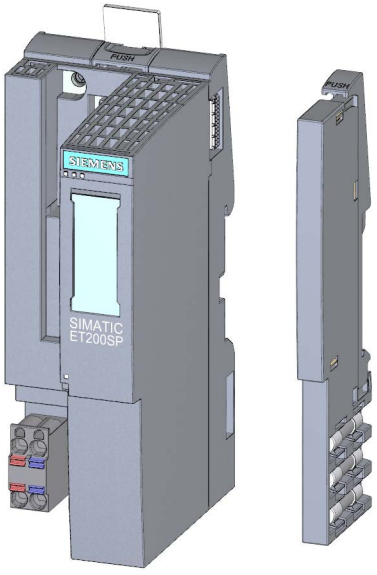


Figure 2-1 View of the 155-6 PN HF interface module with accessories included in delivery

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO.
- Supply voltage 1L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery of the interface module.
- PROFINET IO connection via selectable BusAdapters
  - For RJ45 bus connection plug (BA 2×RJ45)
  - For direct connection of the bus cable (BA 2×FC)
  - For fiber-optic cables POF/PCF (BA 2xSCRJ)
  - For glass fiber-optic cable (BA 2xLC)
  - As media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 plug (BA SCRJ/RJ45)
  - As media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable (BA SCRJ/FC)
  - As media converter for glass fiber-optic cable ⇔ standard RJ45 plug (BA LC/RJ45)
  - As media converter for glass fiber-optic cable ⇔ direct connection of the bus cable (BA LC/FC)
- As of firmware version V 3.0, you can plug a light-colored or a dark-colored BaseUnit into slot 1.

The module supports the following functions (see (Page 13))

Maximum configuration

- 64 ET 200SP I/O modules
- 1 m backplane bus (without interface module)

Note

Incompatible I/O modules

A list of I/O modules that do not allow a configuration with more than 32 I/O modules is available in section Compatibility of modules (Page 48).

Maximum amount of I/O data

The maximum amount of I/O data without user data qualifier (net data) depends on the number and type of I/O modules used. From the maximum I/O data

- 1440 bytes or
- 1000 bytes with system redundancy S2

the bytes for the user data qualifier are deducted to determine the net data length. Note that modules/submodules that have no user data also have user data qualifiers.

The net data length is made up of:

- Maximum amount of I/O data including user data qualifiers (1440 byte/1000 bytes)

minus

- Number of I/O submodules with input **or** output data (in bytes)

minus

- 2 x number of I/O submodules with input **and** output data (in bytes)

minus

- 5 bytes without ET-Connection or 6 bytes with ET-Connection

Regardless of the type and number of I/O modules or module distribution to submodules, a minimum of the following I/O lengths can be used in total:

- 933 bytes (without system redundancy)
- 493 bytes (with system redundancy)

Note

- The ET-Connection components must also be included for the I/O modules.
- The result of the calculation of the maximum net data length applies equally to input and output data.
- In the case of a shared device configuration, the described calculations for the total I/O data apply to all controllers that share the device.
- If more than two (max. four) controllers share the device, the maximum amount of I/O data including user data qualifier is limited to 360 bytes per controller.

Accessories

The following accessories must be ordered separately:

- BA 2×RJ45 BusAdapter
- BA 2×FC BusAdapter
- BA 2×LC BusAdapter
- BA 2xSCRJ BusAdapter
- BA SCRJ/RJ45 BusAdapter
- BA SCRJ/FC BusAdapter
- BA LC/RJ45 BusAdapter
- BA LC/FC BusAdapter
- 24 V DC connector
- Labeling strips
- Reference identification label

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Server module

The server module is included in the scope of delivery of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Includes a holder for 3 spare fuses (5 × 20 mm)
- Provides station functions, for example, group load diagnostics, status bytes
- Identification data I&M 0 to 3

Note

You need to configure and assign parameters to the server module in the configuration software.

Place the server module in the last slot of the configuration. If there are 64 I/O modules, the server module is plugged in slot 65.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration (as of V3.0)

Note

First BaseUnit of an ET 200SP in the configuration

The first BaseUnit of an ET 200SP station may be a dark-colored one if an AC I/O module or AI Energy Meter ST is plugged. Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

A light-colored BaseUnit must be plugged into the slot of the first 24 V DC I/O module in order to route the 24 V DC supply voltage via a fuse.

Pay attention to the type of the BaseUnits during the configuration.

As of firmware V3.x, the interface modules support plugging dark-colored BaseUnits in slot 1. This means that modules without a connection to the integrated voltage buses P1 and P2 can now also be configured starting with slot 1. Currently, this applies to the following modules:

- AI EnergyMeter
- DI 4x120..230VAC ST (6ES7131-6FD00-0BB1)
- DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)

Requirement for configuration of these modules in slot 1:

- Configuration via GSD or GSDML
- Configuration as of STEP 7 V5.5 SP4 with
  - HSP0241 V2.0 for IM155-6 PN ST
  - HSP0242 V2.0 for IM155-6 DP HF
  - HSP0255 V3.0 for IM155-6 PN HF
- Configuration as of STEP 7 V13 SP1

2.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ping, arp, network diagnostics (SNMP)/MIB-2, LLDP-MIB and MRP-MIB
- Port diagnostics
- Disabling ports
- Minimum update time 250 µs
- Device replacement without programming device
- Reset to factory settings via PROFINET IO
- Firmware update via PROFINET IO
- Isochronous real-time communication
- Prioritized startup
- Media redundancy (MRP)
- Shared device
- Distribution of module channels to multiple submodules
- Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)
- Media redundancy with planned duplication (MRPD)
- Isochronous mode
- System redundancy S2
- Station extension via ET-Connection
- The BusAdapter provides the connection system for PROFINET IO. The following versions are available for the IM 155-6 PN HF interface module:

BusAdapter	Up to firmware 2.1	As of firmware 2.2	As of firmware 3.1	Firmware 3.3 or higher
For standard RJ45 connector: BA 2×RJ45	X	X	X	X
For direct connection of the bus cable: BA 2×FC	X	X	X	X
For fiber-optic cable (FOC): BA 2xSCRJ	--	X *	X *	X *

BusAdapter	Up to firmware 2.1	As of firmware 2.2	As of firmware 3.1	Firmware 3.3 or higher
For the transition from POF/PCF fiber-optic cable to RJ45 bus connection: BA SCRJ/RJ45	--	--	X *	X *
For the transition from POF/PCF fiber-optic cable to the direct connection to the bus cable: BA SCRJ/FC	--	--	X *	X *
For glass fiber-optic cable: BA 2xLC	-	-	-	X *
For the transition from glass fiber-optic cable to RJ45 bus connection: BA LC/RJ45	-	-	-	X *
For the transition from glass fiber-optic cable to the direct connection to the bus cable: BA LC/FC	-	-	-	X *

* As of product version 3 of the interface module

The interface module supports additional functions:

- Identification data I&M 0 to I&M 4
- Device replacement without topological configuration
- Oversampling
- PROFIenergy
- Configuration control (option handling)
- Value status (quality information, QI) of I/O modules
- Use of fail-safe modules
- Multi Hot Swap (removal/insertion of multiple I/O modules during operation)
- Reset to factory settings via RESET button

Note

The use of the IM155-6 PN HF interface module as a docking unit (function: IO device changing in operation) in a docking system is not supported.

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN HF interface module:

Table 2- 1 Version dependencies of the module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software			
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)/ software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP3 with HSP 233	STEP 7 as of V5.5 SP4 with HSP 250/255	STEP 7 (TIA Portal) as of V12.0.1 with HSP 0058
Real-time communication	1	V2.0.0	X	X	X	X
Isochronous real-time communication	1	V2.0.0	X	X	X	X
Prioritized startup	1	V2.0.0	X	X	X	X
Device replacement without programming device	1	V2.0.0	X	X	X	X
Media redundancy (MRP)	1	V2.0.0	X	X	X	X
Shared device	1	V2.0.0	X	X	X	X
Value status	1	V2.0.0	X	X	X	X
PROFIenergy	1	V2.0.0	X	X	X	X
Multi Hot Swap	1	V2.0.0	X	X	X	X
Use of fail-safe modules	1	V2.0.0	-	X	X	X
Oversampling	1	V2.1.0	X	X	X	X
Media redundancy with planned duplication (MRPD)	1	V2.1.0	X	---	---	---
Isochronous mode	1	V2.1.0	---	X	X	X
Module-internal Shared Input/Shared Output (MSI/MSO)	1	V2.2.0	X	---	X	X
BusAdapter for fiber-optic cable FOC: BA 2xSCRJ	3	V2.2.0	X	---	X	X (as of V13 SP1)
System redundancy S2	1	V3.0.0	X	---	X	---
Station extension via ET-Connection	1	V3.0.0	X	---	X (as of V5.5 SP4)	X (as of V13 SP1)
Maximum user data length per module: 288 bytes	1	V3.1.0	X	X (as of V5.5 SP4)	X (as of V5.5 SP4)	X (as of V13 SP1)
BA SCRJ/RJ45 BusAdapter	3	V3.1.0	X	---	X (as of V5.5 SP4, HSP0250 V3)	X (as of V13 SP1, HSP0129 V1.0)

Function	Product version of the module as of	Firmware version of the module as of	Configuration software			
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)/ software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP3 with HSP 233	STEP 7 as of V5.5 SP4 with HSP 250/255	STEP 7 (TIA Portal) as of V12.0.1 with HSP 0058
BA SCRJ/FC BusAdapter	3	V3.1.0	X	---	X (as of V5.5 SP4, HSP0250 V3)	X (as of V13 SP1, HSP0129 V1.0)
BA 2xLC BusAdapter	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0250/255 V4)	X (as of V13 SP1, Update 6)
LC/RJ45 BusAdapter	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0250/255 V4)	X (as of V13 SP1, Update 6)
BA LC/FC BusAdapter	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0250/255 V4)	X (as of V13 SP1, Update 6)
Distribution of module channels to multiple submodules	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0255 V4)	X (as of V13 SP1, Update 6)
Maintenance interrupts of I/O modules	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0255 V4)	X (as of V13 SP1, Update 6)
Extended Channel Diagnostics	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0255 V4)	X (as of V13 SP1, Update 6)

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you must also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

Isochronous real-time communication

Synchronized transmission method for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data can also be transferred without being affected by another high network load (e.g. TCP/IP communication or additional real time communication) at reserved, chronologically synchronized intervals.

A topological configuration is required for IRT.

Note

IO controller as sync master with IRT communication

We recommend also operating the IO controller as a sync master when configuring the IRT communication.

Otherwise, IO devices with IRT and RT configuration could fail as a result of sync master failure.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Isochronous mode of I/O data

I/O data, transmission cycle via PROFINET IO, and the user program are synchronized to achieve maximum deterministics. The input and output data of distributed I/O modules in the system is simultaneously collected and simultaneously output. The constant PROFINET IO cycle forms the corresponding clock generator. The interface module supports isochronous mode of I/O data for the modules starting at 250 µs. The IO device can exchange isochronous process data with a maximum of one IO controller.

Note

If the IO controller cannot access a module (for example, module pulled, activated configuration control without written control data record), cycle time violations may occur with activated isochronous mode in the synchronous cycle interrupt OB (OB61). The time error OB (OB80) is called in the event of a cycle time violation.

This behavior is associated with updating the process image by means of the "SYNC_PI" (SFC126) and "SYNC_PO" (SFC127) instructions and depends, among other things, on the set cycle time and the configuration limits.

Note

Isochronous mode restrictions with IM 155-6 PN HF

Isochronous mode of I/O data in combination with the following functions is not possible with the interface module IM 155-6 PN HF:

- Shared device
- PROFIenergy

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Prioritized startup

Prioritized startup describes the PROFINET IO functionality for accelerating the startup of IO devices in a PROFINET IO system with IRT and RT communication.

The function reduces the time that the appropriately configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the supply voltage has returned
- After a station has returned
- After IO devices have been activated

Note

Dependency of the startup time

The interface module permits startup times from 0.5 s.

The startup time depends on the number and type of modules.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Device replacement

Device replacement without topological configuration

The device name is also stored on the BusAdapter in addition to the interface module. A device name saved on the BusAdapter is the requirement for device replacement without topological configuration.

Storing the name on the BusAdapter and the interface module produces a range of scenarios for using the device name when the interface module is replaced.

Table 2- 2 Scenarios for using the device name

	Interface module empty	Interface module with device name
BusAdapter empty	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Be aware of the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the BusAdapter. To prevent the device name from being deleted in the BusAdapter, you can remove the BusAdapter from the interface module before resetting to factory settings.
- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Do not pull/plug the BusAdapter while under voltage. If you pull/plug the BusAdapter while under voltage, the interface module restarts.

Device replacement with topological configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not have to be assigned with the programming device.

The replacement IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

IO devices that have already been used in another configuration should be reset to their factory settings before reuse (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Replacement of an IM 155-6 PN HF

In a replacement scenario, any IO devices in operation must be reset to their as-delivered state via "Reset to factory settings" (see the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Media redundancy (MRP)

Function for safeguarding communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Media redundancy with planned duplication (MRPD)

If media redundancy is to be reached with short update times (together with IRT), you must use the MRP extension "Media redundancy with planned duplication (MRPD)".

The MRPD media redundancy function is enabled for the interface module IM 155-6 PN HF (V2.1):

- With the GSD file as of V5.5 SP3

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Shared device

IO device that makes its data available to up to four IO controllers.

The interface module supports shared device at submodule level.

If **there is no validity check of the shared device projects by the Engineering System**, note the following:

- Make sure the configurations are consistent. In particular, modules or submodules may only be assigned to one controller. Multiple assignment will result in an error; the module or submodule will only be available in the first controller.
- If you reconfigure the shared device configurations without the validity check mentioned above, you must commission the ET 200SP once again. This means that you have to reload the projects of all involved IO controllers to the specific CPU after reconfiguration and, if necessary, switch the interface module POWER OFF/POWER ON.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Note

In the case of a shared device application, make sure that all controllers work with the same send clock. If controllers do not have the same send clock, the differing send clock can result in communication relationships that are not set up.

If you set up all controllers in one project, the same send clock is ensured. Set the same send clock for engineering in separate projects.

Submodules

The IM 155-6 PN HF interface module supports the division of I/O modules into up to 4 submodules. This allows parts of an I/O module to be separately configured and parameterized.

A maximum of 256 submodules is supported, whereby 4 submodules are used for the interface module and one submodule for the server module.

It is possible to assign each of these submodules to different IO controllers.

The functions:

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

can only be executed if you have configured submodule 1 during configuration.

Module-internal Shared Input/Shared Output (MSI/MSO)

The Module-internal Shared Input function allows an input module to make its input data available to up to four IO controllers. Each controller has read access to the same channels.

The Module-internal Shared Output function allows an output module to be operated by up to four IO controllers. One IO controller has write access. Up to three additional IO controllers can have read access to the same channels.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856)

Value status

The IM 155-6 PN HF interface module supports I/O modules with value status.

Additional information on the value status can be found in the manuals for the I/O modules.

Oversampling

The IM 155-6 PN HF interface module supports the Oversampling mode of HS modules. With oversampling, the modules reduce the respective PROFINET send clocks in isochronous mode.

Additional information on oversampling can be found in the manuals for the I/O modules.

Compatibility with IM 155-6 PN interface module

In an existing plant, the IM 155-6 PN HF replaces the IM 155-6 PN ST without reconfiguration. When the IM 155-6 PN HF replaces the IM 155-6 PN ST, it is possible to insert and remove several I/O modules during operation.

For more information on compatibility, refer to section: Compatibility (Page 48)

2.2.1 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You can find more information on PROFIenergy in the:

- I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
- Function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856).
- PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual.
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information.
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.

2.2.2 Configuration control (option handling)

Properties

Configuration control allows you to prepare your automation system for future expansions or changes. Configuration control means you can configure the planned maximum expansion of your automation system in advance and flexibly vary it later by means of the user program.

Reference

You can find more information on configuration control

- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- on the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270).
- in the STEP 7 online help.

2.2.3 Use of fail-safe modules

Properties

The IM 155-6 PN HF interface module as of V2.0 firmware supports the use of fail-safe modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2.4 Multi Hot Swap

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

Note

The IM 155-6 PN HF interface module does not support the removal and insertion of the server module, the interface module and BusAdapter during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Wiring

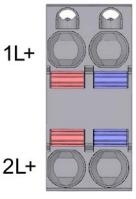
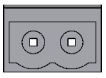
3

3.1 Pin assignment

24 V DC supply voltage

The following table shows the signal names and the descriptions of the pin assignment for a 24 V DC supply voltage.

Table 3- 1 Pin assignment 24 V DC supply voltage

View		Signal name[1]	Description
Connector	IM connection		
		1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

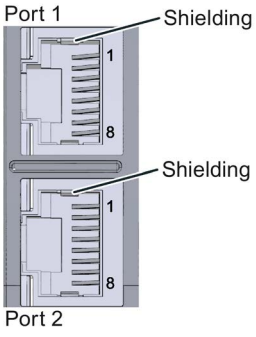
1 1L+ and 2L+ as well as 1M and 2M are bridged internally.

2 Maximum 10 A permitted.

PROFINET IO with BusAdapter BA 2×RJ45

The following table shows the signal names and description of the pin assignment for the BA 2×RJ45 BusAdapter.

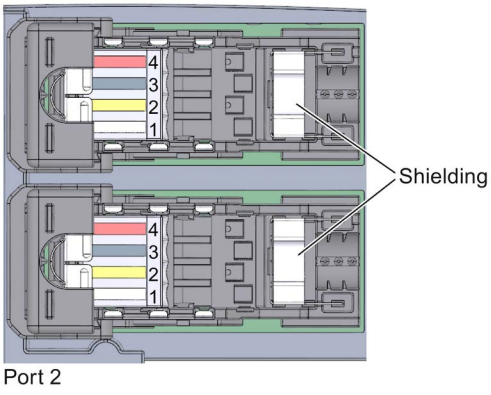
Table 3- 2 PROFINET IO pin assignment with BusAdapter BA 2×RJ45

View	Signal name		Description
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data –
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA 2×FC

The following table shows the signal names and description of the pin assignment for the BA 2×FC BusAdapter.

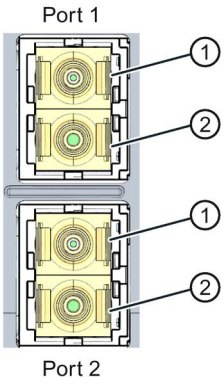
Table 3- 3 PROFINET IO pin assignment with BusAdapter BA 2×FC

View	Signal name		Description
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO with BusAdapter BA 2×SCRJ

The following table shows the signal names and description of the pin assignment for the BA 2×SCRJ BusAdapter.

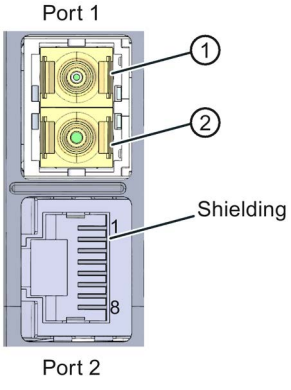
Table 3- 4 PROFINET IO pin assignment with BusAdapter BA 2×SCRJ

View	Signal name	Description
	①	Receiver / Receive data
	②	Sender / Transmit data

PROFINET IO with BusAdapter BA SCRJ/RJ45

The following table shows the signal names and description of the pin assignment for the BA SCRJ/RJ45 BusAdapter.

Table 3- 5 PROFINET IO pin assignment with BusAdapter BA SCRJ/RJ45

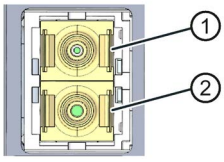
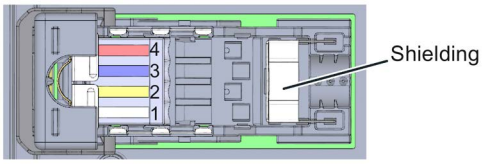
View	Signal name		Description
	①		Receiver / Receive data
	②		Sender / Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data –
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA SCRJ/FC

The following table shows the signal names and description of the pin assignment for the BA SCRJ/FC BusAdapter.

The pin assignment for the BA SCRJ/FC BusAdapter is shown individually for a clearer overview.

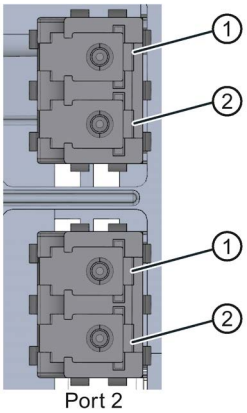
Table 3- 6 PROFINET IO pin assignment with BusAdapter BA SCRJ/FC

View	Signal name		Description
Port 1  	①		Receiver / Receive data
	②		Sender / Transmit data
 Port 2	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO with BusAdapter BA 2×LC

The following table shows the signal names and description of the pin assignment for the BA 2×LC BusAdapter.

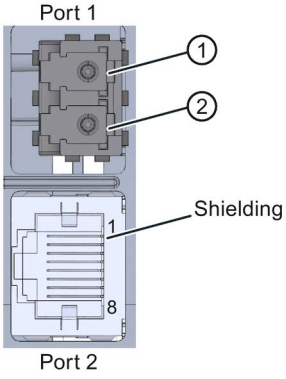
Table 3- 7 PROFINET IO pin assignment with BusAdapter BA 2×LC

View	Signal name	Description
Port 1  Port 2	①	Receiver / Receive data
	②	Sender / Transmit data

PROFINET IO with BusAdapter BA LC/RJ45

The following table shows the signal names and description of the pin assignment for the BA LC/RJ45 BusAdapter.

Table 3- 8 PROFINET IO pin assignment with BusAdapter BA LC/RJ45

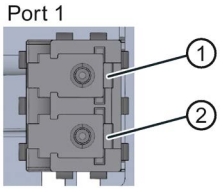
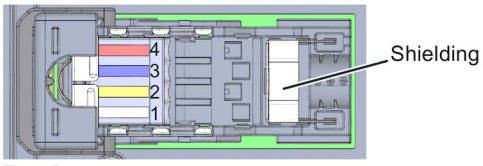
View	Signal name		Description
	①		Receiver / Receive data
	②		Sender / Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data –
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA LC/FC

The following table shows the signal names and description of the pin assignment for the BA LC/FC BusAdapter.

The pin assignment for the BA LC/FC BusAdapter is shown individually for a clearer overview.

Table 3- 9 PROFINET IO pin assignment with BusAdapter BA LC/FC

View	Signal name		Description
	①		Receiver / Receive data
	②		Sender / Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

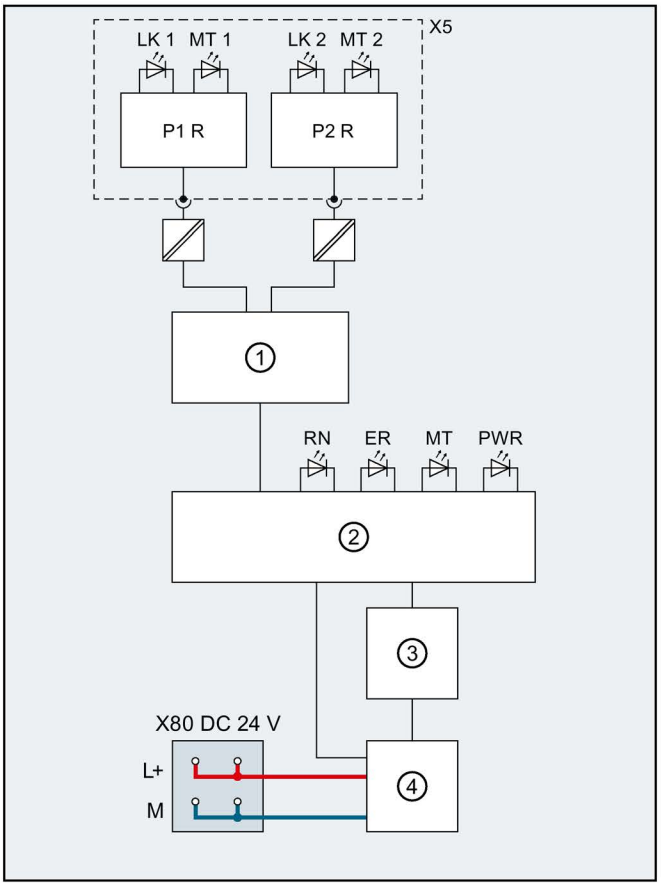
Reference

You can find more information on accessories and how to connect the interface module in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Block diagram

Block diagram

The following figure shows a block diagram of the interface module IM 155-6 PN HF.



①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1,2	LED Link TX/RX
④	Internal power supply	MT 1,2	LED FiberOptic (SCRJ port)
X80 24 V DC	Feed supply voltage	RN	LED RUN/STOP (green/yellow)
X5	BusAdapter	ER	ERROR LED (red)
P1 R	PROFINET interface X1 Port 1	MT	MAINT LED (yellow)
P2 R	PROFINET interface X1 Port 2	PWR	POWER LED (red)

Figure 3-1 Block diagram of the IM 155-6 PN HF interface module

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 PN HF interface module

The following table shows the parameters for the interface module IM 155-6 PN HF.

Table 4- 1 Parameters for interface module IM 155-6 PN HF (GSD file)

Parameters	Value range	Default	Efficiency range
Enable configuration control	Yes/No	No	ET 200SP

4.2 Explanation of parameters

4.2.1 Enable configuration control

Enable configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

Note

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information on the control data record in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.3 Substitute value behavior

Substitute value behavior

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Parameter assignment phase during startup
- Deactivating the IO device
- Station stop
  - Missing server module
  - Insertion of invalid I/O modules
  - At least one I/O module installed on an incorrect BaseUnit

Note

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

The "current-free/voltage-free" behavior becomes effective in the following cases:

- Firmware update
- Reset to factory settings
- Configuration control: The IM has not received a valid control data record 196 yet.
- Incorrectly configured module
- Module with incorrect parameter assignment

Substitute value behavior for module-internal Shared Output (MSO) and module-internal Shared Input (MSI)

Substitute value behavior for module-internal Shared Output (MSO) and module-internal Shared Input (MSI) corresponds to the behavior described above.

4.4 Status of the supply voltage L+ of the I/O modules

The status of the supply voltage L+ of the ET 200SP I/O modules is mapped to the server module with the interface module IM 155-6 PN HF.

You can find information on the status of the supply voltage L+ of the I/O modules in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

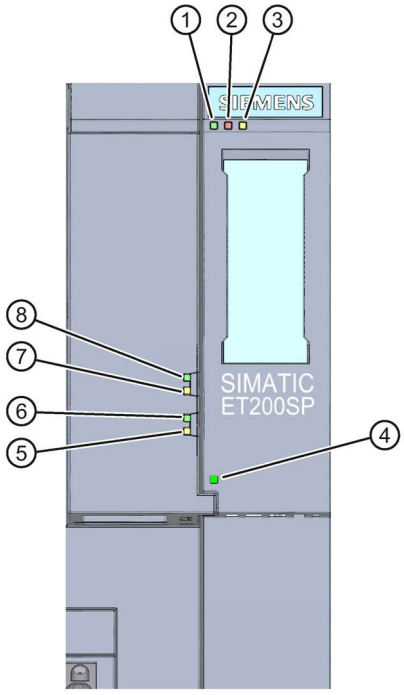
Interrupts, error messages, diagnostics and system alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays on the interface module and BusAdapter.



① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ MT2 (yellow) (SCRJ port)
⑥ LK2 (green)
⑦ MT1 (yellow) (SCRJ port)
⑧ LK1 (green)

Figure 5-1 LED displays on the interface module and BusAdapter

Meaning of the LED displays

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 5- 1 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Solution
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module.*
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	---
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	---
			ET 200SP is being assigned parameters.	
			ET 200SP is being reset to factory settings.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	---
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics and eliminate the error.
			The configured structure does not correspond to the actual structure of the ET 200SP .	Check the structure of the ET 200SP to see whether a module is missing or defective, or whether a non-configured module is inserted.
			Invalid configuration states.	See section Invalid configuration states of the ET 200SP on PROFINET IO (Page 46).
			Parameter assignment error in the I/O module.	Evaluate the display of the module status in STEP 7 and eliminate the error in the respective I/O module.
Not relevant	Not relevant	On	Maintenance	See section Maintenance events (Page 42).
Flashes	Flashes	Flashes	The "Node flash test" is run (LEDs LK1 and LK2 of the PROFINET interface also flash).	---
			Hardware or firmware defective (LEDs LK1 and LK2 of the PROFINET interface do not flash).	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

PWR LED on the interface module

Table 5- 2 Status display of the PWR LED

PWR LED	Meaning	Solution
Off	Supply voltage not present or too small.	Check the supply voltage.
On	Supply voltage present.	---

LK1/LK2 and MT1/MT2 LEDs on the BusAdapter

Table 5- 3 Status and error displays of LK1/LK2 and MT1/MT2 LEDs

LED		Meaning	Solution
LK1/LK2	MT1/MT2*		
Off	Not relevant	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted.
On	Not relevant	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	---
Flashes	Not relevant	The "Node flash test" is run (the RN/ER/MTLEDs also flash).	---
Not relevant	Off	No error	---
Not relevant	On	• Fiber-optic error • Maintenance demanded: Attenuation through the fiber-optic cable is so high that operation will soon no longer be possible.	Causes and measures for the transmission route: • Replacement of fiber-optic cable if damaged or aged • Correct installation of the PROFINET connector/PROFINET connections • Adherence to maximum length of 50 m for POF cable or 100 m for PCF cable • Secure fit of the FOC connector

* Available only on BA 2×SCRJ, BA SCRJ/RJ45 and BA SCRJ/FC BusAdapters

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interface module by the ERROR (red) and MAINT (yellow) LEDs.

The following configuration errors are signaled by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display:

- Is activated during POWER ON and during operation.
- Has priority over all other states that are displayed by means of the ERROR and MAINT LED.
- Remains turned on until the cause of the error has been removed.

Table 5- 4 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Indication of the error type
2	The MAINT LED flashes at 1 Hz	Display of error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Indication of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location / error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location / error code
6	Repeat steps 1 to 5 until the cause of the error has been removed.	

Error display

Table 5- 5 Error display

Error type (MAINT)	Error location (ERROR/ MAINT)	Cause of error	Solution
1	65	• No server module • Interruptions on the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

Note

The following LEDs indicate a short-circuit in the backplane bus supply or in the bus connection supply:

- PWR LED: On
- RN, ER and MT LED: Off

5.2 Interrupts

Introduction

The I/O device triggers interrupts as a reaction to specific errors. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic error interrupts
- Hardware interrupts
- Pull/plug interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the innovated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, alarms are made available on the display of the S7-1500 CPU, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926) function manual.

5.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostic error interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostic error interrupt OB.

5.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

If there is a hardware interrupt, the CPU interrupts user program execution and processes the hardware interrupt block OB, e.g., OB 40. The result that triggered the interrupt is added to the start information of the hardware interrupt OB.

Note

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for functional purposes (e.g. the cyclic generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.3 Triggering of a remove/insert module interrupt

Triggering of a remove/insert module interrupt

In the event of a remove/insert module interrupt, the CPU interrupts processing of the user program and processes the remove/insert module OB, e.g. OB 83. The event that triggered the interrupt is entered in the start information of the remove/insert module OB.

Note

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating OB83. After inserting a module, OB83 is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

5.3 Alarms

5.3.1 Diagnostics alarms

Actions after a diagnostics alarm

There can be more than one diagnostics alarm at the same time. Each diagnostics alarm initiates the following actions:

- The ERROR LED of the interface module flashes.
- Diagnostics are reported as diagnostic error interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- The diagnostic error interrupt OB is called. If the diagnostic error interrupt OB is not available, the IO controller switches to STOP mode.

You can find more information in the STEP 7 online help.

Reading the diagnostics

Table 5- 6 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See...
SIMATIC S7	Diagnostics as plain text in STEP 7 using Online and Diagnostics view	STEP 7 online help • as of STEP 7 V12, function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) • as of STEP 7 V5.5, system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

Additional information on the data records for PROFINET IO

The structure of the diagnostic data records and programming examples are available in the programming manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) and in Example application (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostic alarms are described in the manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section, "Interrupts, error messages, and system events".

See also

Channel diagnostics (Page 42)

5.3.2 Maintenance events

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as soon as possible.

For the interface module, maintenance events signal to the user when a network component must be checked or replaced.

The CPU interrupts user program execution and executes the diagnostic error interrupt OB. The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

The interface module signals a maintenance event to the higher-level diagnostic system in the case of the following event:

Table 5- 7 Triggering of a maintenance event

Maintenance alarm	Event	Alarm/Meaning
Maintenance demanded LED MAINT is lit.	Synchronization loss	• No synchronization frame received. No synchronization frame was received by the sync master within the timeout period after parameter assignment or during operation. • Successive synchronization frames are located outside permitted limits (jitter).

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system alarms:

- Maintenance demanded - indicated for each port by a yellow wrench icon in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

5.3.3 Channel diagnostics

Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read using the instruction "RDREC".

Structure of the diagnostics data records

The data records supported by the ET 200SP distributed I/O system are based on the standard PROFINET IO - Application Layer Service Definition V2.2.

If required, the standard is available for download on the Internet (http://www.profibus.com) from the PROFIBUS user organization home page.

Coding of the extended channel diagnostics (as of V3.3.0)

With the IM 155-6 PN HF interface module, the following extended channel diagnostics are reported:

ChannelErrorType (CET)	ExtendedChannelError-Type (ECET)	Associated value AddValue	Diagnostics
0x0602	0x0691	Slot	Station stop - module parameter "Potential group" faulty or incorrect BaseUnit in actual slot (AddValue)
0x0602	0x0693	0x00	Diagnostics with missing server module
0x0602	0x0698	0x00	Diagnostics backplane bus too large
0x0602	0x0699	slot	Diagnostics with incorrect bus configuration
0x0602	0x069C	0x00	Diagnostics with incorrectly plugged BusAdapter
0x0610	0x06B0	0x00	Group diagnostics: Missing supply voltage L+ for the potential groups Note: The slot in which the light-colored BaseUnit of the respective load module is located is coded in the "ChannelNumber" element.

Structure of the manufacturer-specific diagnostics data records

The structure of the diagnostics data records is differentiated by the BlockVersion. The following BlockVersion applies to the IM 155-6 PN HF interface modules:

Table 5- 8 Structure of the manufacturer-specific diagnostics data records

IM 155-6 PN HF interface module	BlockVersion
6ES7155-6AU00-0CN0	W#16#0101

Manufacturer-specific diagnostics in the User Structure Identifier (USI)

The following manufacturer-specific diagnostics are signaled in the USI with the IM 155-6 PN HF interface module:

Table 5- 9 Manufacturer-specific diagnostics in the USI

USI no. W#16#...	Diagnostics
0003	Group diagnostics: Missing supply voltage L+ for the potential groups
0004	Diagnostics with missing server module
0006	Diagnostics with incorrect BaseUnit
0007	Diagnostics with incorrect bus configuration

USI structure = W#16#0003

Table 5- 10 USI structure = W#16#0003

Data block name		Content	Comment	Bytes
USI		W#16#0003	Manufacturer-specific diagnostics with failure of supply voltage L+ as of slot x of the ET 200SP module	2
Followed by the slot as of which the supply voltage L+ has failed.				
	Slot	W#16#0001 to W#16#0040	Bit 8 to 15	1
			Bit 0 to 7	1
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

USI structure = W#16#0004

Table 5- 11 USI structure = W#16#0004

Data block name		Content	Comment	Bytes
USI		W#16#0004	Manufacturer-specific diagnostics with missing server module Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller	2
Followed by 4 reserved bytes:				
	Reserved			1
	Reserved			1
	Reserved			1
	Reserved			1

USI structure = W#16#0006

Table 5- 12 USI structure = W#16#0006

Data block name		Content	Comment	Bytes
USI		W#16#0006	Manufacturer-specific diagnostics if an ET 200SP I/O module is installed on an incorrect BaseUnit. Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller	2
Followed by the slot for the I/O module:				
	Slot	W#16#0001 to W#16#0040	Bit 8 to 15	1
			Bit 0 to 7	1
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

USI structure = W#16#0007

Table 5- 13 USI structure = W#16#0007

Data block name		Content	Comment	Bytes
USI		W#16#0007	Manufacturer-specific diagnostics if operation is not possible with existing bus configuration Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller	2
Followed by the slot for the I/O module:				
	Slot	W#16#0001 to W#16#0040	Bit 8 to 15	1
			Bit 0 to 7	1
If slot 0 is specified, check the width of the station configuration (maximum 1 m).				
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

5.3.4 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent data exchange:

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is plugged into a different BaseUnit as the one configured in the parameters.
- No server module.
- Invalid or incorrectly configured BusAdapter.

Note

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module continues to exchange data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

See also

Status and error displays (Page 35)

Channel diagnostics (Page 42)

5.3.5 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull interrupt is generated.
- If an I/O module is installed during failure of the supply voltage, a plug interrupt is generated.

5.3.6 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. Read the $E00C_H$ data record in startup OB using the instruction "RDREC". This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the occurring diagnostics in the STOP state of the IO controller, you have to read the $E00C_H$ data record with the "RDREC" instruction. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility

6

6.1 Compatibility of modules

Compatibility with IM 155-6 PN HF interface module

If you exchange or replace an interface module, the following table shows the compatibilities:

- Between the interface modules IM 155-6 PN HF and IM 155-6 PN ST
- Between the various firmware versions

Interface modules	IM 155-6 PN ST V1.0	IM 155-6 PN ST V1.1	IM 155-6 PN ST V3.1	IM 155-6 PN ST V3.3	IM 155-6 PN HF V2.0	IM 155-6 PN HF V2.1	IM 155-6 PN HF V2.2	IM 155-6 PN HF V3.0	IM 155-6 PN HF V3.1
IM 155-6 PN HF V2.0	Yes	---	---	---	Yes	---	---	---	---
IM 155-6 PN HF V2.1	Yes	Yes	---	---	Yes	Yes	---	---	---
IM 155-6 PN HF V2.2	Yes	Yes	---	---	Yes	Yes	Yes	---	---
IM 155-6 PN HF V3.0	Yes	Yes	---	---	Yes	Yes	Yes	Yes	---
IM 155-6 PN HF V3.1	Yes	Yes	Yes	---	Yes	Yes	Yes	Yes	---
IM 155-6 PN HF V3.3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Station configuration with more than 32 I/O modules

Certain modules with product versions 001 and 002 do not support a station configuration with more than 32 I/O modules.

The table below shows all modules that do not support a station configuration with more than 32 I/O modules:

Table 6- 1 Incompatible modules with product versions

Modules	Article number	Up to product version
Analog modules		
AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	002
AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	002
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	002
AI 4xU/I ST	6ES7135-6HD00-0BA1	002
Digital modules		
DI 16x24VDC ST	6ES7131-6BH00-0BA0	002
DI 8x24VDC ST	6ES7131-6BF00-0BA0	002
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	002
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	002
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	002

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules without parameter assignment in the following table, the status of the supply voltage (status byte of the server module) is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7132-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7132-6BF00-0CA0
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0.5A HF	6ES7131-6BF00-0CA0

Resetting an interface module to factory settings via the RESET button

There is a special operation for interface module IM 155-6 PN HF V2.0 to reset it to the factory settings using the Reset button.

Requirements

The supply voltage to the interface module must be switched on.

Required tools

3 to 3.5 mm screwdriver (for resetting via the RESET button)

Procedure

1. Remove the interface module from the mounting rail and swivel it downwards.
2. The RESET button is located on the back of the interface module behind a small opening: Push a screwdriver into the small opening, thus pressing the RESET button.
3. Release the RESET button.
4. Press the RESET button for another 3 seconds.
5. Look at the LED display of the interface module to see whether the reset was successful: RUN LED flashes for 3 seconds, ERROR and MAINT LED are off.
6. Install the interface module back on the mounting rail.
7. Assign parameters to the interface module again.

AQ 4xU/I ST analog output module

Note

For operation of the AQ 4xU/I ST analog output module, firmware version V1.0 (6ES7135-6HD00-0BA1) with the IM 155-6 PN HF interface module (6ES7155-6AU00-0CN0), you need to set the "Reaction to CPU STOP" parameter to "Turn off" with a PROFINET send clock < 1 ms.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules:
Maximum reaction time = configured update time + 400 µs (but at least 1.4 ms)

Operation with activated system redundancy S2

Note

Restrictions in operation with activated system redundancy S2

You cannot use the following functions during operation of the IM155-6 PN HF, firmware version as of V3.0.0 with activated system redundancy S2:

- Station extension with ET 200AL via ET-Connection
- Configuration control (option handling)

Technical specifications

7

Technical specifications of the IM 155-6 PN HF

	6ES7155-6AU00-0CN0
General information	
Product type designation	IM 155-6 PN HF with server module
Firmware version	V3.3
Product function	
I&M data	Yes; I&M0 to I&M4
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 Update 6
STEP 7 can be configured/integrated as of version	V5.5 SP4 or higher
PROFINET as of GSD version/GSD revision	- / V2.3
Configuration control	
Via data record	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption, max.	700 mA
Inrush current, max.	4.5 A
I^2t	0.09 A^2s
Power loss	
Power loss, typ.	2.4 W
Address area	
Address space per module	
Address space per module, max.	288 bytes; for both input and output data
Address space per station	
Address space per station, max.	1440 bytes; depending on configuration
Hardware configuration	
Rack	
Modules per rack, max.	64

	6ES7155-6AU00-0CN0
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1st interface	
Interface hardware	
• Number of ports	2
• Integrated switch	Yes
• BusAdapter (PROFINET)	Yes; usable BusAdapters: BA 2x RJ45, BA 2x FC, BA 2x SCRJ (as of FS03, V2.2), BA SCRJ / RJ45 (as of FS03, V3.1), BA SCRJ / FC (as of FS03, V3,1), BA 2x LC (as of FS03, V3.3), BA LC / RJ45 (as of FS03, V3.3), BA LC / FC (as of FS03, V3.3)
Protocols	
• PROFINET IO device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; as MRP or MRPD client, max. 50 or 30 devices in the ring
Interface hardware	
RJ45 (Ethernet)	
100 Mbps	Yes; PROFINET with 100 Mbps full duplex (100BASE-TX)
Transmission method	PROFINET with 100 Mbps full duplex (100BASE-TX)
Autonegotiation	Yes
Autocrossing	Yes
Protocols	
PROFINET IO device	
Services	
• Isochronous mode	Yes; bus cycle time min. 250 µs
• Open IE communication	Yes
• IRT	Yes; 250 µs, 500 µs, 1 ms, 2 ms, 4 ms additionally with IRT with high performance: 250 µs to 4 ms in 125 µs intervals
• MRP	Yes
• MRPD	Yes
• PROFINET system redundancy	Yes; NAP S2
• PROFIenergy	Yes
• Prioritized startup	Yes
• Shared device	Yes
• Number of IO controllers with shared device, max.	4

	6ES7155-6AU00-0CN0
Open IE communication	
TCP/IP	Yes
SNMP	Yes
LLDP	Yes
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Constant bus cycle time	Yes
Shortest clock pulse	250 µs
Longest clock pulse	4 ms
Bus cycle time (TDP), min.	250 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	Yes
Diagnostics functions	Yes
Diagnostics indicator LED	
RUN LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Monitoring of the supply voltage (PWR LED)	Yes
Connection display LINK TX/RX	Yes
Electrical isolation	
Between PROFINET and all other circuits	Yes
Between supply and all other circuits	Yes
Permissible potential difference	
Between different circuits	75 V DC/60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC between supply voltage and electronics (type test); 1500 V AC between Ethernet and electronics (type test)
Standards, approvals, certificates	
Network loading class	3
Security level	According to Security Level 1 Test Cases V1.1.1
Connection technology	
ET-Connection	
Via BU/BA-Send	Yes
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	147 g; without BusAdapter

Technical specifications of the BusAdapter BA 2×RJ45

Table 7- 1 Technical specifications of the BusAdapter BA 2×RJ45

	6ES7193-6AR00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
RJ45	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	46 g

Technical specifications of the BusAdapter BA 2×FC

Table 7- 2 Technical specifications of the BusAdapter BA 2×FC

	6ES7193-6AF00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
FC (FastConnect)	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	53 g

Technical specifications of the BusAdapter BA 2×SCRJ

Table 7- 3 Technical specifications of the BusAdapter BA 2×SCRJ

	6ES7193-6AP00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (switch) SCRJ FO
SCRJ	2
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/RJ45

Table 7- 4 Technical specifications of the BusAdapter BA SCRJ/RJ45

	6ES7193-6AP20-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + RJ45)
RJ45	Yes; 1 x
SCRJ	1
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/FC

Table 7- 5 Technical specifications of the BusAdapter BA SCRJ/FC

	6ES7193-6AP40-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + FC)
FC (FastConnect)	Yes; 1 x
SCRJ	1
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA 2×LC

Table 7- 6 Technical specifications of the BusAdapter BA 2×LC

	6ES7193-6AG00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (switch) LC multimode glassfiber
LC	2
Cable length	
• Multimode gradient-index fiber 50/125 µm	2 km
• Multimode gradient-index fiber 62.5/125 µm	2 km
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	40 g

Technical specifications of the BusAdapter BA LC/RJ45

Table 7- 7 Technical specifications of the BusAdapter BA LC/RJ45

	6ES7193-6AG20-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (switch) LC / RJ45
RJ45	Yes; 1x
LC	1
Cable length	
• Copper cables	100 m
• Multimode gradient-index fiber 50/125 µm	2 km
• Multimode gradient-index fiber 62.5/125 µm	2 km
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	32 g

Technical specifications of the BusAdapter BA LC/FC

Table 7- 8 Technical specifications of the BusAdapter BA LC/FC

	6ES7193-6AG40-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
FC (FastConnect)	Yes; 1x
LC	1
Cable length	
• Copper cables	100 m
• Multimode gradient-index fiber 50/125 µm	2 km
• Multimode gradient-index fiber 62.5/125 µm	2 km
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Dimension drawing

A

This appendix contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

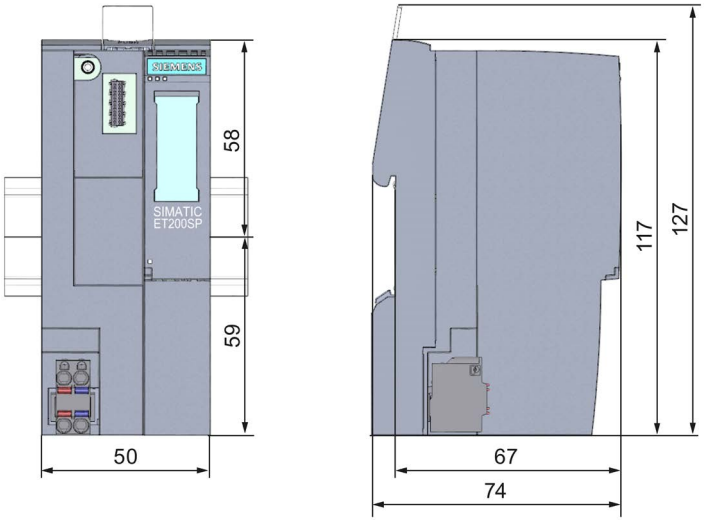


Figure A-1 Dimension drawing of the IM 155-6 PN HF interface module, front and side views

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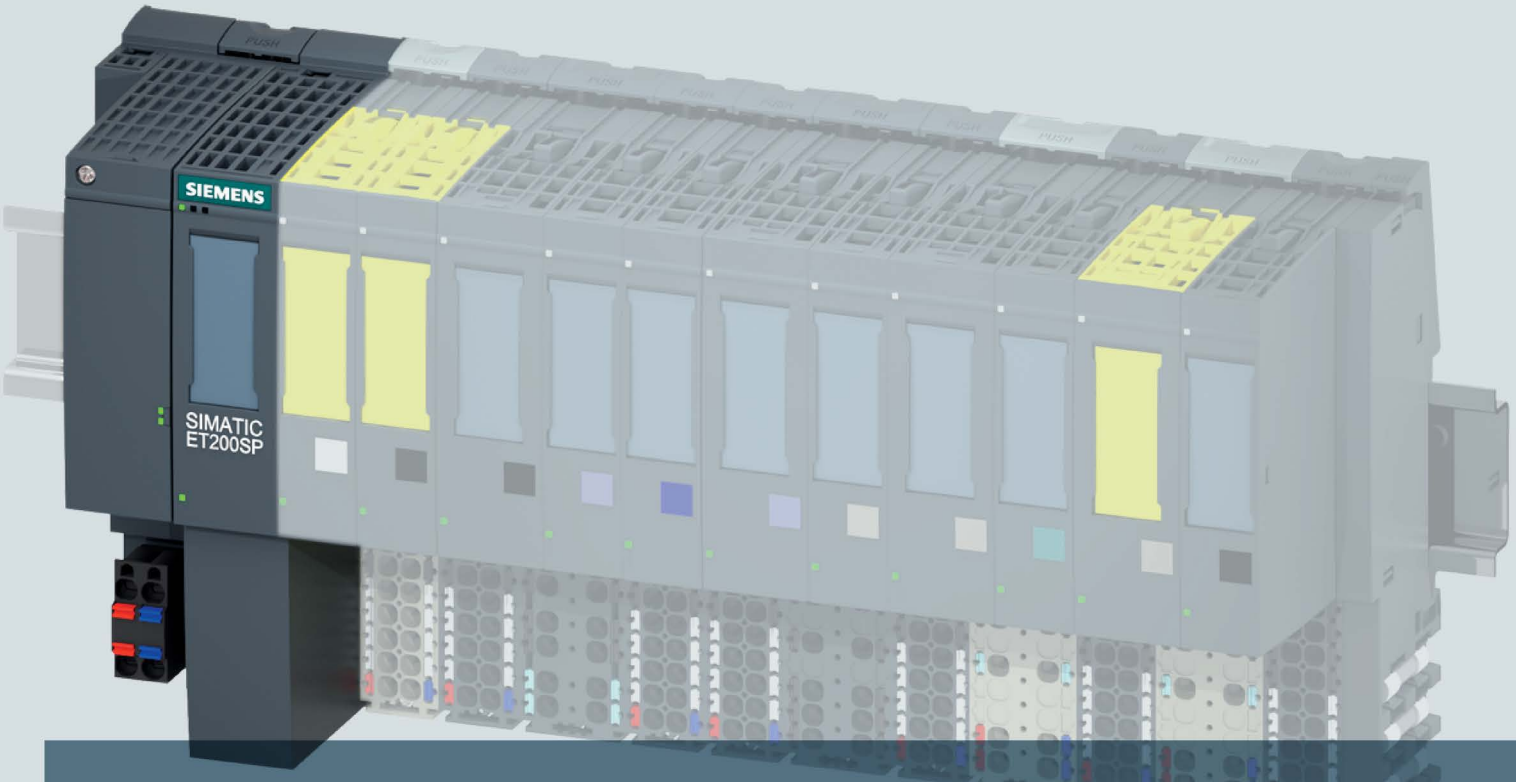

SIMATIC

ET 200SP

Interface module IM 155-6 DP HF (6ES7155-6BA00-0CN0)

Manual

Edition 05/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
IM 155-6 DP HF interface module (6ES7155-6BA00-0CN0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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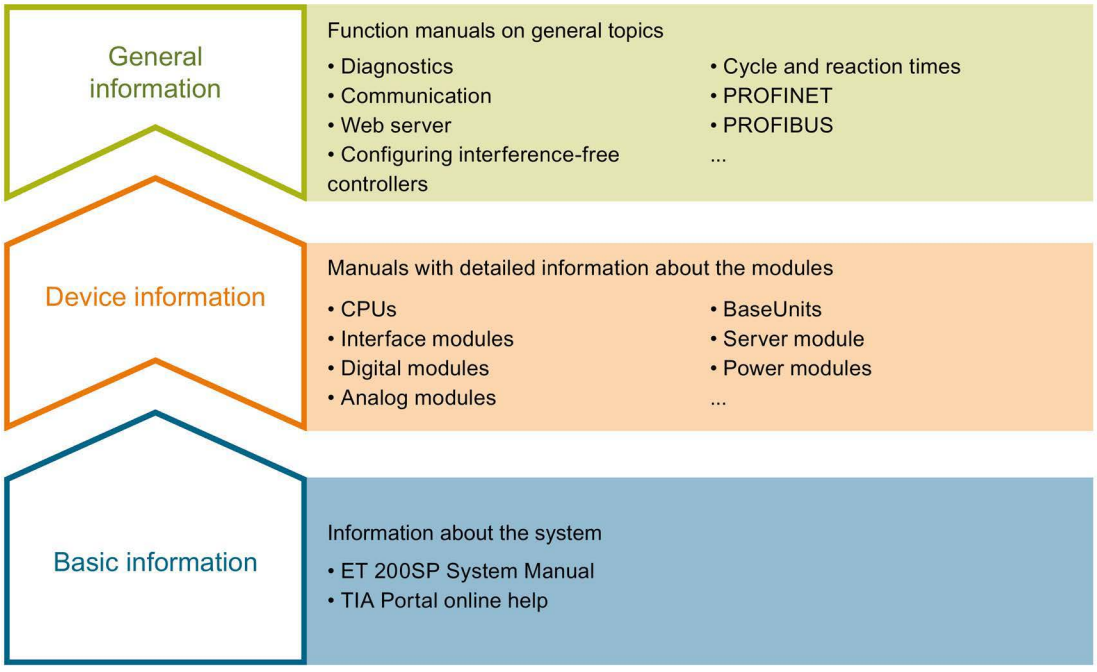
Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (http://support.industry.siemens.com/cs/ww/en/ps/ae).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7155-6BA00-0CN0

Article number 6ES7155-6BA00-0CN0 contains the following components:

- IM 155-6 DP HF interface module (6ES7155-6BU00-0CN0)
- Server module (6ES7193-6PA00-0AA0)
- PROFIBUS FastConnect bus connector (6ES7972-0BB70-0XA0)

View of the module

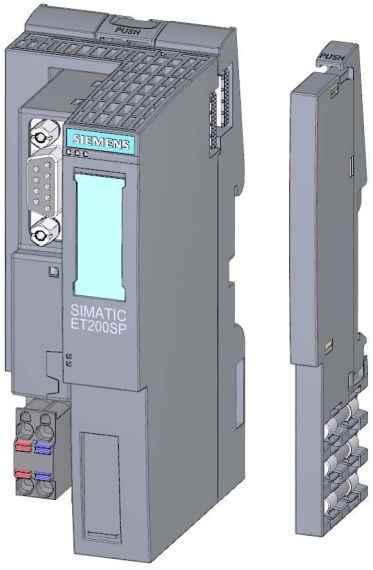


Figure 2-1 View of the 155-6 DP HF interface module with supplied accessories

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFIBUS DP
- Supply voltage 1L+ 24 V DC (SELV/PELV)
- Bus connection via RS485 interface

The module supports the following functions (see (Page 12))

Maximum configuration

- 244 bytes I/O data
- 32 I/O modules

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Server module

The server module is included in the product package of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Provides station functions, e.g., status bytes
- Identification data I&M 0 to 3

Note

You need to configure the server module in the configuration software.

To do so, place the server module with the required length of status bytes at the last slot of the configuration. When there are 32 I/O modules, the server module is inserted at slot 33.

PROFIBUS FastConnect bus connector

The PROFIBUS FastConnect bus connector is included in the product package of the interface module and also available separately as an accessory.

You can find additional information on the PROFIBUS FastConnect bus connector in the corresponding product information on the Internet (http://support.automation.siemens.com/WW/view/en/58648998).

Configuration with more than 244 bytes of parameter data

With a configuration as of STEP 7 V5.5 SP 3 with HSP 242, you have the option of operating the IM 155-6 DP HF interface module as of 6ES7155-6BA00-0CN0 in DPV1 mode with more than 244 bytes of parameter data. Configuration with the GSD file does not offer this option.

Note

With a configuration as of STEP 7 V5.5 SP 3 with HSP 242 without GSD files, a longer startup time of the station is to be expected.

Reference

You can find additional information on identification data in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Functions

Introduction

The interface module supports the following functions:

- Identification data I&M 0 to 3
- PROFIBUS DP
- Firmware update via PROFIBUS DP
- Configuration control by means of the user program
- Operation as DPV1 slave
- Operation after Y-link (not with F-modules)
- Station extension via ET-Connection
- F-direct data exchange

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 DP HF interface module:

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000) / software from a third-party manufacturer[1]	STEP 7 as of V5.5 SP3 with HSP 242	STEP 7 (TIA Portal) as of V13
Operation after Y-link (not with F-modules)	1	V1.1.0	X	---	---
Hot-swapping	1	V1.0.0	X	X	X
Station extension via ET-Connection	1	V3.0.0	X	X (as of HSP 0242 V2)	---
F-direct data exchange	1	V3.1.0	---	X (as of HSP0242 V3)	---

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

2.2.2 Configuration control

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or options. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

Connecting

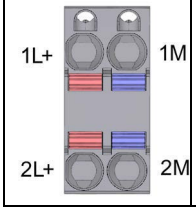
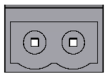
3

3.1 Terminal assignment

24 V DC supply voltage

The table below shows the signal names and descriptions of the pin assignment of the 24 V DC supply voltage.

Table 3- 1 Pin assignment 24 V DC supply voltage

View		Signal name[1)]	Description
Connector	IM connection		
		1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

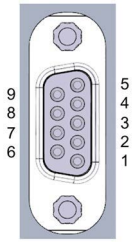
1 1L+ and 2L+ as well as 1M and 2M are internally bridged.

2 Maximum 10 A permitted.

PROFIBUS DP with RS485 interface

The following table shows the signal names and descriptions of the terminal assignment of the PROFIBUS DP interface.

Table 3- 2 Terminal assignment PROFIBUS DP with RS485 interface

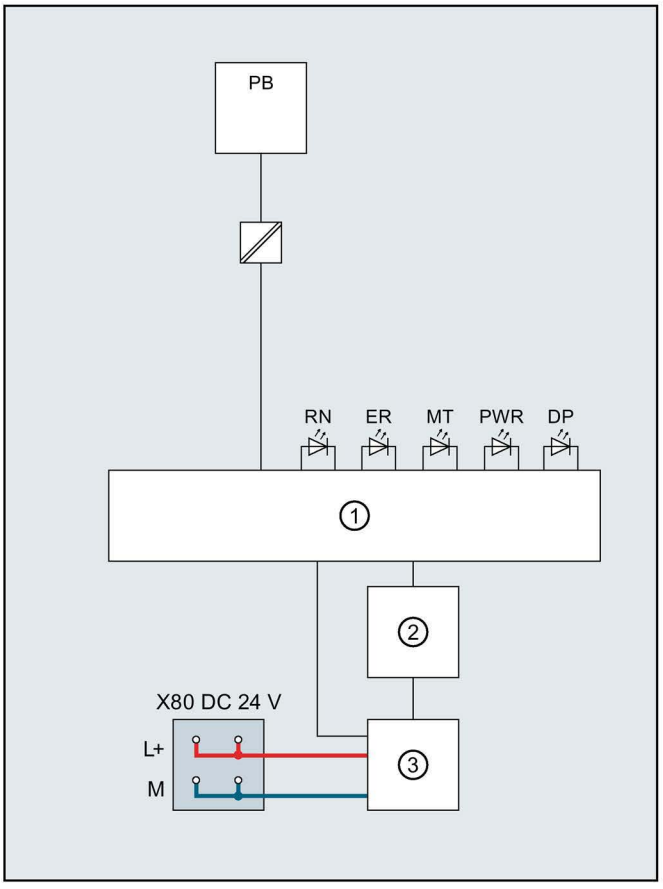
View		Signal name	Description
	1	-	-
	2	-	-
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	DP data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	-	-
	8	RxD/TxD-N	Data line A
	9	-	-

Reference

You can find additional information on connecting the interface module and on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Block diagram

The following figure show the block diagram of the IM 155-6 DP HF interface module.



①	ET 200SP backplane bus interface and electronics	L+	24 V DC supply voltage
②	Backplane bus	M	Ground
③	Internal power supply	RN	RUN/STOP LED (green)
X80 24 V DC	Feed supply voltage	ER	ERROR LED (red)
PB	PROFIBUS interface	MT	MAINT LED (yellow)
		PWR	POWER LED (green)
		DP	PROFIBUS DP LED (green)

Figure 3-1 Block diagram of the IM 155-6 DP HF interface module

3.3 Setting the PROFIBUS DP address

Introduction

On the interface module (PROFIBUS), set the PROFIBUS DP address for PROFIBUS DP using the DIP switch. By setting the PROFIBUS DP address, you specify where the ET 200SP is to be addressed on the PROFIBUS DP.

Requirements

- Each PROFIBUS DP address may be assigned only once on the PROFIBUS DP.
- Valid PROFIBUS DP addresses are 1 to 125.
- The set PROFIBUS DP address must match the PROFIBUS DP address specified for the ET 200SP in the configuration software.

Required tools

Screwdriver 3 - 3.5 mm

Setting the PROFIBUS DP address

1. Slide the window of the interface module upwards.
2. Use a screwdriver to set the required PROFIBUS address via the DIP switch.
3. Close the window.

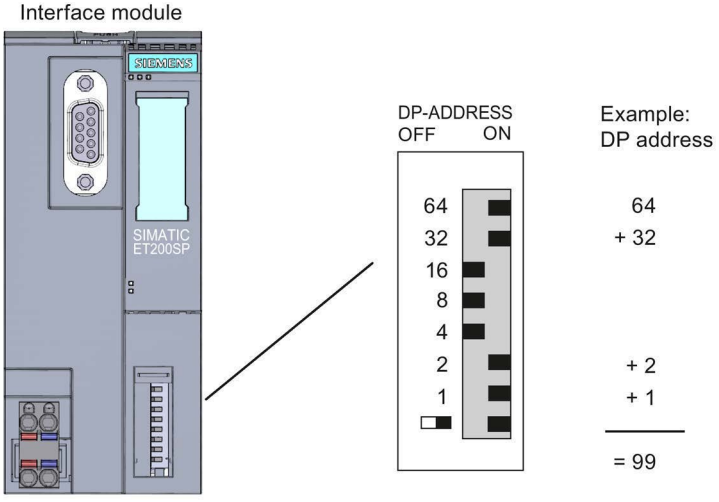


Figure 3-2 Setting the PROFIBUS DP address

Changing the PROFIBUS DP address

You can change the PROFIBUS DP address in exactly the same way as you set it. **A change in the PROFIBUS DP address only becomes valid for the ET 200SP** after a POWER ON of the interface module.

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 DP HF interface module

The following table shows the parameters for the IM 155-6 DP HF interface module.

Table 4- 1 Parameters for IM 155-6 DP HF interface module (GSD file)

Parameters	Value range	Default[3]	Effective range
Configuration control [1]	Disable/enable	Disable	ET 200SP
Startup when preset/actual configuration differ	Yes/No	No	ET 200SP
Diagnostics interrupt	Yes/No	Yes	ET 200SP
Hardware interrupt	Yes/No	Yes	ET 200SP
Pull/plug module interrupt[2]	Yes/No	No	ET 200SP

[1] Note that the "Startup if preset configuration does not match actual configuration" parameter is always activated when you use configuration control.

[2] The “Pull/plug” parameter is always activated in the GSD file.

[3] The defaults apply to the default startup. If no other parameters are specified by the DP master, the IM 155-6 DP HF starts up with these parameters.

Note

Only for configuration using the PROFIBUS GSD file, does not affect configuration with STEP 7 via HSP:

Not all parameters of an I/O module are provided by the GSD file with GSD configuration, because the PROFIBUS standard limits the number of parameters to 244 bytes per ET 200SP. These parameters can be configured later using data record 128, if necessary. The description is available in the respective manual of the employed I/O module.

Note

PROFIBUS GSD configuration as of STEP 7 V5.5 SP3

The universal module must not be configured.

4.2 Description of parameters

4.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

Note

Configuration control

The "Configuration control" function can only be used if you set the parameter "Startup if preset configuration does not match actual configuration" to yes at the same time.

Note

Configuring the enable

If you configure the enable, the ET 200SP distributed I/O system requires control data record 196 from the user program so that the ET 200SP distributed I/O system can operate the I/O modules.

Reference

You can find additional information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.2.2 Startup when expected/actual config differ

If the parameter is enabled and

- modules are removed and inserted during operation, this does not lead to a station failure of the ET 200SP distributed I/O system.
- If the preset configuration does not match the actual configuration, the ET 200SP distributed I/O system continues to exchange data with the DP master.

If the parameter is disabled and

- modules are removed and inserted during operation, this leads to a station failure of the ET 200SP distributed I/O system.
- If the preset configuration does not match the actual configuration, data exchange does not take place between the DP master and the ET 200SP distributed I/O system.

4.2.3 Diagnostic interrupt

You can use this parameter to enable or disable diagnostic interrupts.

4.2.4 Hardware interrupt

You can use this parameter to enable or disable hardware interrupts.

4.2.5 Insert/remove module interrupt

You can use this parameter to enable or disable insert/remove module interrupts.

4.3 Substitute value behavior

The substitute value behavior is implemented by the DP master per slot in the ET 200SP distributed I/O system.

The respective output reacts according to its configured substitute value behavior:

- Current-free/voltage-free
- Keep last value
- Output substitute value

The substitute value behavior is triggered in the following cases:

- STOP DP master
- DP master failure (connection interruption)
- Firmware update
- Station stop, for example, due to:
  - No server module
  - At least one I/O module installed on an incorrect BaseUnit
- Deactivate DP slave

Note

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the new configuration to the CPU, the modules no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage on the BaseUnit BU...D or on the interface module is switched off.

The "current-free/voltage-free" behavior takes effect in the following cases:

- Firmware update
- Configuration control: receipt of a new control data record
- Incorrectly configured module
- Module with incorrect parameter assignment

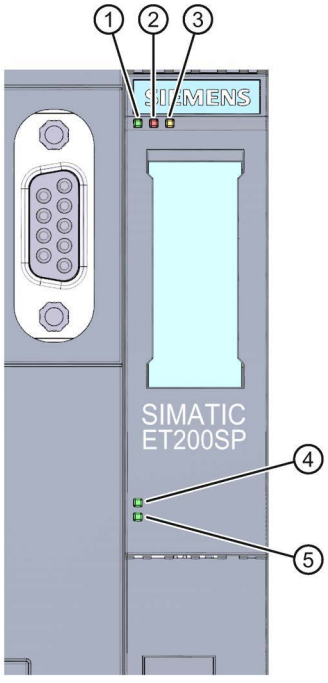
Interrupts, error messages, diagnostics and system alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED display on the interface module:



① RN (green)
② ER (red)
③ MT (yellow)
④ DP (green)
⑤ PWR (green)

Figure 5-1 LED displays on the interface module

Meaning of the LED displays

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 5- 1 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Remedy
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	No or too little supply voltage at interface module	Check the supply voltage or switch it on at the interface module.[1]
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
Flashes	Off	Off	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the DP master.	-
Not relevant	Flashes	Not relevant	Group error and group error channels	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration of the ET 200SP.	Check the configuration of the ET 200SP to see whether a module is missing or faulty, or whether a non-configured module is inserted.
			Invalid configuration states	See the Invalid configuration states of the ET 200SP on PROFINET DP (Page 45) section.
			Parameter assignment error in the I/O module	Evaluate the display of the module status in STEP 7 and correct the error in the corresponding I/O module.
Not relevant	Not relevant	On	Maintenance is demanded.	Perform maintenance
Flashes	Flashes	Flashes	Hardware or firmware faulty.[2]	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

1 PWR LED On (on interface module): Check the backplane bus for a short-circuit.

2 DP LED Off

PWR LED on the interface module

Table 5- 2 Status display of the PWR LED

PWR LED	Meaning	Remedy
□ Off	No or too little supply voltage	Check the supply voltage.
■ On	Supply voltage present	-

LED DP on the RS485 interface

Table 5- 3 Status display of the DP LED

LED DP	Meaning	Remedy
□ Off	There is no connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (for example, DP master).	Check whether the bus cable to the DP master is broken.
■ On	There is a connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (for example, DP master).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interface module by the ERROR (red) and MAINT (yellow) LEDs.

The following configuration errors are signaled by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After a notification by means of a flashing signal, the error type and then the error location/error code are displayed in each case.

The LED error display:

- Is activated during POWER ON and during operation
- Has priority over all other states that are displayed by means of the ERROR- and MAINT-LED
- Remains on until the cause of the error has been eliminated

Table 5- 4 Display of error type and error location

Sequence		Description
1	ERROR- and MAINT-LED flash 3x with 0.5 Hz	Indication of the error type
2	MAINT-LED flashes with 1 Hz	Display of error type (decimal)
3	ERROR- and MAINT-LED flash 3x with 2 Hz	Indication of error location/error code
4	ERROR-LED flashes with 1 Hz	Display of the tens position (decimal) of the error location/error code
5	MAINT-LED flashes with 1 Hz	Display of the units position (decimal) of the error location/error code
6	Repetition of 1 to 5 until the cause of the error has been eliminated.	

Error display

The following table shows the possible causes of error that can occur.

Table 5- 5 Error display

Error type (MAINT)	Error location (ERROR/MAINT)	Cause of error	Solution
1	33*	• No server module • Interruptions on the backplane bus • Short-circuit on the backplane bus	Check the configuration of the ET 200SP.

* Slot

Note

The following LEDs indicate a short-circuit in the backplane bus supply or in the bus connection supply:

- PWR-LED: On
- RN-, ER- and MT-LED: Off

5.2 Interrupts

5.2.1 Introduction

Definition

The interrupt section of the slave diagnostics indicates the interrupt type and the event that led to an interrupt being triggered. The interrupt section comprises 62 bytes including an interrupt header.

Position in the diagnostics frame

The interrupt section is located after the channel diagnostics.

Data record

The diagnostic data of a module are located in the data records 0 and 1:

- Data record 0 contains 4 bytes of diagnostics data that describe the current status of the distributed I/O system. DS0 is part of the header information of OB 82 (local data bytes 8 to 11).
- Data record 1 contains 4 bytes of diagnostics data that are also available in data record 0.

The figure below shows the structure of data record 1:

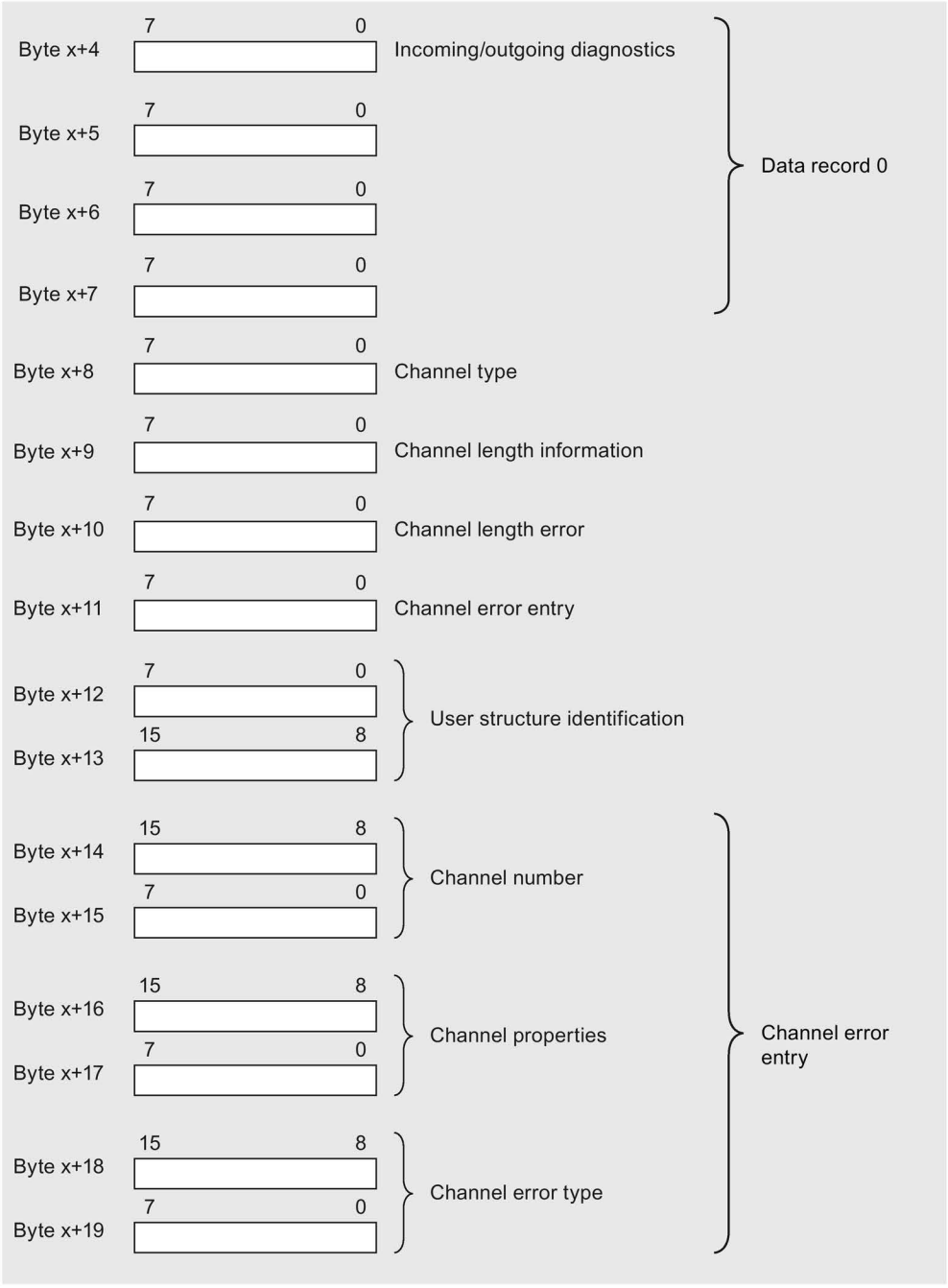


Figure 5-2 Structure of data record 1

Reading data records

DS0 and DS1 can be read with SFC 59 (RD_REC) or SFB 52 (RDREC). The data length of DS 1 can be up to 240 bytes. In this case, DS1 includes up to 38 channel error entries.

Note the figures below in this section.

Content

The contents of the interrupt information depend on the interrupt type:

- In the case of diagnostic interrupts, diagnostic data record 1 (up to 58 bytes) is sent as interrupt status information (starting from byte x+4).
- The length of the interrupt status information for hardware interrupts is 4 bytes.

Structure of interrupts

The figure below shows the structure of the interrupt section for the ET 200SP distributed I/O system:

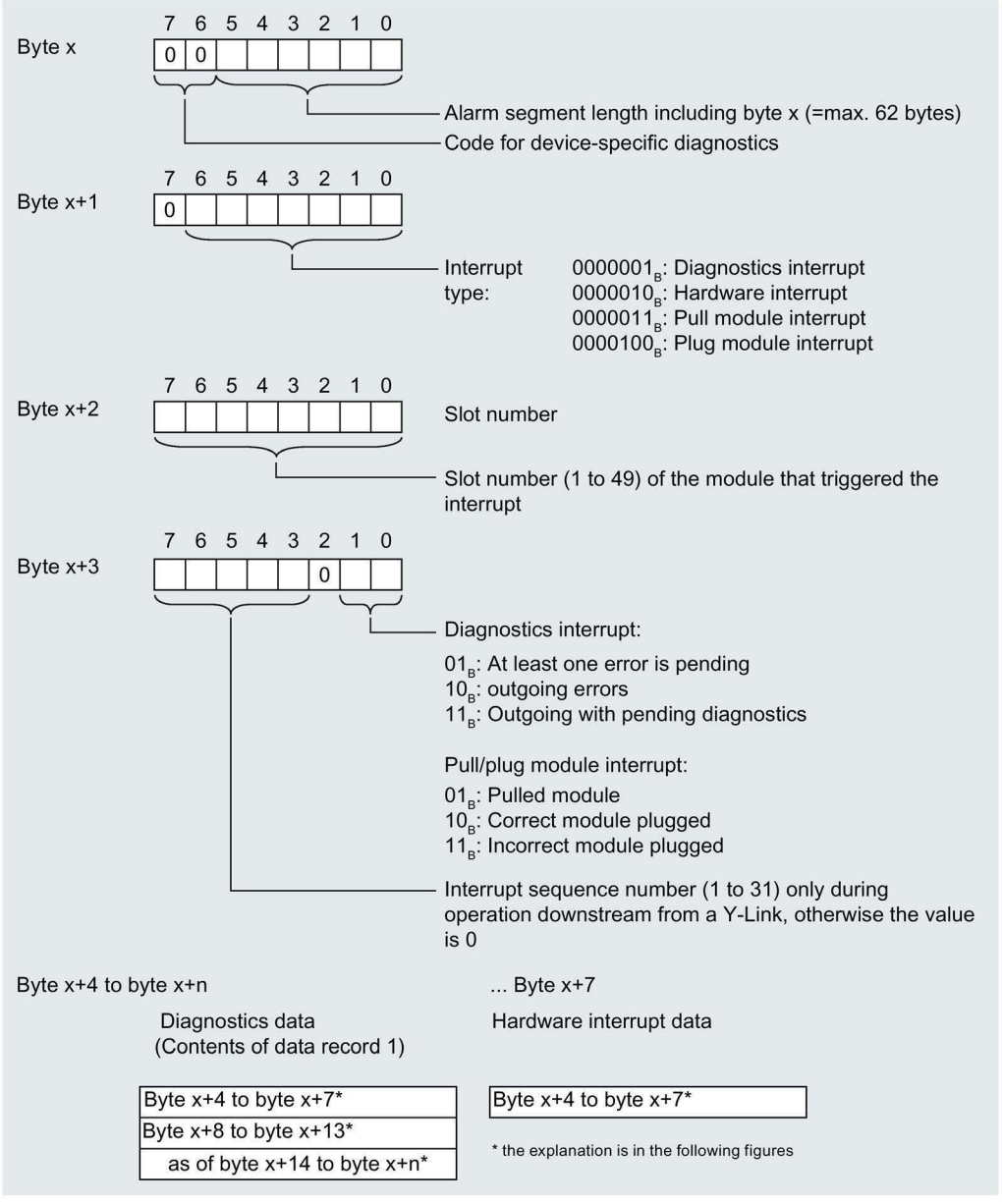


Figure 5-3 Structure of the interrupt status of the interrupt section

Diagnostic interrupt, byte x+4 to x+7

The figure below shows the structure starting at byte x+4 to x+7 for diagnostic interrupt:

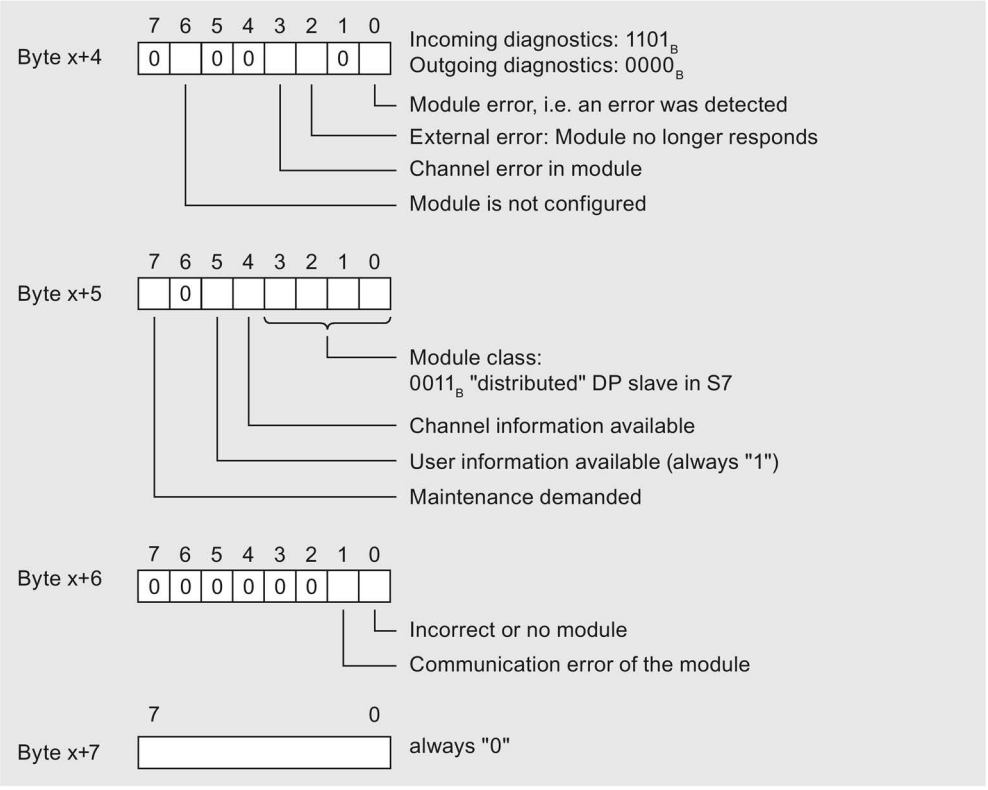


Figure 5-4 Structure of bytes x+4 to x+7 for diagnostic interrupt

Diagnostic interrupt from the modules, starting at byte x+8

The figure below shows the structure starting at byte x+8:

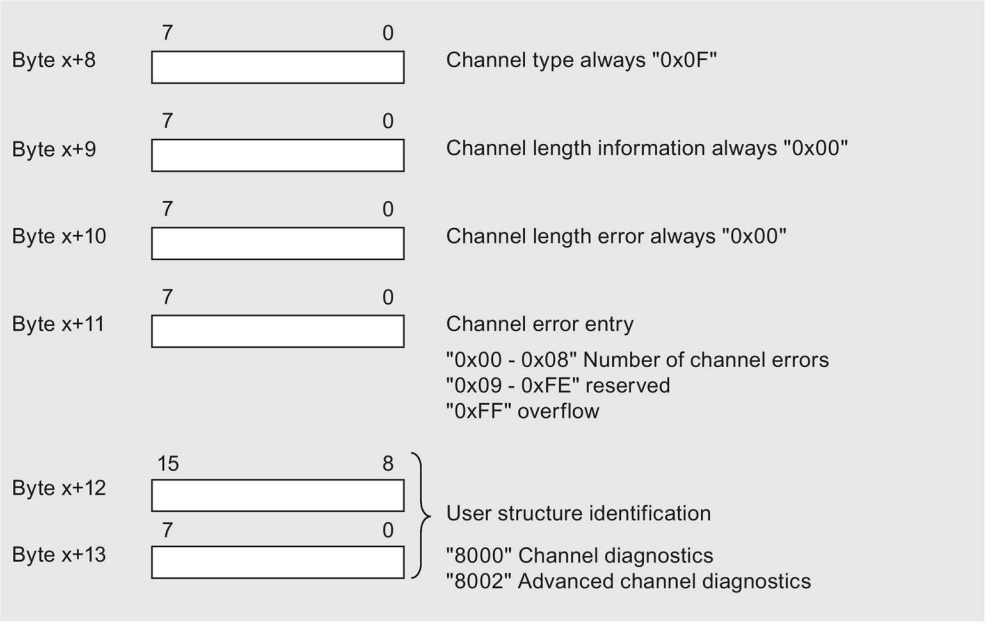


Figure 5-5 Structure starting at byte x+8

Diagnostic interrupt from the modules, starting at byte x+14

The channel error entries start from byte x+14. A channel error entry is 6 bytes long and can follow 8 times starting from byte x+14.

If you read the channel error entries using an SFB or SFC, 38 channel diagnostics are possible.

The figure below shows the structure starting at byte x+14:

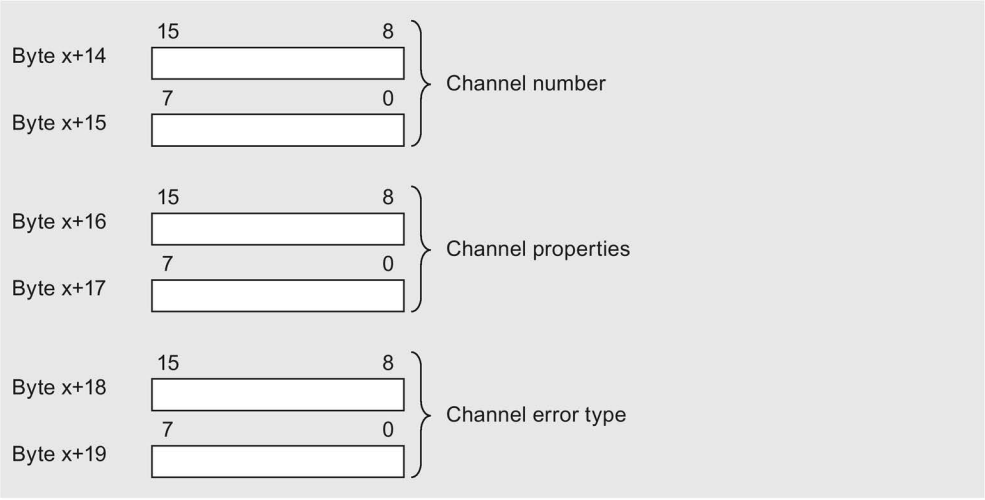


Figure 5-6 Structure starting from byte x+14

The following table is used to explain the channel error entries:

	Description	
Channel number	0 to 63: Channel number for channel error 0x8000: Entire submodule	
Channel properties	Bit 0 to 7	00_H: Free data type 01_H: bit 02_H: 2 bit 03_H: 4 bit 04_H: byte 05_H: word 06_H: Double word 07_H bis FF_H: Reserve
	Bit 8	0: Channel 1: Channel group
	Bit 9, 10	00_H: Diagnostics 01_H: Maintenance demanded 02_H: Maintenance required 03_H: Reserve
	Bit 11, 12	00_H: Channel error-free 01_H: Incoming diagnostics 02_H: Outgoing diagnostics 03_H: Outgoing diagnostics, but other diagnostics are also pending on this channel
	Bit 13 to 15	00_H: Reserve 01_H: Input channel 02_H: Output channel 03_H: Input/output channel
Channel error type	Refer to respective manual for explanation.	

Example of a diagnostic interrupt

The figure below shows an example of a diagnostic interrupt (part 1):

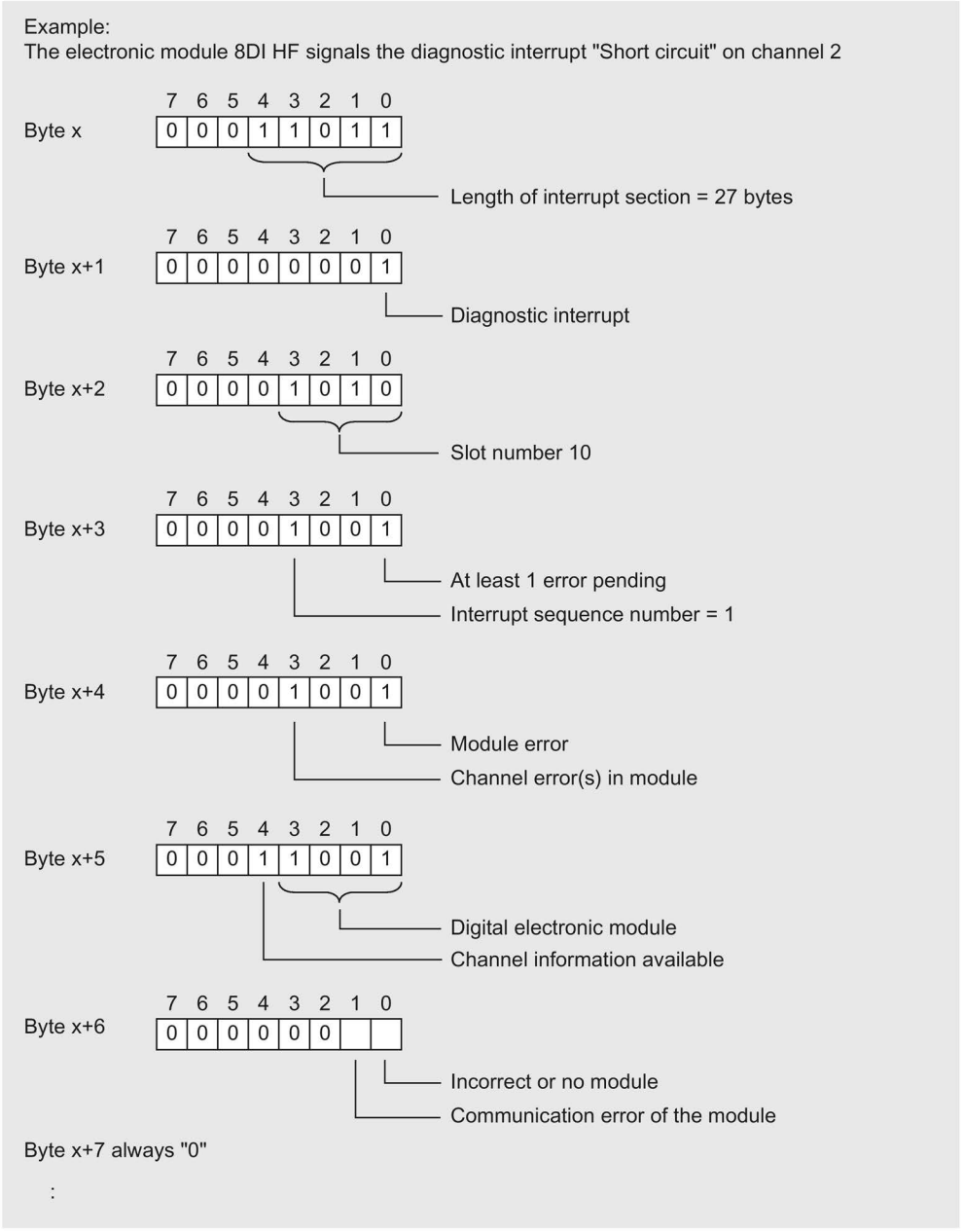


Figure 5-7 Example of a diagnostic interrupt (part 1)

The figure below shows an example of a diagnostic interrupt (part 2):

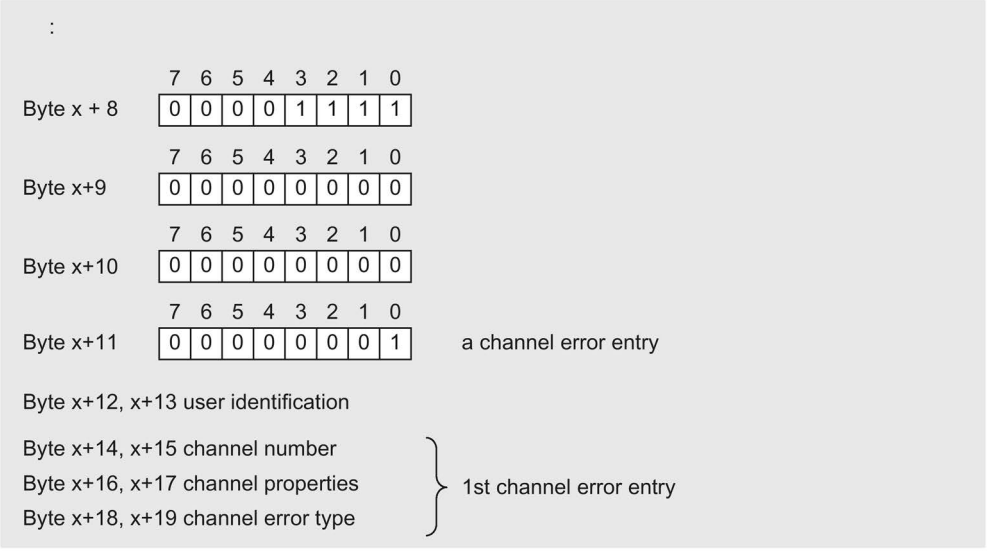


Figure 5-8 Example of a diagnostic interrupt (part 2)

Hardware interrupt of digital and analog input modules

The figure below shows the structure starting at byte x+4 for the hardware interrupt:

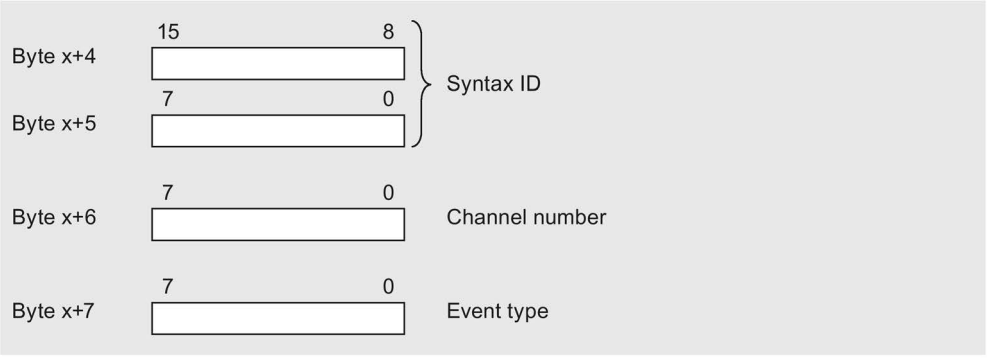


Figure 5-9 Structure starting at byte x+4 for hardware interrupt

5.2.2 Evaluating interrupts of ET 200SP

Introduction

With certain process statuses/errors, the DP slave in each case creates an interrupt block with the corresponding information in the diagnostics frame (DPV1 interrupt mechanism). Regardless of this, the diagnostic status of the DP slave is displayed in the identifier-related diagnostics, in the module status, and in the channel diagnostics.

Interrupts in DPV1 mode

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic interrupts
- Hardware interrupts
- Insert/remove module interrupts

5.2.3 Triggering of a diagnostics interrupt

When an event comes or goes (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if "Enable: diagnostic interrupt" is set.

The CPU interrupts user program execution and processes the diagnostic interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.

5.2.4 Triggering a hardware interrupt

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the hardware interrupt OB, for example OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt OB.

Note

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for technological purposes (e.g., cyclical generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.5 Triggering an insert/remove module interrupt

When an insert/remove module interrupt occurs, the CPU interrupts execution of the user program and processes the insert/remove module interrupt OB (OB 83). The event that triggered the interrupt is entered in the start information of the insert/remove module interrupt OB.

5.3 Alarms

Actions after a diagnostics alarm in DPV1 mode

The error is entered in the channel diagnostics in the diagnostics frame:

- In DPV1 mode, diagnostics can be reported as diagnostic interrupts.
- After a diagnostics alarm, this is
  - entered in the diagnostics frame as diagnostic interrupt block (always for one interrupt only).
  - Stored in the diagnostics buffer of the CPU.
- The ERROR LED of the interface module flashes.
- OB 82 is called. If OB 82 does not exist, the CPU changes to STOP mode.
- Acknowledgment of diagnostic interrupt (a new interrupt is then possible)

Length of the diagnostics frame

- The maximum frame length for the ET 200SP distributed I/O system with IM155-6 DP HF interface module (DPV1 mode) is 244 bytes.
- The minimum frame length is 6 bytes.

Reading out the diagnostics data

Table 5- 6 Reading out the diagnostics data with STEP 7

Automation system with DP master	Application	See...
SIMATIC S7/M7	Slave diagnostics data as plain text in the "DP slave diagnostics" tab in the STEP 7 user interface	"Diagnosing hardware" in the STEP 7 online help
	Instruction "DP NRM_DG" (SFC 13) Reading out slave diagnostics (store in the data area of the user program)	SFC, see STEP 7 online help
	Instruction "RD_REC" (SFC 59) Reading out data records of the S7 diagnostics data (store in the data area of the user program)	See System and Standard Functions reference manual
	Instruction "RDREC" (SFB 52) Reading data records from the DP slave	SFB, see STEP 7 online help (system functions/function blocks)
	Instruction "RALRM" (SFB 54) Receiving interrupts from the interrupt OBs	SFB, see STEP 7 online help (system functions/function blocks)

5.3.1 Slave diagnostics

The figure below shows the structure of the slave diagnostics.

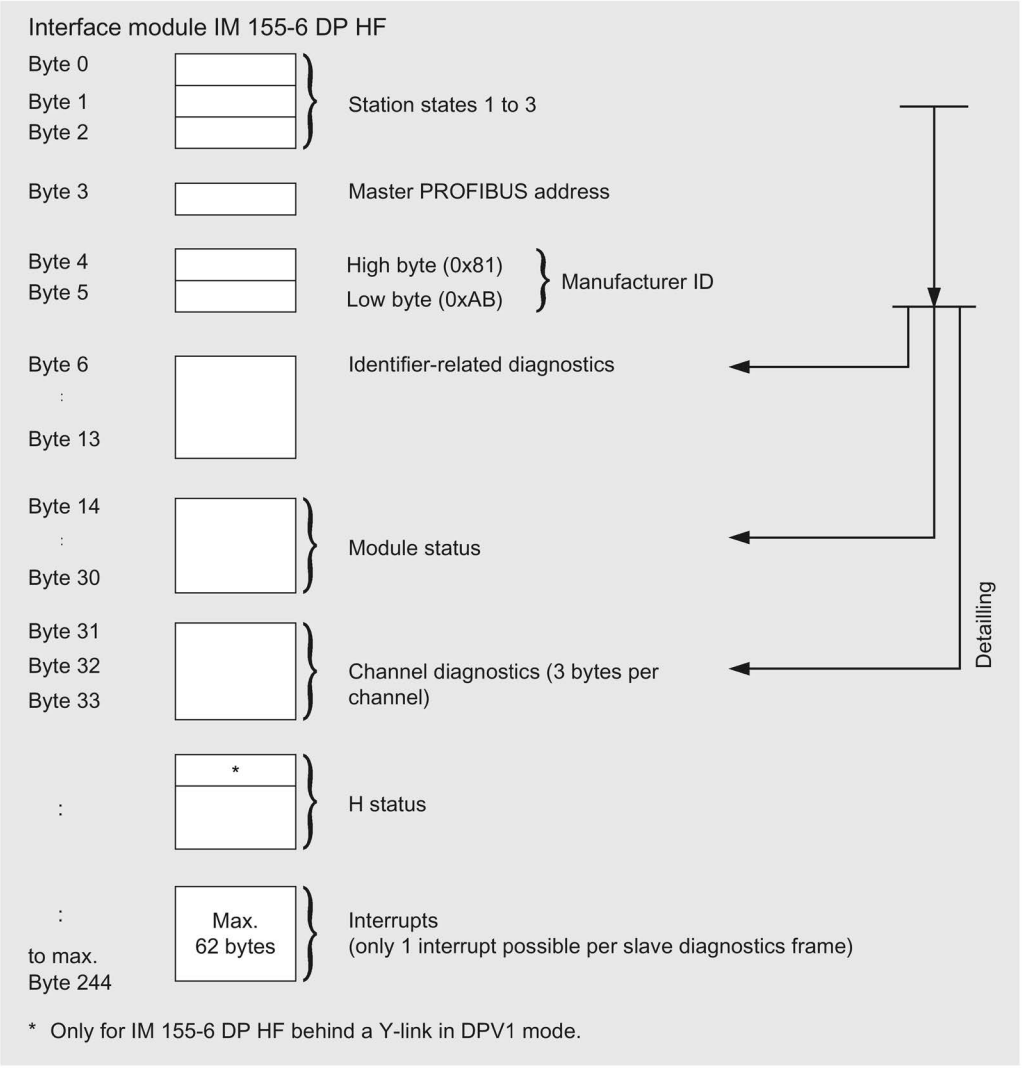


Figure 5-10 Structure of the slave diagnostics

Note

The length of the diagnostics frame varies with the IM 155-6 DP HF (depending on parameter assignment) between 6 and 244 bytes in DPV1 mode.

You can identify the length of the last received diagnostics frame in STEP 7 from the RET_VAL parameter of the SFC 13.

5.3.2 Station statuses 1 to 3

Station statuses 1 to 3 provide an overview of the status of a DP slave.

Structure of station status 1 (byte 0)

Table 5- 7 Structure of station status 1 (byte 0)

Bit	Meaning	Cause/Remedy
0	1: The DP slave is not responding to the DP master.	• Is the correct PROFIBUS address set on the DP slave? • Is the bus connector plugged in? • Is the DP slave connected to the voltage supply? • Is the RS485 repeater properly configured?
1	1: The DP slave is not yet ready to exchange data.	• Wait; the DP slave is currently starting up.
2	1: The configuration data transferred from the DP master to the DP slave does not match the DP slave configuration.	• Has the correct station type or the correct DP slave configuration been entered in the configuration software?
3	1: External diagnostics is available. (Group diagnostics display)	• Evaluate the ID-specific diagnostics, the module status, and/or the channel diagnostics. As soon as all errors have been eliminated, bit 3 is reset. The bit is set again when there is a new diagnostics alarm in the bytes of the aforementioned diagnostics.
4	1: The required function is not supported by the DP slave (for example, changing the PROFIBUS address by means of software).	• Check the configuration.
5	1: The DP master cannot interpret the response of the DP slave.	• Check the bus configuration.
6	1: The DP slave type does not match the software configuration.	• Has the correct station type been entered in the configuration software?
7	1: Parameters have been assigned to the DP slave by a different DP master (not the one that currently has access to the DP slave).	• The bit is always 1, for example, if you access the DP slave with the programming device or another DP master. • The PROFIBUS address of the DP master that assigned parameters to the DP slave is located in the "Master PROFIBUS address" diagnostics byte.

Structure of station status 2 (byte 1)

Table 5- 8 Structure of station status 2 (byte 1)

Bit	Meaning	
0	1:	The DP slave parameters need to be reassigned.
1	1:	A diagnostics alarm is present. The DP slave will not operate until the problem is eliminated (static diagnostics alarm).
2	1:	The bit on the DP slave is always "1".
3	1:	The watchdog is activated for this DP slave.
4	1:	The DP slave has received the "FREEZE" control command.[1]
5	1:	The DP slave has received the "SYNC" control command.[1]
6	0:	Bit is always "0".
7	1:	The DP slave is disabled, that is, it has been removed from the processing in progress.
[1] The bit is updated only if another diagnostics alarm also changes.		

Structure of station status 3 (byte 2)

Table 5- 9 Structure of station status 3 (byte 2)

Bit	Meaning	
0 to 6	0:	Bits are always set to "0".
7	1:	• There are more diagnostic alarms pending than the DP slave is able to store. • The DP master cannot enter all the diagnostics alarms sent by the DP slave in its (channel) diagnostics buffer.

5.3.3 Master PROFIBUS address

The master PROFIBUS address diagnostics byte contains the PROFIBUS address of the DP master:

- That assigned parameters to the DP slave
- That has read and write access to the DP slave

The master PROFIBUS address is located in byte 3 of the slave diagnostics.

5.3.4 Identifier-related diagnostics

The identifier-related diagnostics indicates whether modules of the ET 200SP distributed I/O system have errors or not. Identifier-related diagnostics start at byte 6 and comprise 8 bytes.

The figure below shows how the identifier-related diagnostics for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

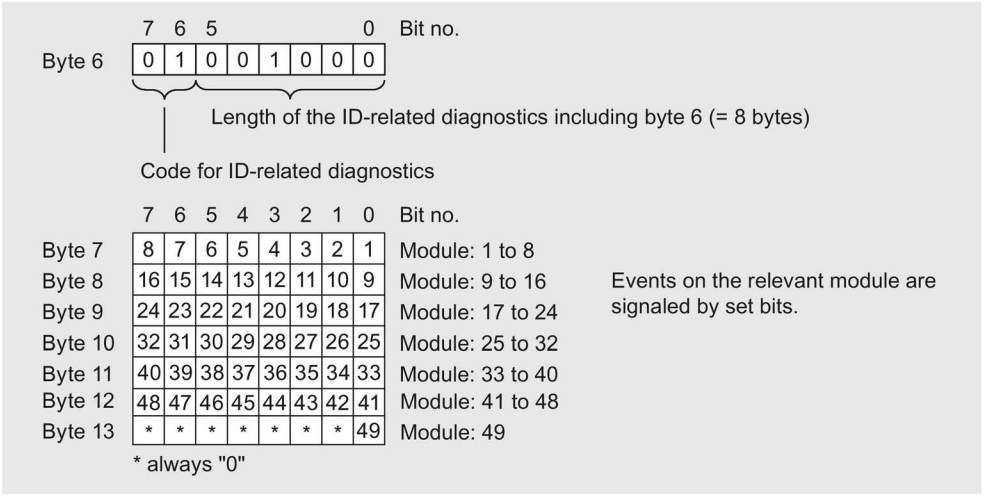


Figure 5-11 Structure of the identifier-related diagnostics

5.3.5 Module status

The module status indicates the status of the configured modules and provides more information on the identifier-related diagnostics with respect to the configuration. The module status begins after the identifier-related diagnostics and comprises 17 bytes.

The following figure shows how the module status for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

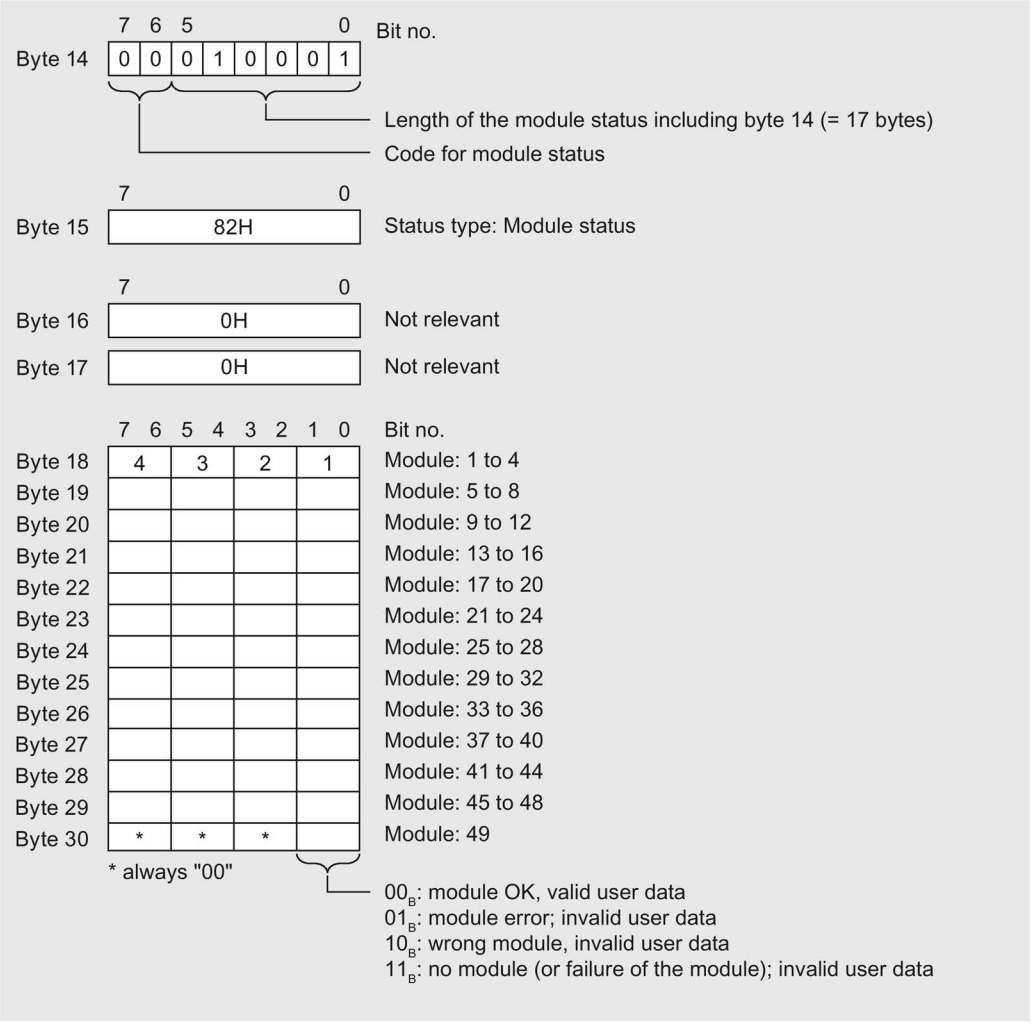


Figure 5-12 Module status structure

5.3.6 Channel diagnostics

Channel diagnostics provides information about channel errors in modules and details of the identifier-related diagnostics. Channel diagnostics begins after the module status. Channel diagnostics does not affect the module status.

The following figure shows how the channel diagnostics for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

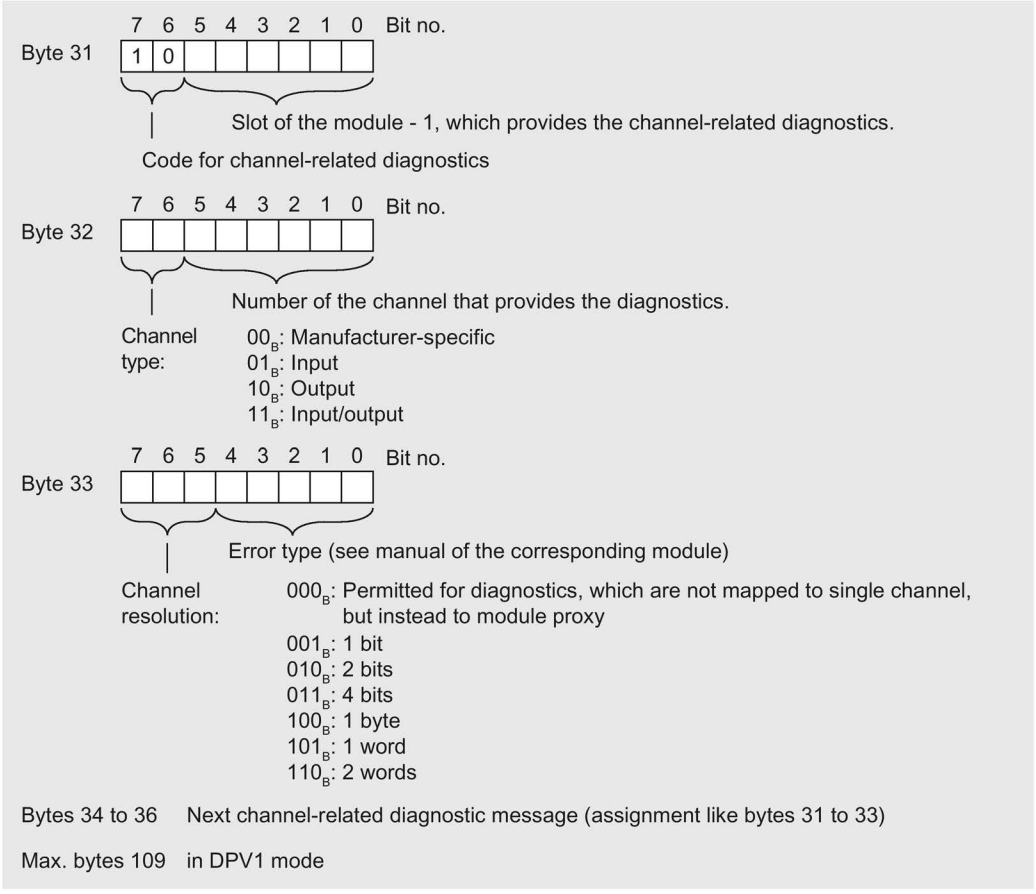


Figure 5-13 Structure of channel diagnostics

When a BaseUnit is incorrectly configured, mapping is made to channel diagnostics. The slot is then apparent from the first byte. In this case, the error type is coded with 0x10 - parameter error. All other fields are set to "0".

5.3.7 H status

Requirements

The H status in the diagnostics frame supplies the IM 155-6 DP HF interface module only when operated behind a Y link (e.g. IM 157) in DPV1 mode. This block can be passed over during the evaluation of the diagnostics frame. The configuration is described in the following section.

Structure of the H status

The following figure shows the structure of the H status of the IM 155-6 DP HF interface module.

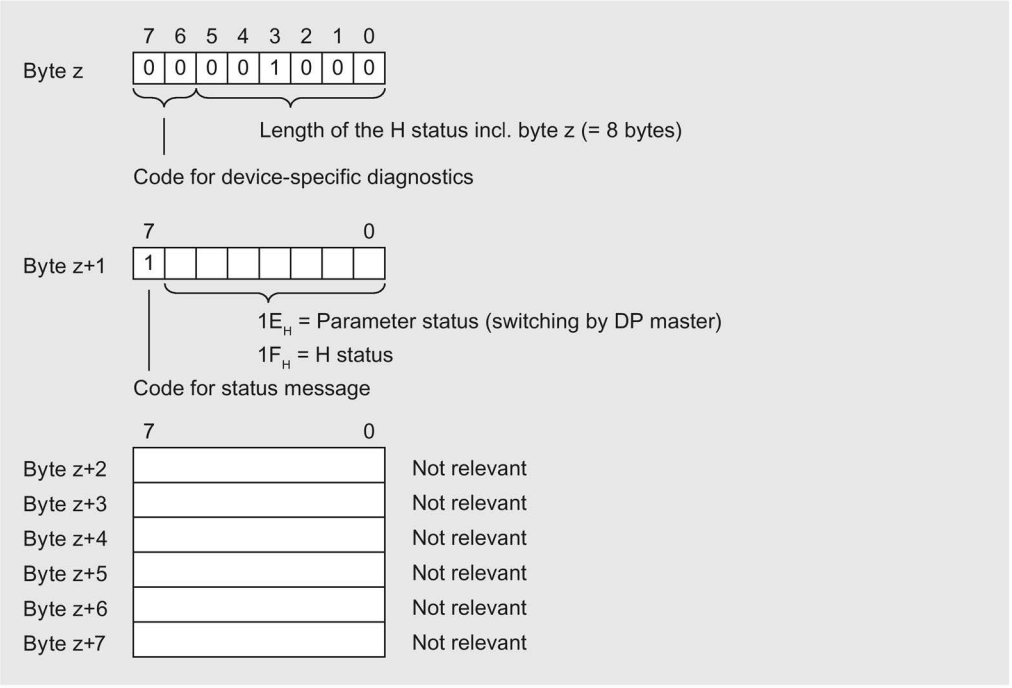


Figure 5-14 Structure of the H status

5.3.8 Invalid configuration states of the ET 200SP on PROFIBUS DP

Incorrect configuration states

The following incorrect configuration states of the ET 200SP distributed I/O system lead to a failure of the DP slave or prevent the start of data exchange.

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g., defective BaseUnit). No interrupt is generated when the ET 200SP backplane bus is interrupted
- No server module
- Configuration exceeds maximum length of 1 m
- Configuration of an incorrect BaseUnit

Note

All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) at a station stop. However, the interface module will continue to exchange data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

Diagnostics

The table below shows the incorrect configurations and their diagnostics:

Table 5- 10 Diagnostics

Identifier-related diagnostics	Module status	Cause	Response
Slot 33 set, remaining slots not relevant	Slot 33 with 11_B: ""No module; invalid user data" set	• No server module • More than 32 I/O modules • Defective backplane bus	All I/O modules and interface modules fail
All 33 bits set	01_B: "Module error; invalid user data" for all modules	• Configuration > 1 m	All I/O modules and interface modules fail

If the BaseUnit is configured incorrectly, the channel diagnostics "Parameter assignment error" is signaled for the respective slot. Check the parameter "Potential group“ in the parameters of the I/O module.

5.3.9 Load voltage failure on the BaseUnit BU...D

Load voltage failure

If supply voltage fails on the BaseUnit BU...D, the I/O modules react as follows:

- A remove module interrupt is generated if an I/O module is removed during the failure of the supply voltage.
- An insert module interrupt is generated if an I/O module is inserted during the failure of the supply voltage.

Compatibility

6

6.1 Compatibility of modules

Valid firmware versions

The table below lists the valid firmware versions and their field of application for the I/O modules.

I/O modules	Firmware version	Comment
DI 8x24VDC ST	V1.0.1	As of this version, you have the option to operate I/O modules after an IM 155-6 DP HF (6ES7155-6BA00-0CN0) interface module.
DI 16x24VDC ST		
DQ 4x24VDC/2A ST		
DQ 8x24VDC/0.5A ST		
DQ 16x24VDC/0.5A ST		
AI 4xI 2-,4-wire ST		
AI 4xU/I 2-wire ST		
AI 4xRTD/TC 2-,3-,4-wire HF		
AQ 4xU/I ST		

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules without parameter assignment in the following table, the status of the supply voltage (status byte of the server module) is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7132-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7132-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0.5A HF	6ES7131-6BF00-0CA0

Firmware update

A firmware update from V01.00.00 to V01.01.00 requires a preceding update of the IM 155-6 DP HF boot code via the interim version S01.00.01. The firmware V01.01.00 is not accepted by the IM 155-6 DP HF without an update of the boot code.

Procedure for a firmware update:

IM 155-6 DP HF with FW V01.00.00 is present

1. Update of boot code to S01.00.01 according to the description below
2. Update of the firmware to V01.01.00

Procedure for updating the boot code:

S01.00.01 is only intended for updating the boot code. It cannot be used to exchange data with the interface module.

1. An update to S01.00.01 is made based on V01.00.00. Do **not** select "Activate firmware after download"!
2. Switch the IM 155-6 DP HF off and on again.
   Run, Error and Maintenance LEDs light up briefly twice.
   The boot code update is complete when the Run LED flashes quickly (2 Hz) and the Maintenance LED flashes slowly (0.5 Hz). If this LED pattern is present immediately after switching on the device, the boot code is already up-to-date.
   NOTICE:Do not disconnect the IM 155-6 DP HF from the power supply until the Run and Maintenance LEDs flash as described.
3. Firmware update to V01.01.00.

Plugging and pulling (hot-swapping) of ET 200SP I/O modules

NOTICE
Pulling and plugging (hot swapping) of ET 200SP I/O modules during operation on S7-300 via PROFIBUS **DP** Pulling and plugging of ET 200SP I/O modules is possible: • as of STEP7 V5.5 SP3 HSP 242 and • if “Operation at Preset <> Actual” parameter is enabled. Note the following when operating the ET 200SP with S7-300 via PROFIBUS DP: Plugging of ET 200SP I/O modules results in a brief station failure of the ET 200SP.

Note

ET 200SP I/O modules can be pulled and plugged without restrictions for all other DP master systems if you enable the “Pull/plug module (OB83)" parameter.

Communication module IO-Link Master CM 4xIO-Link

Note

Communication module IO-Link Master CM 4xIO-Link

Operation of the CM 4xIO-Link IO-Link Master communication module with the IM 155-6 DP HF interface module is supported as of S7-PCT V3.1 and an updated module firmware version/GSD file.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules: **Maximum reaction time = 2.3 ms**

First BaseUnit of an ET 200SP in the configuration (as of V3.0)

Note

First BaseUnit of an ET 200SP in the configuration

The first BaseUnit of an ET 200SP station may be a dark one, if an AC I/O module or AI Energy Meter ST is plugged. Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

A light-colored BaseUnit must be inserted on the slot of the first 24 V DC I/O module in order to route the 24 V DC supply voltage via a fuse.

Note the type of the BaseUnits during the configuration.

As of firmware V3.x, the interface modules support plugging dark-colored BaseUnits in slot 1. This means that modules which do not have a connection to the integrated voltage buses P1 and P2 can now also be configured starting with slot 1. This currently includes the following modules:

- AI EnergyMeter ST (6ES7134-6PA00-0BD0)
- DI 4x120..230VAC ST (6ES7131-6FD00-0BB1)
- DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)
- RQ 4x120..230VAC/5A NO ST (6ES7132-6HD00-0BB1), FW 1.1.0

Requirement for configuration of these modules in slot 1:

- Configuration via GSD or GSDML
- Configuration as of STEP7 V5.5 SP4 with
  - HSP0241 V2.0 for IM155-6 PN ST
  - HSP0242 V2.0 for IM155-6 DP HF
  - HSP0255 V3.0 for IM155-6 PN HF
- Configuration as of STEP7 V13 SP1

Station extension via ET-Connection

Note

If a module on which the configuration control was activated with a valid control data record is upgraded to FW version V3.0.0, the retentivity of the control data record is lost when the firmware is updated. The control data record must be written again to the module in this case.

Technical specifications

7

7.1 Technical specifications

Technical specifications of the IM 155-6 DP HF

Table 7- 1 Technical specifications of the IM 155-6 DP HF

	6ES7155-6BA00-0CN0
Product type designation	IM155-6DP HF with PROFIBUS connector and server module
General information	
Firmware version	V3.1
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP4 or higher
PROFIBUS as of GSD version/GSD revision	GSD as of revision 5
Configuration control	
Via data record	Yes
Supply voltage	
Voltage type of the supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption, max.	250 mA
Inrush current, max.	4.5 A
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	244 bytes; per input/output
Address space per station	
Address space per station, max.	244 bytes; per input/output

	6ES7155-6BA00-0CN0
Hardware configuration	
Rack	
Modules per rack, max.	32; + 16 ET 200AL modules
Interfaces	
Number of interfaces PROFIBUS	1
1st Interface	
Interface hardware	
• RS-485	Yes
• Output current of interface, max.	90 mA
Protocols	
• PROFIBUS DP slave	Yes
Interface hardware	
RS-485	
Transmission rate, max.	12 Mbps
Protocols	
PROFIBUS	
Services	
• SYNC capability	Yes
• FREEZE capability	Yes
• DPV0	Yes
• DPV1	Yes
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	
Interrupts	Yes
Diagnostics alarms	
Diagnostics functions	Yes
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
MAINT LED	Yes; yellow LED
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Connection display DP	Yes; green DP LED
Electrical isolation	
Between backplane bus and electronics	No
between PROFIBUS DP and all other circuit components	Yes
Between supply and all other circuits	Yes

	6ES7155-6BA00-0CN0
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Connection system	
ET connection	
via BU/BA Send	Yes; + 16 ET 200AL modules
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	150 g

Dimension drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

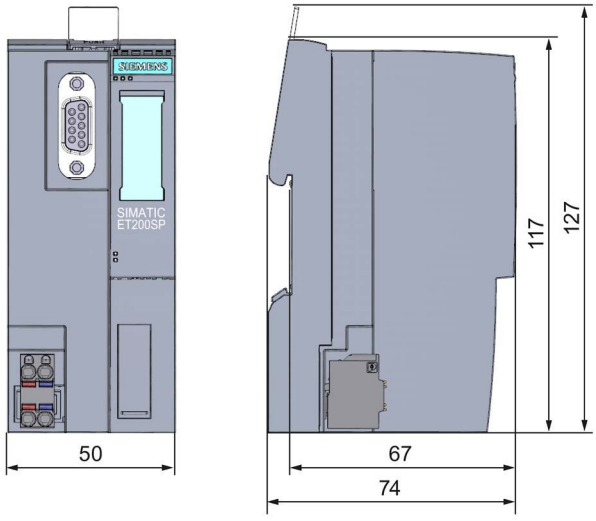


Figure A-1 Dimension drawing of the IM 155-6 DP HF interface module (front and side view)

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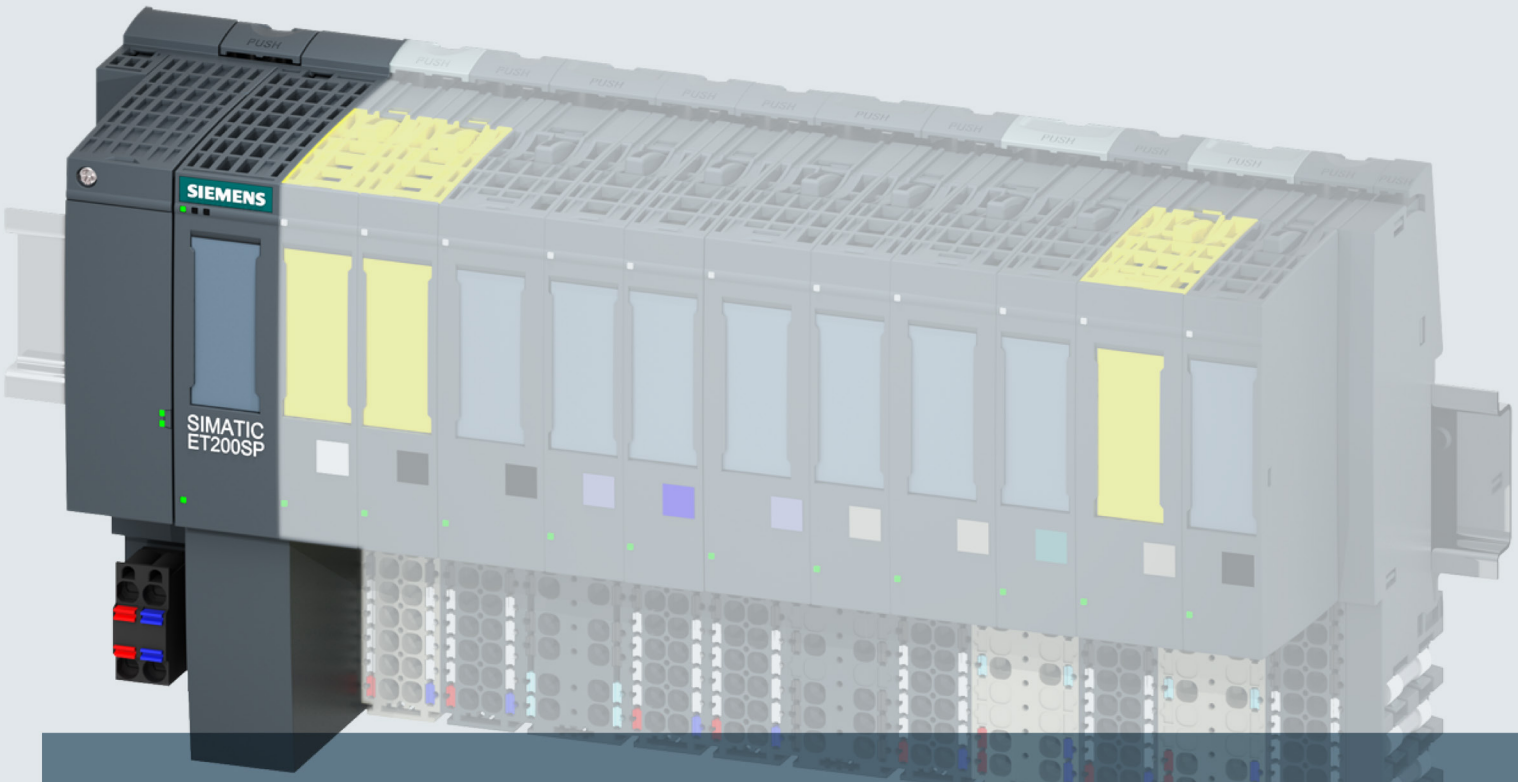

SIMATIC

ET 200SP

Interface module IM 155-6 DP HF (6ES7155-6BA00-0CN0)

Manual

Edition 07/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
IM 155-6 DP HF interface module (6ES7155-6BA00-0CN0)

Manual

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07/2014

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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℗ 08/2014 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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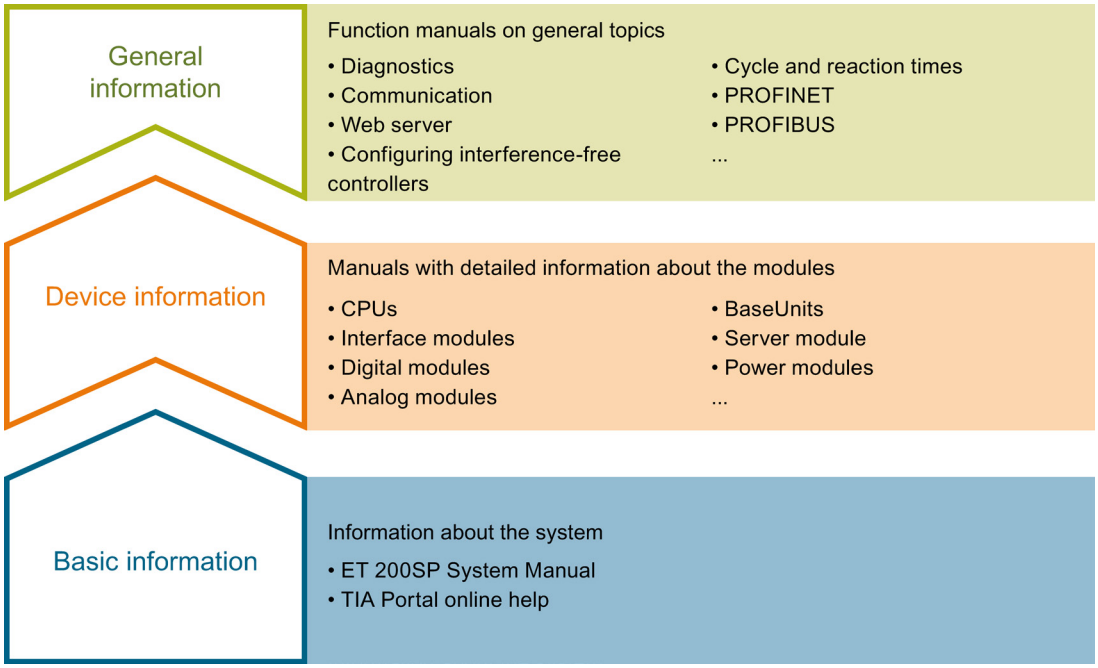
Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics, technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

Product overview

2

2.1 Properties

Article number

6ES7155-6BA00-0CN0

Article number 6ES7155-6BA00-0CN0 contains the following components:

- IM 155-6 DP HF interface module (6ES7155-6BU00-0CN0)
- Server module (6ES7193-6PA00-0AA0)
- PROFIBUS FastConnect bus connector (6ES7972-0BB70-0XA0)

View of the module

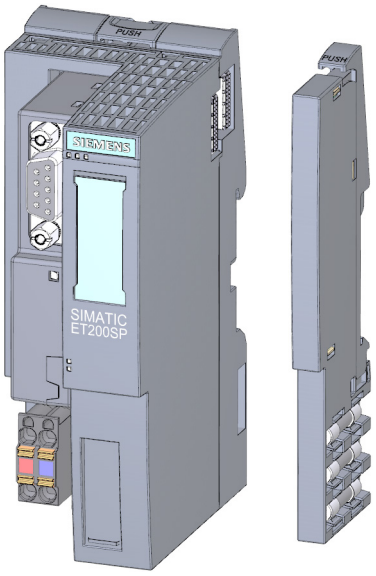


Figure 2-1 View of the 155-6 DP HF interface module with supplied accessories

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFIBUS DP
- Supply voltage 1L+ 24 V DC (SELV/PELV)
- Bus connection via RS485 interface

The module supports the following functions (see (Page 12))

Maximum configuration

- 244 bytes I/O data
- 32 I/O modules

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Server module

The server module is included in the product package of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Provides station functions, e.g., status bytes
- Identification data I&M 0 to 3

Note

You need to configure the server module in the configuration software.

To do so, place the server module with the required length of status bytes at the last slot of the configuration. When there are 32 I/O modules, the server module is inserted at slot 33.

PROFIBUS FastConnect bus connector

The PROFIBUS FastConnect bus connector is included in the product package of the interface module and also available separately as an accessory.

You can find additional information on the PROFIBUS FastConnect bus connector in the corresponding product information on the Internet (http://support.automation.siemens.com/WW/view/en/58648998).

Configuration with more than 244 bytes of parameter data

With a configuration as of STEP 7 V5.5 SP 3 with HSP 242, you have the option of operating the IM 155-6 DP HF interface module as of 6ES7155-6BA00-0CN0 in DPV1 mode with more than 244 bytes of parameter data. Configuration with the GSD file does not offer this option.

Note

With a configuration as of STEP 7 V5.5 SP 3 with HSP 242 without GSD files, a longer startup time of the station is to be expected.

Reference

You can find additional information on identification data in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Functions

Introduction

The interface module supports the following functions:

- Identification data I&M 0 to 3
- PROFIBUS DP
- Firmware update via PROFIBUS DP
- Configuration control by means of the user program
- Operation as DPV1 slave
- Operation after Y-link
- Station extension via ET-Connection

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 DP HF interface module:

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000) / software from a third-party manufacturer[1]	STEP 7 as of V5.5 SP3 with HSP 242	STEP 7 (TIA Portal) as of V13
Operation after Y-link	1	V1.1.0	X	---	---
Hot-swapping	1	V1.0.0	X	X	X
Station extension via ET-Connection	1	V3.0.0	X	---	---

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

2.2.2 Configuration control

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or options. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the Configuration control (Page 19) section
- on the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

Connecting

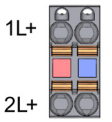
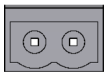
3

3.1 Terminal assignment

24 V DC supply voltage

The table below shows the signal names and descriptions of the pin assignment of the 24 V DC supply voltage.

Table 3- 1 Pin assignment 24 V DC supply voltage

View		Signal name[1)]	Description
Connector	IM connection		
		1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

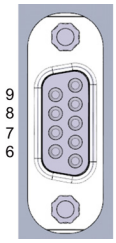
1 1L+ and 2L+ as well as 1M and 2M are internally bridged.

2 Maximum 10 A permitted.

PROFIBUS DP with RS485 interface

The following table shows the signal names and descriptions of the terminal assignment of the PROFIBUS DP interface.

Table 3- 2 Terminal assignment PROFIBUS DP with RS485 interface

View	Signal name		Description
	1	-	-
	2	-	-
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	DP data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	-	-
	8	RxD/TxD-N	Data line A
	9	-	-

Reference

You can find additional information on connecting the interface module and on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Block diagram

The following figure show the block diagram of the IM 155-6 DP HF interface module.

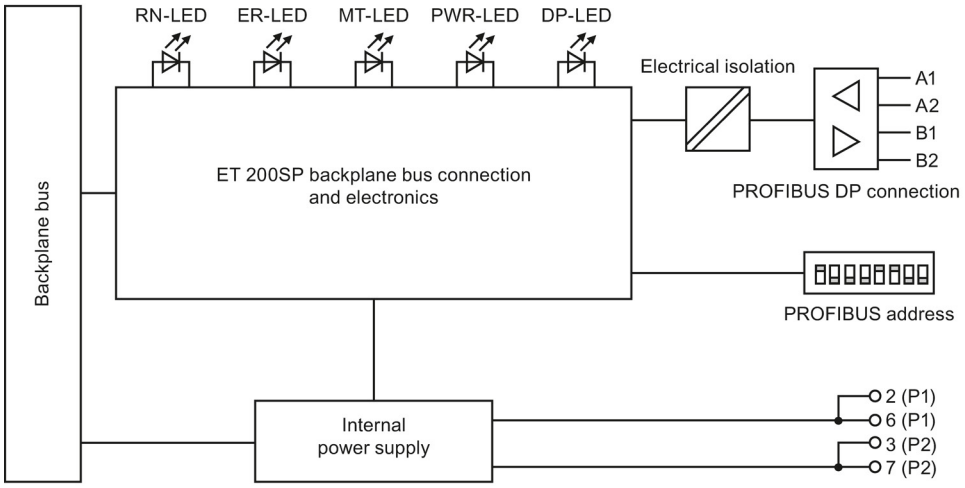


Figure 3-1 Block diagram of the IM 155-6 DP HF interface module

3.3 Setting the PROFIBUS DP address

Introduction

On the interface module (PROFIBUS), set the PROFIBUS DP address for PROFIBUS DP using the DIP switch. By setting the PROFIBUS DP address, you specify where the ET 200SP is to be addressed on the PROFIBUS DP.

Requirements

- Each PROFIBUS DP address may be assigned only once on the PROFIBUS DP.
- Valid PROFIBUS DP addresses are 1 to 125.
- The set PROFIBUS DP address must match the PROFIBUS DP address specified for the ET 200SP in the configuration software.

Required tools

Screwdriver 3 - 3.5 mm

Setting the PROFIBUS DP address

1. Slide the window of the interface module upwards.
2. Use a screwdriver to set the required PROFIBUS address via the DIP switch.
3. Close the window.

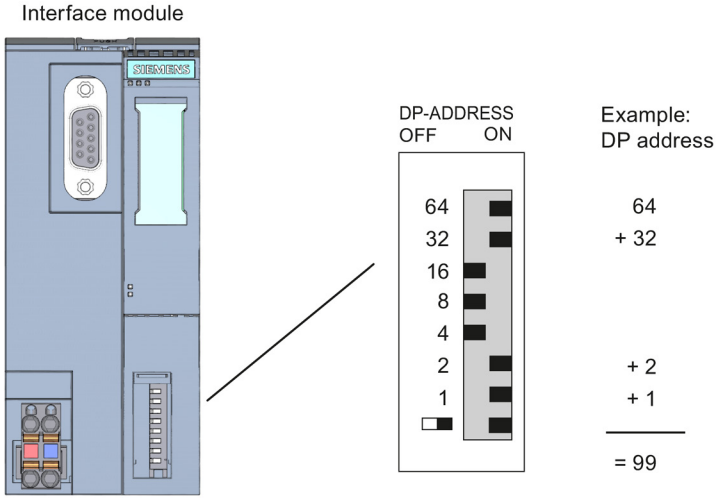


Figure 3-2 Setting the PROFIBUS DP address

Changing the PROFIBUS DP address

You can change the PROFIBUS DP address in exactly the same way as you set it. **A change in the PROFIBUS DP address only becomes valid for the ET 200SP** after a POWER ON of the interface module.

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 DP HF interface module

The following table shows the parameters for the IM 155-6 DP HF interface module.

Table 4- 1 Parameters for IM 155-6 DP HF interface module (GSD file)

Parameters	Value range	Default[3]	Effective range
Configuration control [1]	Disable/enable	Disable	ET 200SP
Startup when preset/actual configuration differ	Yes/No	No	ET 200SP
Diagnostic interrupt	Yes/No	Yes	ET 200SP
Hardware interrupt	Yes/No	Yes	ET 200SP
Insert/remove module interrupt[2]	Yes/No	No	ET 200SP

1 Note that the "Startup if preset configuration does not match actual configuration" parameter is always activated when you use configuration control.

2 The remove/insert parameter is always activated in the GSD file.

3 The defaults apply to the default startup. If no other parameters are specified by the DP master, the IM 155-6 DP HF starts up with these parameters.

Note

Only for configuration using the PROFIBUS GSD file, does not affect configuration with STEP 7 via HSP:

Not all parameters of an I/O module are provided by the GSD file with GSD configuration, because the PROFIBUS standard limits the number of parameters to 244 bytes per ET 200SP. These parameters can be configured later using data record 128, if necessary. The description is available in the respective manual of the employed I/O module.

Note

PROFIBUS GSD configuration with STEP 7 V5.5 SP3

- The universal module must not be configured.
- The DP-Alarm-Mode parameter must not be set to the value DPV0.

4.2 Description of parameters

4.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

Note

Configuration control

The "Configuration control" function can only be used if you set the parameter "Startup if preset configuration does not match actual configuration" to yes at the same time.

Note

Configuring the enable

If you configure the enable, the ET 200SP distributed I/O system requires control data record 196 from the user program so that the ET 200SP distributed I/O system can operate the I/O modules.

Reference

You can find additional information in the chapter Configuration control (Page 19) and in the STEP 7 online help.

4.2.2 Startup when expected/actual config differ

If the parameter is enabled and

- modules are removed and inserted during operation, this does not lead to a station failure of the ET 200SP distributed I/O system.
- If the preset configuration does not match the actual configuration, the ET 200SP distributed I/O system continues to exchange data with the DP master.

If the parameter is disabled and

- modules are removed and inserted during operation, this leads to a station failure of the ET 200SP distributed I/O system.
- If the preset configuration does not match the actual configuration, data exchange does not take place between the DP master and the ET 200SP distributed I/O system.

4.2.3 Diagnostic interrupt

You can use this parameter to enable or disable diagnostic interrupts.

4.2.4 Hardware interrupt

You can use this parameter to enable or disable hardware interrupts.

4.2.5 Insert/remove module interrupt

You can use this parameter to enable or disable insert/remove module interrupts.

4.3 Configuration control

4.3.1 Configuration control and control data record

Operating principle

Configuration control allows you to operate various real configurations (options) with a single configuration of the ET 200SP distributed I/O system.

The following versions are available:

- Configuration control with empty slots
- Configuration control without empty slots
- Expanding the configuration

Requirements

The "Configuration control" parameter must be selected during configuration for this function. Control takes place using a control data record for specification of the required configuration.

Configuration control is not ready for operation without a control data record:

- All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior)
- The interface module continues to exchange data
- An error message is not triggered

Control data record

A control data record 196 that contains a slot assignment is defined for the configuration control. The maximum slot of the configuration corresponds to the slot of the server module.

Table 4- 2 Control data record

Byte	Element	Code	Explanation
0	Block length	4 + (number of slots × 2)	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Assignment of configured slot 1	Real slot 1	Control element Describes in each element which real slot in the DP slave is assigned to the configured slot.
5	Additional function for slot 1		
6	Assignment of configured slot 2	Real slot 2	
7	Additional function for slot 2		
:	:	:	
4 + ((max. slot - 1) × 2)	Assignment of server module slot	Real server module slot	
4 + ((max. slot - 1) × 2) + 1	Additional function for server module slot		

Control element

Each element must include the following information about the slot:

- Assignment of configured slot ⇔ real slot
- Identification of an empty slot (BaseUnit with BU cover)
- Opening a new potential group (replacement of a BaseUnit BU...B to BU...D)

Table 4- 3 Code of control element

Byte	Bit	Meaning
Assignment of configured slot (e.g. 4, on even byte offset)	0 to 6	0000000: Module not available 0000001 up to maximum slot: Real slot
	7	1: An empty slot is possible (with BU cover)
Additional function for slot (e.g. 5, on uneven byte offset)	0	1: Opening a new potential group. Replacing a BU...B with a BU...D. If you set the bit, BU...D is configured. If you do not set a bit for the slot, the previously assigned parameter is taken from the configuration software for this.
	1 to 7	Reserved

Special features

There are some special features you have to observe:

- The control data record is retentively stored in the interface module.
- Slot entries outside the preset configuration are ignored.
- Configuration control is controlled by the interface module (slot 0).
- The control data record can be shortened. It must contain the entries up to the last slot of the current preset configuration.
- Each real slot may only exist once in the data record.

Note

Modified configuration

The writing of a control data record with modified configuration triggers a station failure followed by a restart of the station with the modified configuration.

- If you receive the error code $80B2_H$ when you write the control data record 196, check whether the desired configuration was adopted despite the error code.
- If control data record 196 was not yet written, a 1-to-1 mapping (configured slot → real slot) is adopted internally. This mapping is used to generate the feedback data record.

Error messages

The control data record returns the following error messages, if needed:

Table 4- 4 Error messages

Error code	Meaning
$80B1_H$	Impermissible length
$80B5_H$	Configuration control not configured
$80B8_H$	Parameter error

4.3.2 Feedback data record

Feedback data record

The feedback data record is mapped by means of a separate data record 197.

The feedback data record exists only when configuration control is configured and always refers to the maximum quantity framework, i.e., 33 slots (32 I/O modules and the server module). Partial reading is supported.

Table 4- 5 Feedback data record

Byte	Element	Code	Meaning
0	Block length	70	Header
1	Block ID	197	
2	Version	2	
3		0	
4	Status slot 1	1	Bit 0 = 0: Module removed or invalid
5	Reserved	0	Bit 0 = 1: Slot with correct module
6	Status slot 2	1	Bit 1 to 15: Reserved
7	Reserved	0	
:	:	:	
68	Status slot 33	Maximum slot (server module)	
69	Reserved	0	

Error messages

The feedback data record returns the following error messages, if needed:

Table 4- 6 Error messages

Error code	Meaning
$80B1_H$	Impermissible length
$80B5_H$	Configuration control not configured
$80B8_H$	Parameter error

4.3.3 Configuring configuration control with empty slots

Principle of operation

In configuration control with empty slots, BaseUnits are mounted for the non-required slots. You must insert BU covers on the empty slots. These are not configured.

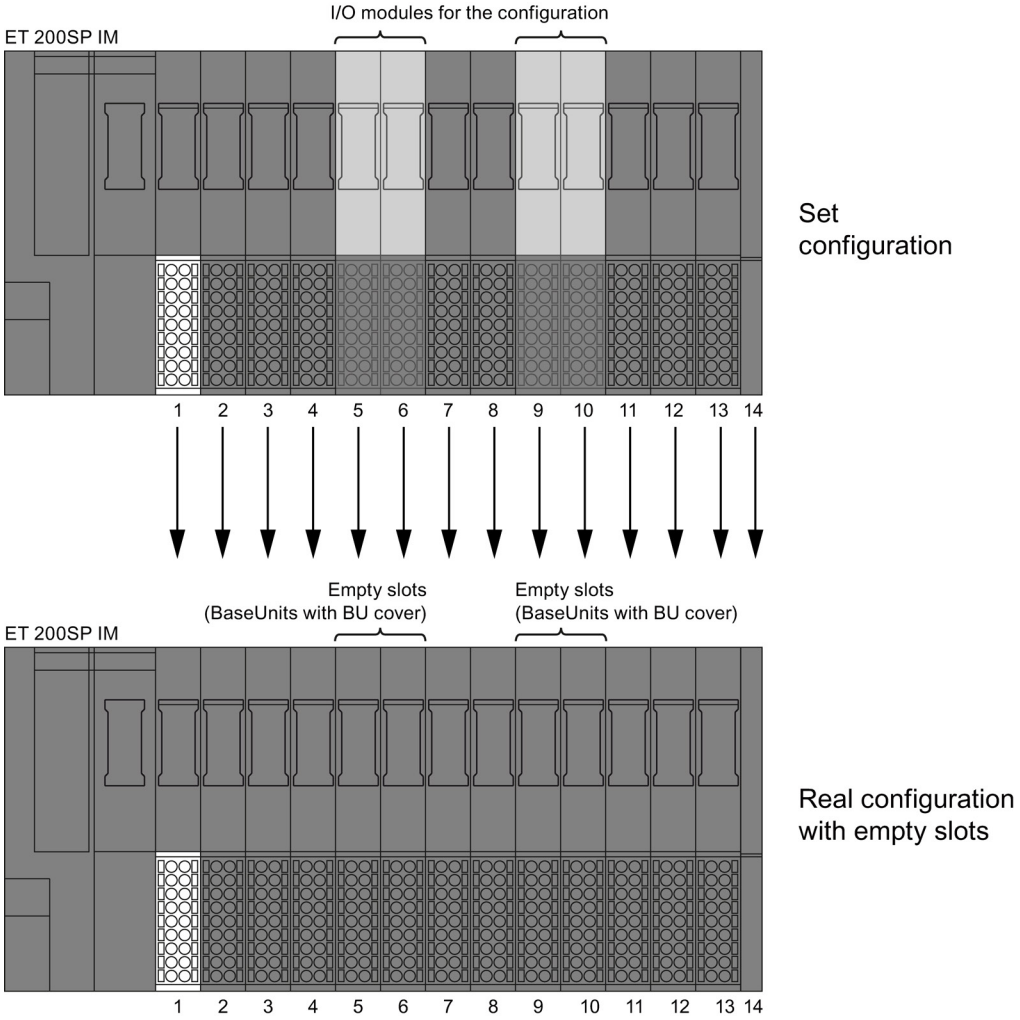


Figure 4-1 Configuring configuration control with empty slots

Note

In the configuration software, you must set for the BU covers whether these are on a light or dark BaseUnit.

Data record of the example

The following table shows the structure of the control data record for the above example.

Table 4- 7 Data record for the example "Configuring configuration control with empty slots"

Byte	Element	Code	Explanation
0	Block length	32	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1	0000001_B	The configured slot 1 is real slot 1.
5	Additional function 1	0000000_B	---
6	Slot 2	0000010_B	The configured slot 2 is real slot 2.
7	Additional function 2	0000000_B	---
8	Slot 3	0000011_B	The configured slot 3 is real slot 3.
9	Additional function 3	0000000_B	---
10	Slot 4	0000100_B	The configured slot 4 is real slot 4.
11	Additional function 4	0000000_B	---
12	Slot 5	1000101_B	The configured slot 5 is real slot 5 (and an empty slot).
13	Additional function 5	0000000_B	---
14	Slot 6	1000110_B	The configured slot 6 is real slot 6 (and an empty slot).
15	Additional function 6	0000000_B	---
16	Slot 7	0000111_B	The configured slot 7 is real slot 7.
17	Additional function 7	0000000_B	---
18	Slot 8	0001000_B	The configured slot 8 is real slot 8.
19	Additional function 8	0000000_B	---
20	Slot 9	1001001_B	The configured slot 9 is real slot 9 (and an empty slot).
21	Additional function 9	0000000_B	---
22	Slot 10	1001010_B	The configured slot 10 is real slot 10 (and an empty slot).
23	Additional function 10	0000000_B	---
24	Slot 11	0001011_B	The configured slot 11 is real slot 11.
25	Additional function 11	0000000_B	---
26	Slot 12	0001100_B	The configured slot 12 is real slot 12.
27	Additional function 12	0000000_B	---
28	Slot 13	0001101_B	The configured slot 13 is real slot 13.
29	Additional function 13	0000000_B	---
30	Slot 14	0001110_B	The configured slot 14 is real slot 14.
31	Additional function 14	0000000_B	---

4.3.4 Configure configuration control without empty slots

Principle of operation

The modules actually not required do not exist. The configuration is pushed together to the left in the direction of interface module IM 155-6 DP HF.

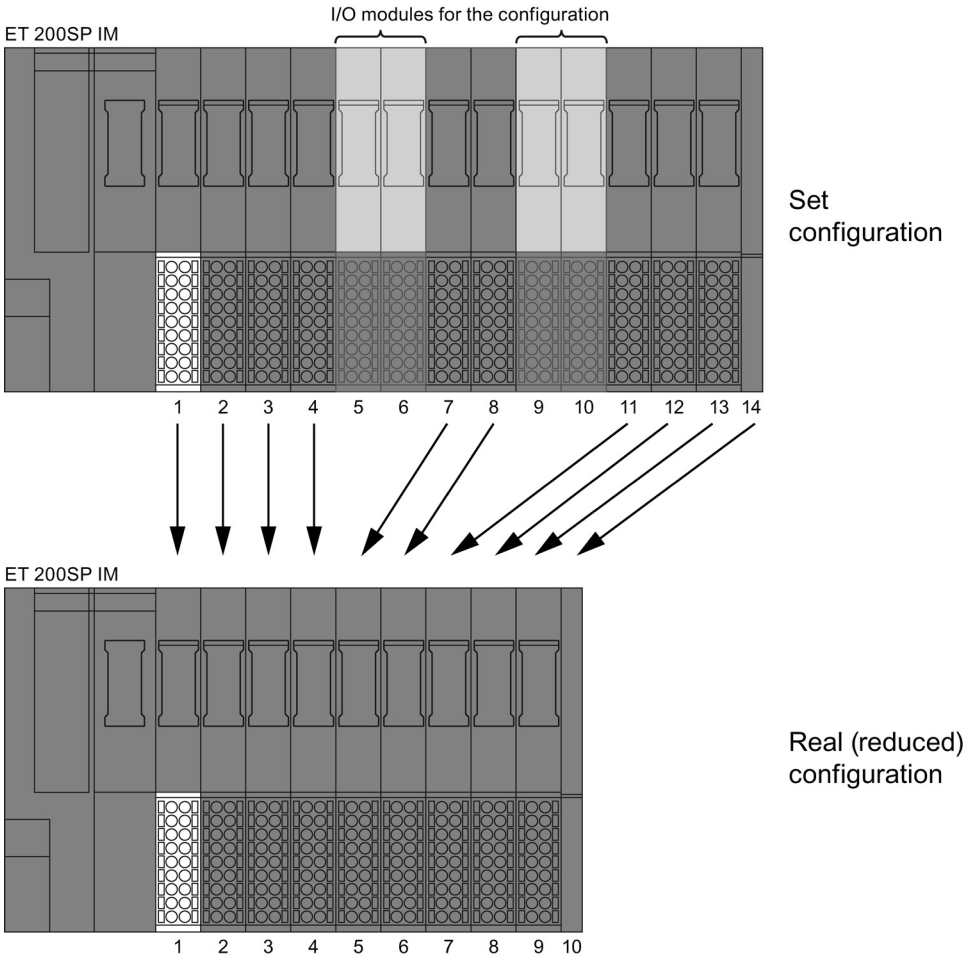


Figure 4-2 Configure configuration control without empty slots

Data record of the example

The following table shows the structure of the control data record for the above example.

Table 4- 8 Data record for example "Configure configuration control without empty slots"

Byte	Element	Code	Explanation
0	Block length	32	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1	0000001_B	The configured slot 1 is real slot 1.
5	Additional function 1	0000000_B	---
6	Slot 2	0000010_B	The configured slot 2 is real slot 2.
7	Additional function 2	0000000_B	---
8	Slot 3	0000011_B	The configured slot 3 is real slot 3.
9	Additional function 3	0000000_B	---
10	Slot 4	0000100_B	The configured slot 4 is real slot 4.
11	Additional function 4	0000000_B	---
12	Slot 5	0000000_B	The configured slot 5 does not exist.
13	Additional function 5	0000000_B	---
14	Slot 6	0000000_B	The configured slot 6 does not exist.
15	Additional function 6	0000000_B	---
16	Slot 7	0000101_B	The configured slot 7 is real slot 5.
17	Additional function 7	0000000_B	---
18	Slot 8	0000110_B	The configured slot 8 is real slot 6.
19	Additional function 8	0000000_B	---
20	Slot 9	0000000_B	The configured slot 9 does not exist.
21	Additional function 9	0000000_B	---
22	Slot 10	0000000_B	The configured slot 10 does not exist.
23	Additional function 10	0000000_B	---
24	Slot 11	0000111_B	The configured slot 11 is real slot 7.
25	Additional function 11	0000000_B	---
26	Slot 12	0001000_B	The configured slot 12 is real slot 8.
27	Additional function 12	0000000_B	---
28	Slot 13	0001001_B	The configured slot 13 is real slot 9.
29	Additional function 13	0000000_B	---
30	Slot 14	0001010_B	The configured slot 14 is real slot 10.
31	Additional function 14	0000000_B	---

4.3.5 Expanding the configuration

Operating principle

You can add modules at the end of the configuration in this version. The configured configuration can also be extended from the center based on freely selectable slot assignment. A new potential group is also opened in this example.

Note

If you open a new potential group or replace a BaseUnit BU...B with a BU...D using configuration control, you must adhere to the maximum electrical configuration (see the Block diagram section).

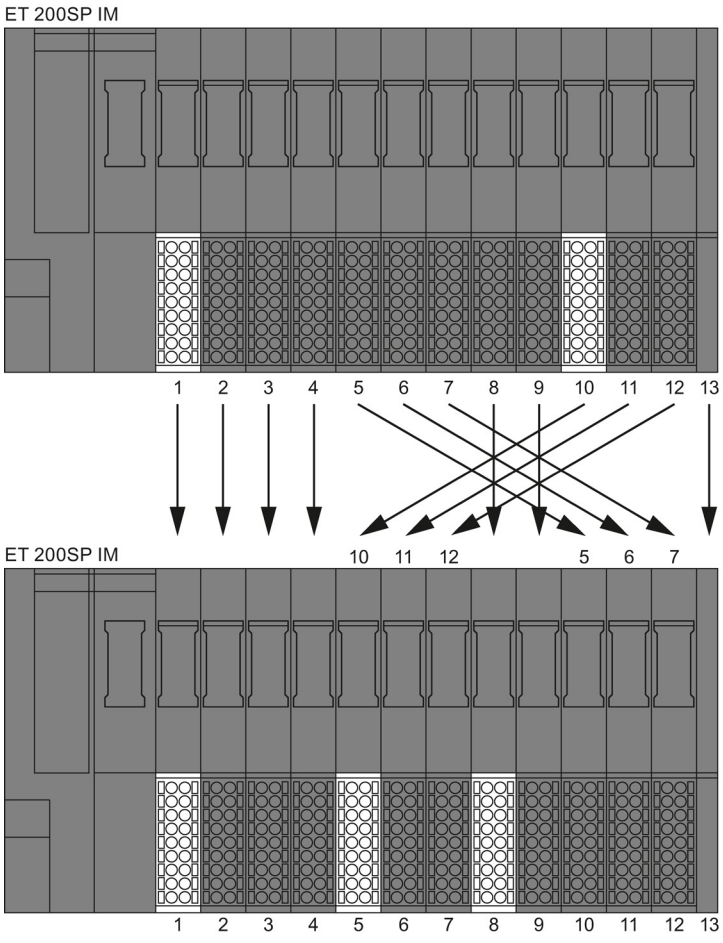


Figure 4-3 Expanding the configuration

Data record of the example

The following table shows the structure of the control data record for the example given above.

Table 4- 9 Data record for "Expanding the configuration" example

Byte	Element	Code	Explanation
0	Block length	30	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1	0000001_B	The configured slot 1 is real slot 1.
5	Additional function 1	0000000_B	---
6	Slot 2	0000010_B	The configured slot 2 is real slot 2.
7	Additional function 2	0000000_B	---
8	Slot 3	0000011_B	The configured slot 3 is real slot 3.
9	Additional function 3	0000000_B	---
10	Slot 4	0000100_B	The configured slot 4 is real slot 4.
11	Additional function 4	0000000_B	---
12	Slot 5	0001010_B	The configured slot 5 is real slot 10.
13	Additional function 5	0000000_B	---
14	Slot 6	0001011_B	The configured slot 6 is real slot 11.
15	Additional function 6	0000000_B	---
16	Slot 7	0001100_B	The configured slot 7 is real slot 12.
17	Additional function 7	0000000_B	---
18	Slot 8	0001000_B	The configured slot 8 is real slot 8.
19	Additional function 8	0000001_B	A new potential group opens.
20	Slot 9	0001001_B	The configured slot 9 is real slot 9.
21	Additional function 9	0000000_B	---
22	Slot 10	0000101_B	The configured slot 10 is real slot 5.
23	Additional function 10	0000101_B	A new potential group opens. This potential group already exists as this light BU has already been configured.
24	Slot 11	0000110_B	The configured slot 11 is real slot 6.
25	Additional function 11	0000000_B	---
26	Slot 12	0000111_B	The configured slot 12 is real slot 7.
27	Additional function 12	0000000_B	---
28	Slot 13	0001101_B	The configured slot 13 is real slot 13.
29	Additional function 13	0000000_B	---

See also

Block diagram (Page 15)

4.3.6 Combining configurations

Principle of operation

You can combine the different versions with configuration control.

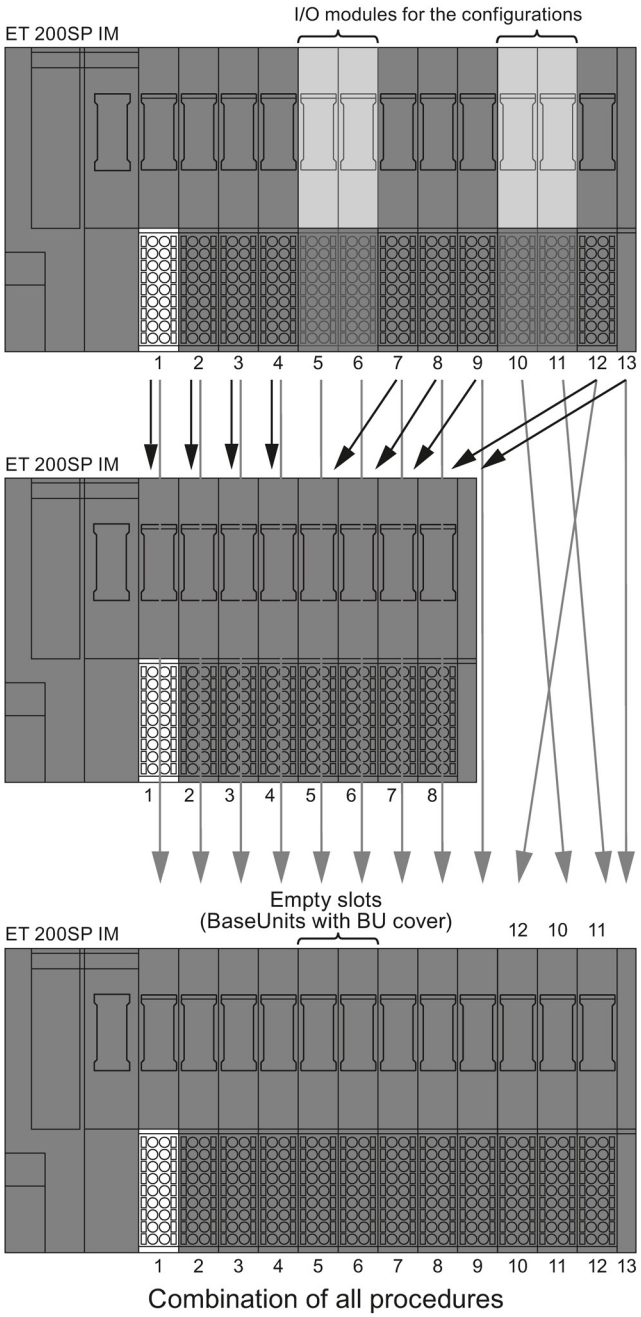


Figure 4-4 Combining configurations

Data record of the example

The following table shows the structure of the control data record for the example listed above.

Table 4- 10 Data record for example "Combining configurations"

Byte	Element	Code for configuration 1	Code for configuration 2	Explanation
0	Block length	30		Header
1	Block ID	196		
2	Version	2		
3	Version	0		
4	Slot 1	0000001_B	0000001_B	The configured slot 1 is real slot 1.
5	Additional function 1	0000000_B	0000000_B	---
6	Slot 2	0000010_B	0000010_B	The configured slot 2 is real slot 2.
7	Additional function 2	0000000_B	0000000_B	---
8	Slot 3	0000011_B	00000011_B	The configured slot 3 is real slot 3.
9	Additional function 3	0000000_B	0000000_B	---
10	Slot 4	0000100_B	0000100_B	The configured slot 4 is real slot 4.
11	Additional function 4	0000000_B	0000000_B	---
12	Slot 5	0000000_B	1000101_B	The configured slot 5 does not exist (configuration 1). The configured slot 5 is real slot 5 and an empty slot (configuration 2).
13	Additional function 5	0000000_B	0000000_B	---
14	Slot 6	0000000_B	1000110_B	The configured slot 6 does not exist (configuration 1). The configured slot 6 is real slot 6 and an empty slot (configuration 2).
15	Additional function 6	0000000_B	0000000_B	---
16	Slot 7	0000101_B	0000111_B	The configured slot is real slot 5 (configuration 1). The configured slot 7 is real slot 7 (configuration 2).
17	Additional function 7	0000000_B	0000000_B	---
18	Slot 8	0000110_B	0001000_B	The configured slot is real slot 6 (configuration 1). The configured slot 8 is real slot 8 (configuration 2).
19	Additional function 8	0000000_B	0000000_B	---
20	Slot 9	0000111_B	0001001_B	The configured slot 9 is real slot 7 (configuration 1). The configured slot 9 is real slot 9 (configuration 2).
21	Additional function 9	0000000_B	0000000_B	---
22	Slot 10	0000000_B	0001011_B	The configured slot 10 does not exist (configuration 1). The configured slot 10 is real slot 11 (configuration 2).
23	Additional function 10	0000000_B	0000000_B	---
24	Slot 11	0000000_B	0001100_B	The configured slot 11 does not exist (configuration 1). The configured slot 11 is real slot 12 (configuration 2).
25	Additional function 11	0000000_B	0000000_B	---

Byte	Element	Code for configuration 1	Code for configuration 2	Explanation
26	Slot 12	0001000_B	0001010_B	The configured slot 12 is real slot 8 (configuration 1). The configured slot 12 is real slot 10 (configuration 2).
27	Additional function 12	0000000_B	0000000_B	---
28	Slot 13	0001001_B	0001101_B	The configured slot 13 is real slot 9 (configuration 1). The configured slot 13 is real slot 13 (configuration 2).
29	Additional function 13	0000000_B	0000000_B	---

4.4 Substitute value behavior

The substitute value behavior is implemented by the DP master per slot in the ET 200SP distributed I/O system.

The respective output reacts according to its configured substitute value behavior:

- Current-free/voltage-free
- Keep last value
- Output substitute value

The substitute value behavior is triggered in the following cases:

- STOP DP master
- DP master failure (connection interruption)
- Firmware update
- Station stop, for example, due to:
  - No server module
  - At least one I/O module installed on an incorrect BaseUnit
- Deactivate DP slave

Note

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the new configuration to the CPU, the modules no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage on the BaseUnit BU...D or on the interface module is switched off.

The "current-free/voltage-free" behavior takes effect in the following cases:

- Firmware update
- Configuration control: receipt of a new control data record
- Incorrectly configured module
- Module with incorrect parameter assignment

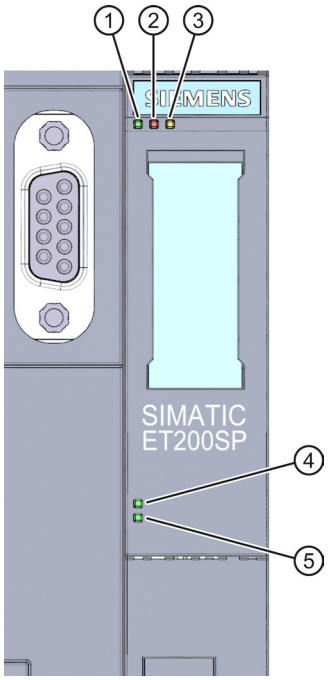
Interrupts, error messages, diagnostics and system alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED display on the interface module:



① RN (green)
② ER (red)
③ MT (yellow)
④ DP (green)
⑤ PWR (green)

Figure 5-1 LED displays on the interface module

Meaning of the LED displays

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 5- 1 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Remedy
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	No or too little supply voltage at interface module	Check the supply voltage or switch it on at the interface module.[1]
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
Flashes	Off	Off	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the DP master.	-
Not relevant	Flashes	Not relevant	Group error and group error channels	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration of the ET 200SP.	Check the configuration of the ET 200SP to see whether a module is missing or faulty, or whether a non-configured module is inserted.
			Invalid configuration states	See the Invalid configuration states of the ET 200SP on PROFINET DP (Page 54) section.
			Parameter assignment error in the I/O module	Evaluate the display of the module status in STEP 7 and correct the error in the corresponding I/O module.
Not relevant	Not relevant	On	Maintenance is demanded.	Perform maintenance
Flashes	Flashes	Flashes	Hardware or firmware faulty.[2]	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

1 PWR LED On (on interface module): Check the backplane bus for a short-circuit.

2 DP LED Off

PWR LED on the interface module

Table 5- 2 Status display of the PWR LED

PWR LED	Meaning	Remedy
□ Off	No or too little supply voltage	Check the supply voltage.
■ On	Supply voltage present	-

LED DP on the RS485 interface

Table 5- 3 Status display of the DP LED

LED DP	Meaning	Remedy
□ Off	There is no connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (for example, DP master).	Check whether the bus cable to the DP master is broken.
■ On	There is a connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (for example, DP master).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interface module by the ERROR (red) and MAINT (yellow) LEDs.

The following configuration errors are signaled by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After a notification by means of a flashing signal, the error type and then the error location/error code are displayed in each case.

The LED error display

- is activated during POWER ON and during operation.
- has priority over all other states that are displayed by means of the ERROR- and MAINT-LED.
- Remains on until the cause of the error has been eliminated.

Table 5- 4 Display of error type and error location

Sequence		Description
1	ERROR- and MAINT-LED flash 3x with 0.5 Hz	Indication of the error type
2	MAINT-LED flashes with 1 Hz	Display of error type (decimal)
3	ERROR- and MAINT-LED flash 3x with 2 Hz	Indication of error location/error code
4	ERROR-LED flashes with 1 Hz	Display of the tens position (decimal) of the error location/error code
5	MAINT-LED flashes with 1 Hz	Display of the units position (decimal) of the error location/error code
6	Repetition of 1 to 5 until the cause of the error has been eliminated.	

Error display

The following table shows the possible causes of error that can occur.

Table 5- 5 Error display

Error type (MAINT)	Error location (ERROR/MAINT)	Cause of error	Solution
1	65*	• No server module • Interruptions on the backplane bus • Short-circuit on the backplane bus	Check the configuration of the ET 200SP.
1	33*		

* Slot

Note

The following LEDs indicate a short-circuit in the backplane bus supply or in the bus connection supply:

- PWR-LED: On
- RN-, ER- and MT-LED: Off

5.2 Interrupts

5.2.1 Introduction

Definition

The interrupt section of the slave diagnostics indicates the interrupt type and the event that led to an interrupt being triggered. The interrupt section comprises 62 bytes including an interrupt header.

Position in the diagnostics frame

The interrupt section is located after the channel diagnostics.

Data record

The diagnostic data of a module are located in the data records 0 and 1:

- Data record 0 contains 4 bytes of diagnostics data that describe the current status of the distributed I/O system. DS0 is part of the header information of OB 82 (local data bytes 8 to 11).
- Data record 1 contains 4 bytes of diagnostics data that are also available in data record 0.

The figure below shows the structure of data record 1:

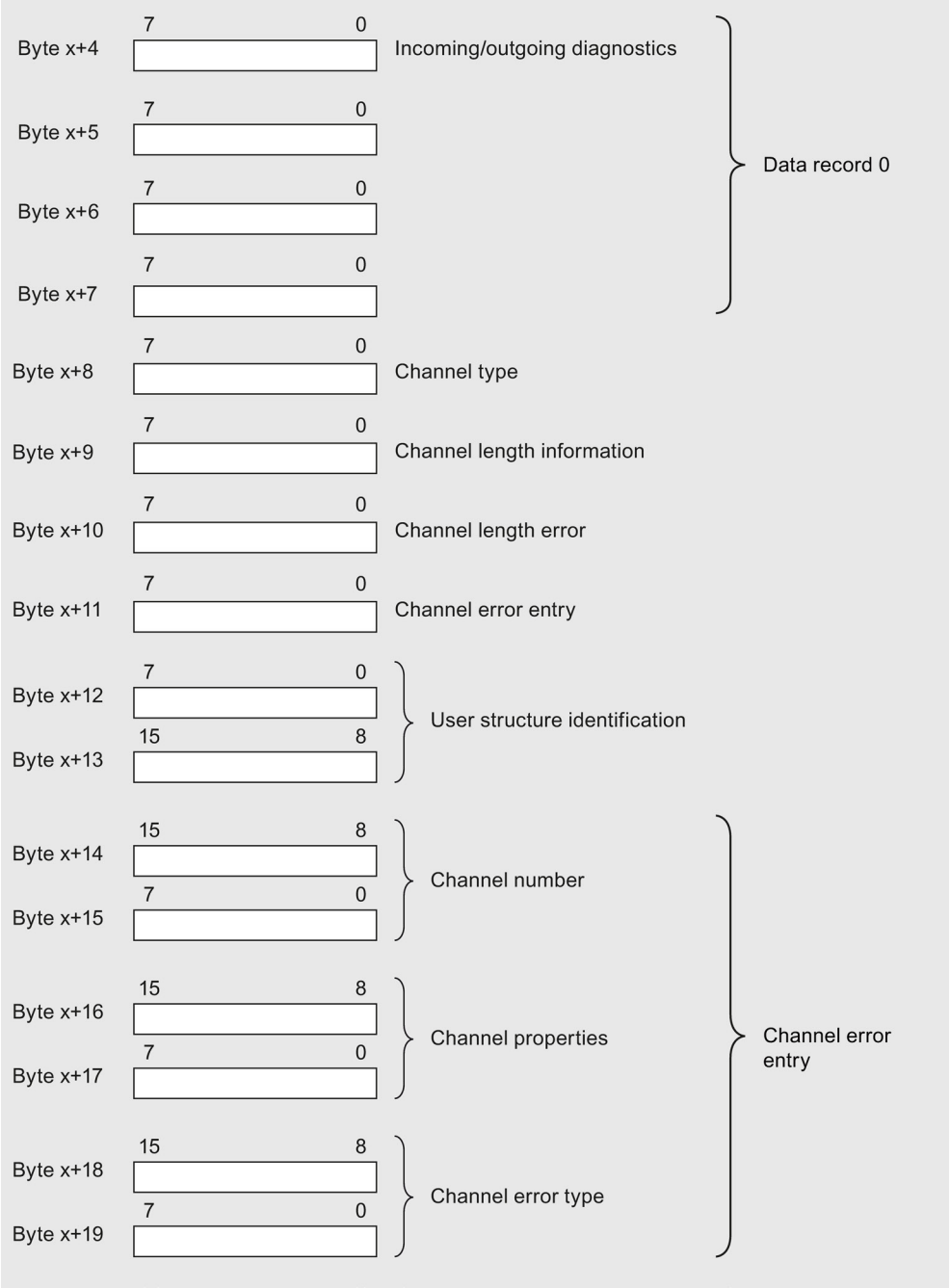


Figure 5-2 Structure of data record 1

Reading data records

DS0 and DS1 can be read with SFC 59 (RD_REC) or SFB 52 (RDREC). The data length of DS 1 can be up to 240 bytes. In this case, DS1 includes up to 38 channel error entries.

Note the figures below in this section.

Content

The contents of the interrupt information depend on the interrupt type:

- In the case of diagnostic interrupts, diagnostic data record 1 (up to 58 bytes) is sent as interrupt status information (starting from byte x+4).
- The length of the interrupt status information for hardware interrupts is 4 bytes.

Structure of interrupts

The figure below shows the structure of the interrupt section for the ET 200SP distributed I/O system:

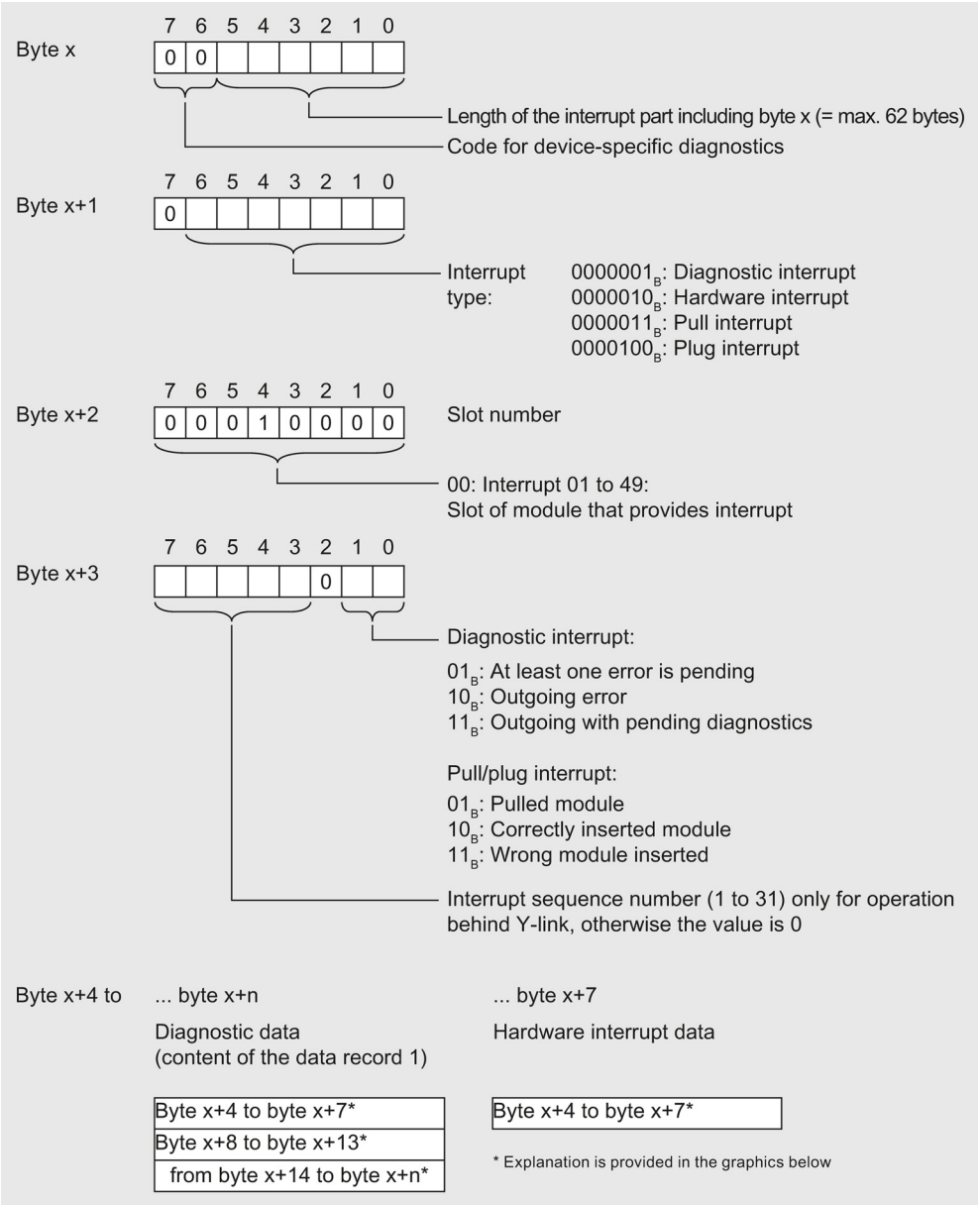


Figure 5-3 Structure of the interrupt status of the interrupt section

Diagnostic interrupt, byte x+4 to x+7

The figure below shows the structure starting at byte x+4 to x+7 for diagnostic interrupt:

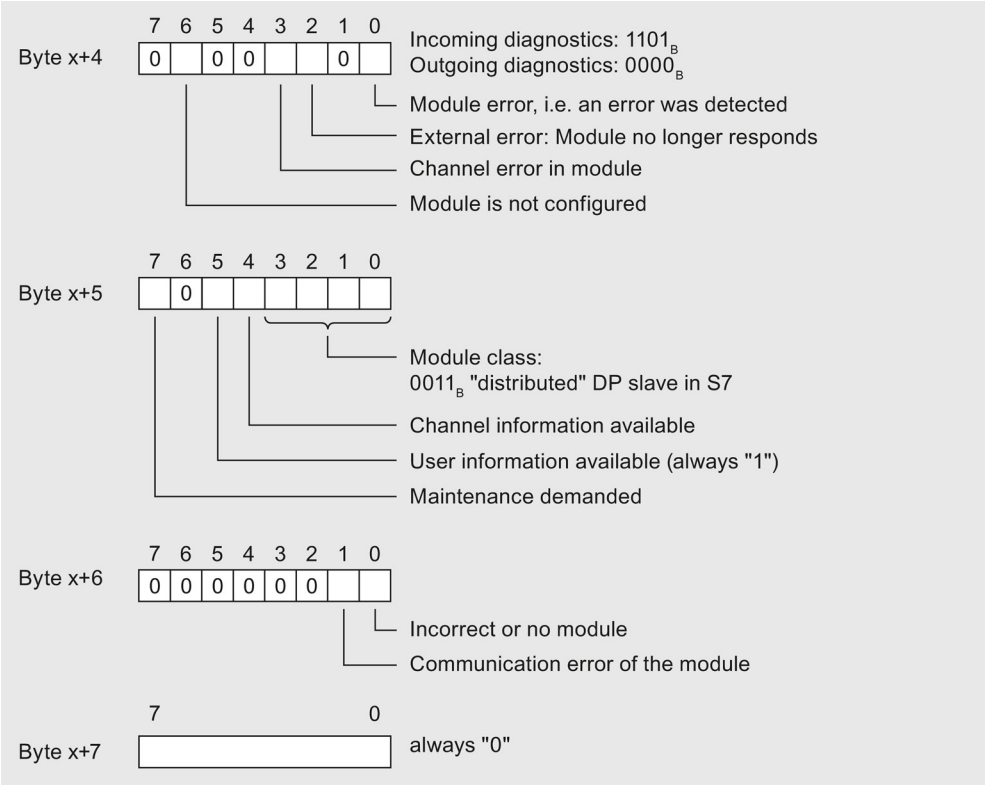


Figure 5-4 Structure of bytes x+4 to x+7 for diagnostic interrupt

Diagnostic interrupt from the modules, starting at byte x+8

The figure below shows the structure starting at byte x+8:

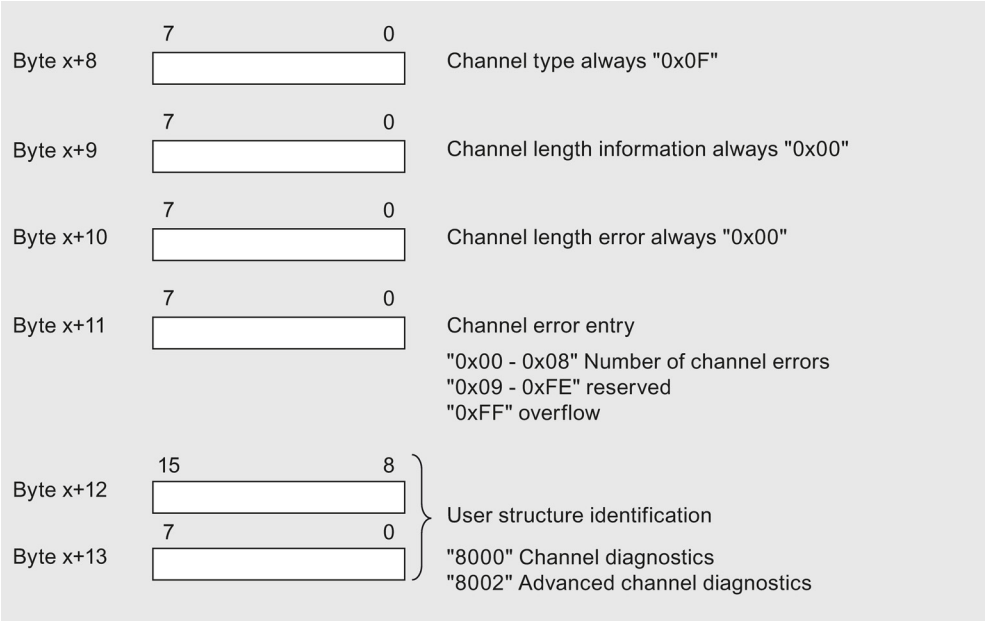


Figure 5-5 Structure starting at byte x+8

Diagnostic interrupt from the modules, starting at byte x+14

The channel error entries start from byte x+14. A channel error entry is 6 bytes long and can follow 8 times starting from byte x+14.

If you read the channel error entries using an SFB or SFC, 38 channel diagnostics are possible.

The figure below shows the structure starting at byte x+14:

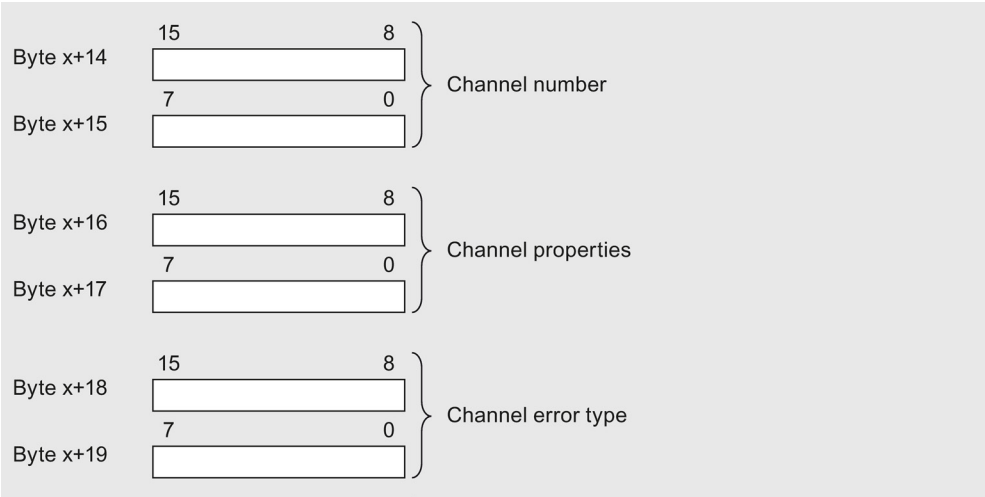


Figure 5-6 Structure starting from byte x+14

The following table is used to explain the channel error entries:

	Description	
Channel number	0 … 63: Channel number for channel error 0x8000: Entire submodule	
Channel properties	Bit 0 to 7	00_H: Free data type 01_H: bit 02_H: 2 bit 03_H: 4 bit 04_H: byte 05_H: word 06_H: Double word 07_H to FF_H: Reserve
	Bit 8	0: Channel 1: Channel group
	Bit 9, 10	00_H: Diagnostics 01_H: Maintenance demanded 02_H: Maintenance required 03_H: Reserve
	Bit 11, 12	00_H: Channel error-free 01_H: Incoming diagnostics 02_H: Outgoing diagnostics 03_H: Outgoing diagnostics, but other diagnostics are also pending on this channel
	Bit 13 to 15	00_H: Reserve 01_H: Input channel 02_H: Output channel 03_H: Input/output channel
Channel error type	Refer to respective manual for explanation.	

Example of a diagnostic interrupt

The figure below shows an example of a diagnostic interrupt (part 1):

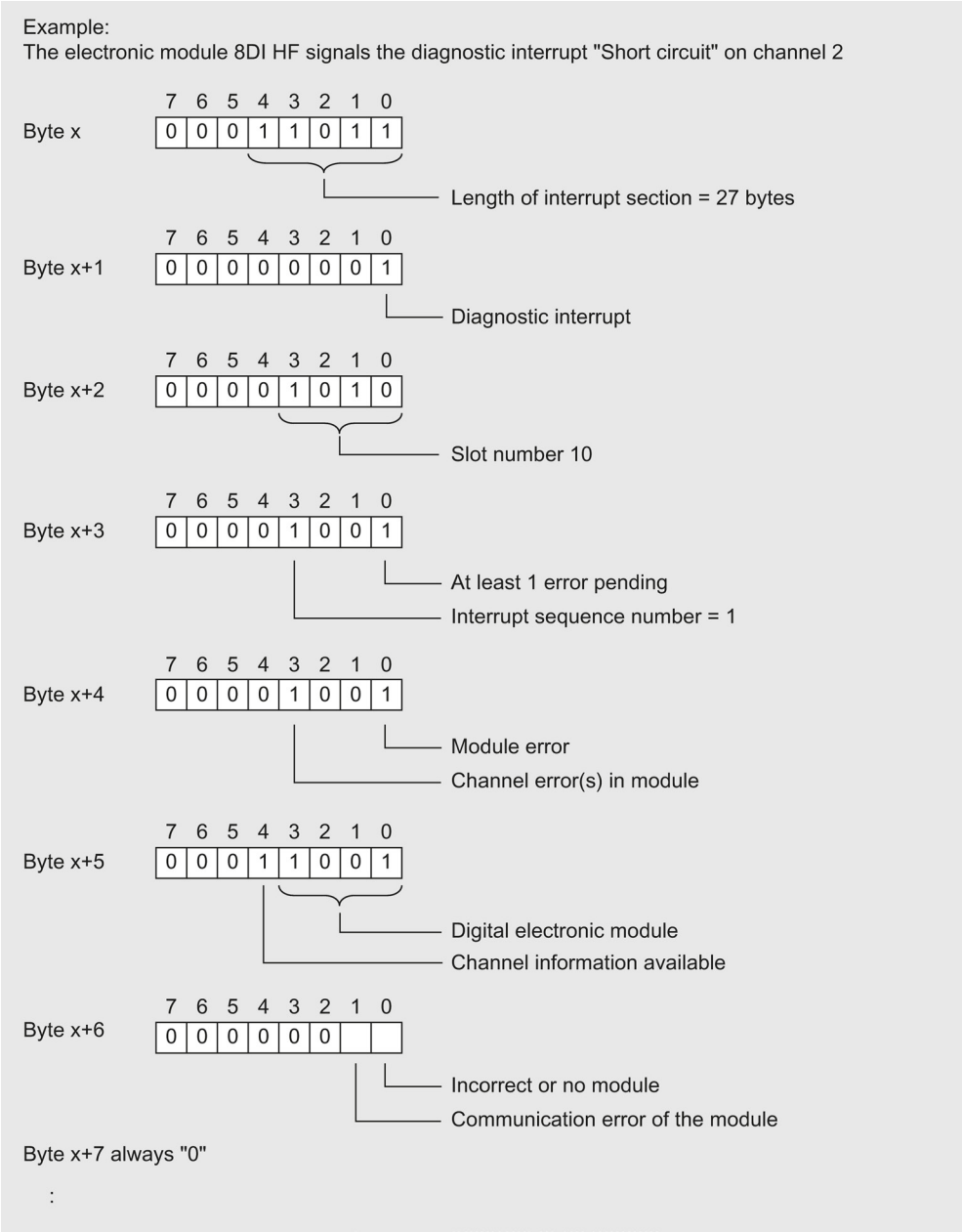


Figure 5-7 Example of a diagnostic interrupt (part 1)

The figure below shows an example of a diagnostic interrupt (part 2):

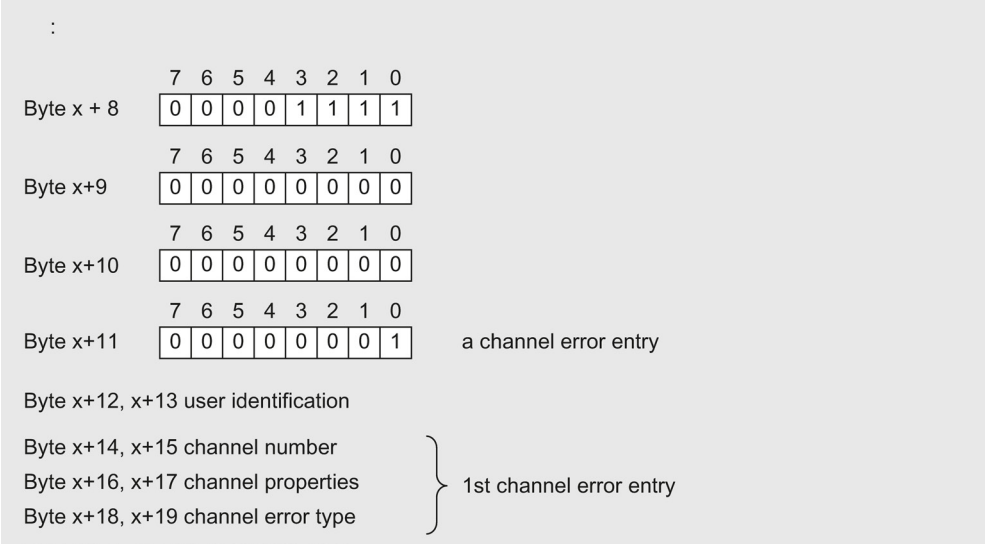


Figure 5-8 Example of a diagnostic interrupt (part 2)

Hardware interrupt of digital and analog input modules

The figure below shows the structure starting at byte x+4 for the hardware interrupt:

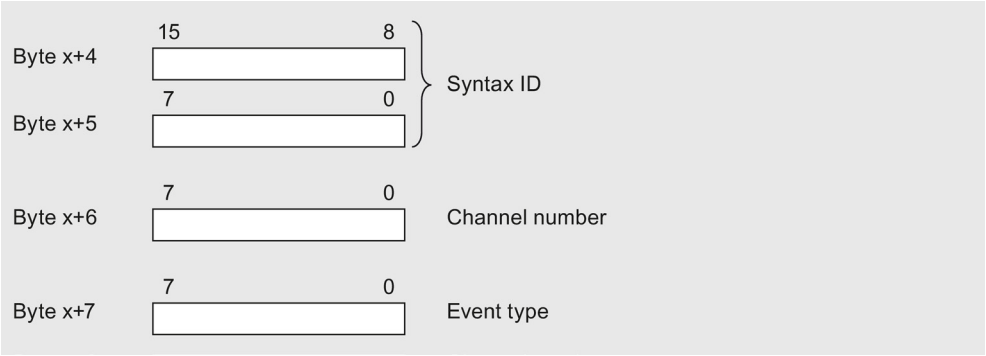


Figure 5-9 Structure starting at byte x+4 for hardware interrupt

5.2.2 Evaluating interrupts of ET 200SP

Introduction

With certain process statuses/errors, the DP slave in each case creates an interrupt block with the corresponding information in the diagnostics frame (DPV1 interrupt mechanism). Regardless of this, the diagnostic status of the DP slave is displayed in the identifier-related diagnostics, in the module status, and in the channel diagnostics.

Interrupts in DPV1 mode

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic interrupts
- Hardware interrupts
- Insert/remove module interrupts

5.2.3 Triggering of a diagnostics interrupt

When an event comes or goes (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if "Enable: diagnostic interrupt" is set.

The CPU interrupts user program execution and processes the diagnostic interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.

5.2.4 Triggering a hardware interrupt

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the hardware interrupt OB, for example OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt OB.

Note

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for technological purposes (e.g., cyclical generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.5 Triggering an insert/remove module interrupt

When an insert/remove module interrupt occurs, the CPU interrupts execution of the user program and processes the insert/remove module interrupt OB (OB 83). The event that triggered the interrupt is entered in the start information of the insert/remove module interrupt OB.

5.3 Alarms

Actions after a diagnostics alarm in DPV1 mode

The error is entered in the channel diagnostics in the diagnostics frame:

- In DPV1 mode, diagnostics can be reported as diagnostic interrupts.
- After a diagnostics alarm, this is
  - entered in the diagnostics frame as diagnostic interrupt block (always for one interrupt only).
  - Stored in the diagnostics buffer of the CPU.
- The ERROR LED of the interface module flashes.
- OB 82 is called. If OB 82 does not exist, the CPU changes to STOP mode.
- Acknowledgment of diagnostic interrupt (a new interrupt is then possible)

Length of the diagnostics frame

- The maximum frame length for the ET 200SP distributed I/O system with IM155-6 DP HF interface module (DPV1 mode) is 244 bytes.
- The minimum frame length is 6 bytes.

Reading out the diagnostics data

Table 5- 6 Reading out the diagnostics data with STEP 7

Automation system with DP master	Application	See...
SIMATIC S7/M7	Slave diagnostics data as plain text in the "DP slave diagnostics" tab in the STEP 7 user interface	"Diagnosing hardware" in the STEP 7 online help
	Instruction "DP NRM_DG" (SFC 13) Reading out slave diagnostics (store in the data area of the user program)	SFC, see STEP 7 online help
	Instruction "RD_REC" (SFC 59) Reading out data records of the S7 diagnostics data (store in the data area of the user program)	See System and Standard Functions reference manual
	Instruction "RDREC" (SFB 52) Reading data records from the DP slave	SFB, see STEP 7 online help (system functions/function blocks)
	Instruction "RALRM" (SFB 54) Receiving interrupts from the interrupt OBs	SFB, see STEP 7 online help (system functions/function blocks)

5.3.1 Slave diagnostics

The figure below shows the structure of the slave diagnostics.

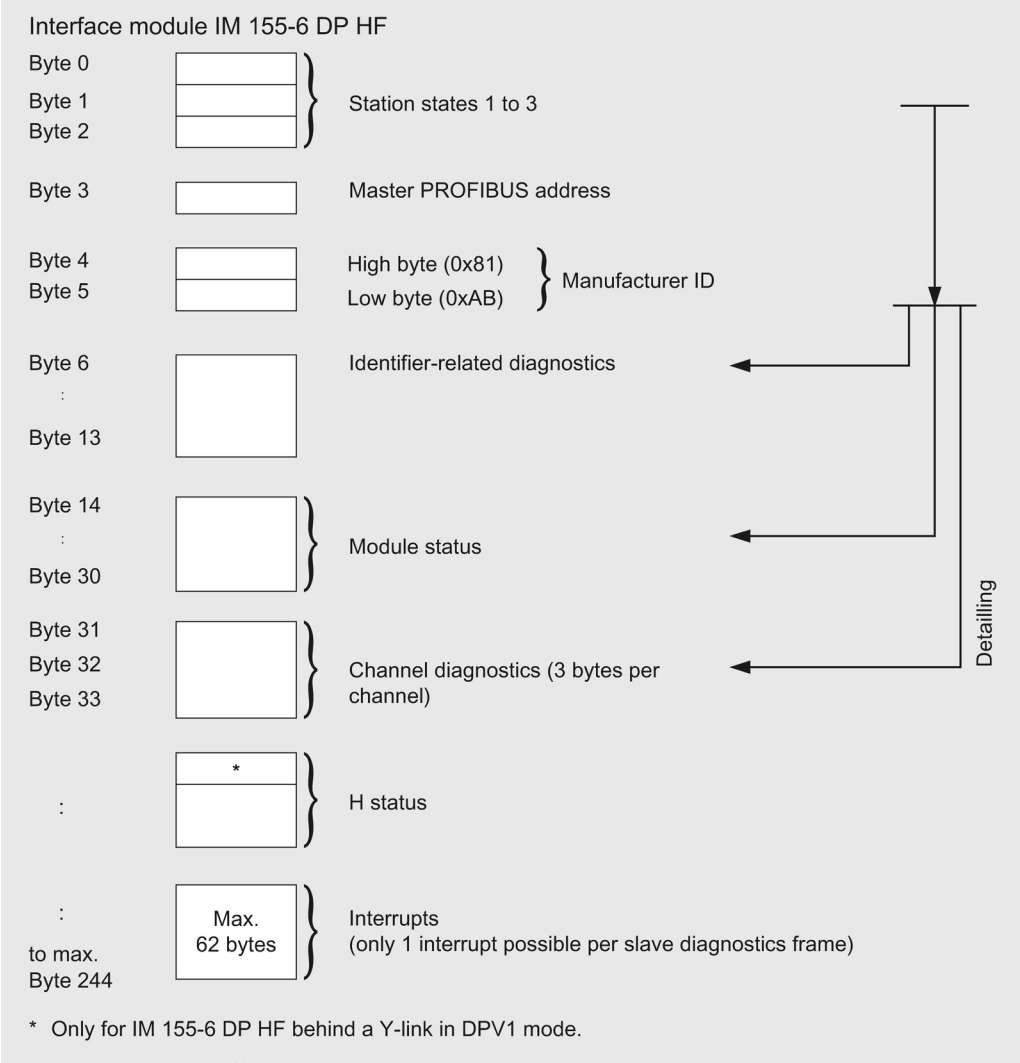


Figure 5-10 Structure of the slave diagnostics

Note

The length of the diagnostics frame varies with the IM 155-6 DP HF (depending on parameter assignment) between 6 and 244 bytes in DPV1 mode.

You can identify the length of the last received diagnostics frame in STEP 7 from the RET_VAL parameter of the SFC 13.

5.3.2 Station statuses 1 to 3

Station statuses 1 to 3 provide an overview of the status of a DP slave.

Structure of station status 1 (byte 0)

Table 5- 7 Structure of station status 1 (byte 0)

Bit	Meaning	Cause/Remedy
0	1: The DP slave is not responding to the DP master.	• Is the correct PROFIBUS address set on the DP slave? • Is the bus connector plugged in? • Is the DP slave connected to the voltage supply? • Is the RS485 repeater properly configured?
1	1: The DP slave is not yet ready to exchange data.	• Wait; the DP slave is currently starting up.
2	1: The configuration data transferred from the DP master to the DP slave does not match the DP slave configuration.	• Has the correct station type or the correct DP slave configuration been entered in the configuration software?
3	1: External diagnostics is available. (Group diagnostics display)	• Evaluate the ID-specific diagnostics, the module status, and/or the channel diagnostics. As soon as all errors have been eliminated, bit 3 is reset. The bit is set again when there is a new diagnostics alarm in the bytes of the aforementioned diagnostics.
4	1: The required function is not supported by the DP slave (for example, changing the PROFIBUS address by means of software).	• Check the configuration.
5	1: The DP master cannot interpret the response of the DP slave.	• Check the bus configuration.
6	1: The DP slave type does not match the software configuration.	• Has the correct station type been entered in the configuration software?
7	1: Parameters have been assigned to the DP slave by a different DP master (not the one that currently has access to the DP slave).	• The bit is always 1, for example, if you access the DP slave with the programming device or another DP master. • The PROFIBUS address of the DP master that assigned parameters to the DP slave is located in the "Master PROFIBUS address" diagnostics byte.

Structure of station status 2 (byte 1)

Table 5- 8 Structure of station status 2 (byte 1)

Bit	Meaning	
0	1:	The DP slave parameters need to be reassigned.
1	1:	A diagnostics alarm is present. The DP slave will not operate until the problem is eliminated (static diagnostics alarm).
2	1:	The bit on the DP slave is always "1".
3	1:	The watchdog is activated for this DP slave.
4	1:	The DP slave has received the "FREEZE" control command.[1]
5	1:	The DP slave has received the "SYNC" control command.[1]
6	0:	Bit is always "0".
7	1:	The DP slave is disabled, that is, it has been removed from the processing in progress.
[1] The bit is updated only if another diagnostics alarm also changes.		

Structure of station status 3 (byte 2)

Table 5- 9 Structure of station status 3 (byte 2)

Bit	Meaning	
0 to 6	0:	Bits are always set to "0".
7	1:	• There are more diagnostic alarms pending than the DP slave is able to store. • The DP master cannot enter all the diagnostics alarms sent by the DP slave in its (channel) diagnostics buffer.

5.3.3 Master PROFIBUS address

The master PROFIBUS address diagnostics byte contains the PROFIBUS address of the DP master:

- That assigned parameters to the DP slave
- That has read and write access to the DP slave

The master PROFIBUS address is located in byte 3 of the slave diagnostics.

5.3.4 Identifier-related diagnostics

The identifier-related diagnostics indicates whether modules of the ET 200SP distributed I/O system have errors or not. Identifier-related diagnostics start at byte 6 and comprise 8 bytes.

The figure below shows how the identifier-related diagnostics for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

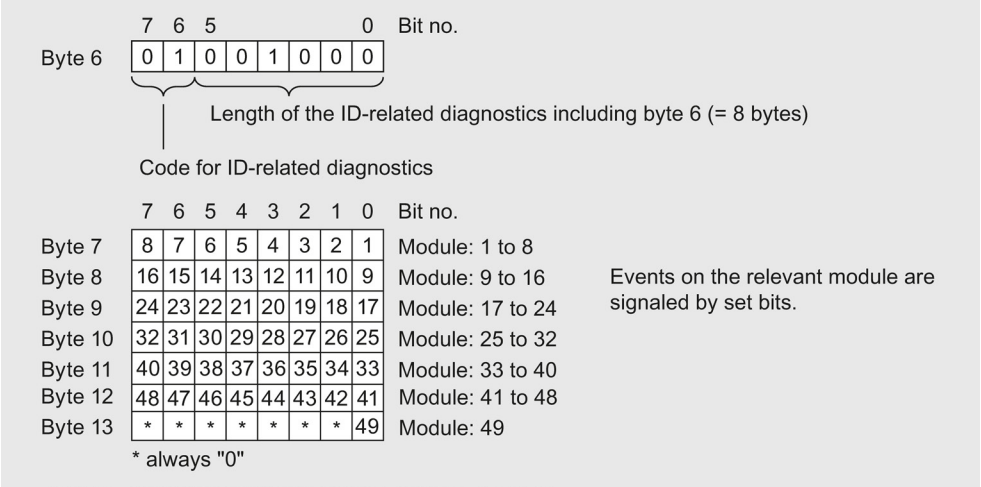


Figure 5-11 Structure of the identifier-related diagnostics

5.3.5 Module status

The module status indicates the status of the configured modules and provides more information on the identifier-related diagnostics with respect to the configuration. The module status begins after the identifier-related diagnostics and comprises 17 bytes.

The following figure shows how the module status for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

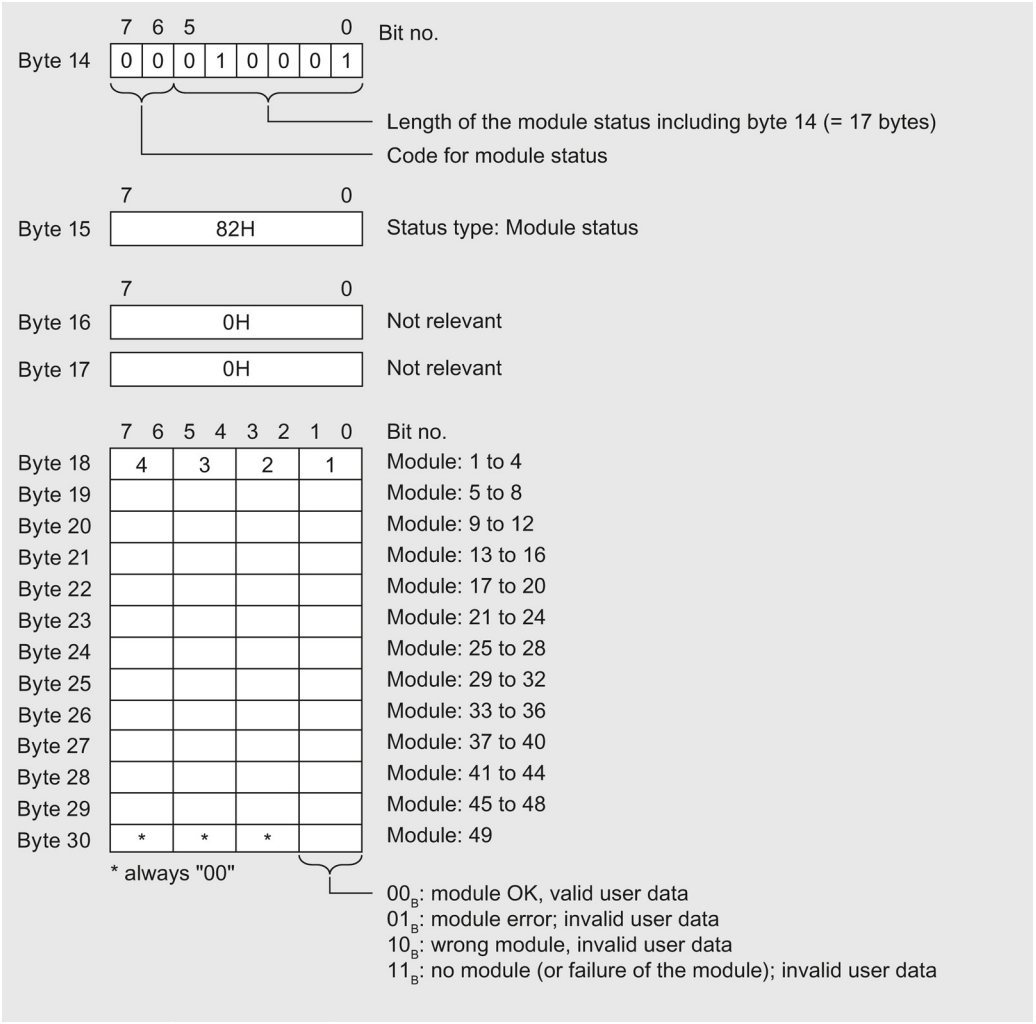


Figure 5-12 Module status structure

5.3.6 Channel diagnostics

Channel diagnostics provides information about channel errors in modules and details of the identifier-related diagnostics. Channel diagnostics begins after the module status. Channel diagnostics does not affect the module status.

The following figure shows how the channel diagnostics for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

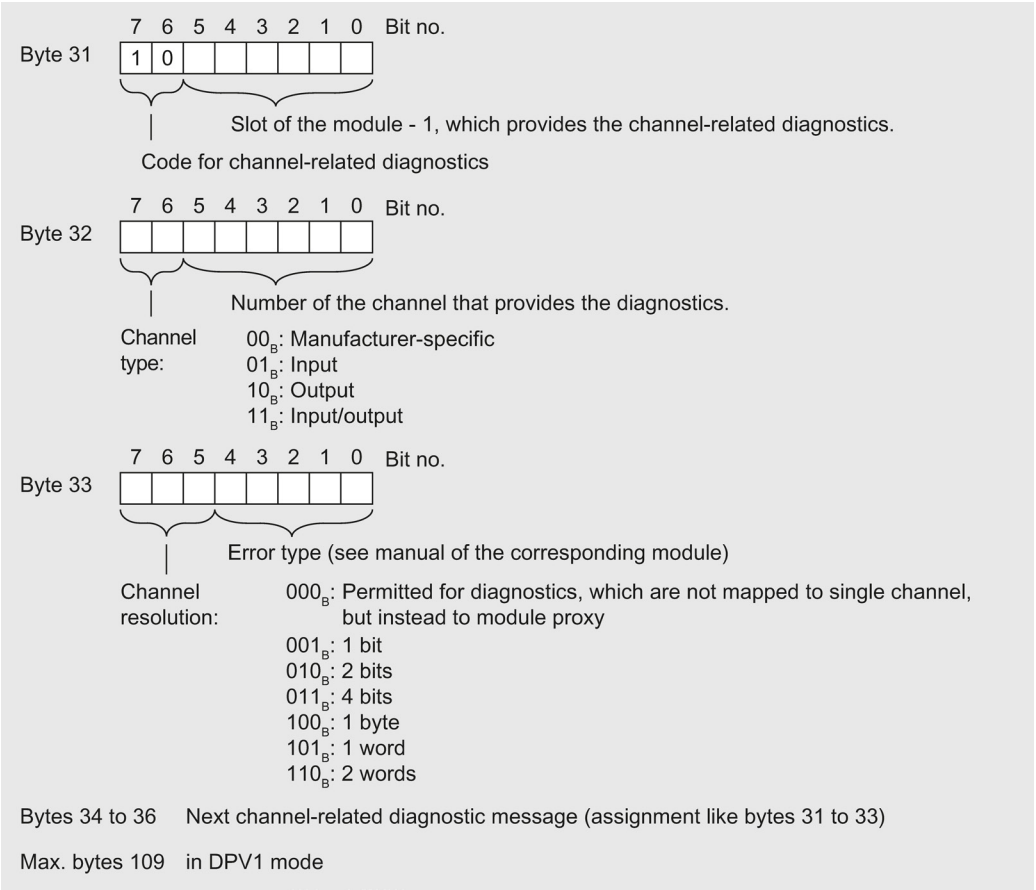


Figure 5-13 Structure of channel diagnostics

When a BaseUnit is incorrectly configured, mapping is made to channel diagnostics. The slot is then apparent from the first byte. In this case, the error type is coded with 0x10 - parameter error. All other fields are set to "0".

5.3.7 H status

Requirements

The H status in the diagnostics frame supplies the IM 155-6 DP HF interface module only when operated behind a Y link (e.g. IM 157) in DPV1 mode. This block can be passed over during the evaluation of the diagnostics frame. The configuration is described in the following section.

Structure of the H status

The following figure shows the structure of the H status of the IM 155-6 DP HF interface module.

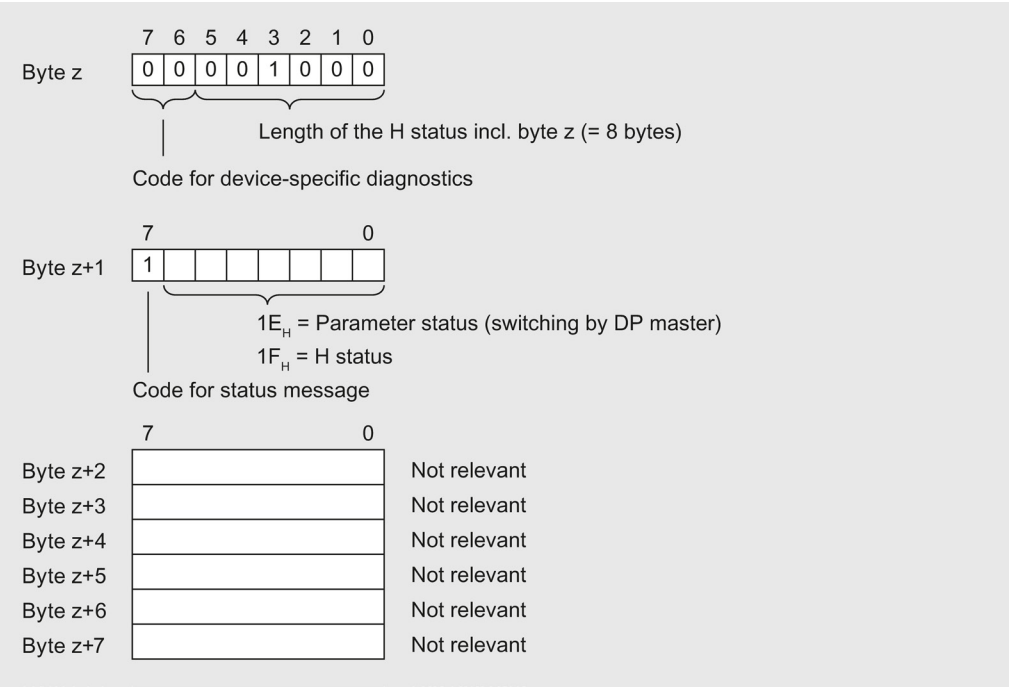


Figure 5-14 Structure of the H status

5.3.8 Invalid configuration states of the ET 200SP on PROFIBUS DP

Incorrect configuration states

The following incorrect configuration states of the ET 200SP distributed I/O system lead to a failure of the DP slave or prevent the start of data exchange.

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g., defective BaseUnit). No interrupt is generated when the ET 200SP backplane bus is interrupted
- No server module
- Configuration exceeds maximum length of 1 m

If a BaseUnit is configured incorrectly, all I/O modules fail and the interface module continues to exchange data.

Diagnostics

The table below shows the incorrect configurations and their diagnostics:

Table 5- 10 Diagnostics

Identifier-related diagnostics	Module status	Cause	Response
Slot 33 set, remaining slots not relevant	Slot 33 with 11_B: "No module; invalid user data" set	• No server module • More than 32 I/O modules • Defective backplane bus	All I/O modules and interface modules fail
All 33 bits set	01_B: "Module error; invalid user data" for all modules	• Configuration > 1 m	All I/O modules and interface modules fail

If the BaseUnit is configured incorrectly, the channel diagnostics "Parameter assignment error" is signaled for the respective slot. Check the parameter "Potential group“ in the parameters of the I/O module.

5.3.9 Load voltage failure on the BaseUnit BU...D

Load voltage failure

If supply voltage fails on the BaseUnit BU...D, the I/O modules react as follows:

- A remove module interrupt is generated if an I/O module is removed during the failure of the supply voltage.
- An insert module interrupt is generated if an I/O module is inserted during the failure of the supply voltage.

Compatibility

6

6.1 Compatibility of modules

Valid firmware versions

The table below lists the valid firmware versions and their field of application for the I/O modules.

I/O modules	Firmware version	Comment
DI8 x DC24V ST	V1.0.1	As of this version, you have the option to operate I/O modules after an IM 155-6 DP HF (6ES7155-6BA00-0CN0) interface module.
DI16 x DC24V ST		
DQ4 x DC24V / 2A ST		
DQ8 x DC24V / 0.5A ST		
DQ16 x DC24V / 0.5A ST		
AI4 x I 2-,4-Draht ST		
AI4 x U/I 2-Draht ST		
AI4 x RTD/TC 2-,3-,4-Draht HF		
AQ4 x U/I ST		

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules without parameter assignment in the following table, the status of the supply voltage (status byte of the server module) is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7132-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7132-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0.5A HF	6ES7131-6BF00-0CA0

Firmware update

A firmware update from V01.00.00 to V01.01.00 requires a preceding update of the IM 155-6 DP HF boot code via the interim version S01.00.01. The firmware V01.01.00 is not accepted by the IM 155-6 DP HF without an update of the boot code.

Procedure for a firmware update:

IM 155-6 DP HF with FW V01.00.00 is present

1. Update of boot code to S01.00.01 according to the description below
2. Update of the firmware to V01.01.00

Procedure for updating the boot code:

S01.00.01 is only intended for updating the boot code. It cannot be used to exchange data with the interface module.

1. An update to S01.00.01 is made based on V01.00.00. Do **not** select "Activate firmware after download"!
2. Switch the IM 155-6 DP HF off and on again.
   Run, Error and Maintenance LEDs light up briefly twice.
   The boot code update is complete when the Run LED flashes quickly (2 Hz) and the Maintenance LED flashes slowly (0.5 Hz). If this LED pattern is present immediately after switching on the device, the boot code is already up-to-date.
   NOTICE: Do not disconnect the IM 155-6 DP HF from the power supply until the Run and Maintenance LEDs flash as described.
3. Firmware update to V01.01.00.

Removing and inserting (hot-swapping) of ET 200SP I/O modules

NOTICE
Removing and inserting (hot swapping) of ET 200SP I/O modules during operation on S7-300 via PROFIBUS **DP** The removing and inserting of ET 200SP I/O modules is possible • as of STEP7 V5.5 SP3 HSP 242 and • enabled “Operation at Preset <> Actual” parameter. Note the following when operating the ET 200SP with S7-300 via PROFIBUS DP: Inserting of ET 200SP I/O modules results in a brief station failure of the ET 200SP.

Note

ET 200SP I/O modules can be removed and inserted without restrictions for all other DP master systems if you enable the "Remove/insert module (OB83)" parameter.

Communication module IO-Link Master CM 4xIO-Link

Note

Communication module IO-Link Master CM 4xIO-Link

Operation of the CM 4xIO-Link IO-Link Master communication module with the IM 155-6 DP HF interface module is supported as of S7-PCT V3.1 and an updated module firmware version/GSD file.

Value status (Quality Information QI)

Note

Value status (Quality Information QI)

The DI 8x24VDC HF (V1.1), DQ 8x24VDC/0.5A HF (V1.1), AI 2xU/I 2-/4-wire HS, AI 4xRTD/TC 2-/3-/4-wire HF (V1.1) and AQ 2xU/I HS I/O modules can evaluate the value status (Quality Information QI). This function is in preparation for the use of these I/O modules with the IM 155-6 DP HF interface module.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules: **Maximum reaction time = 2.3 ms**

First BaseUnit of an ET 200SP in the configuration (as of V3.0)

Note

First BaseUnit of an ET 200SP in the configuration

The first BaseUnit of an ET 200SP station may be a dark one, if an AC I/O module or AI Energy Meter ST is plugged. Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

A light BaseUnit must be inserted on the slot of the first 24 V DC I/O module in order to route the 24 V DC supply voltage via a fuse.

Note the type of the BaseUnits during the configuration.

Station extension via ET-Connection

Note

If a module on which the configuration control was activated with a valid control data record is upgraded to FW version V3.0.0, the retentivity of the control data record is lost when the firmware is updated. The control data record must be written again to the module in this case.

Technical specifications

7

7.1 Technical specifications

Technical specifications of the IM 155-6 DP HF

Table 7- 1 Technical specifications of the IM 155-6 DP HF

	6ES7155-6BA00-0CN0
Product type designation	IM155-6DP HF with PROFIBUS connector and server module
General information	
Firmware version	V3.0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD as of revision 5
Supply voltage	
Voltage type of the supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption, max.	250 mA
Inrush current, max.	4.5 A
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per station	
Address space per station, max.	244 bytes

	6ES7155-6BA00-0CN0
Interfaces	
Number of interfaces PROFIBUS	1
1. Interface	
Interface hardware	
• RS-485	Yes
• Output current of interface, max.	90 mA
Protocols	
• PROFIBUS DP slave	Yes
Interface hardware	
RS-485	
Transmission rate, max.	12 Mbps
Protocols	
PROFIBUS	
Services	
• SYNC capability	Yes
• FREEZE capability	Yes
• DPV0	No
• DPV1	Yes
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	
Interrupts	Yes
Diagnostics alarms	
Diagnostics functions	Yes
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
MAINT LED	Yes; yellow LED
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Connection display DP	Yes; green DP LED
Electrical isolation	
between PROFIBUS DP and all other circuit components	Yes
Between supply and all other circuits	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Connection system	
ET connection	
via BU/BA Send	Yes

	6ES7155-6BA00-0CN0
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	150 g

Dimension drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

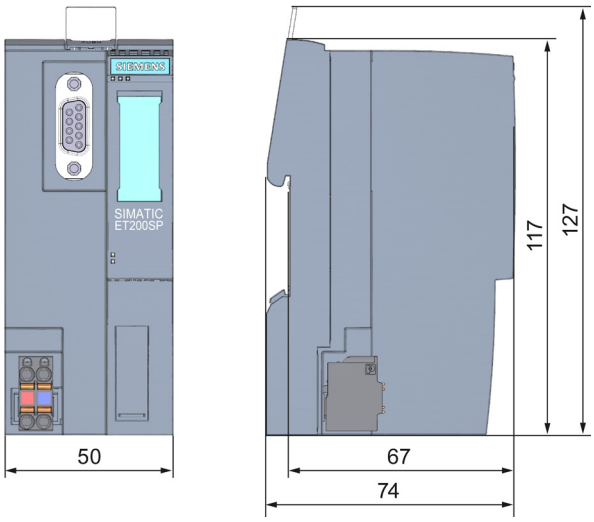
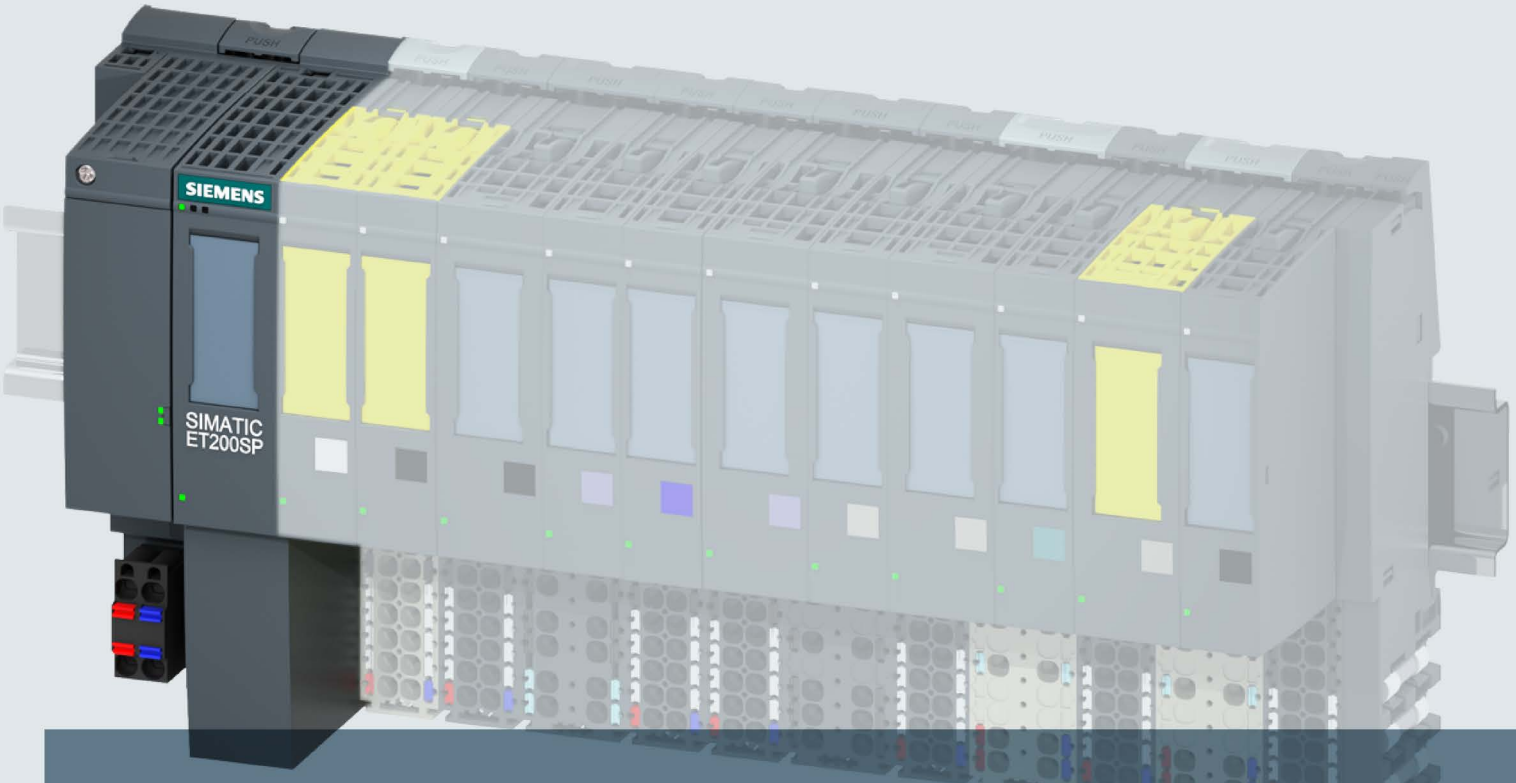


Figure A-1 Dimension drawing of the IM 155-6 DP HF interface module (front and side view)

SIEMENS



SIMATIC

ET 200SP

Interface module IM 155-6 PN HS (6ES7155-6AU00-0DN0)

Manual

Edition 09/2016

siemens.com

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SIMATIC

ET 200SP
IM 155-6 PN HS interface module (6ES7155-6AU00-0DN0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes labeled as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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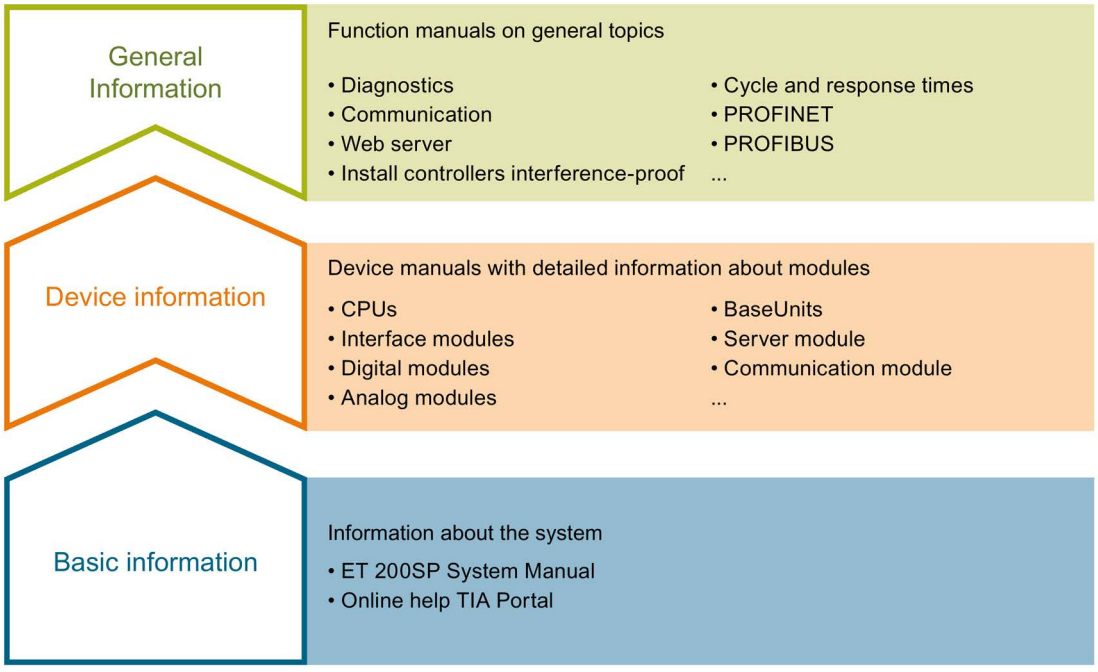
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 Properties

Article number

6ES7155-6AU00-0DN0 (interface module IM 155-6 PN HS and server module)

View of the module

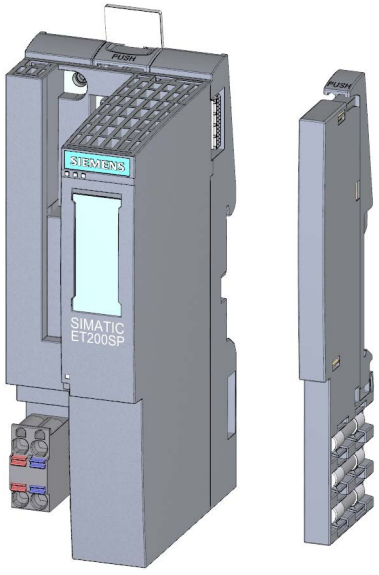


Figure 2-1 View of the IM 155-6 PN HS interface module and the server module

Properties

The module has the following properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO
- High-speed applications as of 125 µs
- Isochronous mode according to PROFINET V2.3
- Supply voltage 1L+ 24 V DC (SELV/PELV).
- The connection plugs for the 24 V DC supply voltage and the server module are included in the scope of delivery of the interface module.
- PROFINET IO connection via selectable BusAdapters
  - For RJ45 bus connection plug (BA 2×RJ45)
  - For direct connection of the bus cable (BA 2×FC)
  - For POF/PCF fiber-optic cable (BA 2xSCRJ)
  - As media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 plug (BA SCRJ/RJ45)
  - As media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable (BA SCRJ/FC)
  - For glass fiber-optic cable (BA 2xLC)
  - As media converter for glass fiber-optic cable ⇔ standard RJ45 plug (BA LC/RJ45)
  - As media converter for glass fiber-optic cable ⇔ direct connection of the bus cable (BA LC/FC)

The module supports the following PROFINET IO functions (see (Page 15))

Maximum configuration

- 30 I/O modules
- 0.5 m backplane bus (without interface module but with server module)

Maximum amount of I/O data

The maximum amount of I/O data without user data qualifier is 968 bytes.

Note

- In the case of a shared device configuration, the 968 bytes apply to the total I/O data of all controllers that share the device.
- If more than two (max. four) controllers share the device, the maximum amount of I/O data including user data qualifier is limited to 360 bytes per controller.

Accessories

You order the following accessories separately:

- BA 2×RJ45 BusAdapter
- BA 2×FC BusAdapter
- BA 2×SCRJ BusAdapter
- BA SCRJ/RJ45 BusAdapter
- BA SCRJ/FC BusAdapter
- BA 2×LC BusAdapter
- BA LC/RJ45 BusAdapter
- BA LC/FC BusAdapter
- Labeling strips
- Reference identification label

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Server module

The server module is included in the scope of delivery of the interface module and is available separately as a spare part. The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Provides station functions, for example, group load diagnostics, status bytes.
- Identification data I&M 0 to 3

Note

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module in the last configuration slot and enable the parameter Group diagnostics: Missing supply voltage L+. When there are 30 I/O modules, the server module is inserted in slot 31.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration

The interface modules support dark-colored BaseUnits in slot 1. This means that modules without a connection to the integrated voltage buses P1 and P2 can be configured starting with slot 1. Currently, this applies to the following modules:

- AI EnergyMeter
- DI 4x120..230VAC ST (6ES7131-6FD00-0BB1)
- DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)
- RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB1)
- RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)

Note

First BaseUnit of an ET 200SP in the configuration

The first BaseUnit of an ET 200SP station may be a dark-colored one if an AC I/O module or AI Energy Meter is plugged. Please observe the information on limiting the overvoltage and power rating in the AC I/O module manuals.

A light-colored BaseUnit must be plugged into the slot of the first 24 V DC I/O module to supply the 24 V DC supply voltage.

Pay attention to the type of the BaseUnits during the configuration.

2.2 Functions

PROFINET IO

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ping, arp, network diagnostics (SNMP)/MIB-2, LLDP-MIB and MRP-MIB
- Port diagnostics
- Disabling ports
- Minimum update time 125 µs
- Device replacement without programming device, also without topological configuration
- Reset to factory settings via PROFINET IO
- Firmware update via PROFINET IO
- Isochronous real-time communication
- Prioritized startup
- Media redundancy (MRP)
- Media redundancy with planned duplication (MRPD)
- Shared device
- Module division of I/O modules (submodules)
- Module-internal Shared Input/Shared Output (MSI/MSO)
- Isochronous mode as of 125 µs
- Performance upgrade PROFINET V2.3
- Freely selectable connection method and connection technology over SIMATIC BusAdapter for PROFINET copper, POF, PCF or fiber-optic cables.

The interface module supports additional functions:

- Identification data I&M 0 to 3
- Oversampling
- PROFIenergy
- Configuration control (option handling)
- Value status of I/O modules
- Use of fail-safe modules
- Multi Hot Swap (removal/insertion of multiple I/O modules during operation)
- Reset to factory settings via RESET button

Note

Docking unit

The use of the IM155-6 PN HS interface module as a docking unit (function: IO device changing in operation) in a docking system is not supported.

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN HS interface module:

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file/software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP4 with HSP0238	STEP 7 (TIA Portal) as of V14
Real-time communication	1	V4.0.0	X	X	X
Isochronous real-time communication according to PROFINET	1	V4.0.0	X	X	X
Prioritized startup	1	V4.0.0	X	X	X
Media redundancy (MRP)	1	V4.0.0	X	X	X
Shared device	1	V4.0.0	X	X	X
Multi Hot Swap	1	V4.0.0	X	X	X
Media redundancy with planned duplication (MRPD)	1	V4.0.0	X	X	X
Isochronous mode ≥ 250 µs	1	V4.0.0	---	X	X
Isochronous mode ≥ 125 µs/187.5 µs	1	V4.0.0	---	---	X
Device replacement without programming device	1	V4.0.0	X	X	X
Module-internal Shared Input/Shared Output (MSI/MSO)	1	V4.0.0	X	X	X
Module division of I/O modules (submodules)	1	V4.0.0	X	X	X
PROFIenergy	1	V4.0.0	X	X	X
Value status	1	V4.0.0	X	X	X
Use of fail-safe modules	1	V4.0.0	---	X	X
Oversampling	1	V4.0.0	---	X	X
BA 2xRJ45 BusAdapter	1	V4.0.0	X	X	X
BA 2xFC BusAdapter	1	V4.0.0	X	X	X
BA 2xSCRJ BusAdapter	1	V4.0.0	X	X	X
BA SCRJ/RJ45 BusAdapter	1	V4.0.0	X	X	X
BA SCRJ/FC BusAdapter	1	V4.0.0	X	X	X
BA 2xLC BusAdapter	1	V4.0.0	X	X	X
BA LC/RJ45 BusAdapter	1	V4.0.0	X	X	X
BA LC/FC BusAdapter	1	V4.0.0	X	X	X

[1] systems of third-party manufacturers: Depending on the range of functions of the third-party system

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you should also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

Isochronous real-time communication

Synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can also be transferred with another high network load (e.g. TCP/IP communication or additional real time communication) at reserved, chronologically synchronized intervals.

A topological configuration is required for IRT.

Note

IO controller as sync master with IRT communication

We recommend also operating the IO controller as a sync master when configuring the IRT communication.

Otherwise, IO devices with IRT and RT configuration could fail as a result of sync master failure.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Isochronous mode of I/O data

I/O data, transmission cycle via PROFINET IO, and the user program are synchronized to achieve maximum deterministics. The input and output data of distributed I/O modules in the system is simultaneously collected and simultaneously output. The constant PROFINET IO cycle forms the corresponding clock generator. The interface module supports isochronous mode of I/O data for the modules starting at 125 µs. The IO device can exchange isochronous process data with a maximum of one IO controller.

Note

If the IO controller cannot access a module (for example, module pulled, activated configuration control without written control data record), cycle time violations may occur with activated isochronous mode in the synchronous cycle interrupt OB (OB61). The time error OB (OB80) is called in the event of a cycle time violation.

This behavior is associated with updating the process image by means of the "SYNC_PI" (SFC126) and "SYNC_PO" (SFC127) instructions and depends, among other things, on the set cycle time and the configuration limits.

Note

Isochronous mode restrictions with IM 155-6 PN HS

Isochronous mode of I/O data in combination with the following functions is not possible with the interface module IM 155-6 PN HS:

- PROFIenergy

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Prioritized startup

Prioritized startup describes the PROFINET IO functionality for accelerating the startup of IO devices in a PROFINET IO system with IRT and RT communication.

The function reduces the time that the appropriately configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the supply voltage has returned
- After a station has returned
- After IO devices have been activated

Note

Dependency on the startup time

The startup time depends on the number and type of modules.

The interface module permits startup times from 0.5 s.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Device replacement

Device replacement without topological configuration

The device name is also stored on the BusAdapter in addition to the interface module. A device name saved on the BusAdapter is the requirement for device replacement without topological configuration.

Storing the name on the BusAdapter and the interface module produces a range of scenarios for using the device name when the interface module is replaced.

Table 2- 2 Scenarios for using the device name

	Interface module empty	**Interface module with device name**
BusAdapter empty	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Be aware of the following constraints:

- Resetting to factory settings via the RESET button deletes the device name in both the interface module and the BusAdapter. To prevent the device name from being deleted in the BusAdapter, you can remove the BusAdapter from the interface module before resetting to factory settings.
- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Do not pull/plug the BusAdapter while under voltage. If you pull/plug the BusAdapter while under voltage, the interface module restarts.

Device replacement with topological configuration

IO devices having this function can be replaced in a simple manner:

- The device name does not have to be assigned with the programming device.

The replaced IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

IO devices that were already operated in a different configuration should be reset to their factory settings before reuse (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Replacement scenario of an IM 155-6 PN HS or of a BusAdapter

In a replacement scenario, any IO device or BusAdapter in operation must be reset to its delivery state via "Reset to factory settings" (see the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Media redundancy (MRP)

Function for safeguarding communication and system availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Media redundancy with planned duplication (MRPD)

If bumpless media redundancy is to be reached with short update times (together with IRT), you must use the MRP extension "Media redundancy with planned duplication (MRPD)".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Shared device

IO device which makes its data available to multiple IO controllers.

The interface module supports shared device at submodule level.

Notes on configuring:

- Always load hardware changes to all affected IO controllers.
- Set the same send clocks in the projects.
- Limit the I/O data including user data qualifier to 360 bytes per IO controller.
- Use the same station name and the same IP address for each shared configuration.
- Assign each module or submodule to only one IO controller.
- In the case of an incorrect configuration, you may need to perform a power OFF/ON on the interface module.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Submodules

The IM 155-6 PN HS interface module supports the module division of I/O modules into up to 4 submodules. This allows parts of an I/O module to be separately configured and assigned parameters.

It is possible to assign each of these submodules to different IO controllers.

The functions

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

can only be executed if you have configured submodule 1 during configuration.

Module-internal Shared Input/Shared Output (MSI/MSO)

The module-internal Shared Input function allows an input module to make its input data available to up to three additional IO controllers. Each controller has read access to the same channels.

The module-internal Shared Output function allows an output module to make the status of its output data available to up to three additional IO controllers. These additional IO controllers can read the status of the channels as input data.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual

Value status

The IM 155-6 PN HS interface module supports I/O modules with value status.

You can find more information on the value status in the manuals for the I/O modules.

Oversampling

The IM 155-6 PN HS interface module supports the oversampling mode of HS modules. With oversampling, the modules reduce the respective PROFINET send clocks in isochronous mode.

You can find more information on oversampling in the manuals for the I/O modules.

2.2.1 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You can find more information on PROFIenergy in the

- I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual
- PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information.
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.

2.2.2 Configuration control (option handling)

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or changes. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

2.2.3 Use of fail-safe modules

Properties

The interface module IM 155-6 PN HS supports the use of fail-safe modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2.4 Multi Hot Swap

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

Note

The IM 155-6 PN HS interface module does not support the removal and insertion of the server module, the interface module and BusAdapter during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Connecting

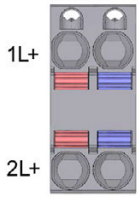
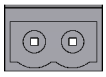
3

3.1 Terminal assignment

24 V DC supply voltage

The table below shows the signal names and descriptions of the pin assignment of the 24 V DC supply voltage.

Table 3- 1 Pin assignment 24 V DC supply voltage

View		Signal name[1]	Description
Connector	IM connection		
		1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

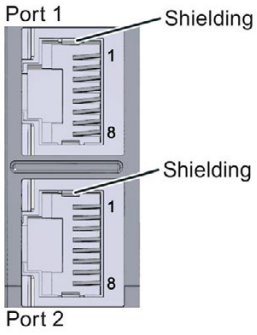
1 1L+ and 2L+ as well as 1M and 2M are bridged internally.

2 Maximum 10 A permitted.

PROFINET IO with BusAdapter BA 2×RJ45

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×RJ45.

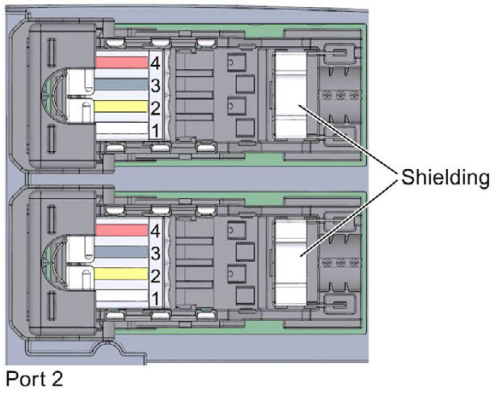
Table 3- 2 PROFINET IO pin assignment with BusAdapter BA 2×RJ45

View	Signal name		Description
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA 2×FC

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×FC.

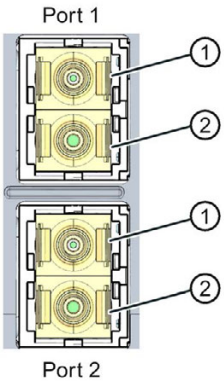
Table 3- 3 PROFINET IO pin assignment with BusAdapter BA 2×FC

View	Signal name		Description
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO with BusAdapter BA 2×SCRJ

The following table shows the signal names and description of the pin assignment for the BA 2×SCRJ BusAdapter.

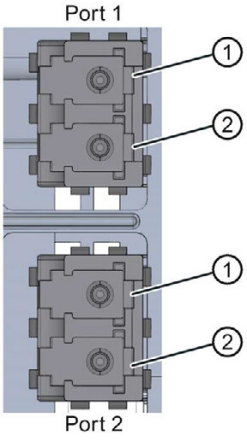
Table 3- 4 PROFINET IO pin assignment with BusAdapter BA 2×SCRJ

View	Signal name	Description
	①	Receiver/Receive data
	②	Sender/Transmit data

PROFINET IO with BusAdapter BA 2×LC

The following table shows the signal names and description of the pin assignment for the BA 2×LC BusAdapter.

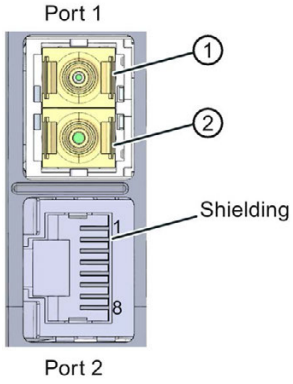
Table 3- 5 PROFINET IO pin assignment with BusAdapter BA 2×LC

View	Signal name	Description
	①	Receiver/Receive data
	②	Sender/Transmit data

PROFINET IO with BusAdapter BA SCRJ/RJ45

The following table shows the signal names and description of the pin assignment for the BA SCRJ/RJ45 BusAdapter.

Table 3- 6 PROFINET IO pin assignment with BusAdapter BA SCRJ/RJ45

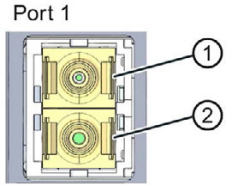
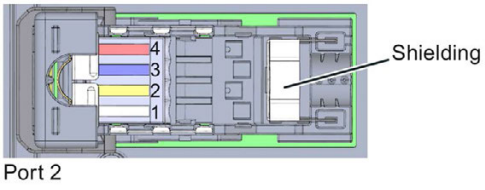
View	Signal name		Description
	①		Receiver/Receive data
	②		Sender/Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data –
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA SCRJ/FC

The following table shows the signal names and description of the pin assignment for the BA SCRJ/FC BusAdapter.

The pin assignment for the BA SCRJ/FC BusAdapter is shown individually for a clearer overview.

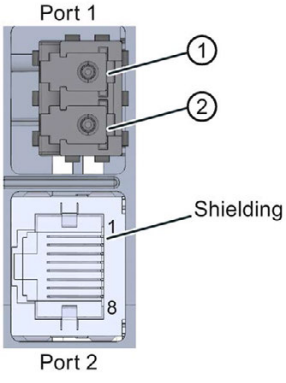
Table 3- 7 PROFINET IO pin assignment with BusAdapter BA SCRJ/FC

View	Signal name		Description
	①		Receiver/Receive data
	②		Sender/Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO with BusAdapter BA LC/RJ45

The following table shows the signal names and description of the pin assignment for the BA LC/RJ45 BusAdapter.

Table 3- 8 PROFINET IO pin assignment with BusAdapter BA LC/RJ45

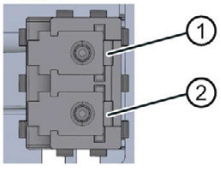
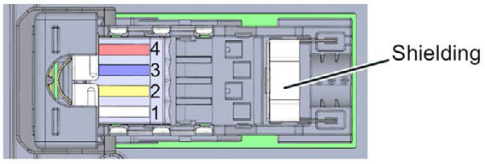
View	Signal name		Description
	①		Receiver/Receive data
	②		Sender/Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data –
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA LC/FC

The following table shows the signal names and description of the pin assignment for the BA LC/FC BusAdapter.

The pin assignment for the BA LC/FC BusAdapter is shown individually for a clearer overview.

Table 3- 9 PROFINET IO pin assignment with BusAdapter BA LC/FC

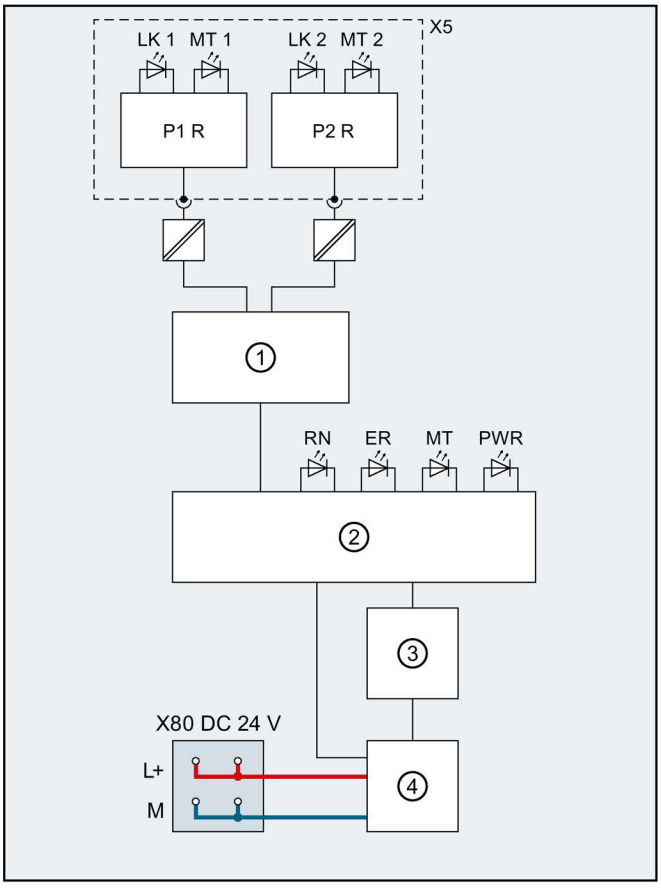
View	Signal name		Description
Port 1  	①		Receiver/Receive data
	②		Sender/Transmit data
 Port 2	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

Reference

You can find more information on accessories and how to connect the interface module in the System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

3.2 Schematic circuit diagram

The following figure shows the block diagram of the interface module IM 155-6 PN HS.



①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1,2	Link TX/RX LED (green)
④	Internal power supply	MT 1,2	MAINT FiberOptic LED (SCRJ port) (yellow)
X80 24 V DC	Feed supply voltage	RN	RUN/STOP LED (green/yellow)
X5	BusAdapter	ER	ERROR LED (red)
P1 R	PROFINET interface X1 Port 1	MT	MAINT LED (yellow)
P2 R	PROFINET interface X1 Port 2	PWR	POWER LED (green)

Figure 3-1 Block diagram of the IM 155-6 PN HS interface module

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 PN HS interface module

The following table shows the parameters for the IM 155-6 PN HS interface module.

Table 4- 1 Parameters for IM 155-6 PN HS interface module (GSD file)

Parameters	Value range	Default	Efficiency range
Configuration control	Disable/enable	Disable	ET 200SP

4.2 Explanation of parameters

4.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

Note

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.3 Substitute value behavior

Substitute value behavior

The substitute value behavior in the ET 200SP distributed I/O system is defined through the configuration.

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Parameter assignment phase during startup
- Deactivating the IO device
- Station stop:
  - Missing server module
  - At least one I/O module installed on an incorrect BaseUnit

Note

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

The "current-free/voltage-free" behavior becomes effective in the following cases:

- Firmware update
- Reset to factory settings
- Configuration control: The IM has not received a valid control data record 196 yet.
- Incorrectly configured module
- Module with incorrect parameter assignment

4.4 Status of the supply voltage L+ of the I/O modules

The status of the supply voltage L+ of the ET 200SP I/O modules is mapped to the server module with the interface module IM 155-6 PN HS.

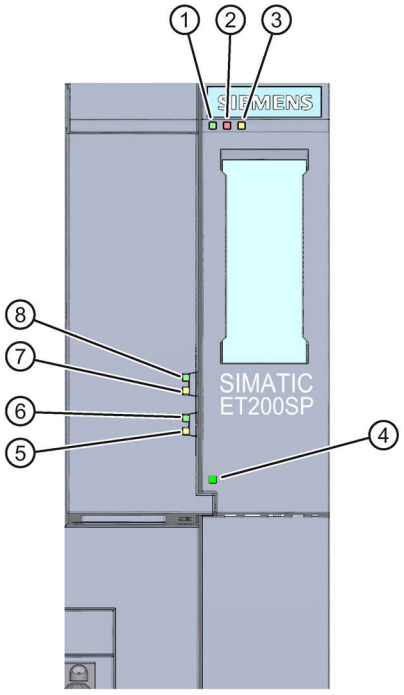
You can find information on the status of the supply voltage L+ of the I/O modules in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

Interrupts, diagnostics, error, and system messages 5

5.1 Status and error displays

LED displays

The following figure shows the LED displays on the interface module and BusAdapter.



① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ MT2 (yellow) (SCRJ port)
⑥ LK2 (green)
⑦ MT1 (yellow) (SCRJ port)
⑧ LK1 (green)

Figure 5-1 LED displays on the interface module and BusAdapter

Meaning of the LEDs

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 5- 1 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Remedy
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module.*
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	---
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	---
			ET 200SP is being assigned parameters.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	---
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics data and remedy the error.
			The configured structure does not correspond to the actual structure of the ET 200SP .	Check the structure of the ET 200SP to see whether a module is missing or defective, or whether a non-configured module is plugged.
			Invalid configuration states.	See section Invalid configuration states of the ET 200SP on PROFINET IO (Page 44)
			Parameter error in the I/O module.	Evaluate the display of the module status in STEP 7 and eliminate the error in the respective I/O module.
Not relevant	Not relevant	On	Maintenance	See section Maintenance events (Page 42)
Flashes	Flashes	Not relevant	Invalid BusAdapter	Check the BusAdapter.
Flashes	Flashes	Flashes	The "Node flash test" is run (the LEDs LK1 and LK2 of the PROFINET interface also flash).	---
			Hardware or firmware defective (the LEDs LK1 and LK2 of the PROFINET interface do not flash).	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.
Not relevant	Flashes	Flashes	Configuration error on backplane bus	Insert the server module as bus termination or check the number of inserted modules.

* PWR LED on (on the interface module): Check the backplane bus for a short circuit.

PWR LED on the interface module

Table 5- 2 Status display of the PWR LED

PWR LED	Meaning	Remedy
☐ Off	Supply voltage not present or too small	Check the supply voltage.
■ On	Supply voltage present	---

LK1/LK2 and MT1/MT2 LEDs on the BusAdapter

Table 5- 3 Status and error displays of LK1/LK2 and MT1/MT2 LEDs

LED		Meaning	Remedy
LK1/LK2	MT1/MT2*		
☐ Off	Not relevant	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted.
■ On	Not relevant	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	---
☼ Flashes	Not relevant	The "Node flash test" is run (the RN/ER/MT LEDs also flash).	---
Not relevant	☐ Off	No error	---
Not relevant	■ On	• Fiber-optic error • Maintenance demanded: Attenuation through the fiber-optic cable is so high that operation will soon no longer be possible.	Causes and measures for the transmission route: • Replacement of fiber-optic cable if damaged or aged • Correct installation of the PROFINET connector/PROFINET connections • Adherence to maximum length of 50 m for POF cable or 100 m for PCF cable. • Secure fit of the FOC connector

* Available only on BA 2×SCRJ, BA SCRJ/RJ45 and BA SCRJ/FC BusAdapters

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interface module by the ER (red) and MT (yellow) LEDs.

The following configuration errors are indicated by the LEDs:

- Missing server module
- Interruptions or short circuit on the backplane bus

Principle of operation

You determine the information for cause of the error with the LED error display. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display

- is active during POWER ON as well as during operation.
- Has priority over all other states that are displayed by means of the ER and MT LEDs.
- remains turned on until the cause of the error has been corrected.

Table 5- 4 Display of error type and error location

Sequence		Description
1	ER and MT LEDs flash 3x with 0.5 Hz	Signaling of error type
2	MT LED flashes with 1 Hz	Display of the error type (decimal)
3	ER and MT LEDs flash 3x with 2 Hz	Signaling of error location/error code
4	ER LED flashes with 1 Hz	Display of tens digit (decimal) of the error location/error code
5	MT LED flashes with 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repeat steps 1 to 5 until the cause of the error has been corrected.	

Error display

The following table shows the possible causes of error that can occur.

Table 5- 5 Error display

Error type (MT)	Error location (ER/MT)	Cause of error	Remedy
1	65*	• Missing server module • Interruptions at the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

* Slot

Note

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN-, ER and MT LED: Off

5.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Swapping interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

STEP 7 (TIA Portal) offers innovative system diagnostics for the devices of the S7-1500 (IO controller CPU S7-1500) and the ET 200SP (IO device) automation system. Independent of the cyclic user program, messages are made available on the display of the CPU S7-1500, the CPU web server and the HMI device.

For more information on system diagnostics, refer to the System Diagnostics function manual. (http://support.automation.siemens.com/WW/view/en/59192926).

5.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts the processing of the user program and processes the diagnostics interrupt (OB 82). The event which led to the interrupt is entered in the start information of the diagnostics interrupt (OB 82).

5.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

During a hardware interrupt, the CPU interrupts the processing of the user program and processes the hardware interrupt block (e.g., OB 40). The event that triggered the interrupt is entered in the start information of the hardware interrupt block.

Note

Diagnostics "Hardware interrupt lost" (from I/O module)

Avoid creating hardware interrupts cyclically.

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.3 Triggering a swapping interrupt

Triggering a remove/insert interrupt

In the event of a remove/insert interrupt, the CPU interrupts processing of the user program and processes the remove/insert interrupt (OB 83). The event which led to the interrupt is entered in the start information of the remove/insert interrupt (OB 83).

Note

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating the remove/insert interrupt (OB83). After inserting a module, the remove/insert interrupt (OB83) is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

5.3 Alarms

Actions after a diagnostics alarm

There can be more than one diagnostic alarm at a given time. Actions initiated by diagnostics alarms:

- The ER LED on the interface module flashes.
- Diagnostic data is reported as diagnostic interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- The diagnostics interrupt (OB 82) is called. If the diagnostics interrupt (OB 82) is not available, the I/O controller goes into STOP mode.

You can find more information on this topic in the STEP 7 online help.

Reading out the diagnostics data

Table 5- 6 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See...
SIMATIC S7	Diagnostics as plain text in STEP 7 in online and diagnostics view	STEP 7 online help • As of STEP 7 V14, function manual PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) • As of STEP 7 V5.5, system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

Additional information on the data records for PROFINET IO

The structure of the diagnostic data records and programming examples are available in the Programming Manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) and in Example application (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostics alarms are described in the product manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section "Interrupts/diagnostics alarms".

See also

Channel diagnostics (Page 43)

5.3.1 Maintenance events

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158-6-10 standard. The goal is to detect and remove potential problems as soon as possible.

For the interface module, maintenance events signal to the user when a network component must be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostics interrupt (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostics interrupt (OB 82).

At the following events:

- The interface module signals a maintenance event to the higher-level diagnostic system
- The I/O module signals a maintenance event.

Table 5- 7 Triggering of a maintenance event

Maintenance alarm	Event	Meaning
Maintenance demanded (*maintenance demanded*) MT LED is lit	Synchronization loss	• No synchronization telegram received No synchronization telegram was received by the sync master within the timeout period after parameter assignment or during operation. • Successive synchronization telegrams are located outside permitted limits (jitter)
	Critical FOC attenuation	The received light intensity at the FOC port is critical. The FOC should be replaced.
	Maintenance request from I/O module	An I/O module signals a maintenance event that is sent and displayed by the interface module

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 with the following system alarms:

- Maintenance demanded - indicated for each port by a yellow wrench icon in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

5.3.2 Channel diagnostics

Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read using the instruction "RDREC".

Structure of the diagnostics data records

The data records supported by the ET 200SP distributed I/O system are based on the standard PROFINET IO - Application Layer Service Definition V2.3.

You can download the standard PROFIBUS user organization (http://www.profibus.com) from the homepage of the PROFIBUS User Organization.

Codes of the extended channel diagnostics

With the IM 155-6 PN HS interface module, the following extended channel diagnostics are reported:

Slot number	ChannelError-Type (CET)	ExtendedChannel-ErrorType (ECET)	Associated value AddValue	Diagnostics
Module slot	0x0602	0x0691	Slot	Station stop - module parameter "Potential group" faulty or incorrect BaseUnit in actual slot (AddValue)
Slot 0	0x0602	0x0693	0x00	Diagnostics with missing server module
	0x0602	0x0698	0x00	Diagnostics backplane bus too long
	0x0602	0x0699	Slot	Diagnostics with incorrect bus configuration
	0x0602	0x069C	0x00	Diagnostics with incorrectly plugged BusAdapter
Server module slot	0x0610	0x06B0	0x00	Group diagnostics: Missing supply voltage L+ for the potential groups Note: The slot in which the light-colored BaseUnit of the respective load module is located is coded in the "ChannelNumber" element.

5.3.3 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent the exchange of user data with the I/O modules.

- Number of modules exceeds maximum configuration
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is installed in a different BaseUnit than the one configured in the parameters.
- Missing server module
- Invalid or incorrectly configured BusAdapter.

Note

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module is still exchanging data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

See also

Status and error displays (Page 34)

Channel diagnostics (Page 43)

5.3.4 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull alarm is generated.
- If an I/O module is installed during failure of the supply voltage, an insert alarm is generated.

5.3.5 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics frames received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. You must read the data record $E00C_H$ with the "RDREC" instruction in OB 100. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the diagnostics of a station after its return, you have to read the $E00C_H$ data record with the "RDREC" instruction in the rack interrupt (OB 86). This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility

6

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Order number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0
DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 8x24VDC/0,5A HF	6ES7132-6BF00-0CA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules:
maximum reaction time = configured update time + 400 µs (but at least 1.4 ms)

Technical specifications

7

Technical specifications of the IM 155-6 PN HS

	6ES7155-6AU00-0DN0
General information	
Product type designation	ET 200SP, IM 155-6 PN HS with server module
Firmware version	V4.0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	As of STEP 7 V14
STEP 7 can be configured/integrated as of version	V5.5 SP4 or higher
PROFINET as of GSD version/GSD revision	- / V2.3
Configuration control	
Via data record	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption, max.	700 mA
Inrush current, max.	3.7 A
I^2t	0.09 A^2s
Power loss	
Power loss, typ.	2.4 W
Address area	
Address space per module	
Address space per module, max.	32 bytes; for both input and output data
Address space per station	
Address space per station, max.	968 bytes each for input data and output data

	6ES7155-6AU00-0DN0
Hardware configuration	
Racks	
Modules per rack, max.	30
Submodules	
Number of submodules per station, max.	125
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1st interface	
Interface hardware	
Number of ports	2
Integrated switch	Yes
BusAdapter (PROFINET)	Yes; usable BusAdapters: BA 2x RJ45, BA 2x FC, BA 2x SCRJ, BA SCRJ / RJ45, BA SCRJ / FC, BA 2x LC, BA LC / RJ45, BA LC / FC
Protocols	
PROFINET IO device	Yes
Open IE communication	Yes
Media redundancy	Yes; as MRP or MRPD client, max. 50 or 30 devices in the ring
Interface hardware	
RJ 45 (Ethernet)	
Transmission method	PROFINET with 100 Mbps full duplex (100BASE-TX)
10 Mbps	Yes; for Ethernet services
100 Mbps	Yes; PROFINET with 100 Mbps full duplex (100BASE-TX)
Autonegotiation	Yes
Autocrossing	Yes
Protocols	
PROFINET IO device	
Services	
• S7 communication	Yes
• Isochronous mode	Yes; bus cycle time min. 125 µs
• IRT	Yes; 125 µs, 250 µs, 500 µs, 1 ms, 2 ms, 4 ms additionally with IRT with high performance: 250 µs to 4 ms in 125 µs intervals
• MRP	Yes
• MRPD	Yes
• PROFINET system redundancy	No
• PROFIenergy	Yes
• Prioritized startup	Yes
• Shared device	Yes
• Number of IO controllers with shared device, max.	4

	6ES7155-6AU00-0DN0
Open IE communication	
TCP/IP	Yes
SNMP	Yes
LLDP	Yes
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Constant bus cycle time	Yes
Shortest clock pulse	125 µs
Longest clock pulse	4 ms
Bus cycle time (TDP), min.	125 µs
Jitter, max.	0.25 µs
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	Yes
Diagnostic functions	Yes
Diagnostic indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
MAINT LED	Yes; yellow LED
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Connection display LINK TX/RX	Yes; 2x green Link LED on BusAdapter
Electrical isolation	
Between backplane bus and electronics	No
between PROFINET and all other circuits	Yes
Standards, approvals, certificates	
Network loading class	3
Security level	According to Security Level 1 Test Cases V1.1.1
Ambient conditions	
Ambient temperature during operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	147 g; without BusAdapter

Technical specifications of the BusAdapter BA 2×RJ45

Table 7- 1 Technical specifications of the BusAdapter BA 2×RJ45

	6ES7193-6AR00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
RJ45	Yes; 2 x
FC (FastConnect)	No
SCRJ	0
LC	0
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	46 g

Technical specifications of the BusAdapter BA 2×FC

Table 7- 2 Technical specifications of the BusAdapter BA 2×FC

	6ES7193-6AF00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
FC (FastConnect)	Yes; 2 x
Cable length	
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	53 g

Technical specifications of the BusAdapter BA 2×SCRJ

Table 7- 3 Technical specifications of the BusAdapter BA 2×SCRJ

	6ES7193-6AP00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (switch) SCRJ FO
RJ45	No
FC (FastConnect)	No
SCRJ	2
LC	0
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/RJ45

Table 7- 4 Technical specifications of the BusAdapter BA SCRJ/RJ45

	6ES7193-6AP20-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + RJ45)
RJ45	Yes; 1x
FC (FastConnect)	No
SCRJ	1
LC	0
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/FC

Table 7- 5 Technical specifications of the BusAdapter BA SCRJ/FC

	6ES7193-6AP40-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + FC)
RJ45	No
FC (FastConnect)	Yes; 1x
SCRJ	1
LC	0
Cable length	
• PCF	100 m
• Plastic FOC (POF)	50 m
• PCF-GI	300 m
• Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA 2×LC

Table 7- 6 Technical specifications of the BusAdapter BA 2×LC

	6ES7193-6AG00-0AA0
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC multimode glass-fiber
PROFINET IO	
RJ45	No
FC (FastConnect)	No
SCRJ	0
LC	2
Cable length	
• Multimode gradient-index fiber 50/125 µm	3 km
• Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	40 g

Technical specifications of the BusAdapter BA LC/RJ45

Table 7- 7 Technical specifications of the BusAdapter BA LC/RJ45

	6ES7193-6AG20-0AA0
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC / RJ45
PROFINET IO	
RJ45	Yes; 1x
FC (FastConnect)	No
SCRJ	0
LC	1
Cable length	
• Copper cables	100 m
• Multimode gradient-index fiber 50/125 µm	3 km
• Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	32 g

Technical specifications of the BusAdapter BA LC/FC

Table 7- 8 Technical specifications of the BusAdapter BA LC/FC

	6ES7193-6AG40-0AA0
Interfaces	
Number of PROFINET interfaces	1
PROFINET IO	
RJ45	No
FC (FastConnect)	Yes; 1x
SCRJ	0
LC	1
Cable length	
• Copper cables	100 m
• Multimode gradient-index fiber 50/125 µm	3 km
• Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Dimensional drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

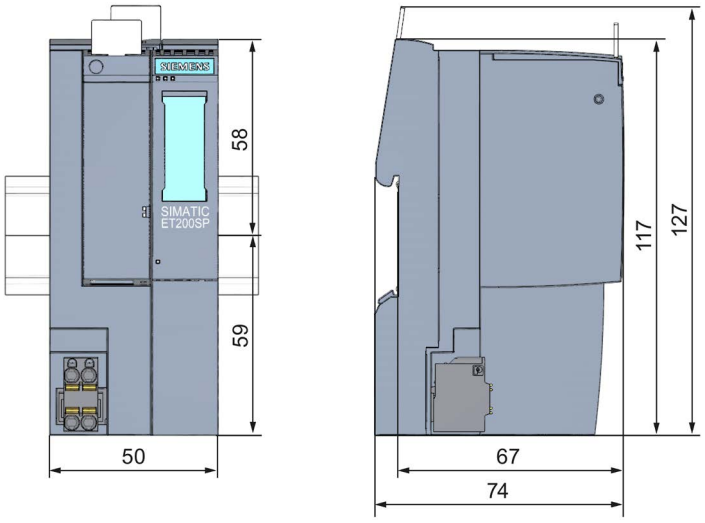


Figure A-1 Dimension drawing of the IM 155-6 PN HS interface module (front and side view)

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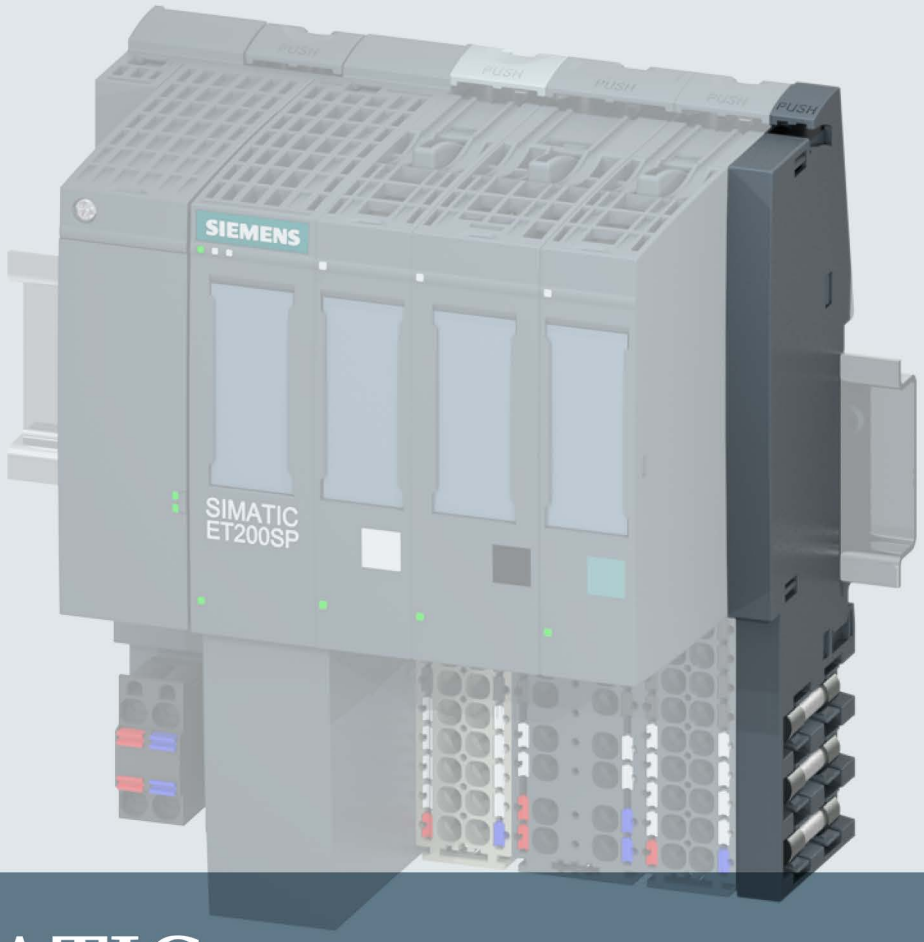

SIMATIC

ET 200SP

Server module (6ES7193-6PA00-0AA0)

Manual

Edition 03/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Server module
(6ES7193-6PA00-0AA0)

Manual

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03/2015

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 03/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes labeled as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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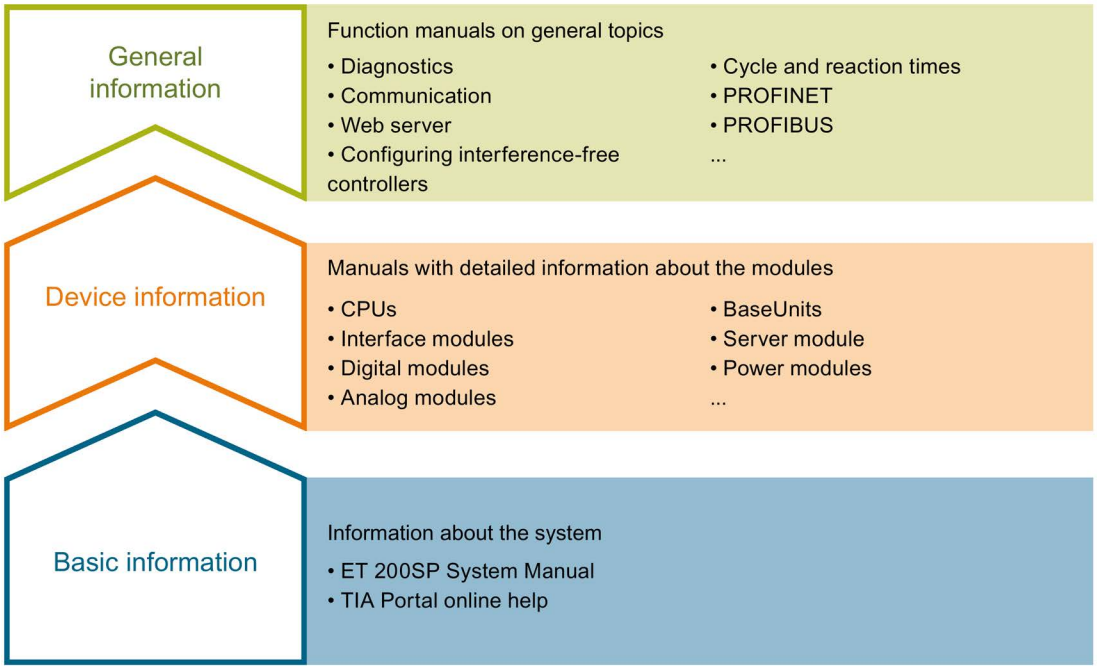
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7193-6PA00-0AA0

View of the module

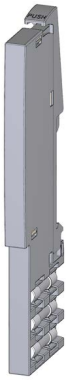


Figure 2-1 View of the server module

Properties

The module has the following technical properties:

- Closes off the backplane bus of the ET 200SP
- Contains a support for 3 spare fuses (5 × 20 mm)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- Representation of the statuses of supply voltage L+ and the feedback voltage (Page 15) per slot.
- Retentive storage of device name for device replacement without topological configuration of the IM 155-6 PN BA.

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Function and properties	Product version of the module as of	Firmware version of the module as of
Support of the IM 155-6 PN BA	1	V1.1.1

Parameters/address space

3

3.1 Parameters

Parameters for the server module

The effective range of the configurable parameter depends on the type of configuration. Possible configuration: Distributed operation on PROFINET IO in an ET 200SP system.

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameter to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 19).

The following parameter settings are possible:

Table 3- 1 Configurable parameter and its default (GSD file)

Parameters	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Group diagnostics: No supply voltage L+	• Disable • Enable	No	Yes	ET 200SP	---

3.2 Explanation of the parameters

Group diagnostics: No supply voltage L+

When you enable this parameter, the ET 200SP generates one diagnostic per potential group (as group information) when the supply voltage L+ fails.

This function does not depend on enabling the parameter "Diagnostics: No supply voltage L+" of the I/O modules.

The diagnostics is formed from the states of the supply voltage of the installed I/O modules within the potential group.

Requirements

- All I/O modules must be inserted, i.e. the current configuration must not have any empty slots.
- If no I/O modules are inserted on light-colored BaseUnits BU..D, the beginning of this potential group is not recognized. The I/O modules of this potential group are therefore part of the previous potential group.
  If the I/O module is installed on the light-colored BaseUnit, the potential group is detected, the diagnostics is reevaluated according to the potential group arrangement and new diagnostics may be reported. The position of the light-colored BaseUnit remains stored in the structure until the supply voltage 1L+ of the CPU/interface module is turned off.

3.3 Address space

Introduction

You can read out the status of the supply voltage L+ and the feedback voltage of I/O modules via the address space of the server module:

- All I/O modules:
  No supply voltage L+ or no I/O module available
- Additional digital output module HF:
  feedback voltage present

Requirements

- The I/O module used must support monitoring of the supply voltage.
- The I/O module used must support monitoring of a feedback voltage.

Length of input data

The length of the input data depends on the CPU/interface module:

- Interface module with 12 I/O modules maximum configuration: 2/4 bytes
- Interface module with 32 I/O modules maximum configuration: 4/8 bytes
- CPU/interface module with 64 I/O modules maximum configuration: 8/16 bytes

Configurations

In the configuration software, you can select 3 configurations for the server module for operation on the CPU/interface module:

- Configuration with disabled "Status of the supply voltage L+" and disabled "Status of the feedback voltage":
  - The server module only has one diagnostics address.
- Configuration with enabled "Status of the supply voltage L+" and disabled "Status of the feedback voltage":
  - The server module has 2/4/8 bytes of input data for the display of the status of the supply voltage L+ of the inserted I/O modules.
  - Display in the input data of the server module:

    Supply voltage L+ present/missing or I/O module available/not available
- Configuration with enabled "Status of the supply voltage L+" and enabled "Status of the feedback voltage":
  - The server module has 4/8/16 bytes of input data for the display of the status of the supply voltage L+ and the status of the feedback voltage of the inserted I/O modules.
  - Display in the input data of the server module:

    Supply voltage L+ present/missing or I/O module available/not available

    Feedback voltage present/missing

Table 3- 2 Data length depending on configuration and maximum configuration

Maximum configuration	"Status supply voltage" deactivated	Activated	Activated
	"Status feedback voltage" deactivated	Deactivated	Activated
12 slots	0	2	4
32 slots	0	4	8
64 slots	0	8	16

3.3.1 Input data for interface modules with maximum 12 I/O modules

Configuration with enabled status detection of the supply voltage L+ (2 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 1):

- Supply voltage L+ present/missing or I/O module available/not available (2 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	x	x	x	x	12	11	10	9

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or no I/O module available
X = 0

Figure 3-1 Configuration with enabled status detection of the supply voltage L+ (2 bytes)

Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (4 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 3).

- Supply voltage L+ present/missing or I/O module available/not available (2 bytes)
- Feedback voltage present/missing (2 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	x	x	x	x	12	11	10	9

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or I/O module not available
x = 0

Byte 2	8	7	6	5	4	3	2	1
Byte 3	x	x	x	x	12	11	10	9

Bit = 1:
Feedback voltage present
Bit = 0:
Feedback voltage missing
x = 0

Figure 3-2 Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (4 bytes of input data)

Note

- An inserted or missing server module always signals bit=0 for the slot.
- If the server module is missing, the input data is invalid.
- For I/O modules without feedback voltage monitoring, the bit for the feedback voltage is the same as the bit for the missing supply voltage L+.

3.3.2 Input data for interface modules with maximum 32 I/O modules

Configuration with enabled status detection of the supply voltage L+ (4 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 3):

- Supply voltage L+ present/missing or I/O module available/not available (4 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or no I/O module available

Figure 3-3 Supply voltage L+ missing or I/O module not available (4 bytes); feedback voltage not available

Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (8 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 7).

- Supply voltage L+ present/missing or I/O module available/not available (4 bytes)
- Feedback voltage present/missing (4 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or I/O module not available

Byte 4	8	7	6	5	4	3	2	1
Byte 5	16	15	14	13	12	11	10	9
Byte 6	24	23	22	21	20	19	18	17
Byte 7	32	31	30	29	28	27	26	25

Bit = 1:
Feedback voltage present
Bit = 0:
Feedback voltage missing

Figure 3-4 Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (8 bytes of input data)

Note

- An inserted or missing server module always signals bit=0 for the slot.
- If the server module is missing, the input data is invalid.
- For I/O modules without feedback voltage monitoring, the bit for the feedback voltage is the same as the bit for the missing supply voltage L+.

3.3.3 Input data for CPU/interface modules with maximum 64 I/O modules

Configuration with enabled status detection of the supply voltage L+ (8 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 7):

- Supply voltage L+ present/missing or I/O module available/not available (8 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25
Byte 4	40	39	38	37	36	35	34	33
Byte 5	48	47	46	45	44	43	42	41
Byte 6	56	55	54	53	52	51	50	49
Byte 7	64	63	62	61	60	59	58	57

Slots of I/O modules
Bit = 1:
Supply voltage L+ present and I/O module available
Bit = 0:
Missing supply voltage L+ or no I/O module available

Figure 3-5 Configuration with enabled status detection of the supply voltage L+ (8 bytes)

Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (16 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 15):

- Supply voltage L+ present/missing or I/O module available/not available (8 bytes)
- Feedback voltage present/missing (8 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25
Byte 4	40	39	38	37	36	35	34	33
Byte 5	48	47	46	45	44	43	42	41
Byte 6	56	55	54	53	52	51	50	49
Byte 7	64	63	62	61	60	59	58	57

Slots of I/O modules
Bit = 1:
Supply voltage L+ present and I/O module available
Bit = 0:
Missing supply voltage L+ or no I/O module available

	8	7	6	5	4	3	2	1
Byte 8	8	7	6	5	4	3	2	1
Byte 9	16	15	14	13	12	11	10	9
Byte 10	24	23	22	21	20	19	18	17
Byte 11	32	31	30	29	28	27	26	25
Byte 12	40	39	38	37	36	35	34	33
Byte 13	48	47	46	45	44	43	42	41
Byte 14	56	55	54	53	52	51	50	49
Byte 15	64	63	62	61	60	59	58	57

Bit = 1:
Feedback voltage available
Bit = 0:
Feedback voltage not available

Figure 3-6 Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (16 bytes of input data)

Note

- An inserted or missing server module always signals bit=0 for the slot.
- If the server module is missing, the input data is invalid.
- For I/O modules without feedback voltage monitoring, the bit for the feedback voltage is the same as the bit for the missing supply voltage L+.

3.3.4 Evaluating feedback voltage

Ranges of error

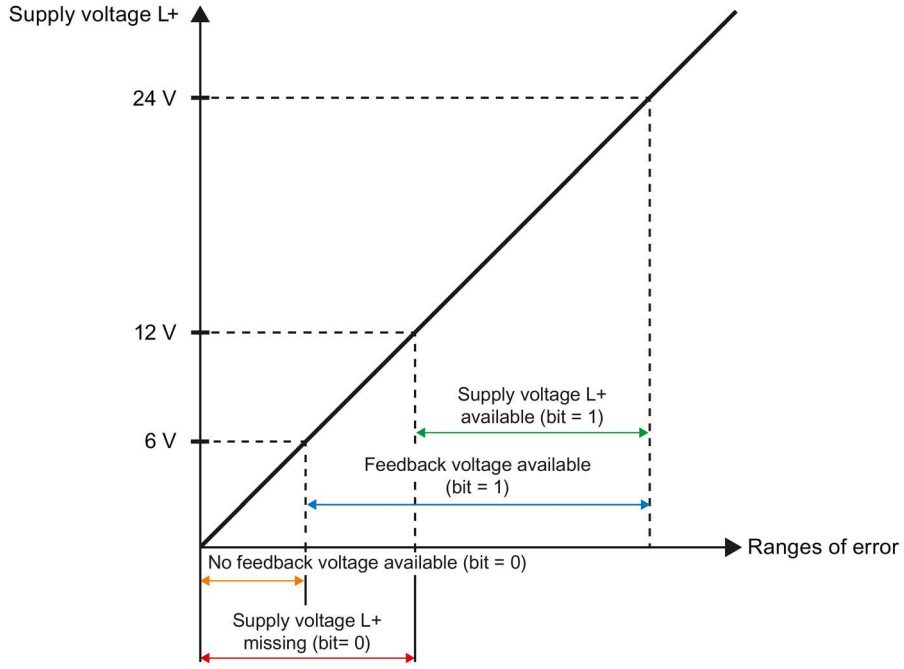


Figure 3-7 Ranges of error of the supply voltage L+ and the feedback voltage

Feedback voltage

A feedback may occur, for example, due to a crossover in a cable of a digital output module and depends on the target status of the supply voltage L+:

If the supply voltage L+ of the I/O module is greater than 6 V, this is entered in the input data in the respective bit.

- Byte 2 and 3 (for 12 I/O modules and 4 bytes of input data)
- Byte 4 to 7 (for 32 I/O modules and 8 bytes of input data)
- Byte 8 to 15 (for 64 I/O modules and 16 bytes of input data)

The feedback voltage can be evaluated via the user program in the following cases:

Table 3- 3 Under what circumstances can the feedback voltage be evaluated via the user program?

Supply voltage L+ safely disconnected[1]	Status detection of supply voltage L+ (input data)	Status detection of feedback voltage (input data)	Explanation
Yes	Not available: Bit = 0	Available: Bit = 1	The feedback voltage detected is in the range 6 to 12 V (e.g. in the event of a fault in the system)
Yes	Available: Bit = 1	Available: Bit = 1	The feedback voltage detected is > 12 V (e.g. in the event of a fault in the system)

[1] This does not refer to the supply voltage applied to the BaseUnit, but, for example, to the status information of a safety relay.

Diagnostics alarms

4

A diagnostics alarm is output for each diagnostics event. The diagnostics alarms can, for example, be read out in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 4- 1 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Server module with invalid firmware version (< V1.1.1)	$1B_H$	General error	• Replace the server module. • Firmware update of the server module.

Technical specifications

5

5.1 Technical specifications

Technical specifications of the server module

	6ES7193-6PA00-0AA0
Dimensions	
Width	7 mm
Height	117 mm
Depth	36 mm
Weights	
Weight, approx.	19 g

Parameter data record

6

6.1 Parameter assignment and structure of parameter data record

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

STATUS output parameter

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

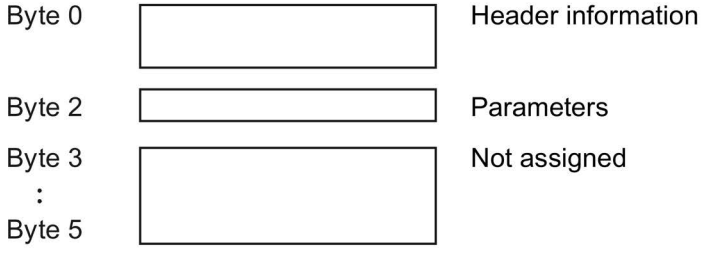


Figure 6-1 Structure of data record 128

Header information

The following diagram shows the structure of the header information.

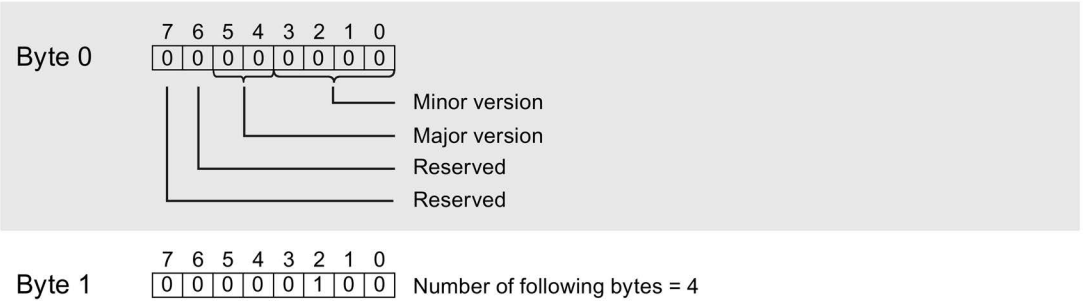


Figure 6-2 Header information

Parameters

The following diagram shows the structure of the parameter in byte 2.

Enable the parameter by setting the corresponding bit to "1".

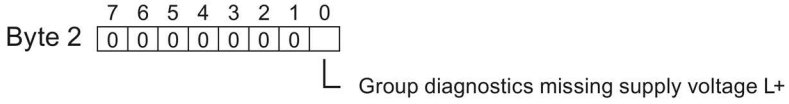


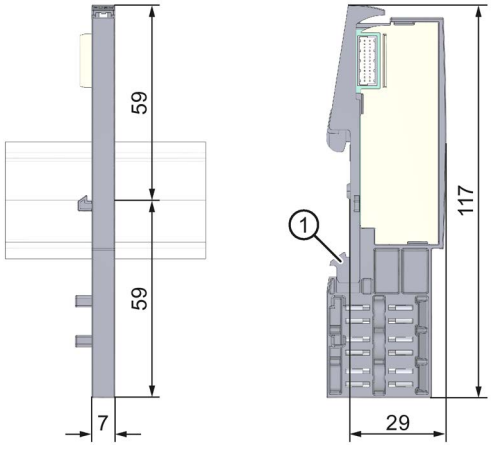
Figure 6-3 Structure of byte 2

Dimensional drawing

A

A.1 Server module

Dimensional drawing of the server module



① Contact plating of mounting rail

Figure A-1 Dimensional drawing of the server module

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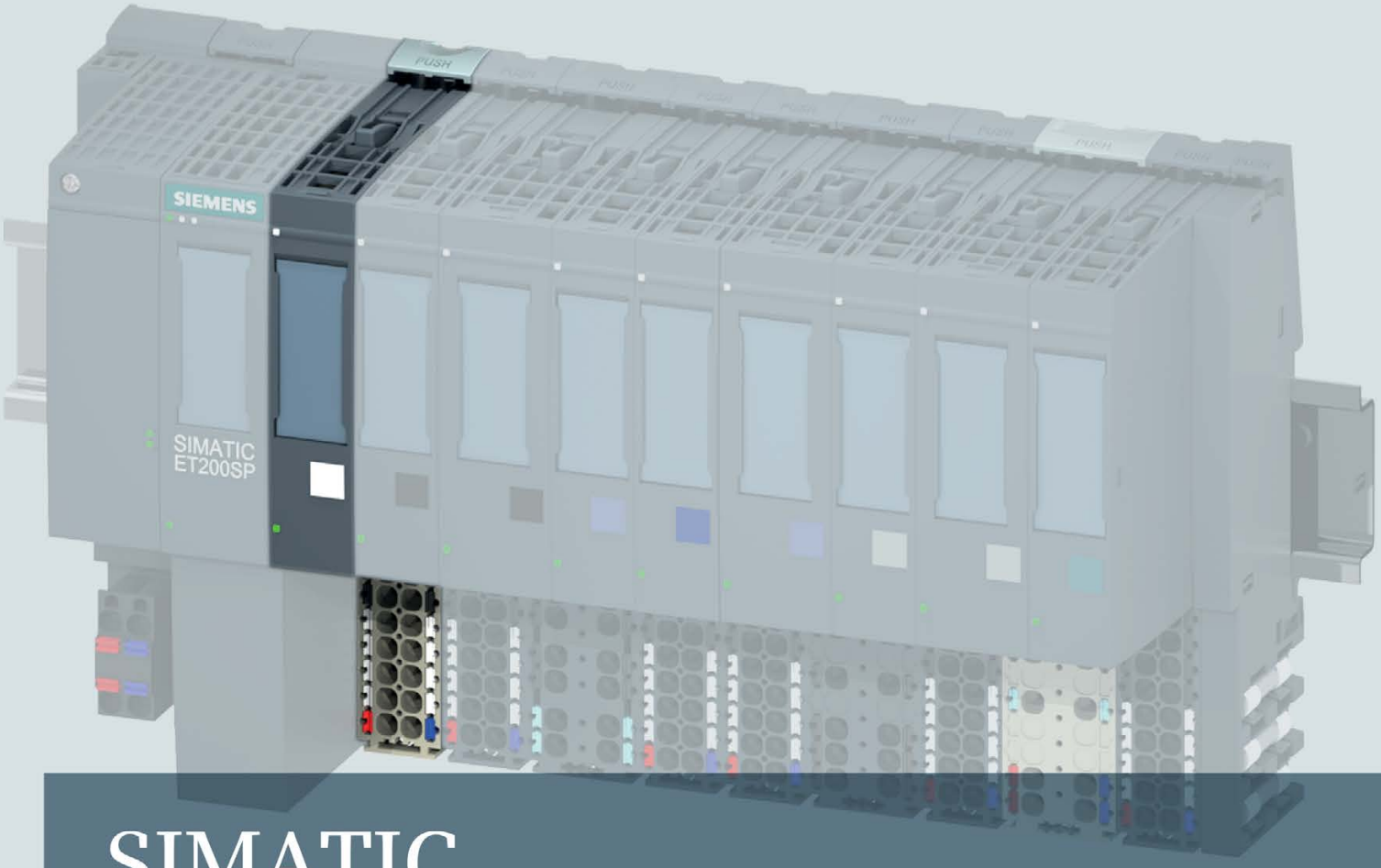

SIMATIC

ET 200SP

Digital input module DI 8x24VDC BA (6ES7131-6BF00-0AA0)

Manual

Edition 03/2015

Answers for industry.

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ET 200SP
Digital input module DI 8x24VDC BA (6ES7131-6BF00-0AA0)

Manual

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Parameter data record A

03/2015

A5E34941724-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: The term "CPU" is used in this manual both for the central processing units of the S7-1500 automation system and for interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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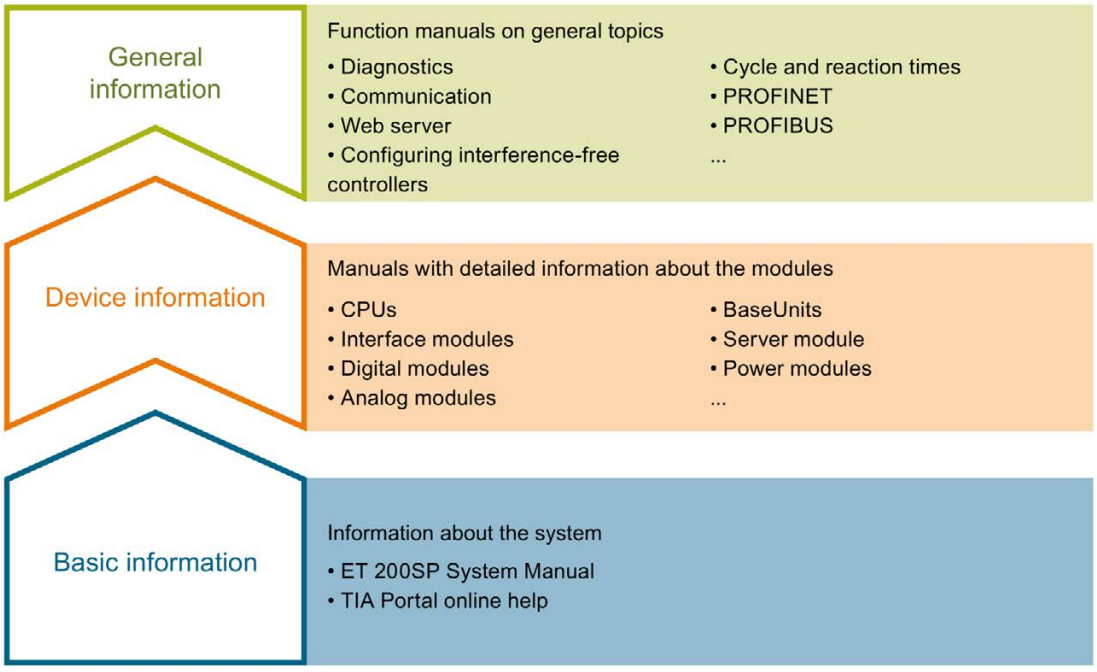
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (http://support.industry.siemens.com/cs/ww/en/ps/ae).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

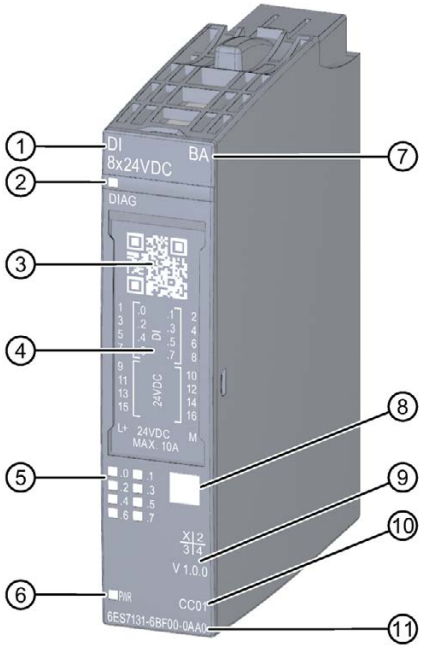
2

2.1 Properties

Article number

6ES7131-6BF00-0AA0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-1 View of the DI 8×24VDC BA module

Properties

The module has the following technical properties:

- Digital input module with 8 inputs
- Supply voltage L+
- Sink input (PNP, sinking input)
- Configurable input delay 0.05 ms to 20 ms (per channel)
- Suitable for connection of switches and 2-wire sensors according to IEC 61131, type 1, 2 and 3

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 8x24VDC BA module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

Information about wiring of the BaseUnit is available in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Note

You may use and combine the different wiring options for all channels.

Note

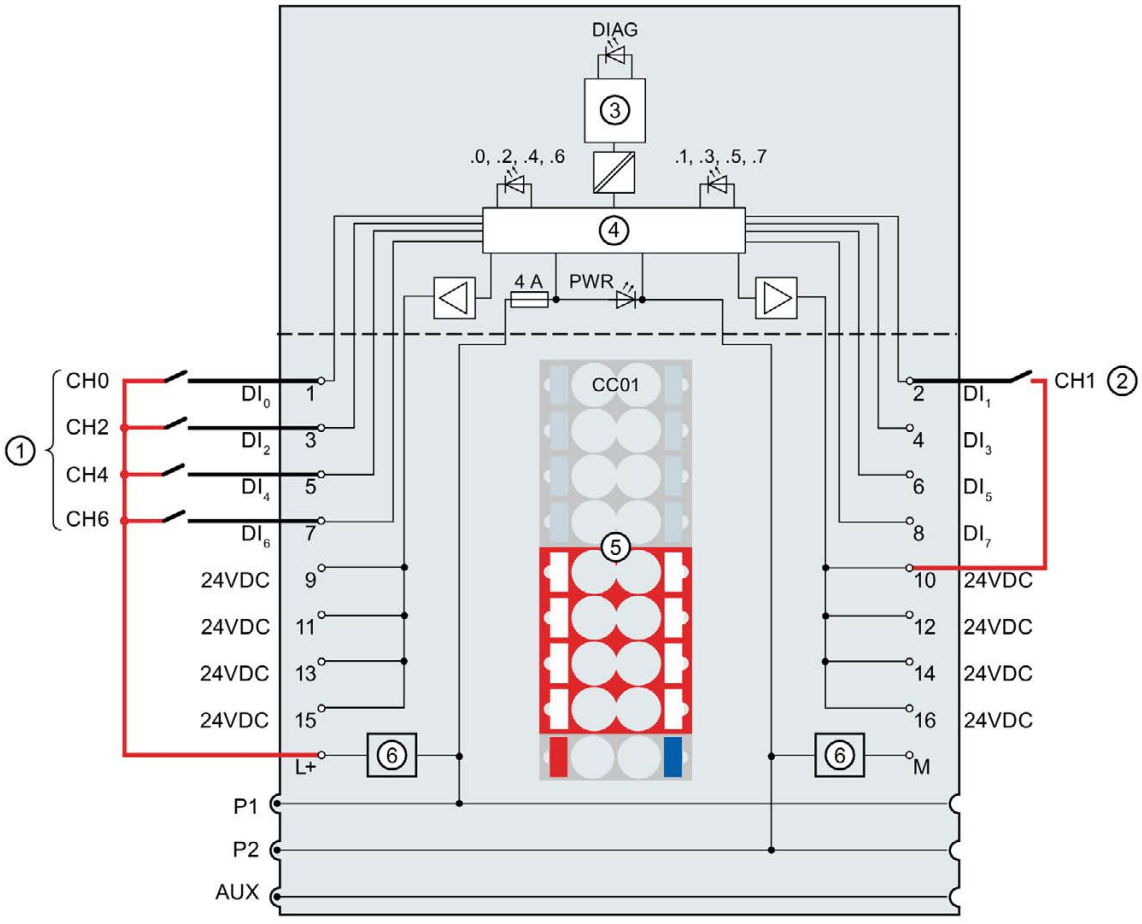
The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Note

The input channels provide values even without connected supply voltage L+. The characteristic type 2 is only maintained with connected supply voltage L+.

Connection: 1-wire and 2-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the digital input module DI 8x24VDC BA on the BaseUnit BU type A0 without AUX terminals (1-wire and 2-wire connection).

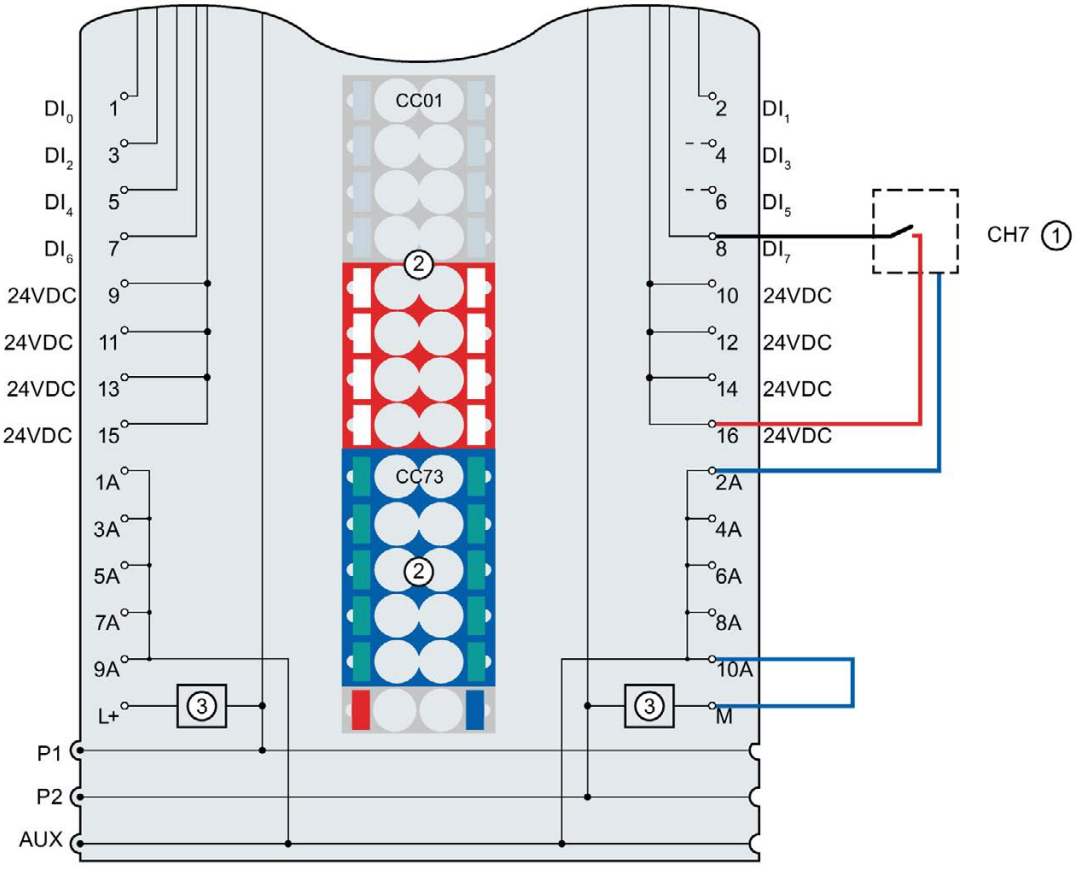


①	1-wire connection	DI_n	Input signal, channel n
②	2-wire connection	24 V DC	Encoder supply, channel n
③	Backplane bus interface	L+	24 V DC (feed for light-colored BaseUnit only)
④	Input electronics	M	Ground
⑤	Color identification label CCxx (optional)	DIAG	Error or Diagnostics LED (green, red)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)	.0 to .7	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)

Figure 3-1 Wiring and block diagram for 1-wire and 2-wire connection of encoders

Connection: 3-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the digital input module DI 8x24VDC BA on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection
②	Color identification labels CCxx (optional)
③	Filter connection supply voltage (only when light-colored BaseUnit is present)
DI_n	Input signal, channel n
24 V DC	Encoder supply, channel n
L+	24 V DC (feed for light-colored BaseUnit only)
M	Ground
1 A to 10 A	AUX terminals
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Figure 3-2 Wiring and block diagram for 3-wire connection of encoders

Parameters/address space

4

4.1 Parameters

DI 8x24VDC BA parameters

The effective range of the parameters that can be set depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of the parameter data record (Page 22).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Operating mode	• Channel deactivated • Channel activated	Channel activated	Yes	Channel	Channel
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module [1]

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP: The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 3 bytes.

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Operating mode

Determines whether a channel is activated or deactivated.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends before a new light-colored BaseUnit or the end of the station.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Address space

The figure below shows the assignment of the address space for DI 8x24VDC BA.

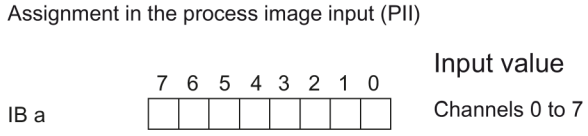


Figure 4-1 Address space of DI 8x24VDC BA

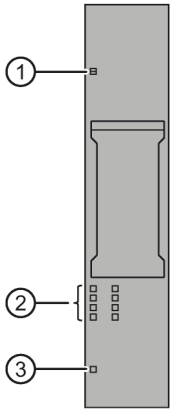
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays of the DI 8x24VDC BA.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED displays

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 18).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Process signal = 0
On	Process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ present

5.2 Interrupts

The DI 8×24VDC BA digital input module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Channel temporarily unavailable
- Parameter assignment error
- Load voltage missing

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	No or insufficient supply voltage L+.	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read in process values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8×24VDC BA

	6ES7131-6BF00-0AA0
Product type designation	DI 8x24VDC BA
General information	
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC01
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD as of revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DI	Yes
Counter	No
Oversampling	No
MSI	No
Supply voltage	
Rated value (DC)	24 V
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	8 mA; without encoder supply
Current consumption, max.	70 mA; all channels supplied from encoder supply

	6ES7131-6BF00-0AA0
Encoder supply	
Number of outputs	8
Output voltage encoder supply, min.	19.2 V
Short-circuit protection	Yes
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	700 mA
Power loss	
Power loss, typ.	1.6 W; 24 V, 8 inputs supplied via encoder supply
Address area	
Address space per module	
Address space per module, max.	1 byte
Input	1 byte
Digital inputs	
Number of inputs	8
Sinking/sourcing input	Sinking input
Input characteristic curve acc. to IEC 61131, type 2	Yes
Pulse stretching	No
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
For signal "0"	-30 V to +5 V
For signal "1"	+11 V to +30 V
Input current	
For signal "1", typ.	6.8 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on cable length)
For interrupt inputs	
• Configurable	No
For counter/technological functions	
• Configurable	No
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m

	6ES7131-6BF00-0AA0
Encoders	
Connectable encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	2 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostic information can be read	Yes
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	No
Diagnostics indicator LED	
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Permissible potential difference	
Between different circuits	75 V DC / 60 V AC
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

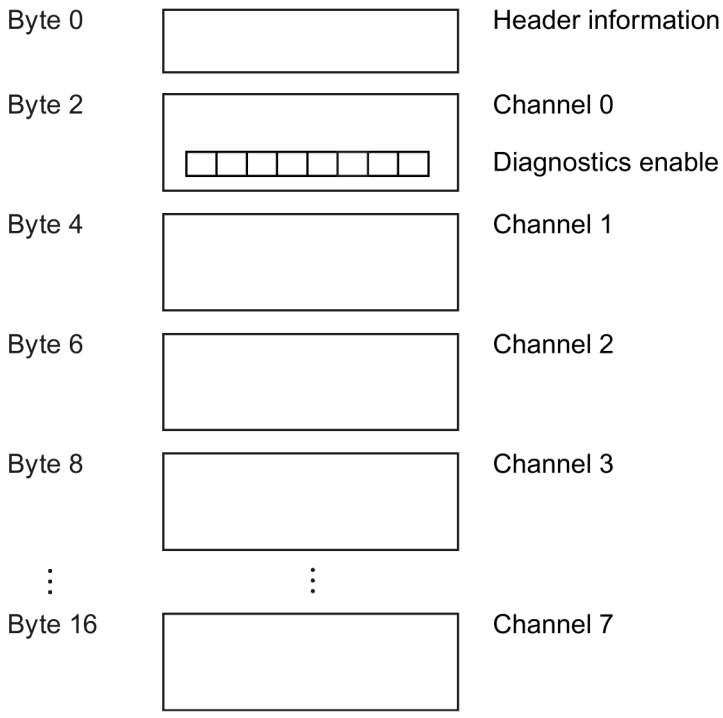


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

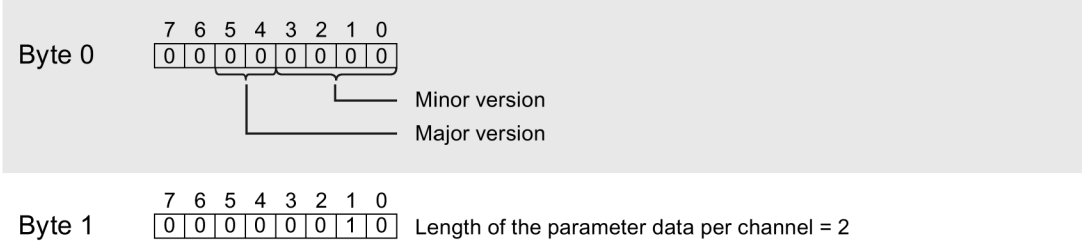
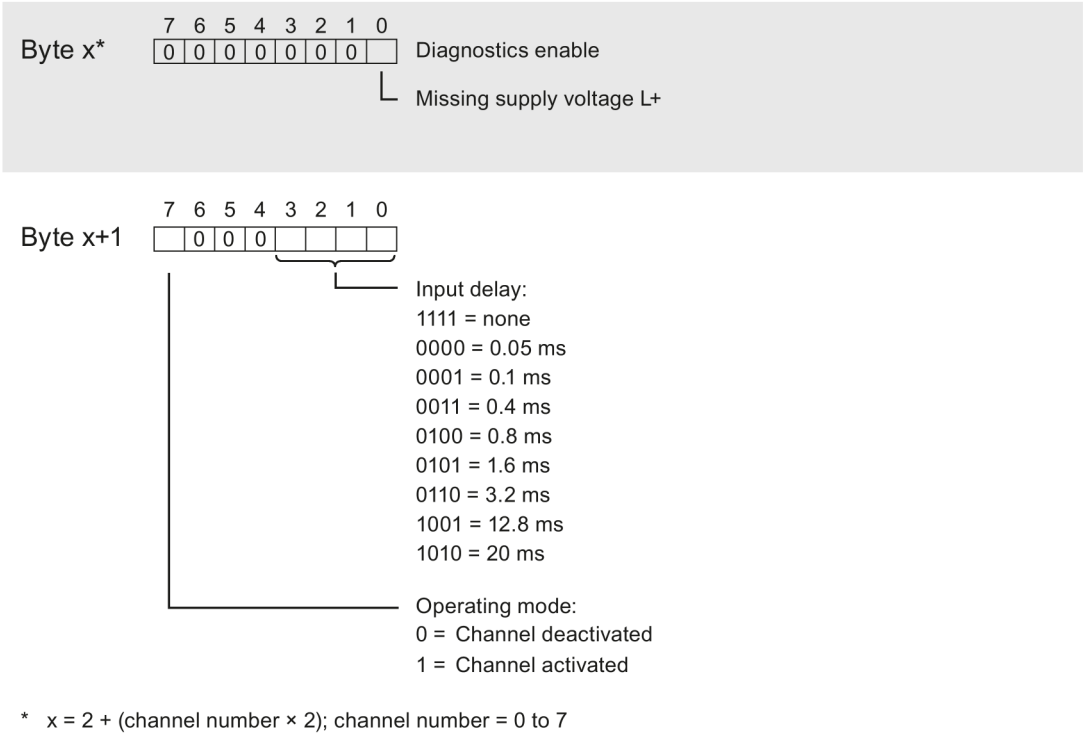


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 2); channel number = 0 to 7

Figure A-3 Structure byte x to x+1 for the channels 0 to 7

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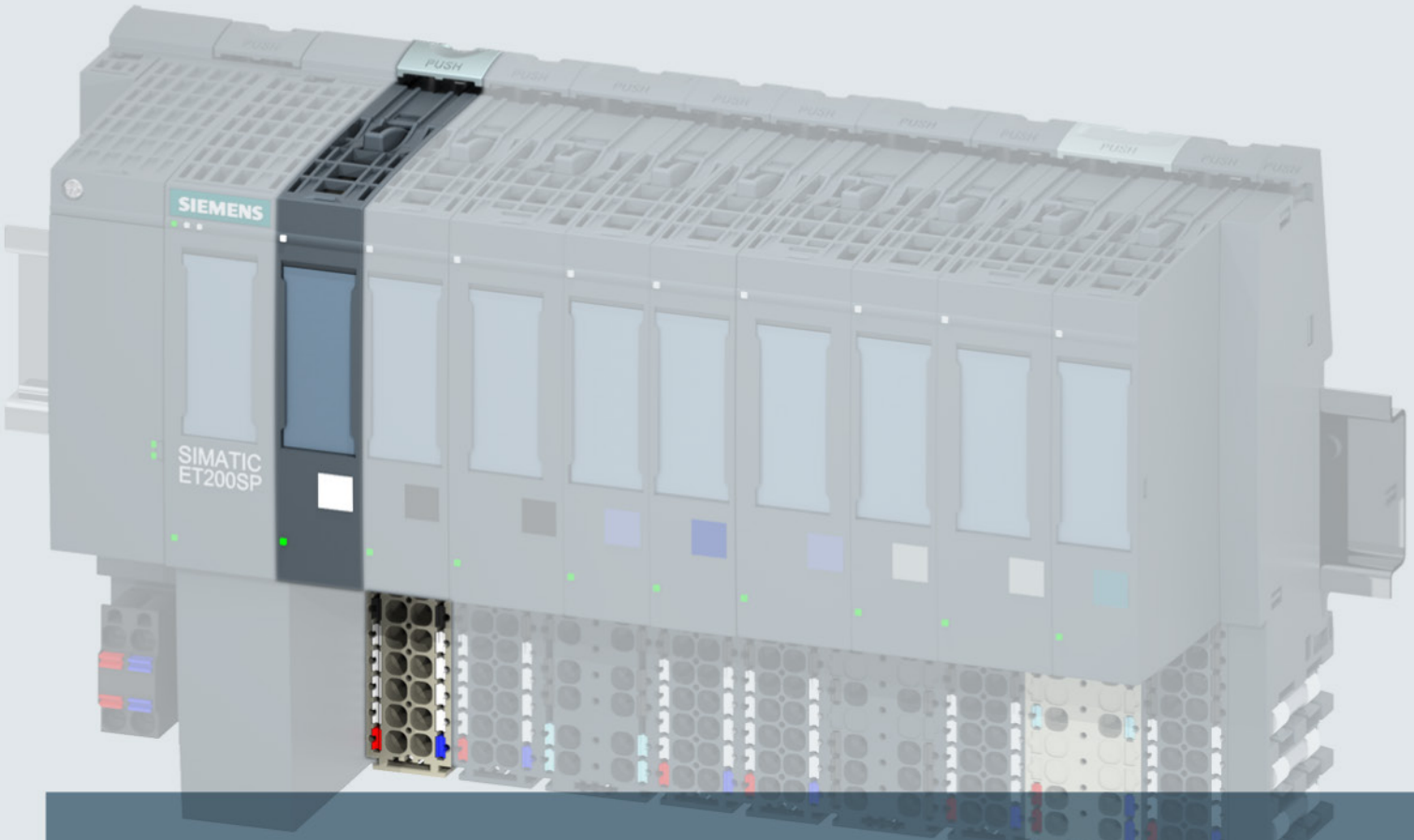

SIMATIC

ET 200SP

Digital input module DI 8x24VDC ST (6ES7131-6BF00-0BA0)

Manual

Edition 07/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
DI 8x24VDC ST digital input module (6ES7131-6BF00-0BA0)

Manual

Preface

Documentation guide 1

Product overview 2

Wiring up 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

07/2014

A5E03574157-AC

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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℗ 07/2014 Subject to change

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Preface

Purpose of the documentation

This device manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that relate generally to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you when commissioning the ET 200SP distributed I/O system.

Conventions

Please pay particular attention to notes highlighted as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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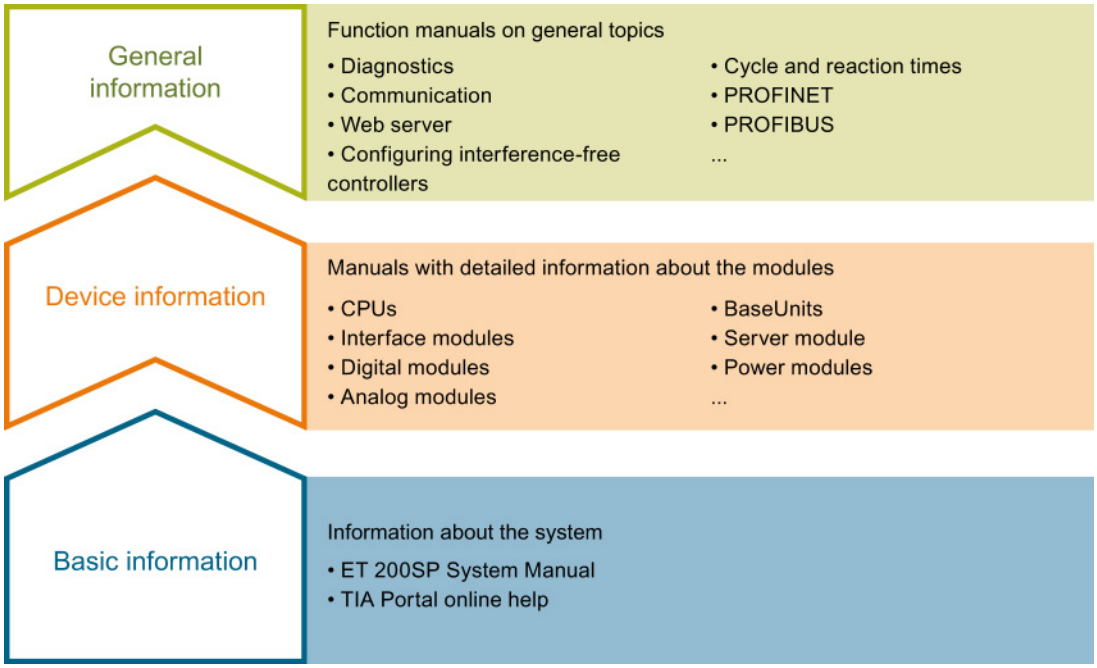
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC distributed I/O system. ET 200SP. The STEP 7 online help supports you in the configuration and programming.

Device information

Manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics, technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

Product overview

2

2.1 Properties

Article number

6ES7131-6BF00-0BA0

View of the module

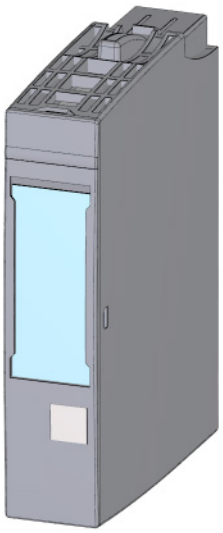


Figure 2-1 View of the module DI 8×24VDC ST

Properties

The module has the following technical properties:

- Digital input module with 8 inputs
- Supply voltage L+
- Sink input (PNP)
- Configurable input delay 0.05 ms to 20 ms

- Module-oriented selectable diagnostics
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 1 and 3

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

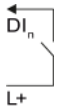
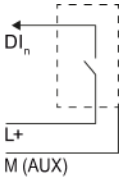
Wiring up

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment

<table>
<tr><th colspan="7">Terminal assignment for DI 8×24VDC ST (6ES7131-6BF00-0BA0)</th></tr>
<tr><th>Terminal</th><th>Assignment</th><th>Terminal</th><th>Assignment</th><th>Explanation</th><th>BaseUnit[1]</th><th>Color identification label (terminals 1 to 16)</th></tr>
<tr><td>1</td><td>DI_0</td><td>2</td><td>DI_1</td><td rowspan="9">• DI_n: Input signal, channel n
• L+: Encoder supply</td><td rowspan="9">A0</td><td rowspan="9">
CC01
6ES7193-6CP01-2MA0</td></tr>
<tr><td>3</td><td>DI_2</td><td>4</td><td>DI_3</td></tr>
<tr><td>5</td><td>DI_4</td><td>6</td><td>DI_5</td></tr>
<tr><td>7</td><td>DI_6</td><td>8</td><td>DI_7</td></tr>
<tr><td>9</td><td>L+</td><td>10</td><td>L+</td></tr>
<tr><td>11</td><td>L+</td><td>12</td><td>L+</td></tr>
<tr><td>13</td><td>L+</td><td>14</td><td>L+</td></tr>
<tr><td>15</td><td>L+</td><td>16</td><td>L+</td></tr>
<tr><td>L+</td><td>24 VDC</td><td>M</td><td>M</td></tr>
<tr><td colspan="3">2-wire
 
</td><td colspan="4">3-wire
 

Only with BaseUnits with AUX connections (6ES7193-BU15-P16-A10-2D)</td></tr>
</table>

[1] Usable BaseUnit types, can be identified by the last two digits of the article number.

Note

The first BaseUnit of an ET 200SP station must be a light-colored BaseUnit. Also keep this in mind during the configuration.

See also

You will find additional information on the BaseUnit types in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Schematic circuit diagram

Schematic circuit diagram

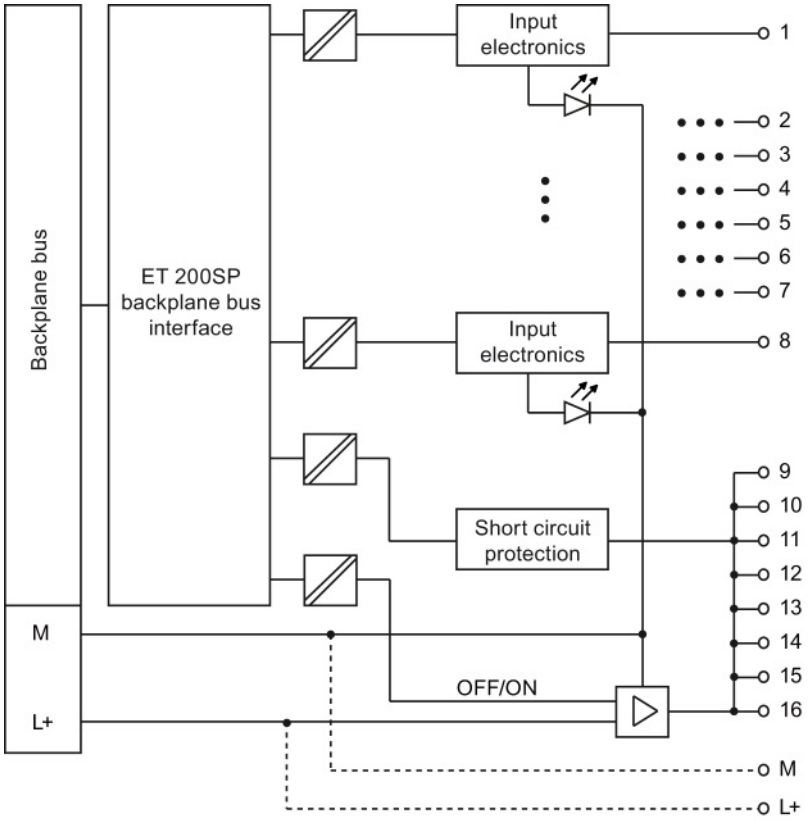


Figure 3-1 Schematic circuit diagram DI 8×24VDC ST

Parameters/address space

4

4.1 Parameters

Parameters for DI 8x24VDC ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 23).

The following parameter settings are possible:

Table 4- 1 Settable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [2]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Diagnostics wire break[1]	• Disable • Enable	Disable	yes	Module	Module
Operating mode	• Channel disabled • Channel enabled	Channel enabled	yes	Channel	Channel
Input delay	• none • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	yes	Channel	Module
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	no	Module	Module

[1] If you use a simple switch, you need to connect a resistor in parallel so that the wire break diagnostics is enabled in the open state (sensor resistance for the wire break diagnostics: 25 kΩ to 45 kΩ).

[2] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 16 bytes.

4.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

Diagnostics wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

Operating mode

Determines whether a channel is enabled or disabled.

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Potential group

Specifies that a BaseUnit with voltage supply feed-in is located in this slot (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

4.3 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 7 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DI 8×24VDC ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

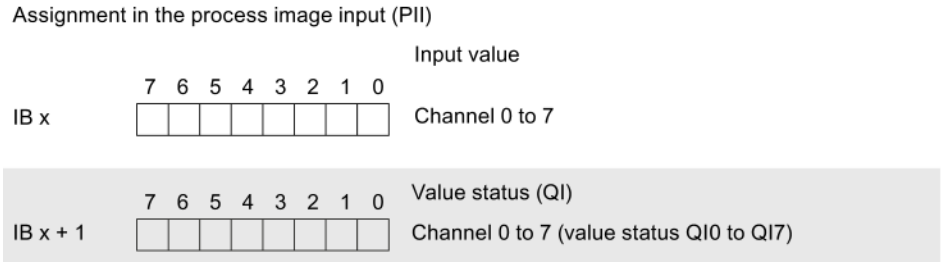


Figure 4-1 Address space of the DI 8×24VDC ST with value status

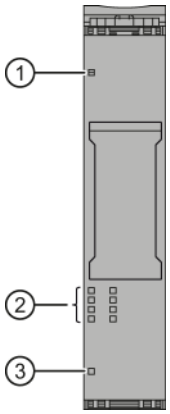
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the DI 8x24VDC ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 19).

DIAG LED

Table 5- 1 DIAG LED fault/error display

DIAG LED	Meaning
off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
on	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
off	Process signal = 0
on	Process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
off	No supply voltage L+
on	Supply voltage L+ present

5.2 Interrupts

The DI 8×24VDC ST digital input module supports diagnostic interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit
- Wire break
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been cancelled. The module reads no process values in this state.	• Wait for firmware update • Restart the firmware update
Short-circuit	1_H	Short-circuit to ground at encoder supply	Correct the process wiring
Wire break	6_H	Impedance of encoder circuit too high.	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor of 25 kilohms to 45 kilohms to the encoder contacts
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8×24VDC ST

	6ES7131-6BF00-0BA0
Product type designation	DI 8x24VDC ST
General information	
Firmware version	V1.1
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC01
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V11 SP2 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD as of revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	50 mA
Encoder supply	
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	700 mA

	6ES7131-6BF00-0BA0
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Hardware configuration	
Fieldbus connection via separate transceiver	Yes
Digital inputs	
Number of inputs	8
Input characteristic curve acc. to IEC 61131, type 1	Yes
Input characteristic curve acc. to IEC 61131, type 3	Yes
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
For signal "0"	-30 to 5 V
For signal "1"	11 to 30 V
Permitted voltage at input, min.	-30 V
Permitted voltage at input, max.	30 V
Input current	
For signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on cable length)
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Encoders	
Supported encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Interfaces	
Number of RS 485 interfaces	0
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes
Short-circuit	Yes

	6ES7131-6BF00-0BA0
Diagnostics display LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic isolation)
Insulation	
Insulation tested with	707 VDC (type test)
Degree of protection and protection class	
IP (rear)	IP20
Standards, approvals, certificates	
Use in hazardous areas	
Explosion protection category for gas	ATEX II 3 G Ex nA IIC T4 Gc
Associated equipment (Ex ia)	No
Associated equipment (Ex ib)	No
Environmental conditions	
Operating temperature	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g
Information for market places	
Digital inputs/outputs, configurable	Yes

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 contains the diagnostics for the entire module.

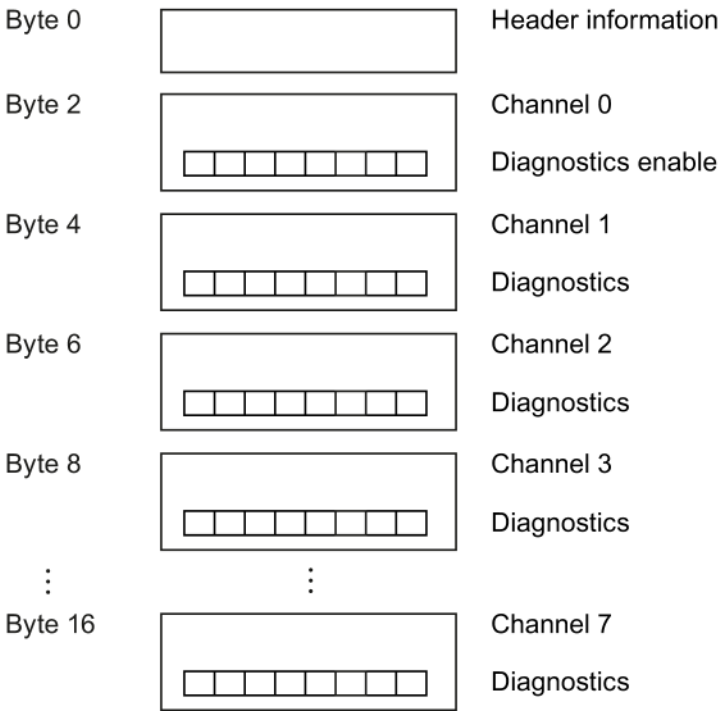


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

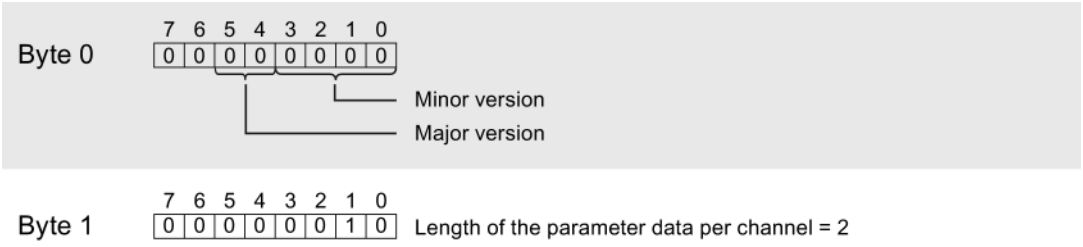


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

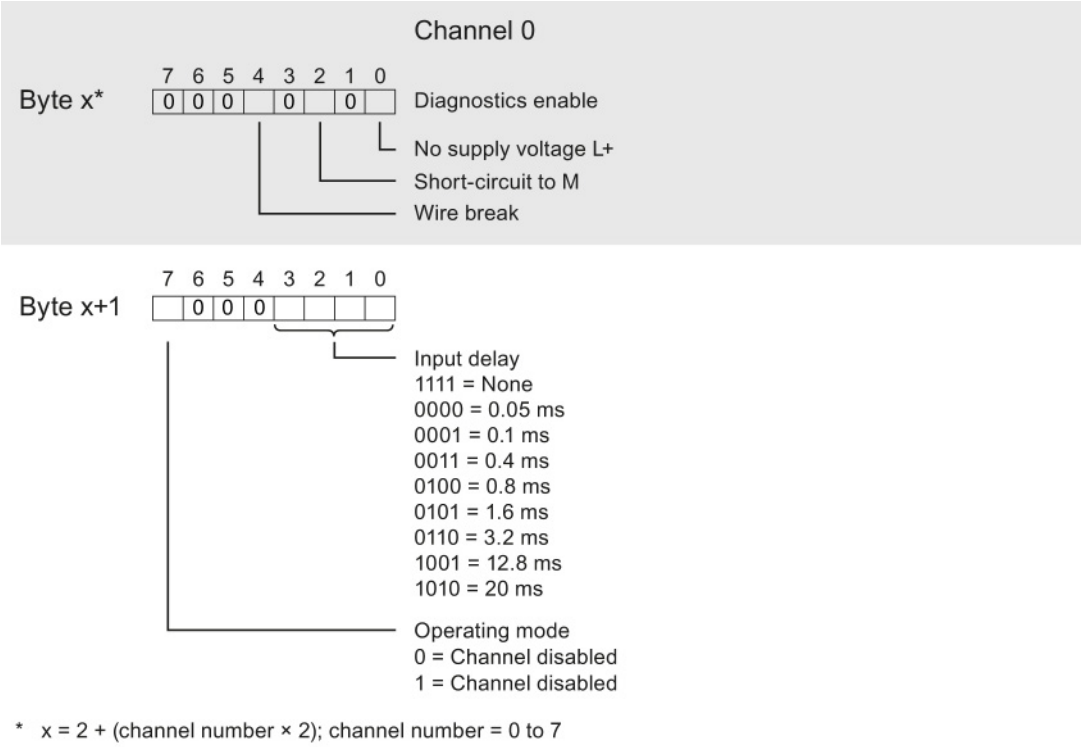


Figure A-3 Structure byte x to x+1 for the channels 0 to 7

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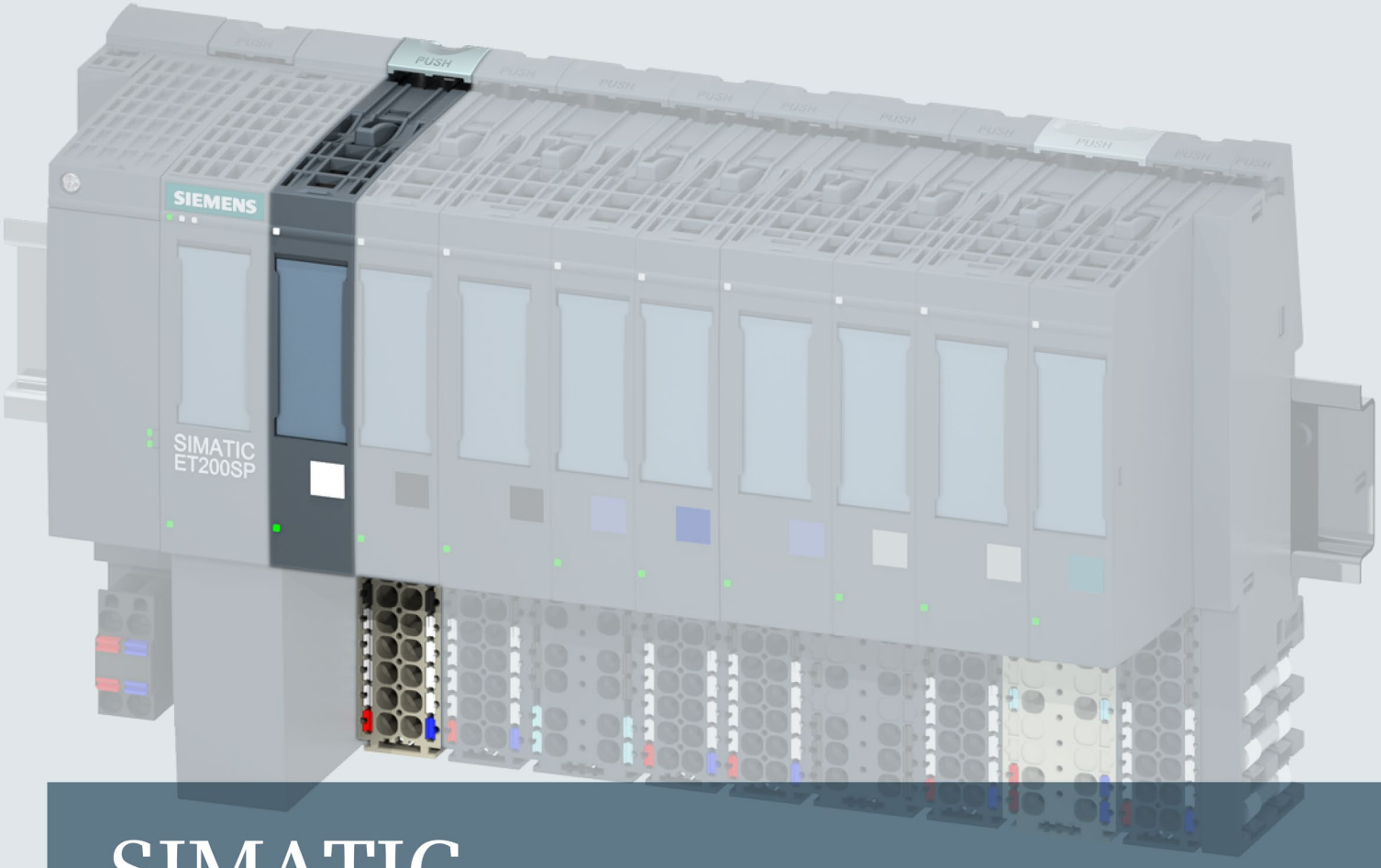

SIMATIC

ET 200SP

Digital input module DI 8x24VDC HF (6ES7131-6BF00-0CA0)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 8x24VDC HF (6ES7131-6BF00-0CA0)

Manual

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Parameter data record A

12/2015

A5E03576305-AD

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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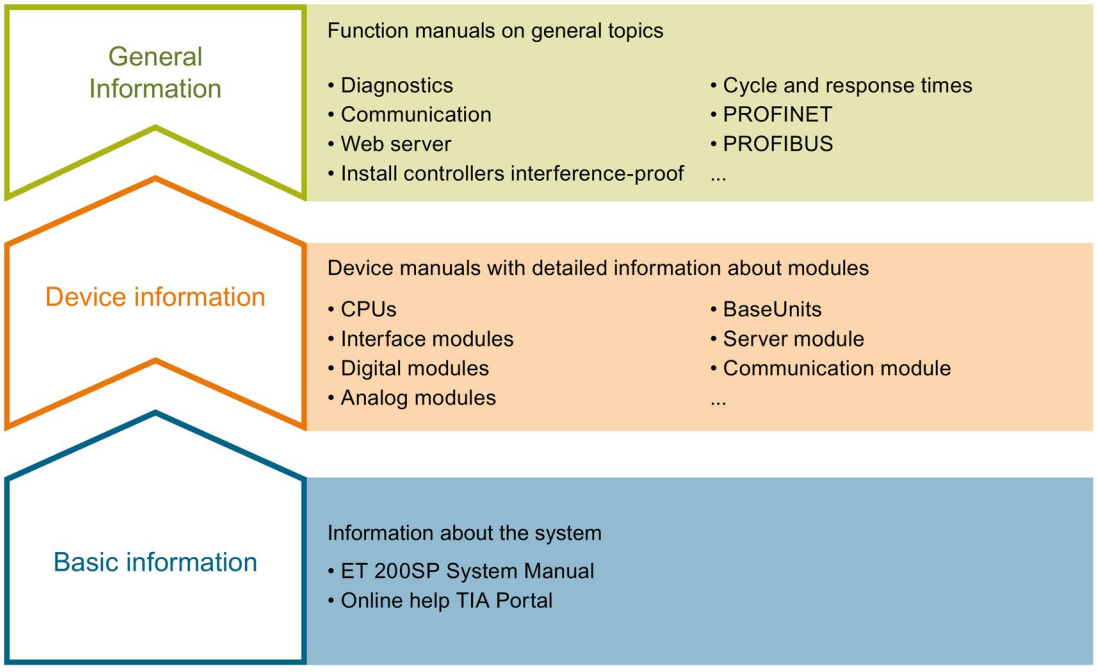
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

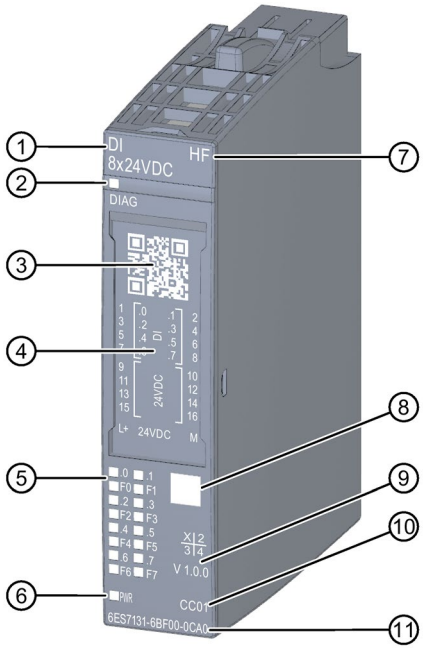
2

2.1 Properties

Article number

6ES7131-6BF00-0CA0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module DI 8×24VDC HF

Properties

The module has the following technical properties:

- Digital input module with 8 inputs
- Sink input (PNP, active high)
- Supply voltage L+
- Configurable input delay 0.05 ms to 20 ms (per channel)
- Configurable diagnostics (per channel)
- Configurable hardware interrupts (per channel)
- Suitable for connection of switches and 2-wire sensors according to IEC 61131, type 1 and 3

The module supports the following functions:

- Pulse stretching
- Firmware update
- I&M identification data
- Configuration in RUN

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0
Isochronous mode	1	V1.1.0
Module-internal Shared Input (MSI)	1	V1.2.0
Configurable submodules/ submodules for shared device	1	V2.0.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connector

See also

You can find additional information on the accessories in the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/91696622).

Wiring

3

3.1 Wiring and block diagrams

This section includes the block diagram of the DI 8x24VDC HF module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection in the DI operating mode. You can use and combine the different wiring options for all channels.

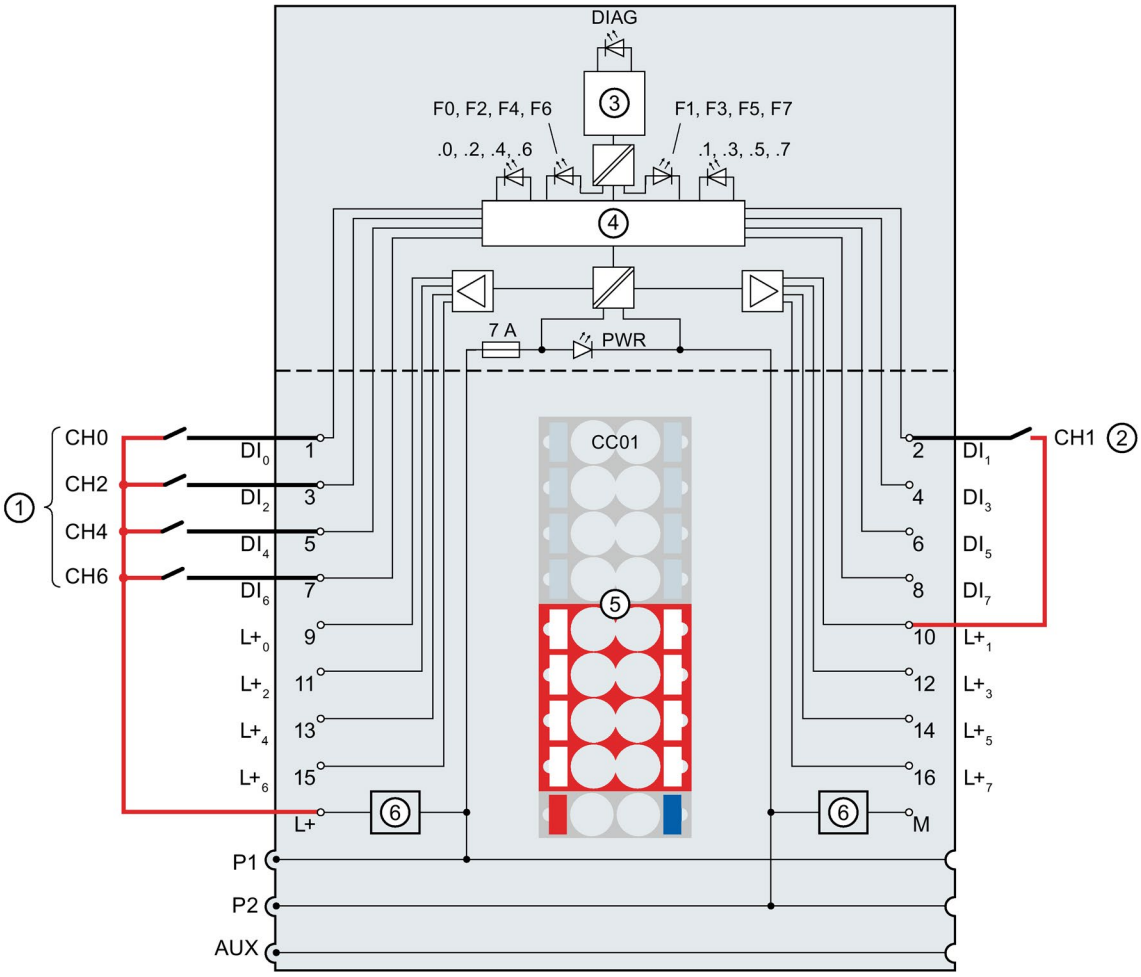
You can find information on wiring the BaseUnit in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DI 8×24VDC HF on the BaseUnit BU type A0 without AUX terminals (1- and 2-wire connection).

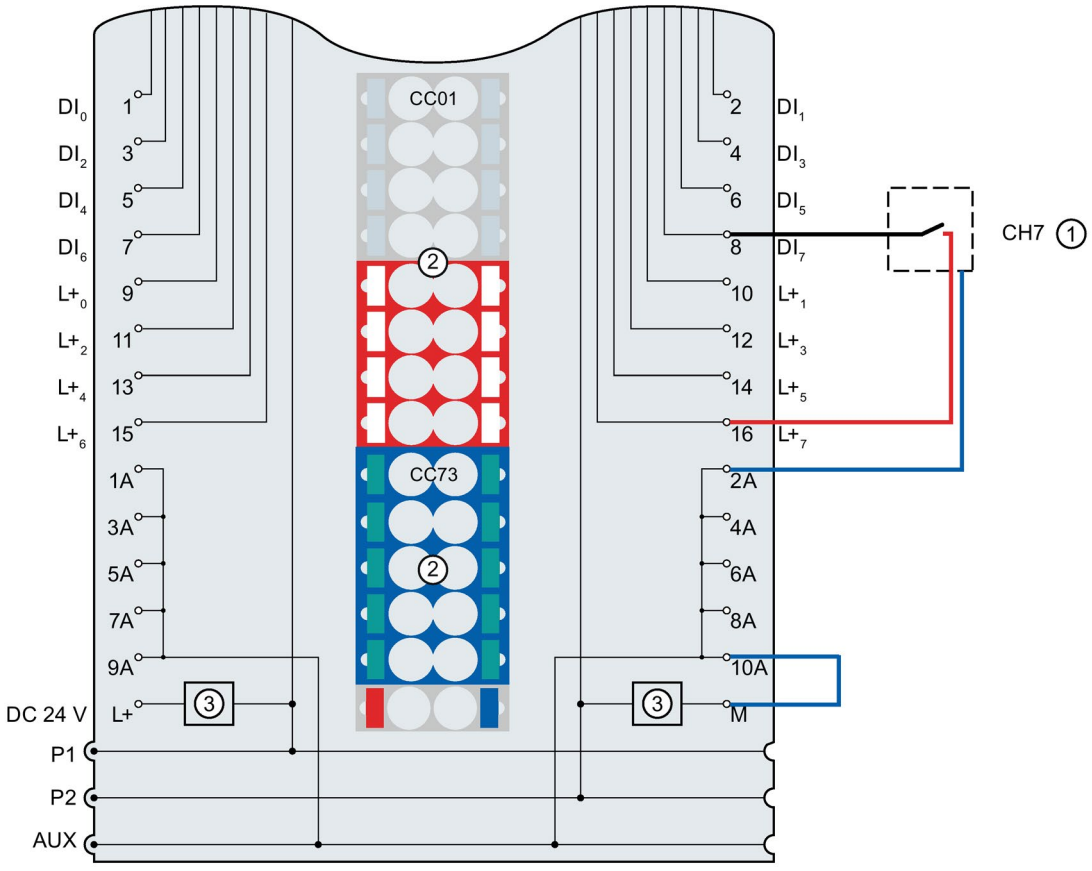


①	1-wire connection	$L+_n$	Encoder supply, channel n
②	2-wire connection	L+	24 V DC (infeed only with light BaseUnit)
③	Backplane bus interface	DIAG	Error or diagnostics LED (green, red)
④	Input electronics	.0 to .7	Channel status LED (green)
⑤	Color-coded label with color code CC01 (optional)	PWR	Power LED (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	F0 to F7	Channel fault LED (red)
M	Ground	P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)
DI_n	Input signal, channel n		

Image 3-1 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The following figure shows an example of the terminal assignment of the digital input module DI 8×24VDC HF on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection
②	Color-coded labels with color code CC01 and CC73 (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Image 3-2 Pinout and block diagram for 3-wire connection of encoders

Parameters/address space

4

4.1 Parameters

GSD file parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 33)).

Table 4- 1 Parameters for DI 8x24VDC HF (GSD file)

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [2]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics wire break[1]	• Disable • Enable	Disable	Yes	Channel	Channel
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [2]
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module
Pulse stretching	• None • 0.05 s • 0.1 s • 0.2 s • 0.5 s • 1 s • 2 s	None	Yes	Channel	-
Hardware interrupt rising edge	• Disable • Enable	Disable	Yes	Channel	-
Hardware interrupt falling edge	• Disable • Enable	Disable	Yes	Channel	-
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] If you use a floating switch, you need to connect a resistor in parallel so that the wire break diagnostics is enabled in the open state (sensor resistance for the wire break diagnostics: 25 kΩ to 45 kΩ).

[2] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP. The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign these parameters using data records 0 to 7 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 6 bytes.

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Wire break

Enabling diagnostics if the line to the encoder is interrupted.

Channel activated

Determines whether a channel is activated or deactivated.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). The read-in time T_i refers to the channel for which no input delay time was configured.

For input channels with longer input delays, the read-in time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a negative impact on the possible cycle time.

Isochronous configuration is only possible if there is no input delay configured for at least one channel.

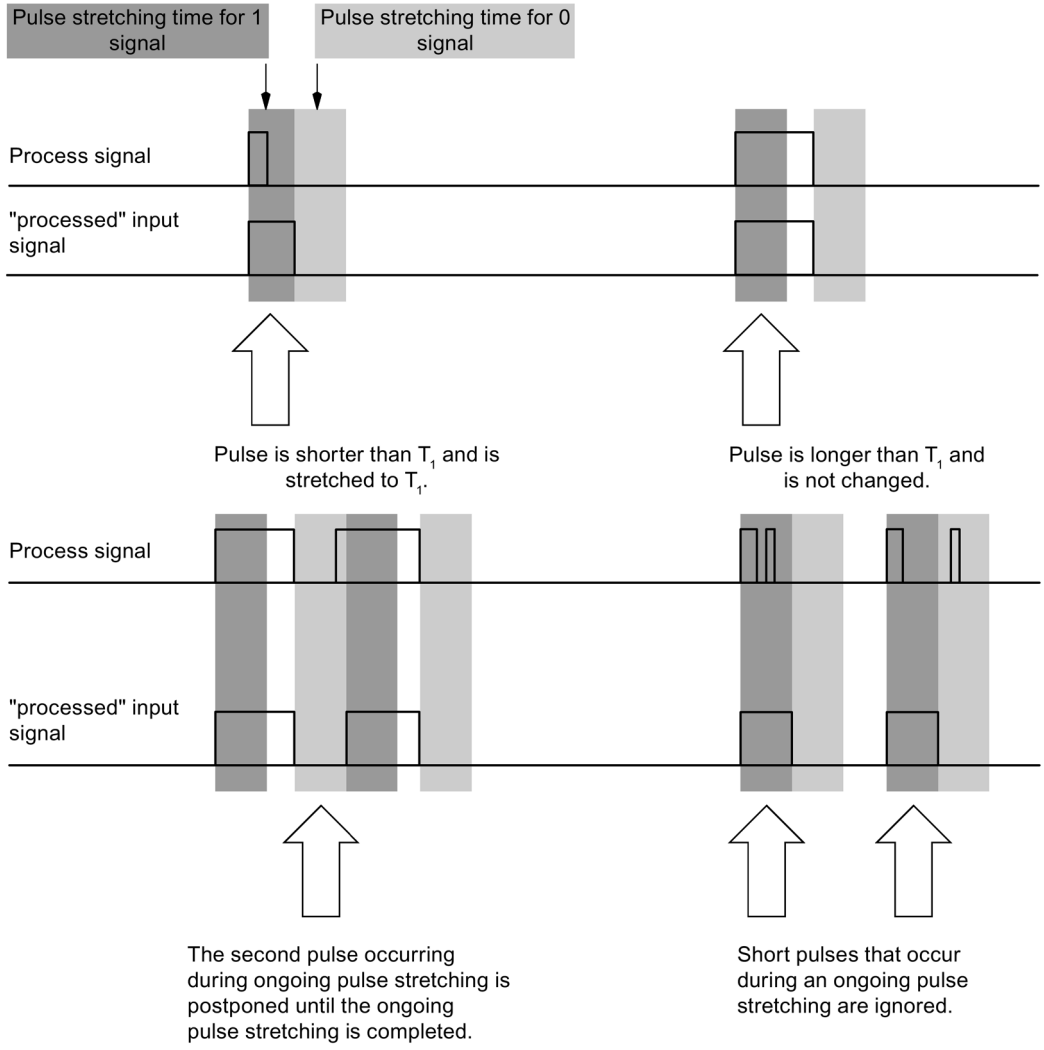
Pulse stretching

Pulse stretching is a function used to change a digital input signal. A pulse on a digital input is stretched to at least the configured length. If the input pulse is already longer than the configured length, the pulse is not changed.

In isochronous mode, the terminal signal is read in at time T_i (time for reading in the input data), i.e. smaller pulses than T_DC (data cycle) are not recognized in certain cases.

Principle of pulse stretching

The figure below uses examples to show whether and how input pulses are changed.



T_1 Pulse stretching parameter

Image 4-1 Principle of pulse stretching

Hardware interrupt, rising edge

Specifies whether a hardware interrupt is generated by a rising edge.

Hardware interrupt, falling edge

Specifies whether a hardware interrupt is generated by a falling edge.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of DI 8x24VDC HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DI 8x24VDC HF V1.0	X	X	X
1 x 8-channel without value status	DI 8x24VDC HF V1.1	X	X	X
1 x 8-channel with value status	DI 8x24VDC HF V1.1, QI	X	X	---
1 x 8-channel without value status	DI 8x24VDC HF V1.2	X	X	X
1 x 8-channel with value status for module-internal Shared Input with up to 4 submodules	DI 8x24VDC HF V1.2, MSI	X	X	---
1 x 8-channel with value status	DI 8x24VDC HF V1.2, QI	X	X	---
1 x 8-channel without value status	DI 8x24VDC HF V2.0	---	X	X
1 x 8-channel with value status for module-internal Shared Input with up to 4 submodules	DI 8x24VDC HF V2.0, MSI	---	X	---
1 x 8-channel with value status	DI 8x24VDC HF V2.0, QI	---	X	---
2 x 4-channel without value status	DI 8x24VDC HF V2.0, S.2	---	X	---
2 x 4-channel with value status	DI 8x24VDC HF V2.0, S.2 QI	---	X	---
4 x 2-channel without value status	DI 8x24VDC HF V2.0, S.4	---	X	---
4 x 2-channel with value status	DI 8x24VDC HF V2.0, S.4 QI	---	X	---

Note

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

2 x 4- / 4 x 2-channel configuration

For the configuration, the channels of the module are divided into submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Read the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DI 8x24VDC HF QI,
- DI 8x24VDC HF MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

Address space for configuration as 1 x 8-channel DI 8x24VDC HF

The figure below shows the address space assignment for configuration as a 8-channel module without value status.

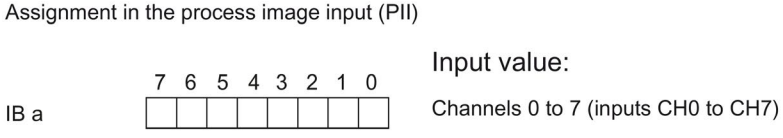


Image 4-2 Address space for configuration as 1 x 8-channel DI 8x24VDC HF without value status

Address space for configuration as 1 x 8-channel DI 8x24VDC HF, QI

The following figure shows the assignment of the address space for the configuration as a 8-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

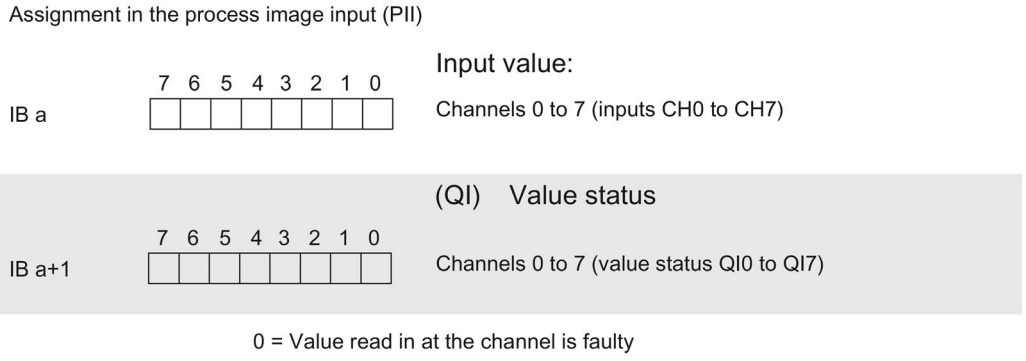


Image 4-3 Address space for configuration as 1 x 8-channel DI 8x24VDC HF QI with value status

Address space for configuration as 1 x 8-channel DI 8x24VDC HF MSI

The channels 0 to 7 of the module are copied in up to four submodules with configuration 1 x 8-channel module (Module-internal shared input, MSI). Channels 0 to 7 are then available with identical input values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information,QI)

The meaning of the value status depends on the submodule on which it occurs.

For the 1st submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodule 1, 2, 3 and 4 and the value status.

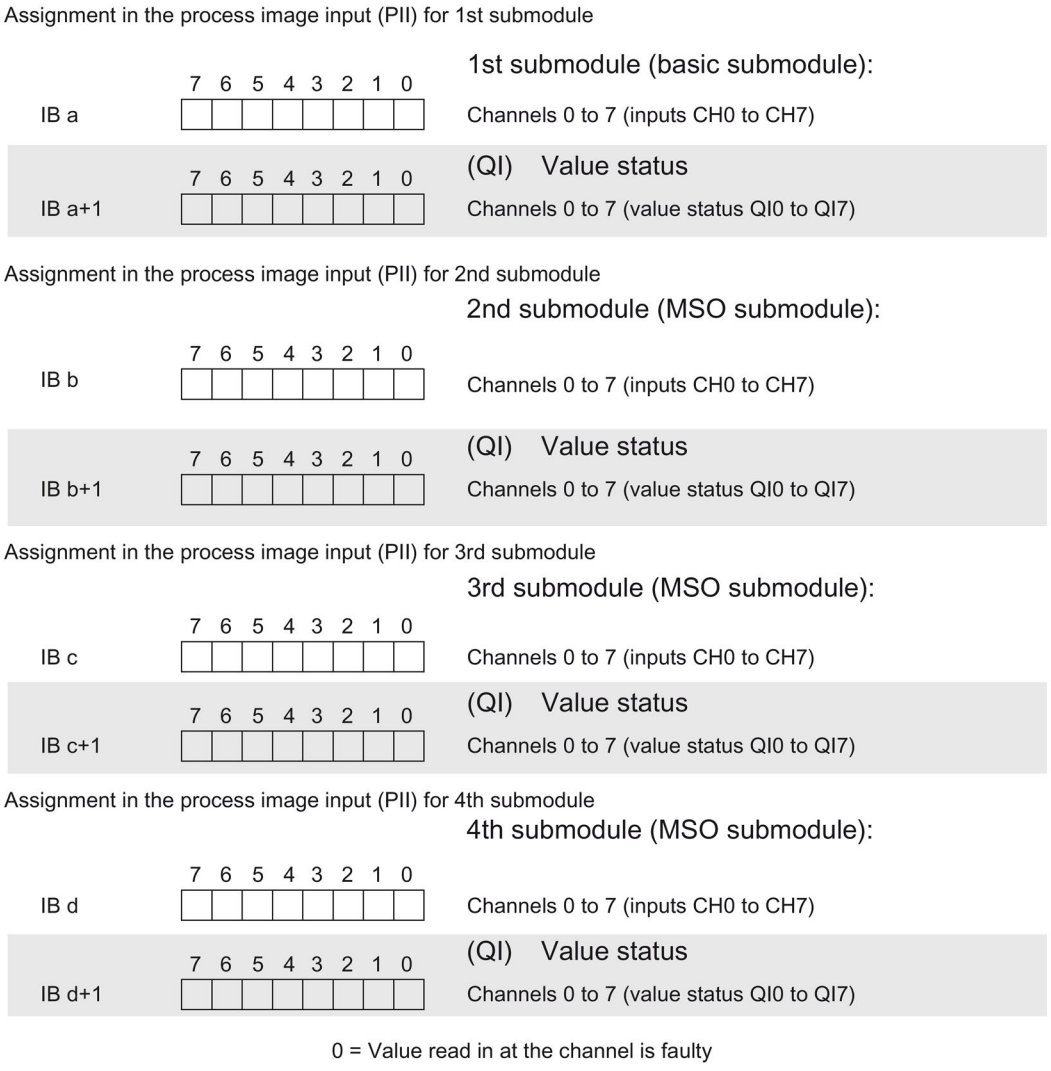


Image 4-4 Address space for configuration as 1 x 8-channel DI 8x24VDC HF MSI with value status

Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2

The figure below shows the address space assignment for configuration as a 2 x 4-channel module without value status.

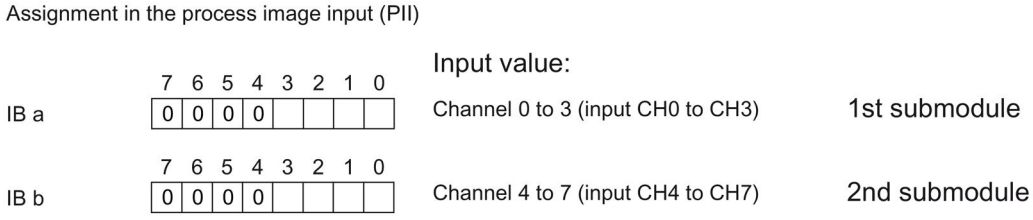


Image 4-5 Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2 without value status

Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2 QI

Each of the two submodules has a freely assignable start address.

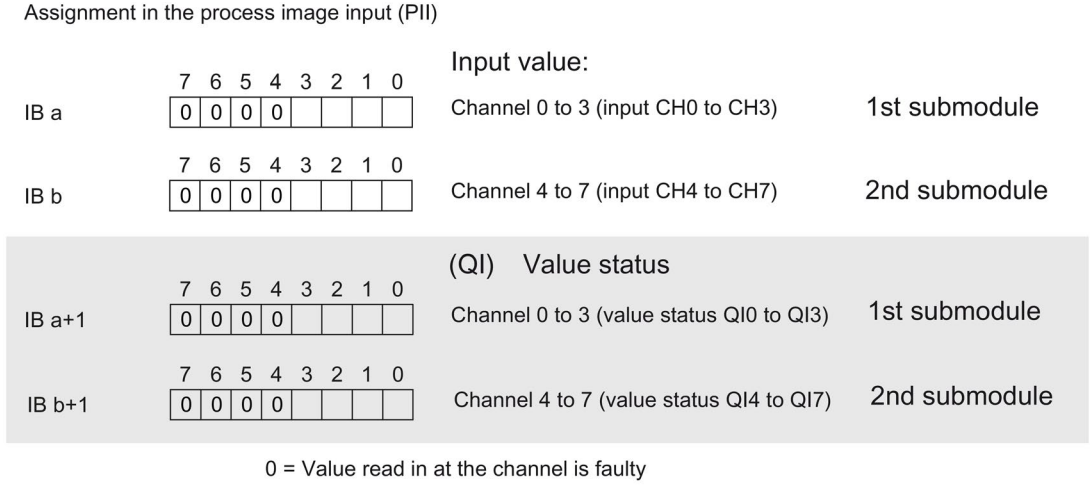


Image 4-6 Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2 QI with value status

Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4

The figure below shows the address space assignment for configuration as a 4 x 2-channel module without value status.

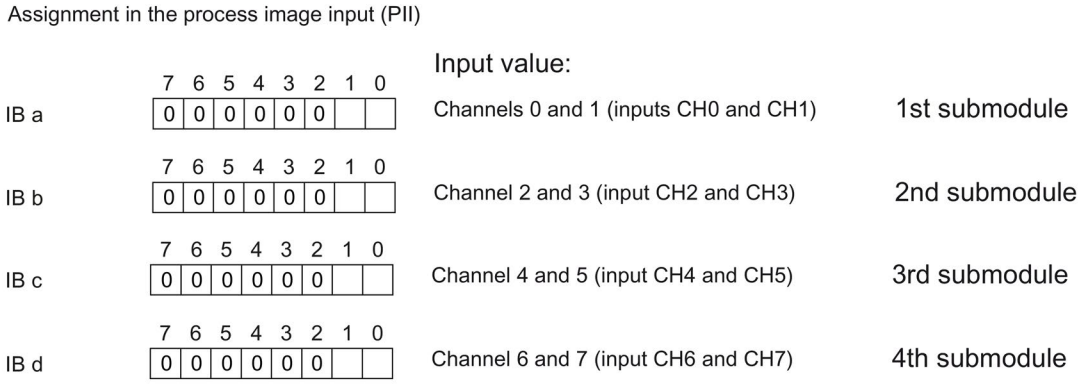


Image 4-7 Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4 without value status

Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4 QI

Each of the four submodules has a freely assignable start address.

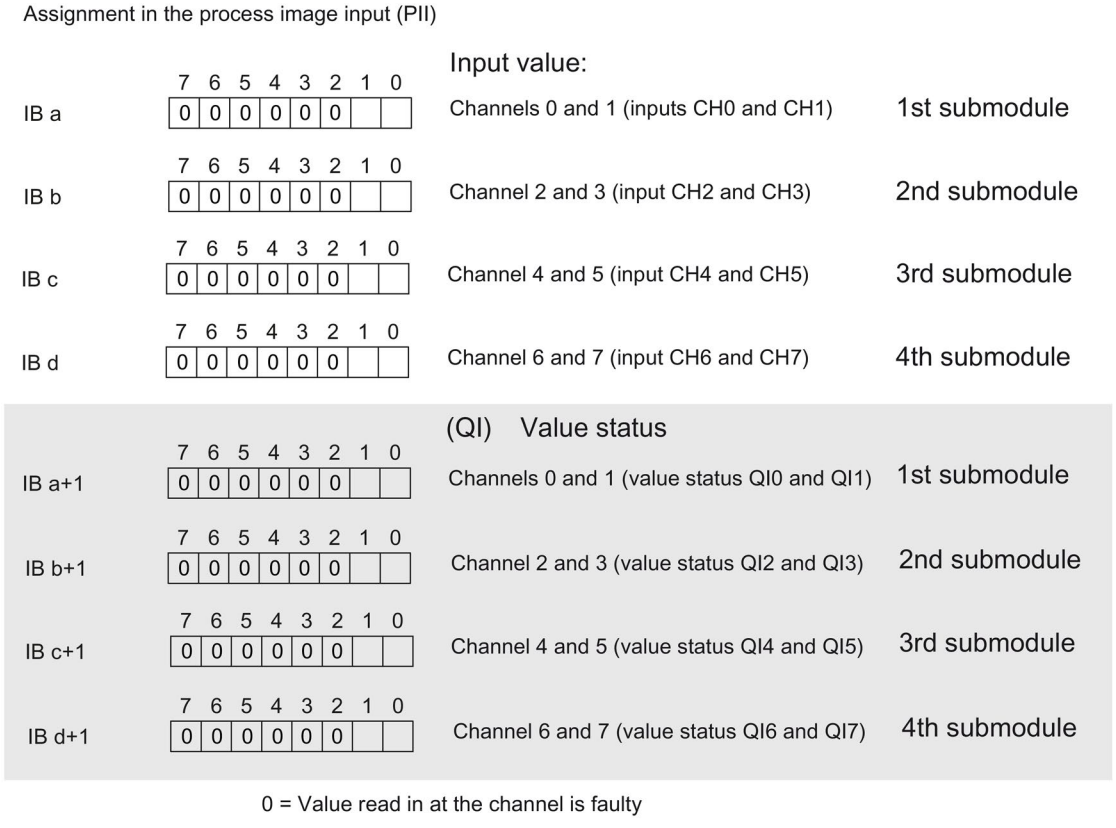


Image 4-8 Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4 QI with value status

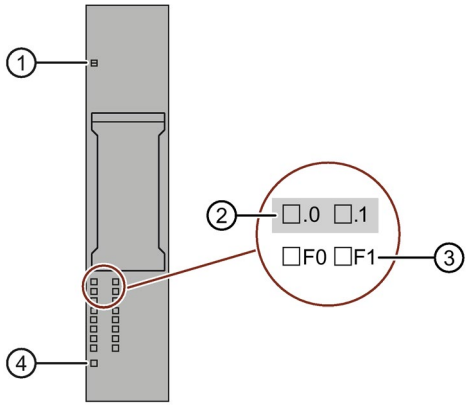
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC HF.



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The tables below explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 29).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
▫ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ On	Module parameters assigned and no module/channel diagnostics
☼ Flashes	Module parameters assigned and module/channel diagnostics

LED channel status/channel error

Table 5- 2 Status / error display of the LED channel status / channel error

LED channel status	LED channel error	Meaning
▫ Off	▫ Off	Channel deactivated or process signal = 0
■ On	▫ Off	• No supply voltage present or • Process voltage > 11 V is present regardless of whether or not the channel is activated and regardless of whether diagnostics was detected
▫ Off	■ On	Supply voltage is available and process voltage < 11V is present regardless of whether or not the channel is activated and regardless of whether diagnostics was detected
■ On	■ On	Channel activated and diagnostics enable was recognized

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
▫ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The digital input module DI 8×24VDC HF supports hardware and diagnostics alarms.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Hardware interrupt lost
- Channel temporarily unavailable

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- At positive edge (signal change from 0 to 1)
- At negative edge (signal change from 1 to 0)

In the event of an interrupt, interrupt OBs are automatically executed in the CPU of the IO controller.

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

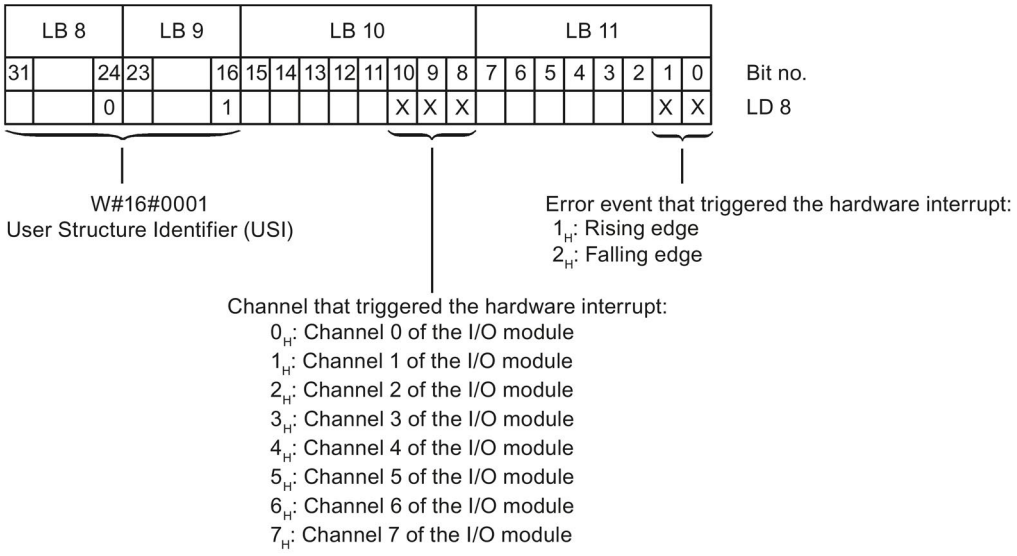


Image 5-2 Start information of the organization block

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name		Content	Comment	Bytes
USI		W#16#0001	User Structure Identifier: Additional interrupt information for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
It follows the error event that triggered the hardware interrupt.				
	Error event	B#16#01	Positive edge	1
		B#16#02	Negative edge	

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	Short-circuit to ground at sensor supply	Correct the process wiring
Wire break	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor of 25 kohms to 45 kohms to the encoder contacts
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Hardware interrupt lost	16_H	The module cannot trigger an interrupt because the previous interrupt was not acknowledged; possible configuration error	• Change interrupt processing in the CPU and, if necessary, edit the module parameters. • The error persists until the module is assigned new parameters
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read in process values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8×24VDC HF

	6ES7131-6BF00-0CA0
General information	
Product type designation	ET 200SP, DI 8x24VDC HF, PU 1
Firmware version	V2.0
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC01
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 / -
STEP 7 can be configured/integrated as of version	V5.5 / -
PCS 7 can be configured/integrated as of version	V8.1 SP1
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DI	Yes
Counter	No
Oversampling	No
MSI	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Encoder supply	
Number of outputs	8
Output voltage encoder supply, min.	19.2 V
Short-circuit protection	Yes; per channel, electronic

	6ES7131-6BF00-0CA0
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	700 mA
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	8 bytes; 2 channels per submodule + QI information
Digital inputs	
Number of inputs	8
Sinking/sourcing input	Yes; reading p
Input characteristic curve acc. to IEC 61131, type 1	Yes
Input characteristic curve acc. to IEC 61131, type 2	No
Input characteristic curve acc. to IEC 61131, type 3	Yes
Pulse stretching	Yes; as of 4 µs pulse duration
• Length	2 s; 50 ms, 100 ms, 200 ms, 500 ms, 1 s, 2 s
Edge evaluation	Yes, rising edge, falling edge, edge change
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
For signal "0"	-30 ... +5 V
For signal "1"	+11 ... +30 V
Input current	
For signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on cable length)
For interrupt inputs	
• Configurable	Yes
for counters/technological functions	
• Configurable	No
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m
Encoders	
Supported encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA

	6ES7131-6BF00-0CA0
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Filtering and processing time (TCI), min.	420 µs
Bus cycle time (TDP), min.	500 µs
Jitter, max.	8 µs
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes; channel-based
Hardware interrupt	Yes, configurable, channels 0 to 7
Diagnostics alarms	
Diagnostic information can be read	Yes
Diagnostics	Yes
Monitoring of the supply voltage	Yes
• Configurable	Yes
Monitoring of the encoder supply	Yes; channel-based
Wire break	Yes; channel-based
Short-circuit	Yes; channel-based
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

With data records 0 to 7, you can reconfigure individual channels.

Operation of the module behind a PROFIBUS DP interface module

If the module is operated behind a PROFIBUS DP interface module, the parameter data records 0 and 1 cannot be read back. You obtain the diagnostics data records 0 and 1 with the read back parameter data records 0 and 1. You can find additional information in the Interrupts section of the PROFIBUS DP interface module manual on the Internet (http://support.automation.siemens.com/WW/view/en/78324181).

Parameter assignment in the user program

You can reassign the module parameters in RUN (e.g. "Switch on diagnostics" can be changed in RUN).

Changing parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128 or data records 0 to 7. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Data record structure

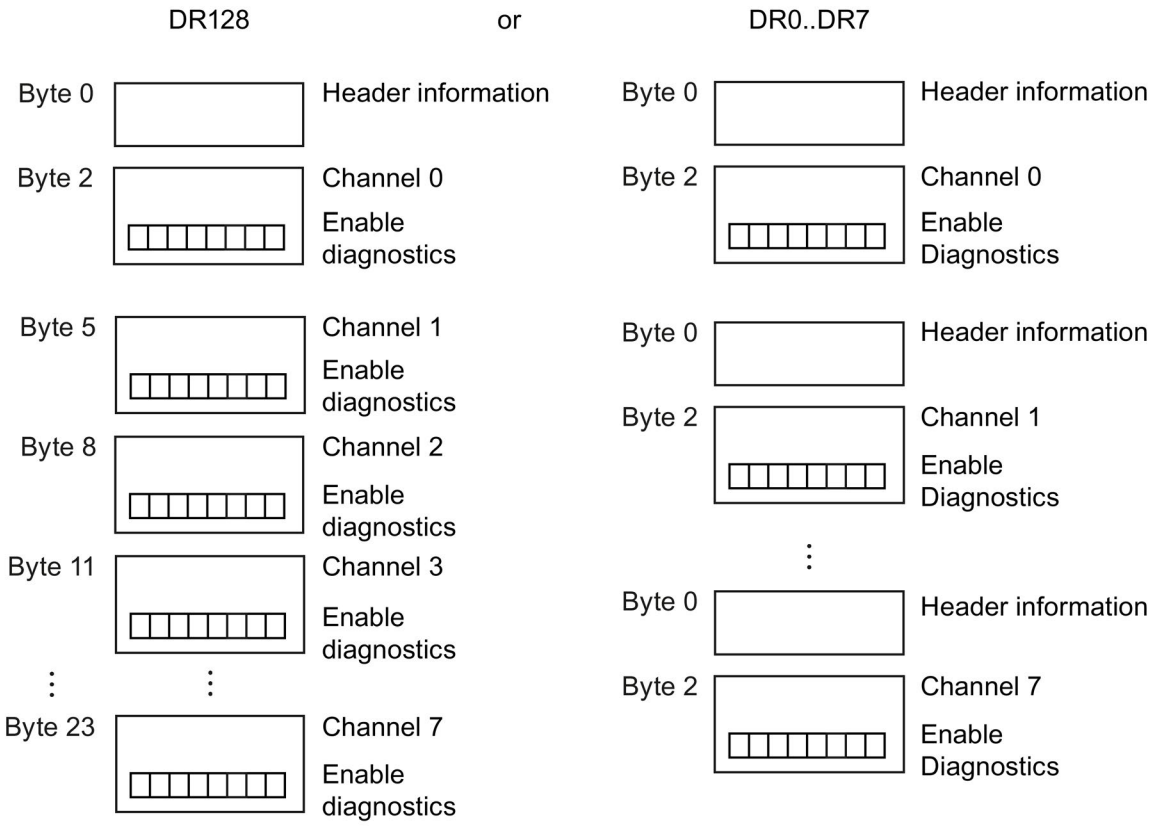


Image A-1 Structure of data record 128 and data records 0 to 7

Header information

The figure below shows the structure of the header information.

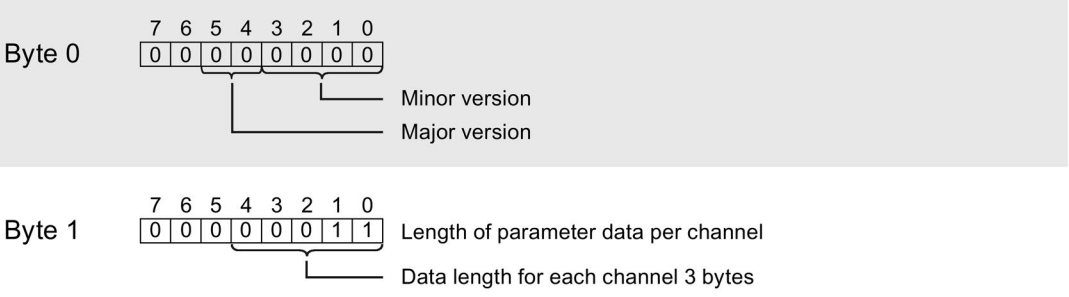
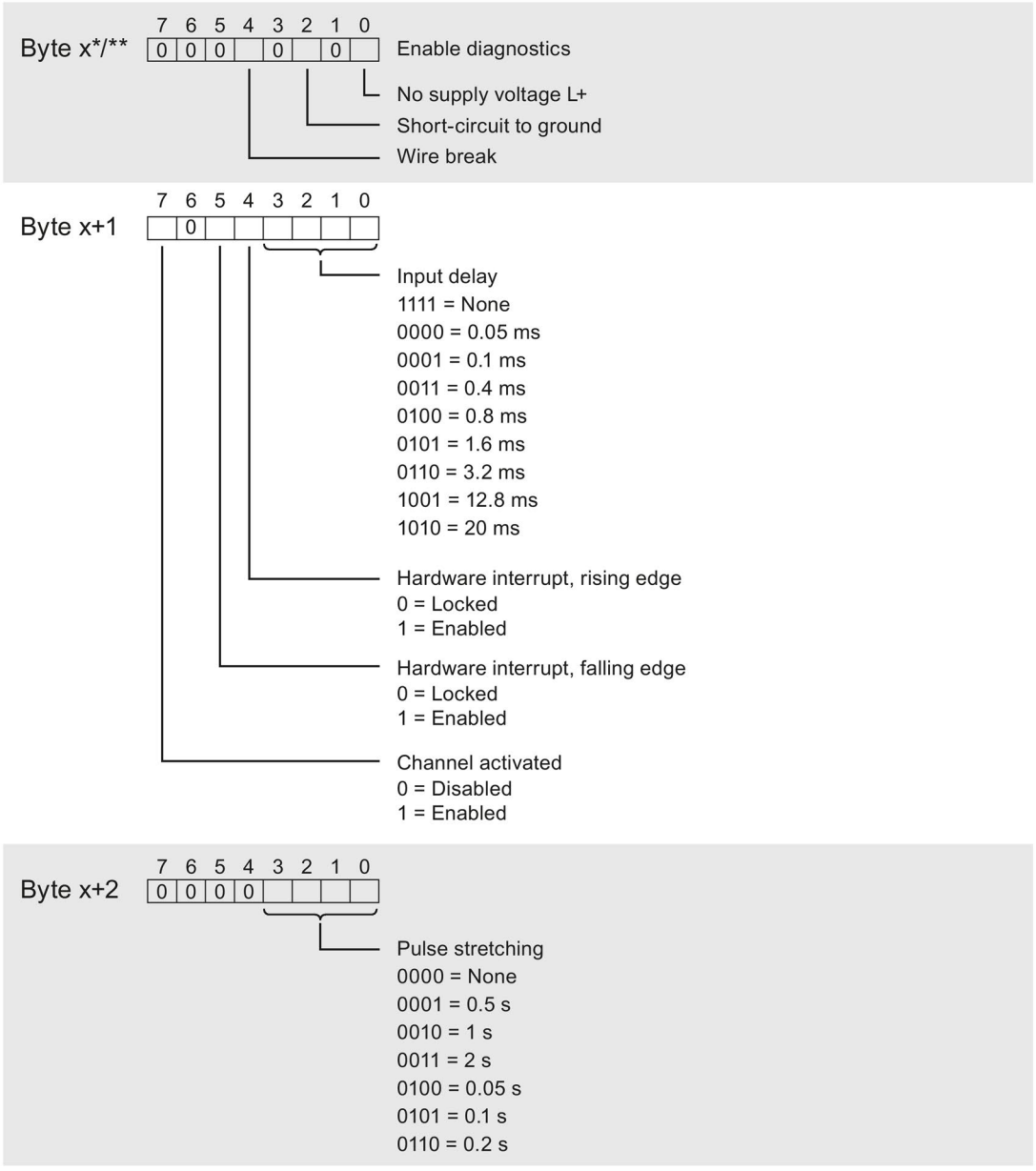


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 3); channel number = 0 to 7 for DR 128
** x = 2 for DR 0 to DR 7

Image A-3 Structure of byte x to x+2 for channels 0 to 7

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

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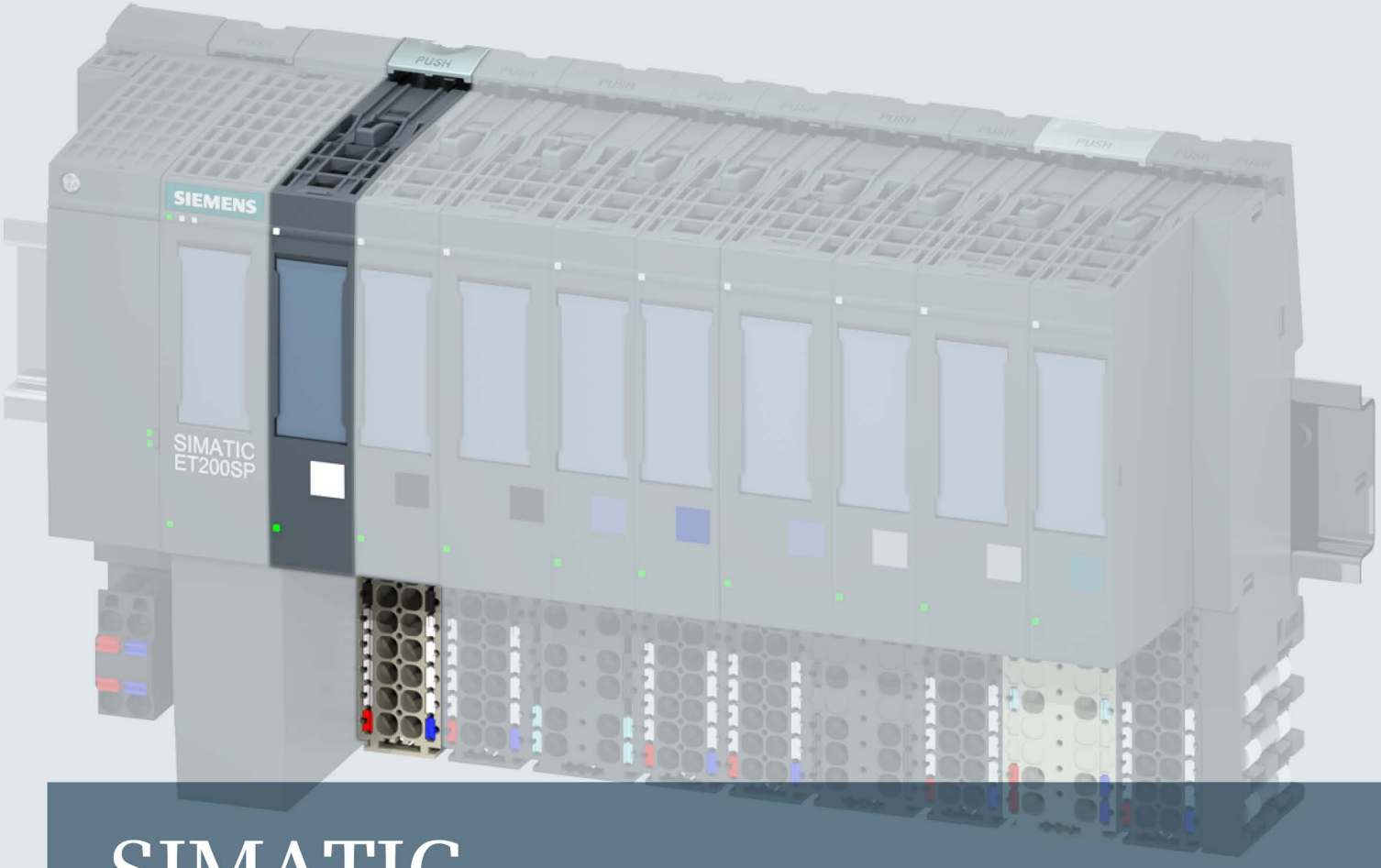

SIMATIC

ET 200SP

Digital input module DI 8x24VDC HS (6ES7131-6BF00-0DA0)

Manual

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ET 200SP
Digital input module DI 8x24VDC HS (6ES7131-6BF00-0DA0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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Preface

Purpose of the documentation

This device manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that relate generally to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you when commissioning the ET 200SP distributed I/O system.

Conventions

Please pay particular attention to notes highlighted as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

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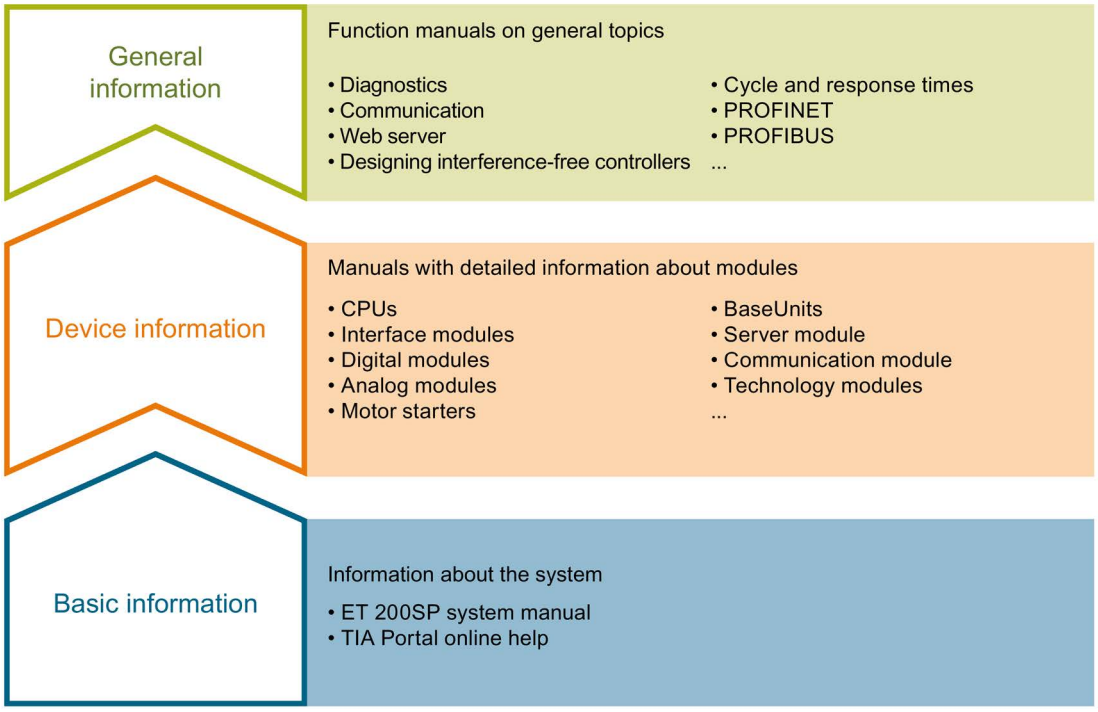
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

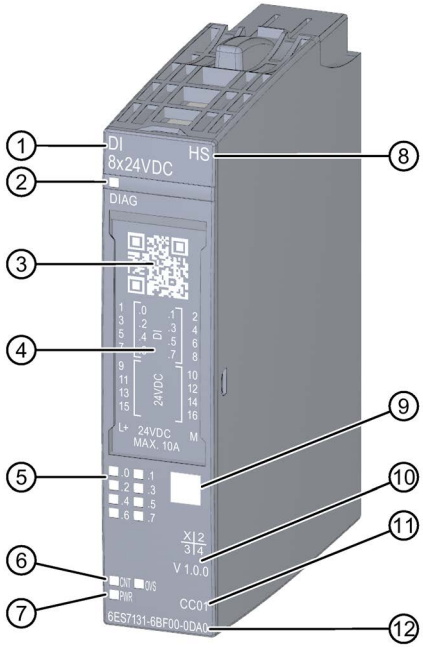
2

2.1 Properties

Article number

6ES7131-6BF00-0DA0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LEDs for operating mode
⑦ LED for supply voltage
⑧ Function class
⑨ Color coding module type
⑩ Function and firmware version
⑪ Color code for selecting the color identification labels
⑫ Article number

Figure 2-1 View of the DI 8×24VDC HS module

Properties

The module has the following technical properties:

- Digital input module with 8 high-speed inputs
- Supply voltage L+
- Sink input (PNP)
- Module-specific configurable diagnostics for supply voltage and short-circuit to M
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 1 and 3
- Three operating modes:

Table 2- 1 Operating modes of the DI 8×24VDC HS

Property		Operating mode			
		DI (Page 14)		Counting (CNT) (Page 28)	Oversampling (OVS) (Page 47)
		Without value status (QI)	With value status (QI)		
Number of channels		8	8	4	8
Isochronous mode		Yes, optional	Yes, optional	Yes, optional	Yes, required
• Shortest send clock		125 µs	125 µs	125 µs	250 µs
Oversampling		No	No	No	Yes
• Number of oversampling levels (sampling rate)		—	—	—	2 ... 32
• Shortest sub-cycle (= shortest sampling time)		—	—	—	7.8125 µs
Counter length, max. counting frequency		—	—	32-bit, 10 kHz *	—
Configurable input delay		0 ms ... 20 ms	0 ms ... 20 ms	0.05 ms - 20 ms	0 ms ... 20 ms
Configurable hardware interrupts; rising edge and/or falling edge (per channel)		×	×	—	—
Data length	Inputs	1 byte	2 bytes	25 bytes	32 bytes
	Outputs	0 bytes	0 bytes	20 bytes	0 bytes

* If a diagnostic event occurs, the maximum counting frequency is reduced to 9 kHz.

The module supports the following functions:

- Isochronous mode
- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy

The module can be configured with HSP or a GSD file. The configurations for the operating modes can be found under various codes / module names:

Table 2- 2 Codes / module names for the configuration options

Operating mode		Configuration software			
		HSP0127 for STEP 7 (TIA Portal)	HSP0229 for STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
DI	Without QI	DI 8×24VDC HS	DI 8×24VDC HS DI/OVS	DI 8×24VDC HS	DI 8×24VDC HS
	With QI			DI 8×24VDC HS QI	—
Counting (CNT)			DI 8×24VDC HS CNT	DI 8×24VDC HS CNT	DI 8×24VDC HS CNT
Oversampling (OVS) *			DI 8×24VDC HS DI/OVS	—	—

* The interface module or CPU with which the module is used must support isochronous mode.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Operating mode DI

3

3.1 Wiring up

3.1.1 Wiring and block diagrams

This section contains the block diagram for the DI 8x24VDC HS with the pin assignments for 1, 2 and 3-wire connection in DI operating mode. You may use and combine the different wiring options for all channels.

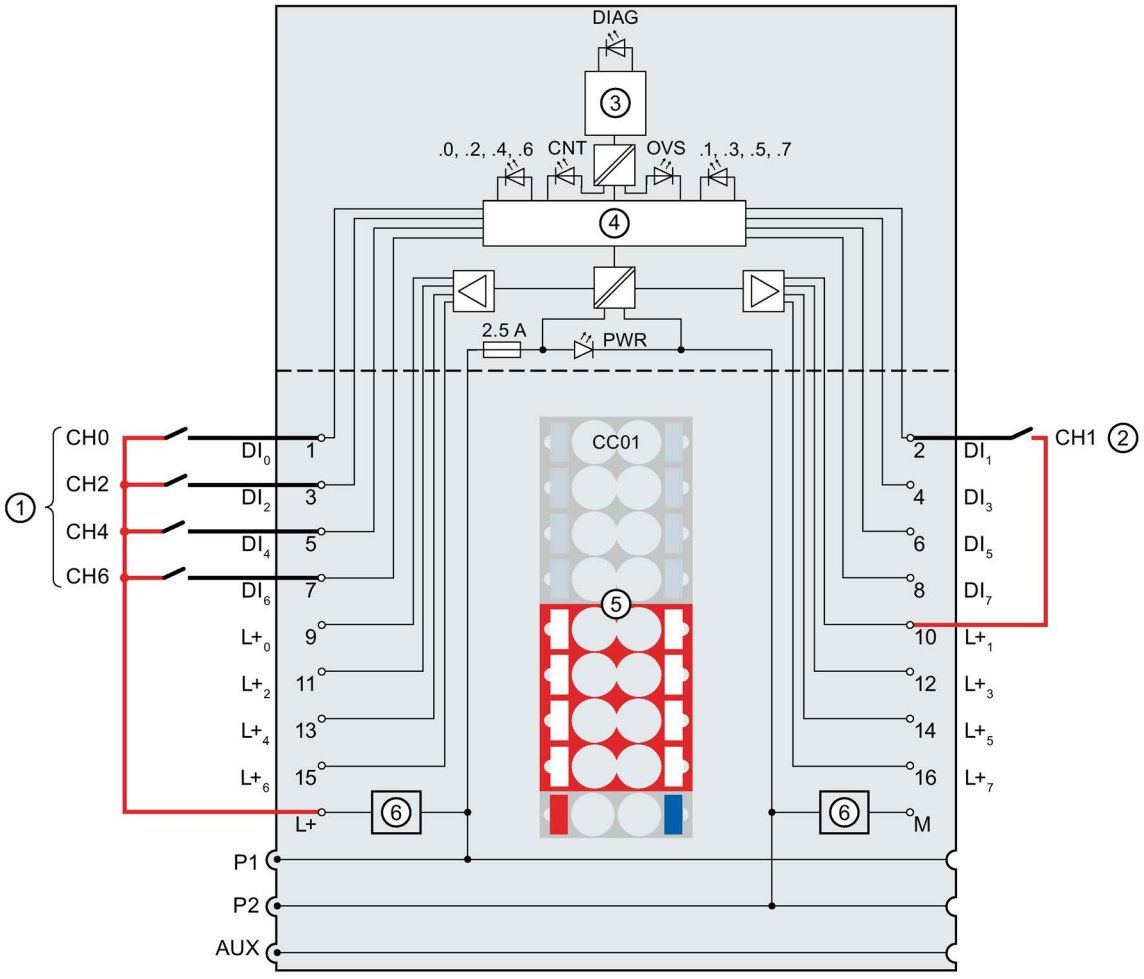
Information on wiring the BaseUnit can be found in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

Note

The module's load group must start with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The figure below shows the block diagram and an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 without AUX terminals (1 and 2-wire connection).

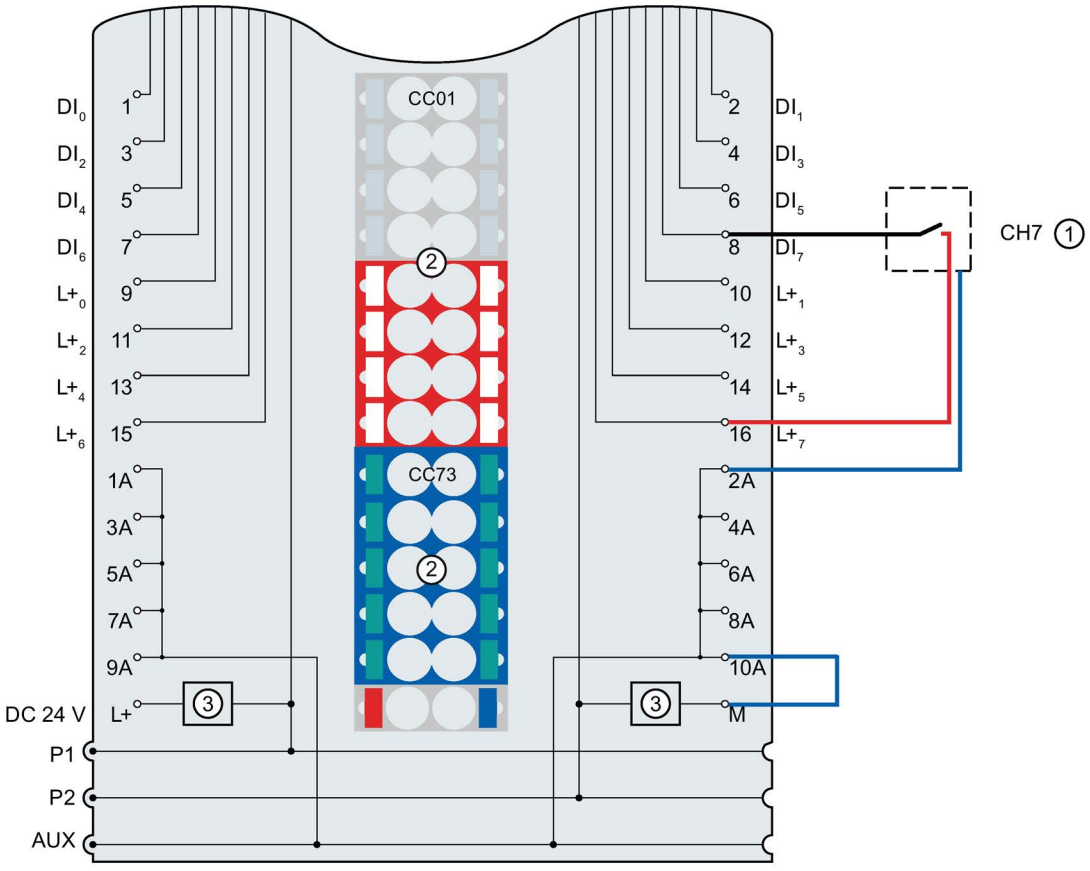


①	1-wire connection	$L+_n$	Encoder supply, channel n
②	2-wire connection	L+	24 V DC (infeed only with light BaseUnit)
③	Backplane bus interface	DIAG	LED error or diagnostics (green, red)
④	Input electronics	.0 to .7	LED channel status (green)
⑤	Color-coded label CCxx (optional)	PWR	LED power (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	CNT	LED operating mode Count (green)
M	Ground	OVS	LED operating mode Oversampling (green)
DI_n	Input signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 3-1 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The figure below shows an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection
②	Color-coded labels CCxx (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 3-2 Pinout and block diagram for 3-wire connection of encoders

3.2 Parameters/address space

3.2.1 High-speed inputs

Function

In operating mode DI, use all eight channels as digital high-speed inputs. High-speed inputs make sense when rapid reactions to input signals are needed (reaction time < 2 ms).

Requirement

Low reaction times require a cycle time of less than 750 µs.

3.2.2 Parameters

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of parameter data record for DI operating mode (Page 64).

The following parameter settings are possible for each operating mode:

Table 3- 1 Configurable parameters in DI operating mode

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Operating mode[1]	• DI / Oversampling • Counting	—	no	Module	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module

Parameters	Value range	Default	Recon-figura-tion in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Channel activated	• Disable • Enable	Enable	yes	Channel	Channel
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	yes	Channel	Module [2]
Pulse stretching	• None • 0.05 s • 0.1 s • 0.2 s • 0.5 s • 1 s • 2 s	None	yes	Channel	— [3]
Hardware interrupt: rising edge	• Disable • Enable	Disable	yes	Channel	— [3]
Hardware interrupt: falling edge	• Disable • Enable	Disable	yes	Channel	— [3]
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

[1] When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

[2] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128.

[3] If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

3.2.3 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated:

- DI / Oversampling (Page 47)
- Counting (Page 28)

When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Channel activated

Determines whether a channel is enabled or disabled. If a digital input is disabled, the module ignores its signals.

Pulse stretching

Pulse stretching is a function used to change a digital input signal. A pulse on a digital input is stretched to at least the configured length. If the input pulse is already longer than the configured length, the pulse is not changed. With Pulse stretching, you can reliably detect very short input signals without having to use a correspondingly short cycle time.

In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). In some cases, pulses that are shorter than the cycle time (send clock) are not detected.

If you want to detect short signals isochronously, the Oversampling operating mode is recommended. Oversampling also provides more precise information about the time at which a signal occurs.

Principle of pulse stretching

The figure below uses examples to show whether and how input pulses are changed.

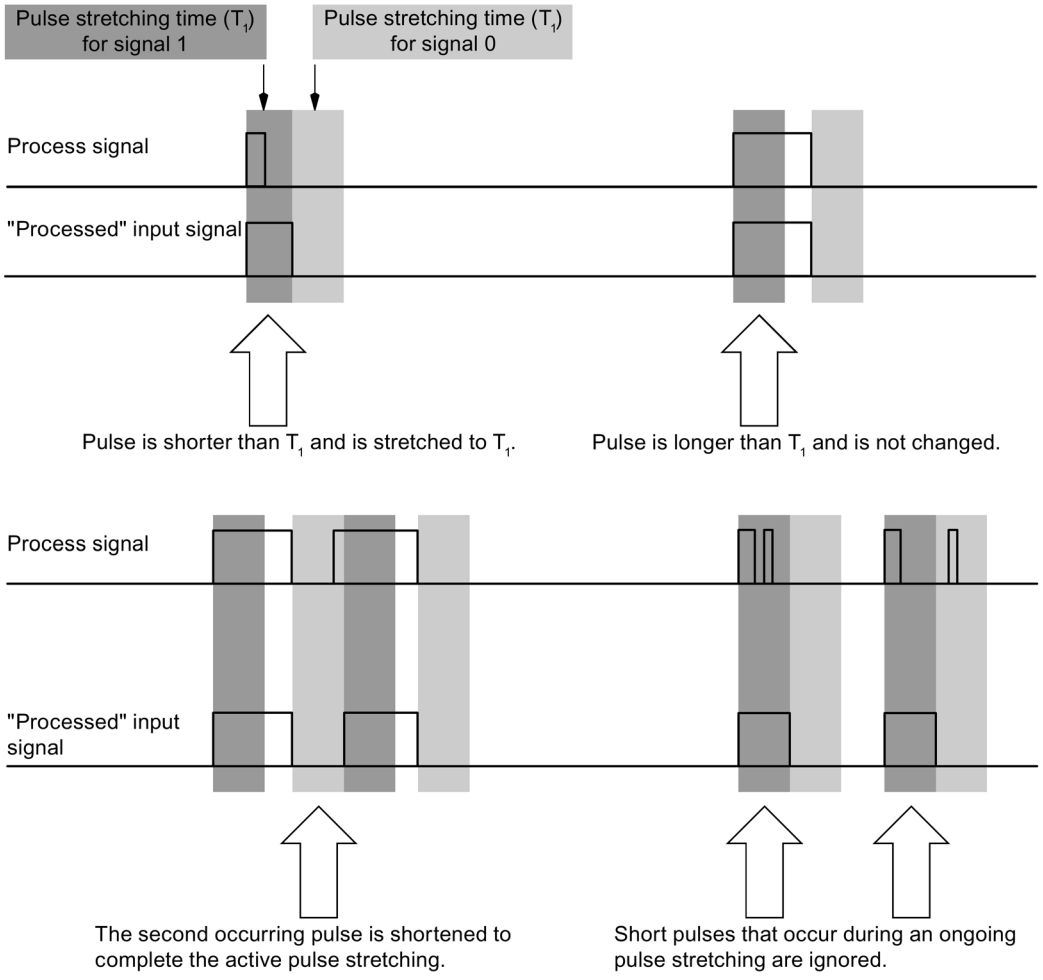


Figure 3-3 Principle of pulse stretching

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Isochronous configuration is only possible if there is no input delay configured for at least one channel. In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). The read time T_i refers to the channel for which no input delay time was configured.

For input channels with longer input delays, the read time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a negative impact on the possible cycle time.

Note

If you select the "None" or "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Hardware interrupt: rising edge

Specifies whether a hardware interrupt is generated for a rising edge.

Hardware interrupt: falling edge

Specifies whether a hardware interrupt is generated for a falling edge.

Potential group

Specifies whether a light-colored BaseUnit with incoming supply voltage is located on this slot (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

3.2.4 Address space

Address space with value status (Quality Information, QI)

The figure below shows the assignment of the address space with value status (Quality Information (QI)). "IB x" represents the start address of input byte x.

The addresses for the value status are only available if the value status is enabled.

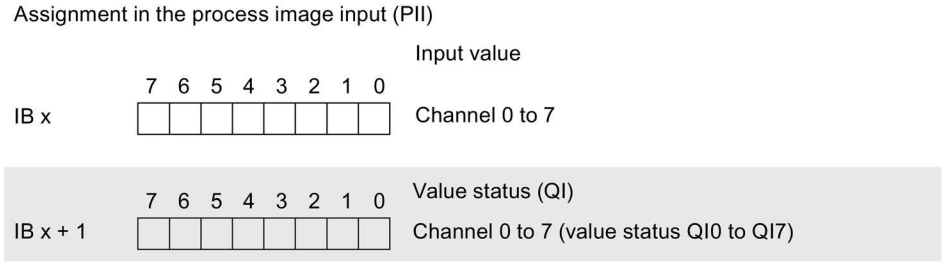


Figure 3-4 Address space with value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 7 in this byte are each assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

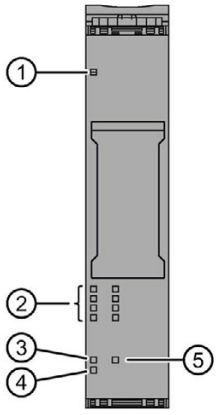
If a fault/error occurs on a channel with this module, the value status for all channels is 0.

3.3 Interrupts/diagnostics alarms

3.3.1 Status and error display

LED display

The figure below shows the LED display of the DI 8×24VDC HS.



① DIAG (green/red)
② Channel status (green)
③ CNT (green)
④ PWR (green)
⑤ OVS (green)

Figure 3-5 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for dealing with diagnostic interrupts can be found in the section Diagnostics alarms (Page 27).

DIAG LED

Table 3- 2 DIAG LED fault/error display

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 3- 3 Status display of the channel status LED

Channel status LED	Meaning
Off	Process signal = 0
On	Process signal = 1

CNT LED

Table 3- 4 Status display of the CNT LED

CNT LED	Meaning
Off	Counting operating mode disabled
On	Counting operating mode enabled

OVS LED

Table 3- 5 Status display of the OVS LED

OVS LED	Meaning
□ Off	Oversampling operating mode disabled
■ On	Oversampling operating mode enabled

PWR LED

Table 3- 6 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

3.3.2 Interrupts

The digital input module DI 8×24VDC HS supports hardware and diagnostics alarms in the DI mode.

Diagnostic interrupts

The module generates a diagnostics interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit
- Parameter assignment error
- No load voltage
- Hardware interrupt lost

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- At rising edge (signal change from 0 to 1)
- At falling edge (signal change from 1 to 0)

If an interrupt occurs, a corresponding interrupt OB is called in the CPU of the IO controller.

S7-1500

Detailed information on the event is available in the STEP 7 online help.

The block interface is shown here with optimized block access, which is set in the TIA Portal by default.

Name	Data type	Comment
LADDR	HW_IO	Hardware identifier of the module triggering the interrupt
USI	WORD	USI (High/Low)
IChannel	USInt	Channel that triggered the hardware interrupt
EventType	Byte	Error event

S7-300/400 or a different CPU

The module generates a hardware interrupt at the following events:

- At rising edge (signal change from 0 to 1)
- At falling edge (signal change from 1 to 0)

If an interrupt occurs, a corresponding interrupt OB is called in the CPU of the IO controller.

You will find detailed information on the event in the hardware interrupt organization block with the "RALRM" (read additional interrupt information) instruction and in the STEP 7 online help.

The channel of the module that triggered the hardware interrupt is entered in the start information of OB40 in the OB40_POINT_ADDR tag. The following figure shows the assignment to the bits of double word 8 in local data.

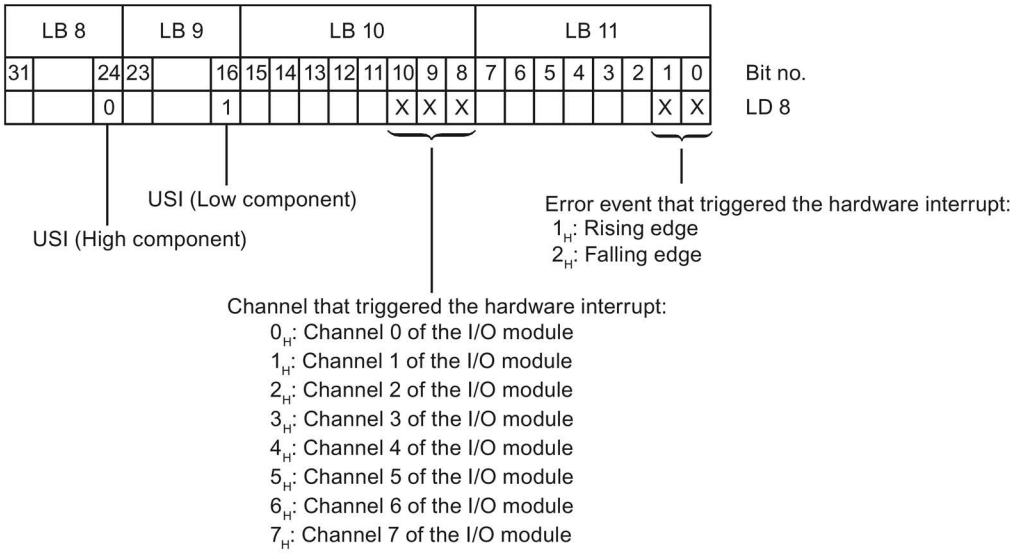


Figure 3-6 OB40_POINT_ADDR tag

Structure of the additional interrupt information

Table 3- 7 Structure of USI = W#16#0001

Data block name		Content	Comment	Bytes
USI		W#16#0001	User Structure Identifier: Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
It follows the error event that triggered the hardware interrupt.				
	Error event	B#16#01	Rising edge	1
		B#16#02	Falling edge	

3.3.3 Diagnostics alarms

A diagnostic interrupt is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostic interrupts can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 3- 8 Diagnostic interrupts, their meaning and how to deal with them

Diagnostic interrupt	Error code	Meaning	Remedy
Short-circuit	1_H	Short-circuit to ground at encoder supply	Correct process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel/module. • Incorrect parameter assignment.	Correct parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Hardware interrupt lost	16_H	• Module cannot send an interrupt because a previous interrupt has not been processed • Possible cause: Too many hardware interrupts in too short a time	Change interrupt processing in the CPU and re-assign module parameters correspondingly
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module reads no process values in this state.	• Wait for firmware update. • Restart the firmware update.

Counting operating mode (CNT) 4

4.1 Connecting

4.1.1 Wiring and block diagrams

This section contains the block diagram for the DI 8×24VDC HS module with the pin assignments for 1, 2 and 3-wire connection in counting operating mode. You may use and combine the different wiring options for all channels.

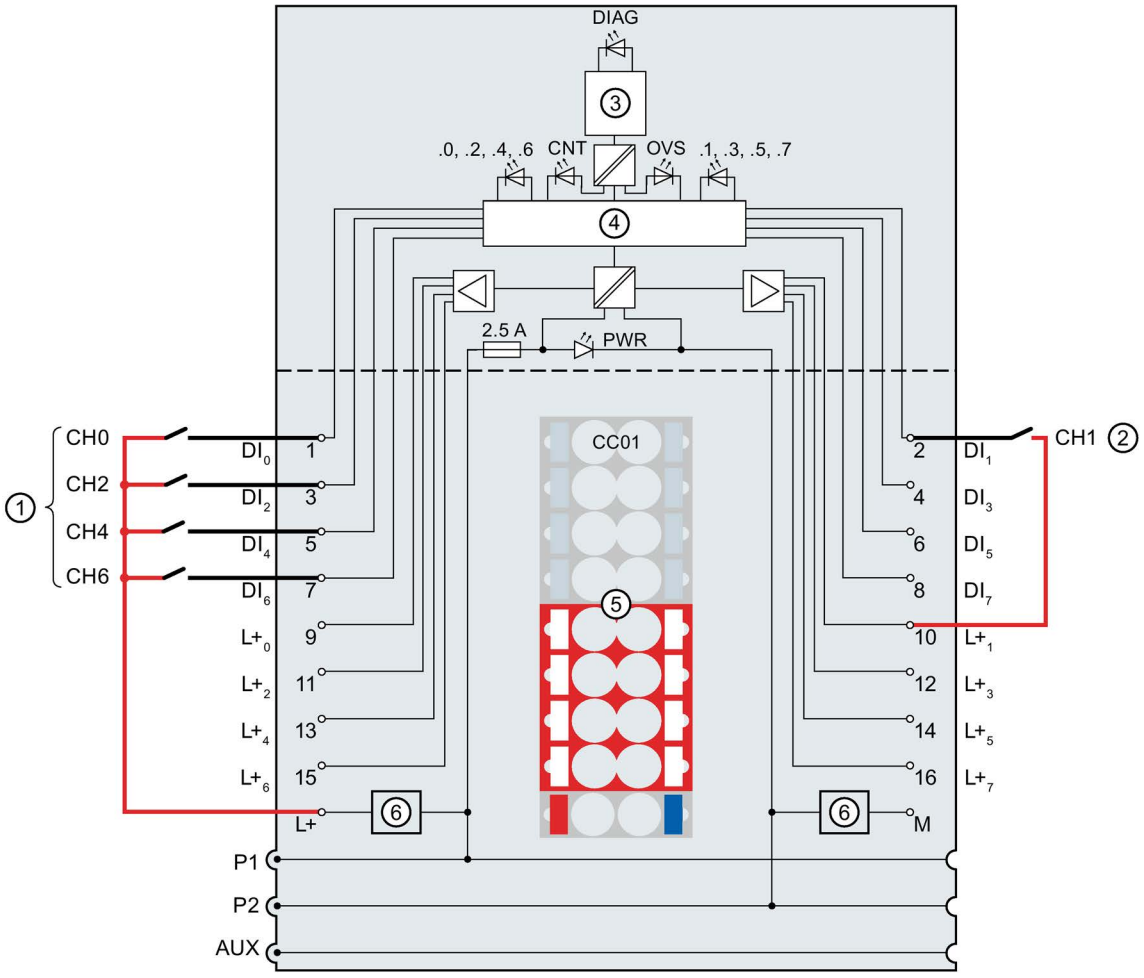
Information on wiring the BaseUnit can be found in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

Note

The module's load group must start with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The figure below shows the block diagram and an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 without AUX terminals (1 and 2-wire connection).

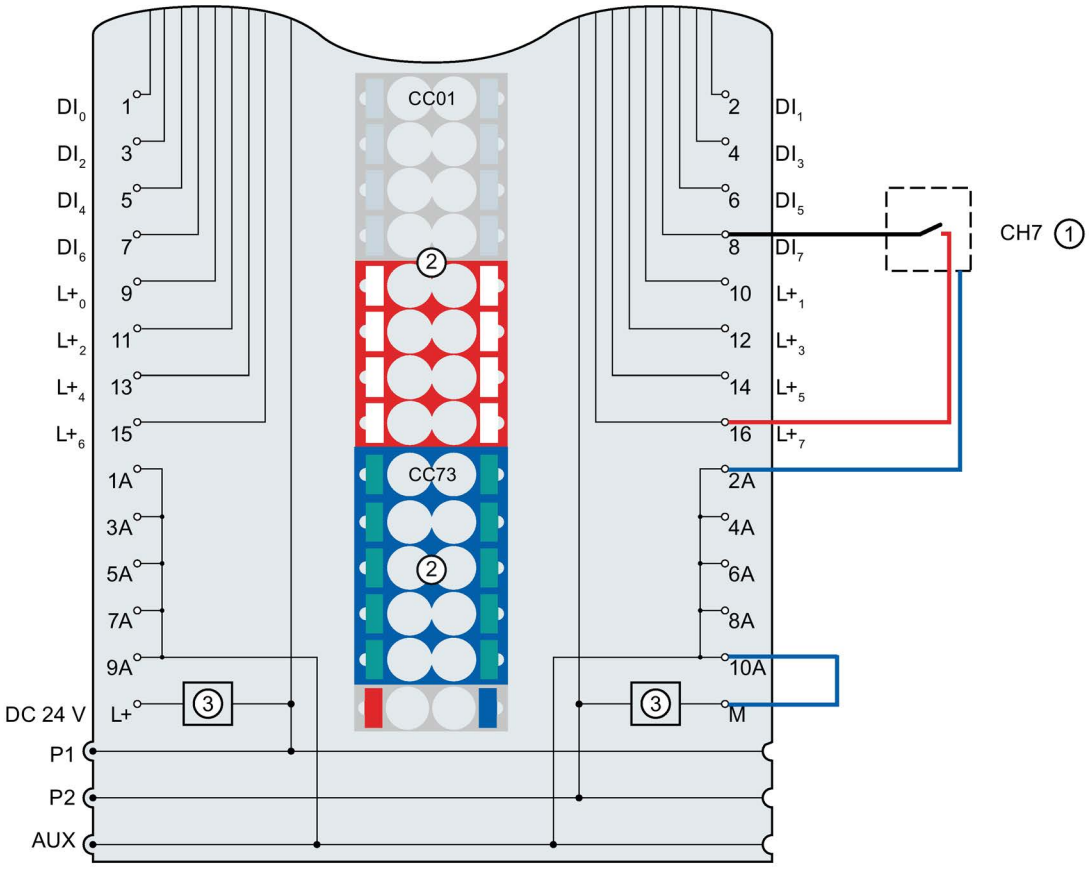


①	1-wire connection	DIAG	LED error or diagnostics (green, red)
②	2-wire connection	.0 to .7	LED channel status (green)
③	Backplane bus interface	PWR	LED power (green)
④	Input electronics	CNT	LED operating mode Count (green)
⑤	Color-coded label CCxx (optional)	OVS	LED operating mode Oversampling (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	DI_0 - DI_3	Counter input, channels 0-3
M	Ground	DI_4	Direction input or gate input for DI_0, channel 4
$L+_n$	Encoder supply, channel n	DI_5	Direction input or gate input for DI_1, channel 5
L+	24 V DC (infeed only with light BaseUnit)	DI_6	Direction input or gate input for DI_2, channel 6
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)	DI_7	Direction input or gate input for DI_3, channel 7

Figure 4-1 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The figure below shows an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection
②	Color-coded labels CCxx (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 4-2 Pinout and block diagram for 3-wire connection of encoders

4.2 Parameters/address space

4.2.1 Counting

Function

Counting refers to the detection and summation of events. The respective counters of the module detect encoder signals and pulses and evaluate them accordingly, for example:

- For counting general piece goods up to a maximum limit
- For applications with recurring counting processes

You can count with DI_0 through DI_3. You can specify each counter's characteristics using the functions described below.

Counter limits

The counting limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program.

The maximum possible counting limit is 2147483647 (2^{31}–1). The minimum possible counting limit is –2147483648 ($–2^{31}$).

You can continue or stop counting upon violation of a counting limit (automatic gate stop) Upon high and low limit violations of the counter value, an event bit is set in the feedback interface (Page 40) in each case.

Start value

You can configure a start value within the counter limits. The start value can be modified during runtime with the user program.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are recordd.

The control of the hardware gate takes place externally via the digital inputs DI_4 through DI_7. The software gate is controlled via the user program. Use of the hardware gate can be enabled through parameter assignment.

Count direction

The counting direction is specified either via suitable external pulse signals at the each counter's control input or via the configuration.

Comparison values

You define two comparison values that can control the STS_DQ feedback bit, independent of the user program. If the current counter value meets the configured comparison condition, the STS_DQ reset bit is set. You can use the STS_DQ reset bit in order to control a digital output module's digital output.

The comparison values are configurable and can be modified during runtime with the user program. When a comparison event occurs, in each case an event bit is set in the feedback interface (Page 40).

4.2.2 Parameters

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of parameter data record for Counting operating mode (Page 68).

The following parameter settings are possible for each operating mode:

Table 4- 1 Configurable parameters in Counting operating mode

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Operating mode[1]	• DI / Oversampling • Counting	—	no	Module	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Channel activated	• Disable • Enable	Enable	yes	Channel	Channel

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Input delay	• 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	yes	Channel	Module [2]
Reaction to violation of a counting limit	• Stop counting • Continue counting	Stop counting	yes	Channel	Channel
Edge selection	• At rising edge • At falling edge	At rising edge	yes	Channel	Channel
Count direction	• Up • Down	Up	yes	Channel	Channel
Set output	• Off (DQ = 0) • Off (DQ = 1) • Counter value between comparison value 0 and 1 • Counter value not between comparison value 0 and 1	Off (DQ = 0)	yes	Channel	Channel
Setting function of the DI	• Digital input without function • Gate start/stop • Reverse direction	Digital input without function	yes	Channel	Channel
Counter high limit	-2147483648...2147483647	2147483647	yes	Channel	Channel
Counter low limit	-2147483648...2147483647	0	yes	Channel	— [3]
Start value	-2147483648...2147483647	0	yes	Channel	— [3]
Comparison value 1	-2147483648...2147483647	10	yes	Channel	Channel

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Comparison value 0	-2147483648...2147483647	0	yes	Channel	— [3]
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

[1] When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

[2] If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

[3] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128.

4.2.3 Explanation of parameters

Operating mode

Selection of the operating mode in which all of the module's channels are operated.

- DI (Page 14) / Oversampling (Page 47)
- Counting

When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Channel activated

Determines whether a channel is enabled or disabled. If a digital input is disabled, the module ignores its signals.

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

In isochronous mode, the feedback interface is updated at the time T_i (time for reading the input data).

Note

If you select the "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Reaction to violation of a counting limit

Selection of the reaction to violation of the counter high limit in the upward direction or the counter low limit in the downward direction:

- Stop counting:
  After a counting limit is violated, the internal gate is closed. This stops the counting process. The counter value is set to the opposite counting limit. To restart counting, you must close and reopen the software/hardware gate.
- Continue counting:
  After a counting limit is violated, the counter value is set to the opposite counting limit and counting continues.

Edge selection

Selects the edge that is counted:

- At rising edge:
  The respective counter counts all rising edges at the digital input.
- At falling edge:
  The respective counter counts all falling edges at the digital input.

Note

If the "Reverse direction" option is selected in "Set function of DI" and the counting direction in the process changes, the counting edge is automatically adjusted (opposite edges).

Count direction

Count direction selection:

- Up:
  The respective counter counts up.
- Down:
  The respective counter counts down.

Note

This parameter has no effect if the "Reverse direction" option is selected in "Set function of DI".

Set output

Selects the function that controls the response of the STS_DQ feedback bit (Page 40): You can use the STS_DQ reset bit in order to control a digital output module's digital output.

- Off (DQ = 0):
  STS_DQ is independent of the counter value and permanently not set.
- Off (DQ = 1):
  STS_DQ is independent of the counter value and permanently set.
- Counter value between comparison value 0 and 1:
  STS_DQ is set if counter value ≥ comparison value 0 and counter value ≤ comparison value 1.
- Counter value not between comparison value 0 and 1:
  STS_DQ is set if counter value < comparison value 0 or counter value > comparison value 1.

Setting function of the DI

Selects the function of DI_{n+4}, which controls the assigned counter input DI_n:

- Digital input without function:
  No function is assigned to DI_{n+4}. The signal status of DI_{n+4} can be read by the CPU using the feedback interface (Page 40).
- Gate start/stop:
  Setting DI_{n+4} opens the hardware gate for DI_n. Resetting DI_{n+4} closes the hardware gate for DI_n.
- Reverse direction:
  DI_{n+4} reverses the counting direction at DI_n, in order to adjust it to the process. If DI_{n+4} is not set, DI_n counts up. If DI_{n+4} is set, DI_n counts down.

Counter high limit

Sets counter high limit.

The following applies:

- Counter high limit > counter low limit
- Counter high limit ≤ 2147483647 (2^{31} - 1)

Counter low limit

Sets the counter low limit.

The following applies:

- Counter low limit < counter high limit
- Counter low limit ≥ -2147483648 (-2^{31})

Start value

Sets the start value.

The following applies:

- Start value ≥ counter low limit
- Start value ≤ counter high limit

Comparison value 1

Sets the second comparison value.

The following applies:

- Comparison value 1 > comparison value 0
- Comparison value 1 ≤ counter high limit

Comparison value 0

Sets the first comparison value.

The following applies:

- Comparison value 0 < comparison value 1
- Comparison value 0 ≥ counter low limit

Potential group

Specifies whether a light-colored BaseUnit with incoming supply voltage is located on this slot (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

4.2.4 Address space

4.2.4.1 Assignment of the control interface

Control interface

The user program uses the control interface to influence the behavior of the module's counter. The figure below shows the address space allocation for the control interface in the process image of the outputs.

"QB x" represents the start address of output byte x.

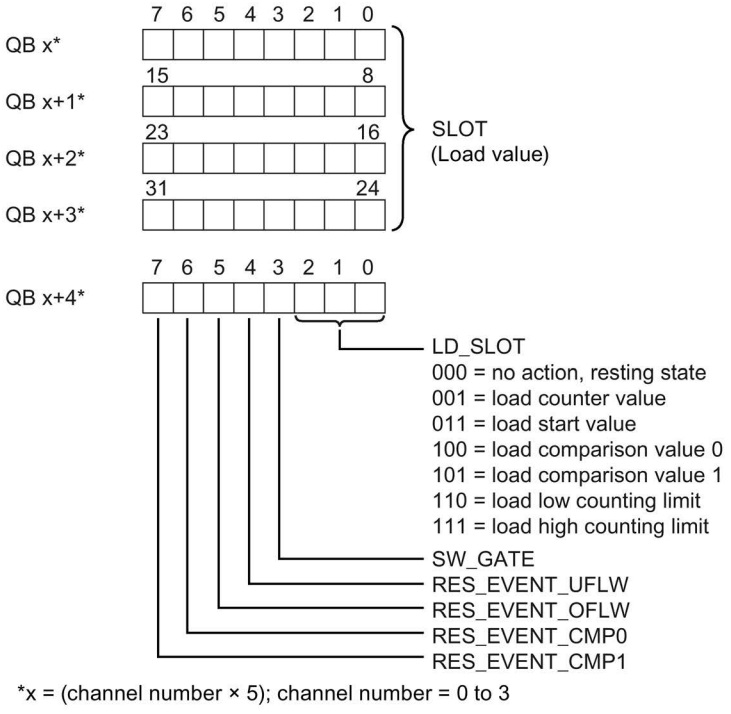


Figure 4-3 Assignment of the control interface

Notes on the control bits

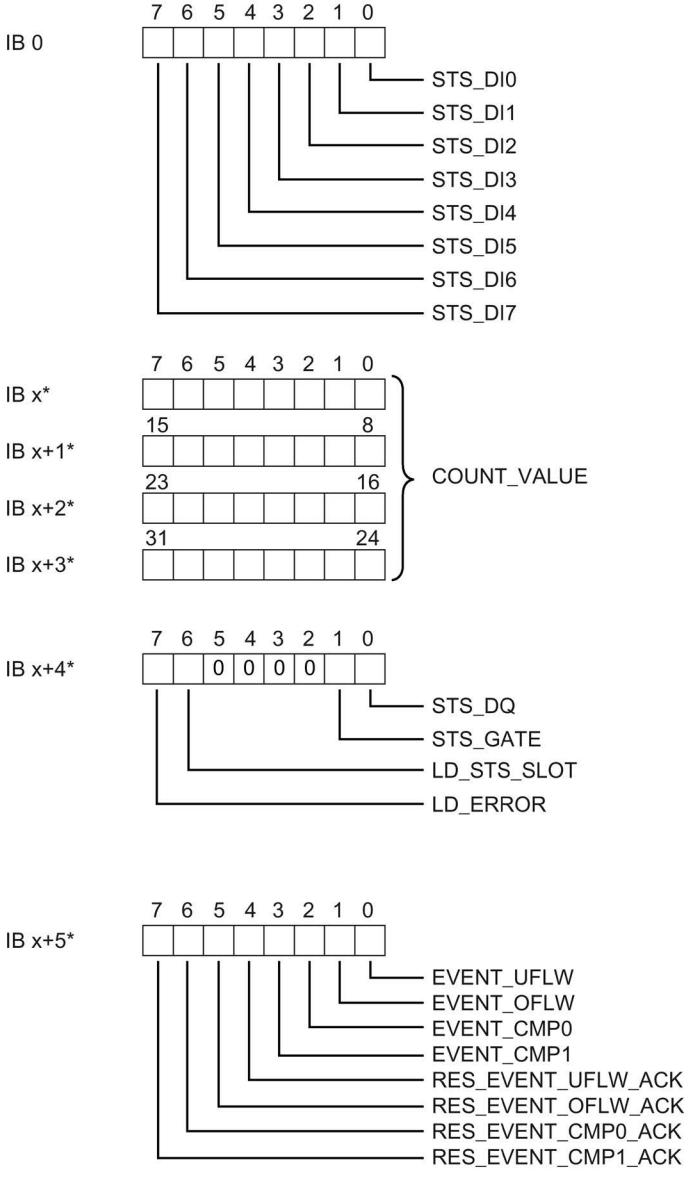
Control bit	Notes
SLOT	This value is used to specify the loaded value for each channel. Use the LD_SLOT load request to evaluate the loaded value.
LD_SLOT	This load request is used to specify the meaning of the SLOT (loaded value) value for each channel. The user program performs the respective action, as soon as LD_SLOT changes. When the loading request LD_SLOT = 011_B is entered and the software gate is opened, each counting operation begins with the start value. If another load request is entered and the software gate is opened, counting continues with the current count at each start of the counting operation. These two situations are also in effect when the hardware gate is configured and the software gate is closed.
SW_GATE	With this bit, you open and close the software gate of the respective channel. Together, the software gate and the hardware gate form the internal gate. The module only counts if the internal gate is open. 0 means: Software gate closed 1 means: Software gate open
RES_EVENT_UFLW	Use this bit to initiate the resetting of the saved event in the EVENT_UFLW feedback bit for the respective channel.
RES_EVENT_OFLW	Use this bit to initiate the resetting of the saved event in the EVENT_OFLW feedback bit for the respective channel.
RES_EVENT_CMP0	Use this bit to initiate the resetting of the saved event in the EVENT_CMP0 feedback bit for the respective channel.
RES_EVENT_CMP1	Use this bit to initiate the resetting of the saved event in the EVENT_CMP1 feedback bit for the respective channel.

4.2.4.2 Assignment of the feedback interface

Feedback interface

The user program receives current values and status information from the module via the feedback interface. The figure below shows the address space allocation for the feedback interface in the process image of the inputs.

"IB x" represents the start address of input byte x.



*x = 1 + (channel number × 6); channel = 0 to 3

Figure 4-4 Assignment of the feedback interface

Notes on the feedback bits

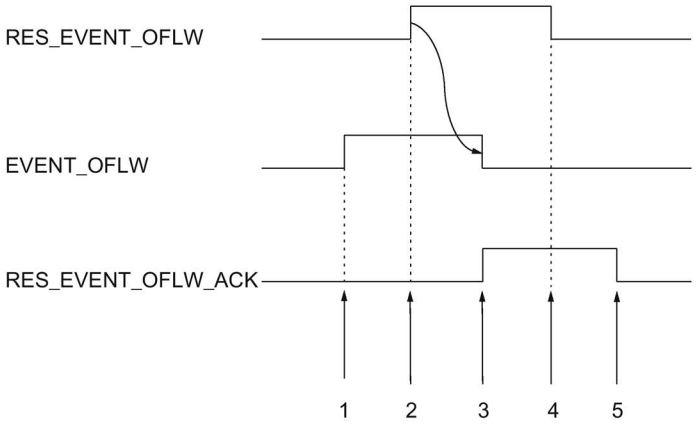
Feedback bit	Notes
STS_DIn	This bit indicates the status of the respective digital input DI_n.
COUNT_VALUE	This value returns the current counter value for the respective channel.
STS_DQ	This bit depends on the "Set output" parameter of the respective channel. You can use STS_DQ in each case, in order to control a digital output module's digital output.
STS_GATE	Together, the software gate and the hardware gate form the internal gate. This bit indicates the status of the internal gate for the respective channel. The module only counts if the internal gate is open. 0 means: Gate closed 1 means: Gate open Note: If you change a channel parameter in RUN mode via data record 128, all of the changed channel's values are retransferred to the module. In doing so, the internal gate of the respective channel is closed and the counter value is set to the start value. To restart counting, you need to close and reopen the software gate in each case.
LD_STS_SLOT	This bit indicates for the respective channel, by mean of a status change (toggling), that the load request for SLOT (LD_SLOT) has been detected and executed.
LD_ERROR	This bit indicates for the respective channel that an error occurred (latching) during loading via the control interface. The loaded value was not applied. One of the following conditions has not been met: • Counter low limit ≤ counter value (If this condition is not met, the start value is loaded as the current counter value.) • Counter low limit ≤ start value • Counter low limit ≤ comparison value 0/1 • Counter high limit ≥ counter value (If this condition is not met, the start value is loaded as the current counter value.) • Counter high limit ≥ start value • Counter high limit ≥ comparison value 0/1 • Counter low limit < counter high limit • Comparison value 0 < comparison value 1 • Do not write a reserved load request in LD_SLOT
EVENT_UFLW	For the respective channel, this bit indicates the saved state which shows that there was a counter value underflow (a violation of the counter low limit). You reset the status by acknowledgment with RES_EVENT_UFLW.
EVENT_OFLW	For the respective channel, this bit indicates the saved state which shows that there was a counter value overflow (a violation of the counter high limit). You reset the status by acknowledgment with RES_EVENT_OFLW.
EVENT_CMP0	For the respective channel, this bit indicates the saved status which shows that a comparison event with comparison value 0 has occurred. You reset the status by acknowledgment with RES_EVENT_CMP0. The EVENT_CMP0 bit is not set when you set the counter value to the start value.
EVENT_CMP1	For the respective channel, this bit indicates the saved status which shows that a comparison event with comparison value 1 has occurred. You reset the status by acknowledgment with RES_EVENT_CMP1. The EVENT_CMP1 bit is not set when you set the counter value to the start value.

Feedback bit	Notes
RES_EVENT_UFLW_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_UFLW is active.
RES_EVENT_OFLW_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_OFLW is active.
RES_EVENT_CMP0_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_CMP0 is active.
RES_EVENT_CMP1_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_CMP1 is active.

Complete acknowledgment principle

Saving bits are acknowledged according to the complete acknowledgment principle.

The figure below shows an example of the sequence of the complete acknowledgment principle in the event of an overflow:



① The EVENT_OFLW feedback bit is set as a saving event upon overflow.
② You set the RES_EVENT_OFLW control bit to trigger EVENT_OFLW reset.
③ The RES_EVENT_OFLW_ACK feedback bit is set when reset of EVENT_OFLW is detected.
④ You then rest the control bit RES_EVENT_OFLW .
⑤ The RES_EVENT_OFLW_ACK feedback bit is reset.

Figure 4-5 Acknowledgment principle

Note

If you have initiated the reset of an event bit, you must wait for the respective feedback bit. Then you can initiate another reset.

Note

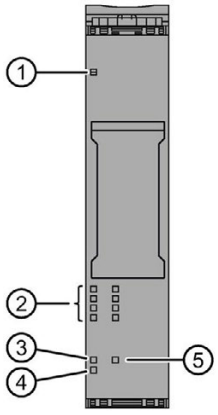
Opening the software gate or hardware gate (0-1 transition) resets all event bits.

4.3 Interrupts/diagnostic messages

4.3.1 Status and error display

LED display

The figure below shows the LED display of the DI 8×24VDC HS.



① DIAG (green/red)
② Channel status (green)
③ CNT (green)
④ PWR (green)
⑤ OVS (green)

Figure 4-6 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for dealing with diagnostic interrupts can be found in the section Diagnostics alarms (Page 46).

DIAG LED

Table 4- 2 DIAG LED fault/error display

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 4- 3 Status display of the channel status LED

Channel status LED	Meaning
Off	Process signal = 0
On	Process signal = 1

CNT LED

Table 4- 4 Status display of the CNT LED

CNT LED	Meaning
Off	Counting operating mode disabled
On	Counting operating mode enabled

OVS LED

Table 4- 5 Status display of the OVS LED

OVS LED	Meaning
□ Off	Oversampling operating mode disabled
■ On	Oversampling operating mode enabled

PWR LED

Table 4- 6 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

4.3.2 Interrupts

The digital input module DI 8×24VDC HS supports diagnostics alarms in the Counting mode.

Diagnostic interrupts

The module generates a diagnostics interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit
- Parameter assignment error
- No load voltage

4.3.3 Diagnostics alarms

A diagnostic interrupt is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostic interrupts can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 4- 7 Diagnostic interrupts, their meaning and how to deal with them

Diagnostic interrupt	Error code	Meaning	Remedy
Short-circuit	1_H	Short-circuit to ground at encoder supply	Correct process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module reads no process values in this state.	• Wait for firmware update. • Restart the firmware update.

Oversampling (OVS) operating mode

5

5.1 Connecting

5.1.1 Wiring and block diagrams

This section contains the block diagram for the DI 8×24VDC HS module with the pin assignments for 1, 2 and 3-wire connection in Oversampling operating mode. You may use and combine the different wiring options for all channels.

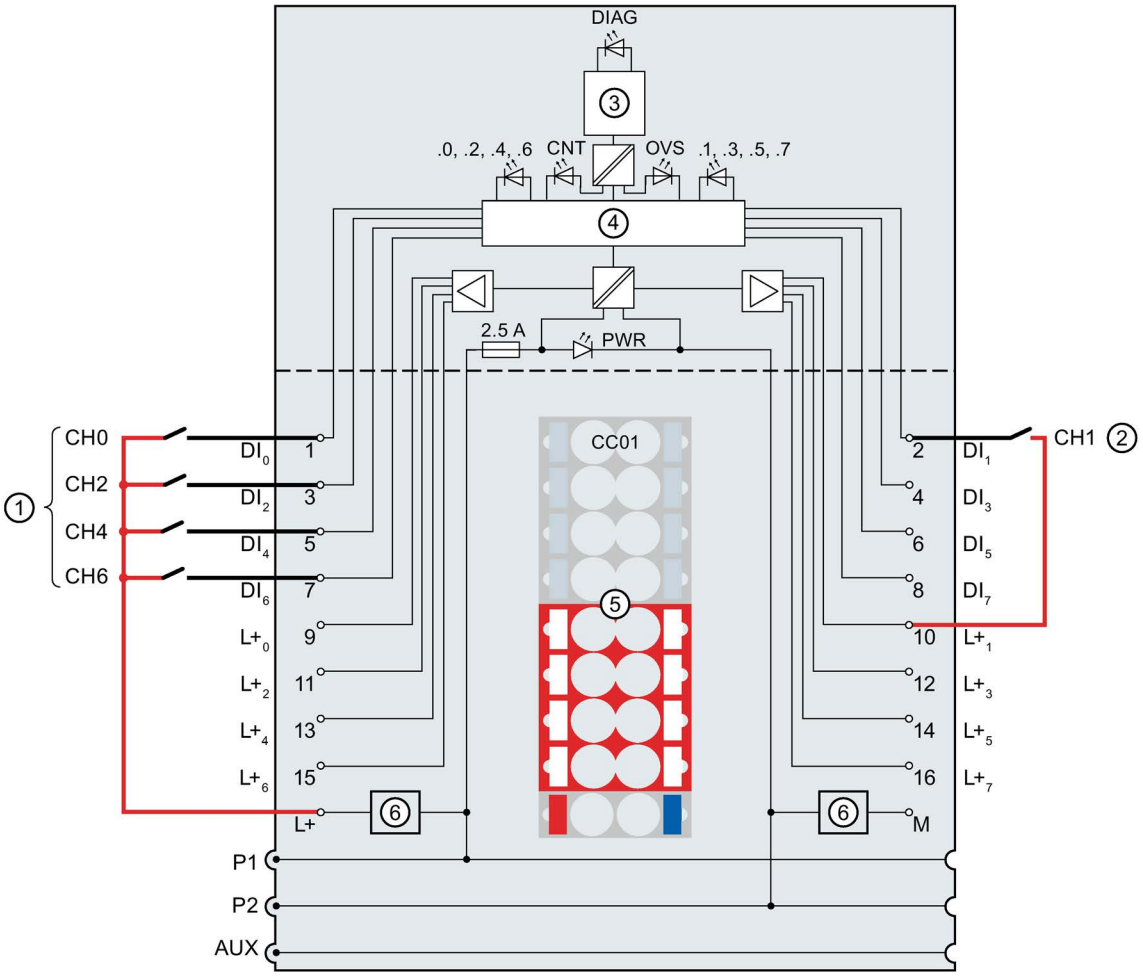
Information on wiring the BaseUnit can be found in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

Note

The module's load group must start with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The figure below shows the block diagram and an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 without AUX terminals (1 and 2-wire connection).

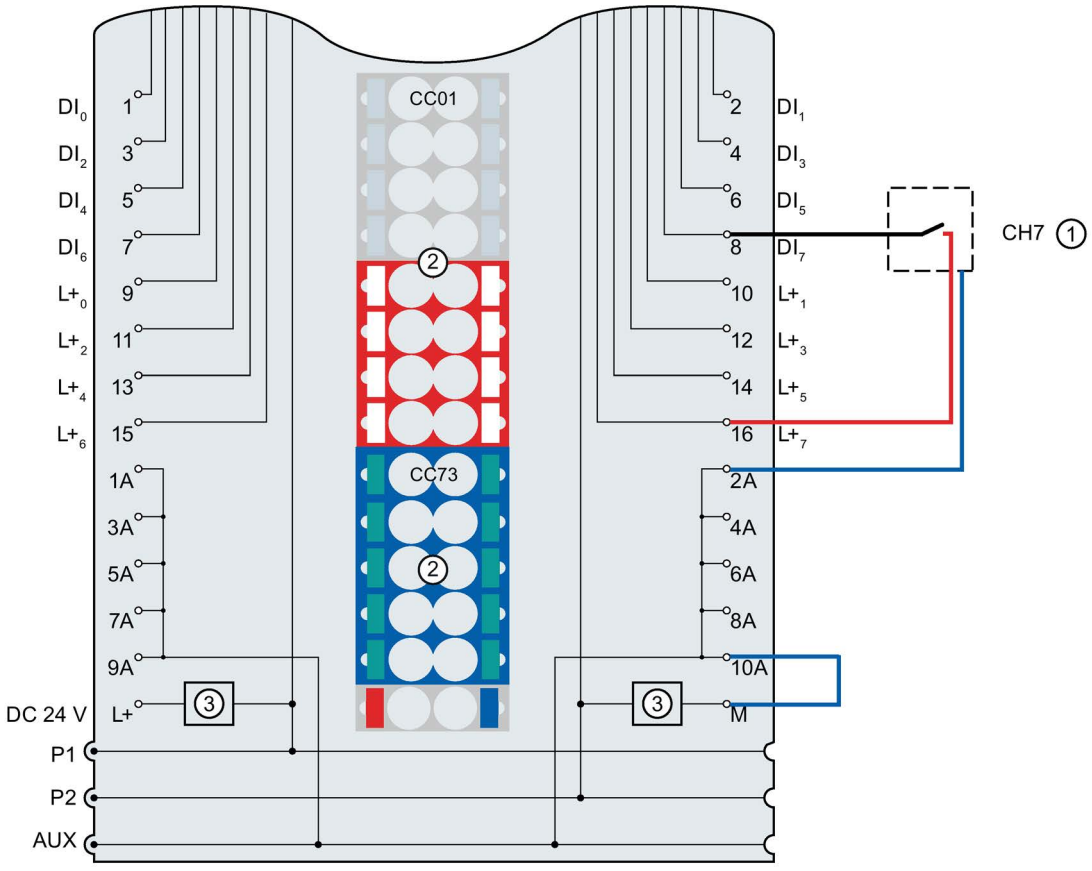


①	1-wire connection	$L+_n$	Encoder supply, channel n
②	2-wire connection	L+	24 V DC (infeed only with light BaseUnit)
③	Backplane bus interface	DIAG	LED error or diagnostics (green, red)
④	Input electronics	.0 to .7	LED channel status (green)
⑤	Color-coded label CCxx (optional)	PWR	LED power (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	CNT	LED operating mode Count (green)
M	Ground	OVS	LED operating mode Oversampling (green)
DI_n	Input signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 5-1 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The figure below shows an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection
②	Color-coded labels CCxx (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 5-2 Pinout and block diagram for 3-wire connection of encoders

5.2 Parameters/address space

5.2.1 Oversampling

Function

Oversampling is the acquisition of data in constant bus cycle segments (sub-cycles), whereby n sub-cycles correspond to one PROFINET bus cycle.

Oversampling is useful whenever you require acquisition of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With the oversampling function, a PROFINET bus cycle is divided into constant bus sub-cycles:

- Each subcycle detects an 8-bit value.
- A subcycle is at least 7.8125 µs in length.
- Subcycles are possible in steps from 2 to 32 (sampling rate).

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameter:

- Sampling rate

Note

Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

Sampling interval

The duration of a subcycle is the sampling interval. The cycle time T (send clock) for isochronous mode is specified in the configuration software. This time, divided by the configured sampling rate n_{Sample}, yields the sampling interval t_{Sample} of the module.

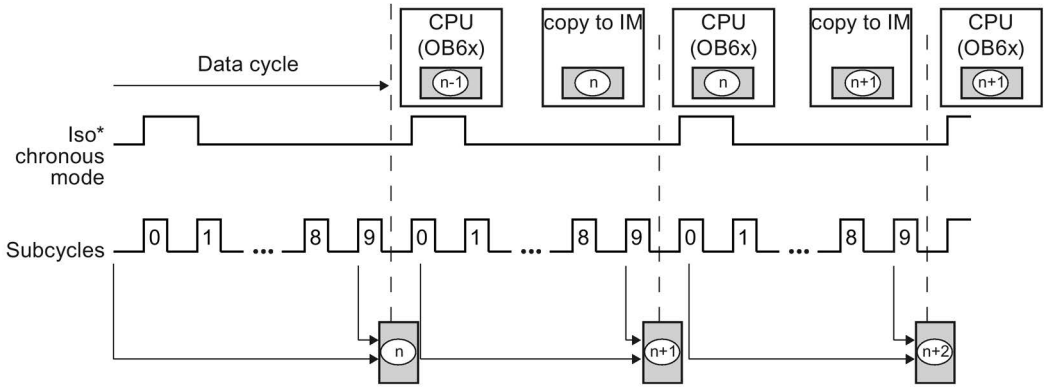
Example calculation:

$$t_{Sample} = \frac{T}{n_{Sample}} = \frac{1\ ms}{16} = 62{,}5\ \mu s$$

Figure 5-3 Example of calculating the sampling interval

Chronological sequence

The figure below shows the chronological sequence for oversampling. The detected input data of a data cycle (send clock) is copied to the interface module in the next cycle data and are available to the CPU in the data cycle after the next one.



n	Detected value from cycle n
Sub-cycle	8 bits apiece x 32 (max.) = max. 32 bytes of input data per data cycle

Figure 5-4 Oversampling

Note

Do not use a reduction ratio for the send clock in this operating mode for blocks in your user program (for example, OB61). This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

5.2.2 Parameters

In distributed mode, you can use the Oversampling operating mode on the PROFINET IO in an ET 200SP system.

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of parameter data record for Oversampling operating mode (Page 73).

The following parameter settings are possible:

Table 5- 1 Configurable parameters in the Oversampling operating mode

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7
Operating mode[1]	• DI / Oversampling • Counting	—	no	Module
Sampling rate	• 2 values / cycle • 3 values / cycle • ... • 32 values / cycle	—	yes	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module
Channel activated	• Disable • Enable	Enable	yes	Channel

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	None	yes	Channel
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module

[1] When configuring with HSP0229 for STEP 7, the operating mode is specified by selecting the module name.

5.2.3 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated.

- DI (Page 14) / Oversampling
- Counting (Page 28)

When configuring with HSP0229 for STEP 7, the operating mode is specified by selecting the module name.

Sampling rate

Specifies the number of subcycles per isochronous data cycle.

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Channel activated

Determines whether a channel is enabled or disabled. If a digital input is disabled, the module ignores its signals.

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Isochronous configuration is only possible if there is no input delay configured for at least one channel. In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). The read time T_i refers to the channel for which no input delay time was configured.

For input channels with longer input delays, the read time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a negative impact on the possible cycle time.

Note

If you select the "None" or "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Potential group

Specifies whether a light-colored BaseUnit with incoming supply voltage is located on this slot (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

5.2.4 Address space

Address space

The figure below shows the assignment of the address space. "IB x" represents the start address of input byte x.

In the respective bit, the subcycles are counted from left to right. Up to 32 subcycles are possible. If fewer than 32 subcycles are configured, the bits that are consequently unused are set to 0.

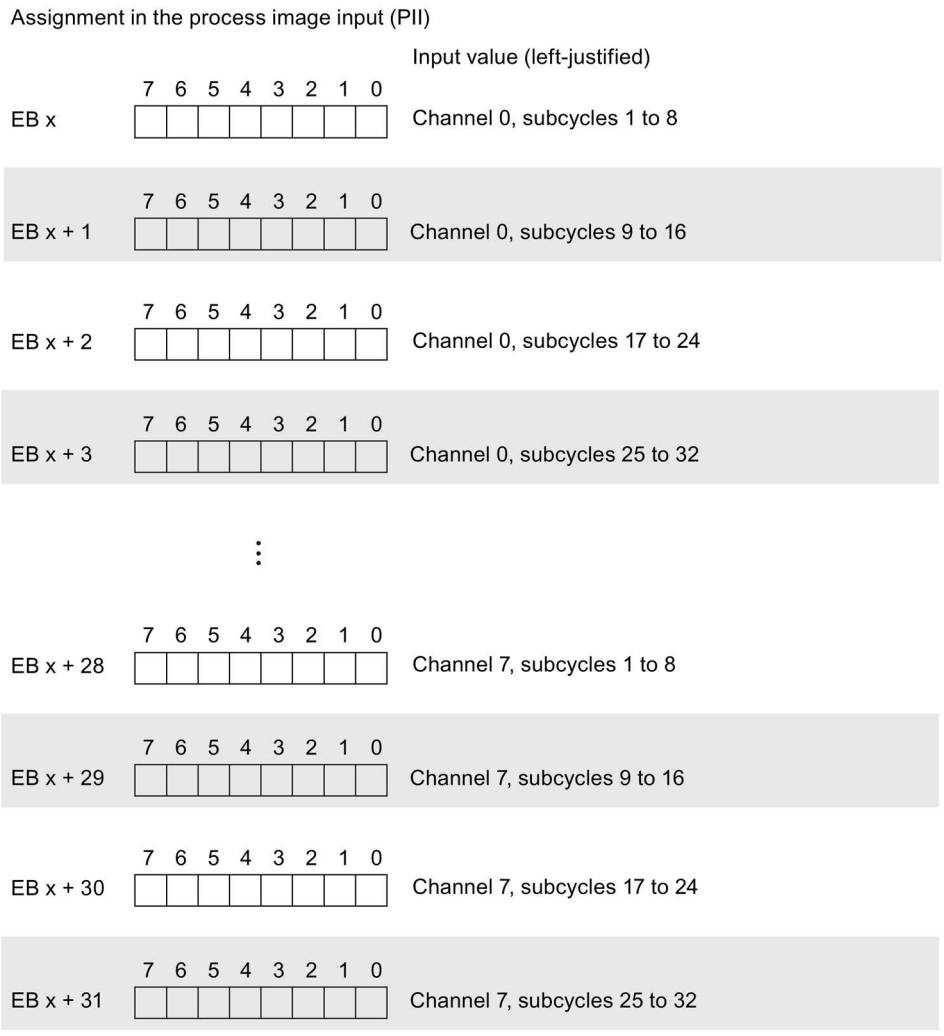


Figure 5-5 Address space for oversampling

Note

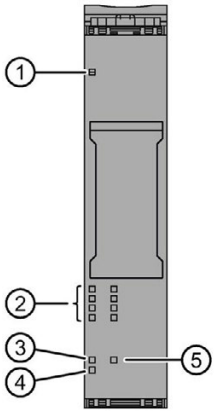
While you are changing parameters in RUN mode, corruption of input data can occur.

5.3 Interrupts/diagnostic messages

5.3.1 Status and error display

LED display

The figure below shows the LED display of the DI 8×24VDC HS.



① DIAG (green/red)
② Channel status (green)
③ CNT (green)
④ PWR (green)
⑤ OVS (green)

Figure 5-6 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for dealing with diagnostic interrupts can be found in the section Diagnostics alarms (Page 59).

DIAG LED

Table 5- 2 DIAG LED fault/error display

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 3 Status display of the channel status LED

Channel status LED	Meaning
Off	Process signal = 0
On	Process signal = 1

CNT LED

Table 5- 4 Status display of the CNT LED

CNT LED	Meaning
Off	Counting operating mode disabled
On	Counting operating mode enabled

OVS LED

Table 5- 5 Status display of the OVS LED

OVS LED	Meaning
□ Off	Oversampling operating mode disabled
■ On	Oversampling operating mode enabled

PWR LED

Table 5- 6 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.3.2 Interrupts

The digital input module DI 8×24VDC HS supports diagnostics alarms in the Oversampling mode.

Diagnostic interrupts

The module generates a diagnostics interrupt at the following events:

- Short-circuit
- Parameter assignment error
- No load voltage
- Channel temporarily unavailable

5.3.3 Diagnostics alarms

A diagnostic interrupt is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostic interrupts can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 7 Diagnostic interrupts, their meaning and how to deal with them

Diagnostic interrupt	Error code	Meaning	Remedy
Short-circuit	1_H	Short-circuit to ground at encoder supply	Correct process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module reads no process values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8×24VDC HS

	6ES7131-6BF00-0DA0
Product type designation	DI 8x24VDC HS
General information	
Firmware version	V1.0.1
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC01
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DI	Yes
Counters	Yes
Oversampling	Yes
MSI	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	70 mA; without encoder supply
Encoder supply	
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	700 mA

	6ES7131-6BF00-0DA0
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	45 bytes
Input	32 bytes; 1 byte + 1 byte for QI information in DI operating mode; 32 bytes in oversampling operating mode (OVS); 25 bytes in counting operating mode (CNT)
Output	20 bytes; in counting operating mode (CNT)
Digital inputs	
Number of inputs	8
Input characteristic curve acc. to IEC 61131, type 1	Yes
Input characteristic curve acc. to IEC 61131, type 2	No
Input characteristic curve acc. to IEC 61131, type 3	Yes
Pulse stretching	Yes
• Length	50 ms, 100 ms, 200 ms, 500 ms, 1 s, 2 s
Digital input functions, configurable	
Gate start/stop	Yes
Freely assignable digital input	Yes
Counters	Yes
• Number, max.	4
• Counting frequency, max.	10 kHz
• Counter length	32 bit
• Counting direction up/down	Yes
Digital input with oversampling	Yes
• Number, max.	8
• Values per cycle, max.	32
• Resolution, min.	7.8125 µs
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
For signal "0"	-30 ... +5 V
For signal "1"	+11 ... +30 V
Input current	
For signal "1", typ.	6 mA

	6ES7131-6BF00-0DA0
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
For interrupt inputs	
• Configurable	Yes
For counters/technological functions	
• Configurable	Yes
Cable length	
shielded, max.	50 m
unshielded, max.	50 m
Encoders	
Supported encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Bus cycle time (TDP), min.	125 µs
Jitter, max.	5 µs
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Hardware interrupt	Yes
Diagnostics alarms	
Diagnostic information can be read	Yes
Diagnostics	Yes
Monitoring of supply voltage	Yes
Short-circuit	Yes
Diagnostics display LED	
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Parameters	
Monitoring of supply voltage	Yes
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes

	6ES7131-6BF00-0DA0
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data records

A

A.1 Parameter assignment and structure of parameter data record for DI operating mode

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Note

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for the complete module

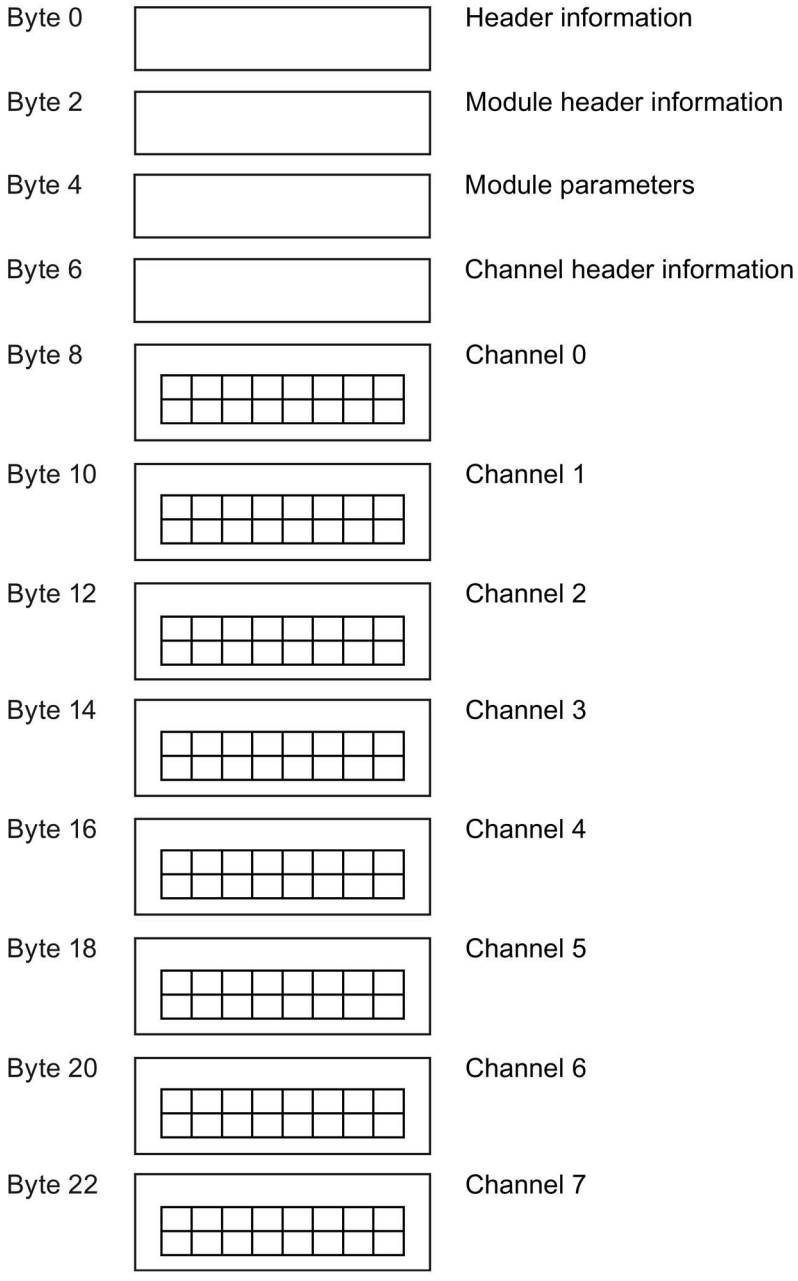


Figure A-1 Structure of data record 128 for the complete module

Header information

The figure below shows the structure of the header information.

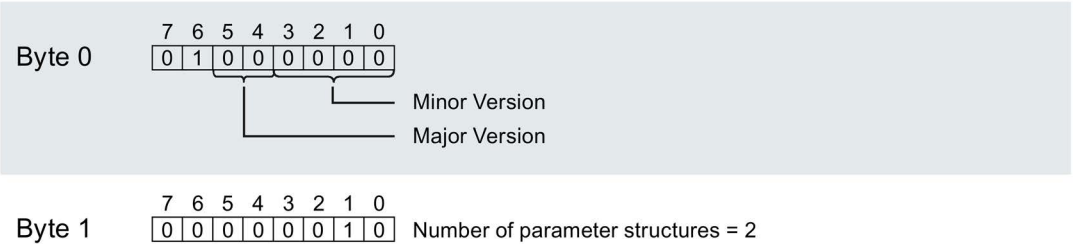


Figure A-2 Structure of the header information

Module header information

The figure below shows the structure of the module header information.

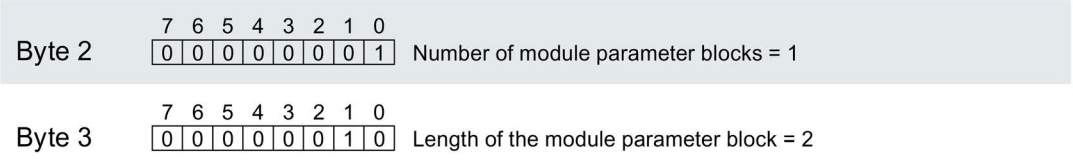


Figure A-3 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

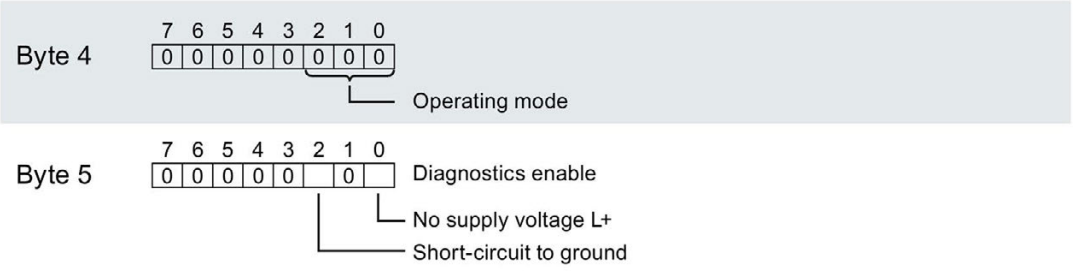


Figure A-4 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

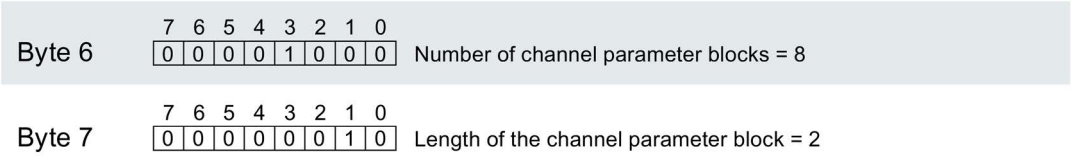
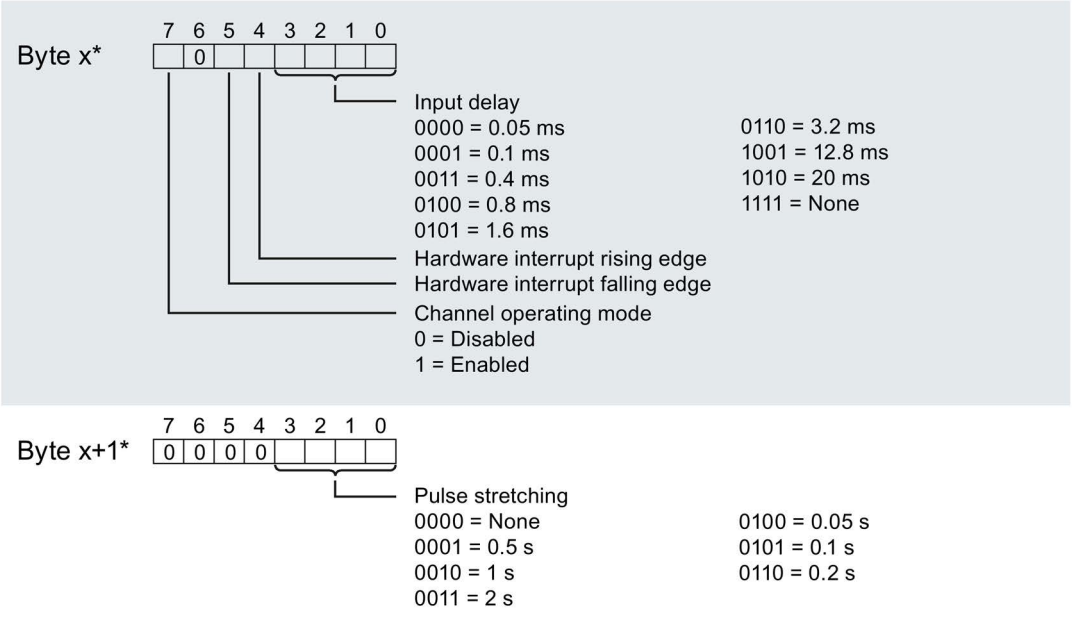


Figure A-5 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block. You enable a parameter by setting the corresponding bit to "1".



*x = 8 + (channel number × 2); channel number = 0 to 7

Figure A-6 Structure byte x to x+1 for the channels 0 to 7

A.2 Parameter assignment and structure of parameter data record for Counting operating mode

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Note

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for the complete module

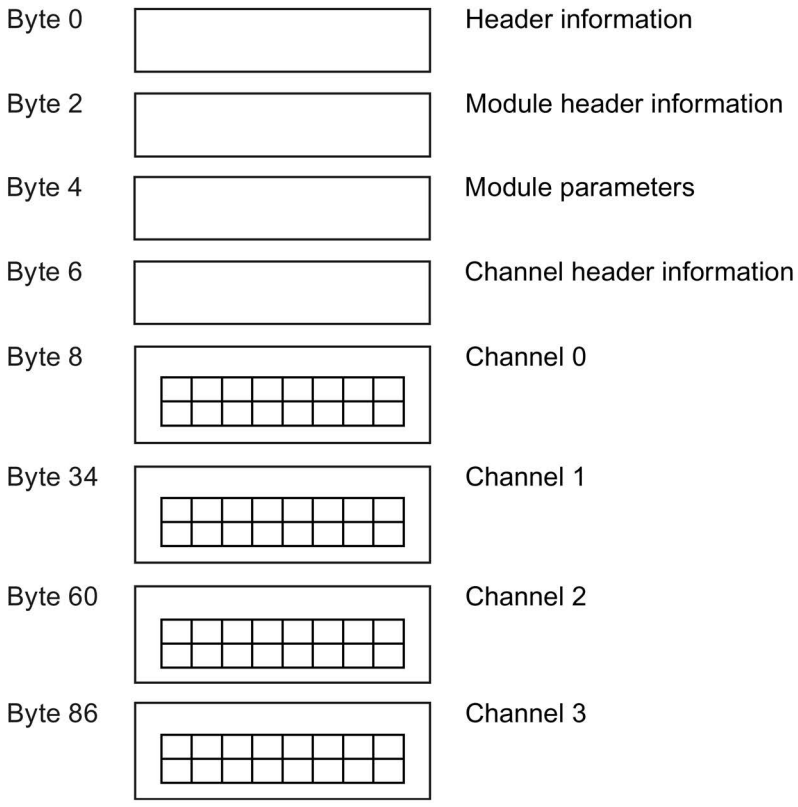


Figure A-7 Structure of data record 128 for the complete module

Header information

The figure below shows the structure of the header information.

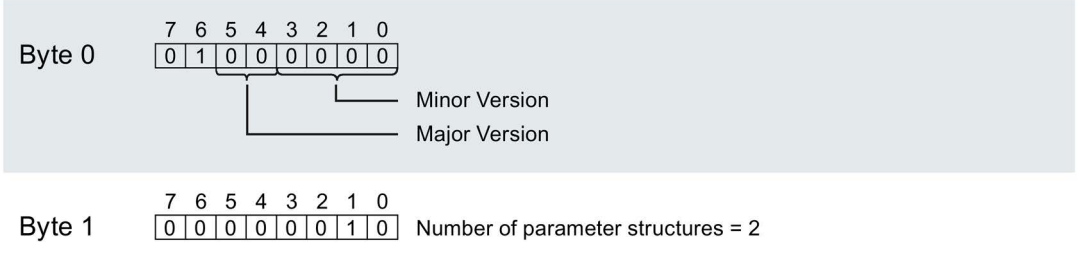


Figure A-8 Structure of the header information

Module header information

The figure below shows the structure of the module header information.

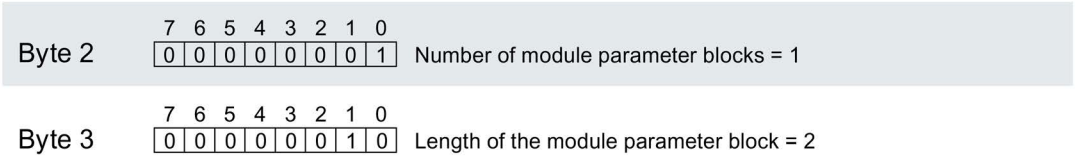


Figure A-9 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 3. You enable a parameter by setting the corresponding bit to "1".

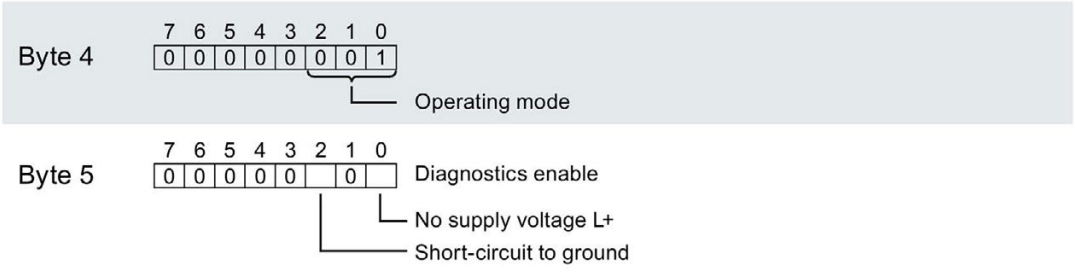


Figure A-10 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

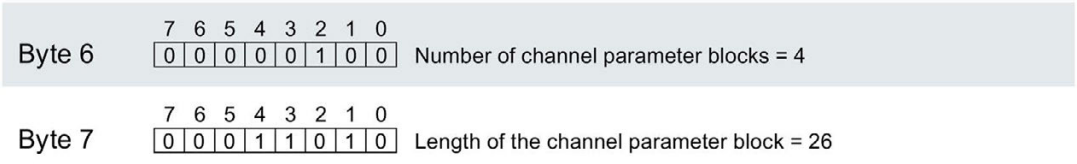
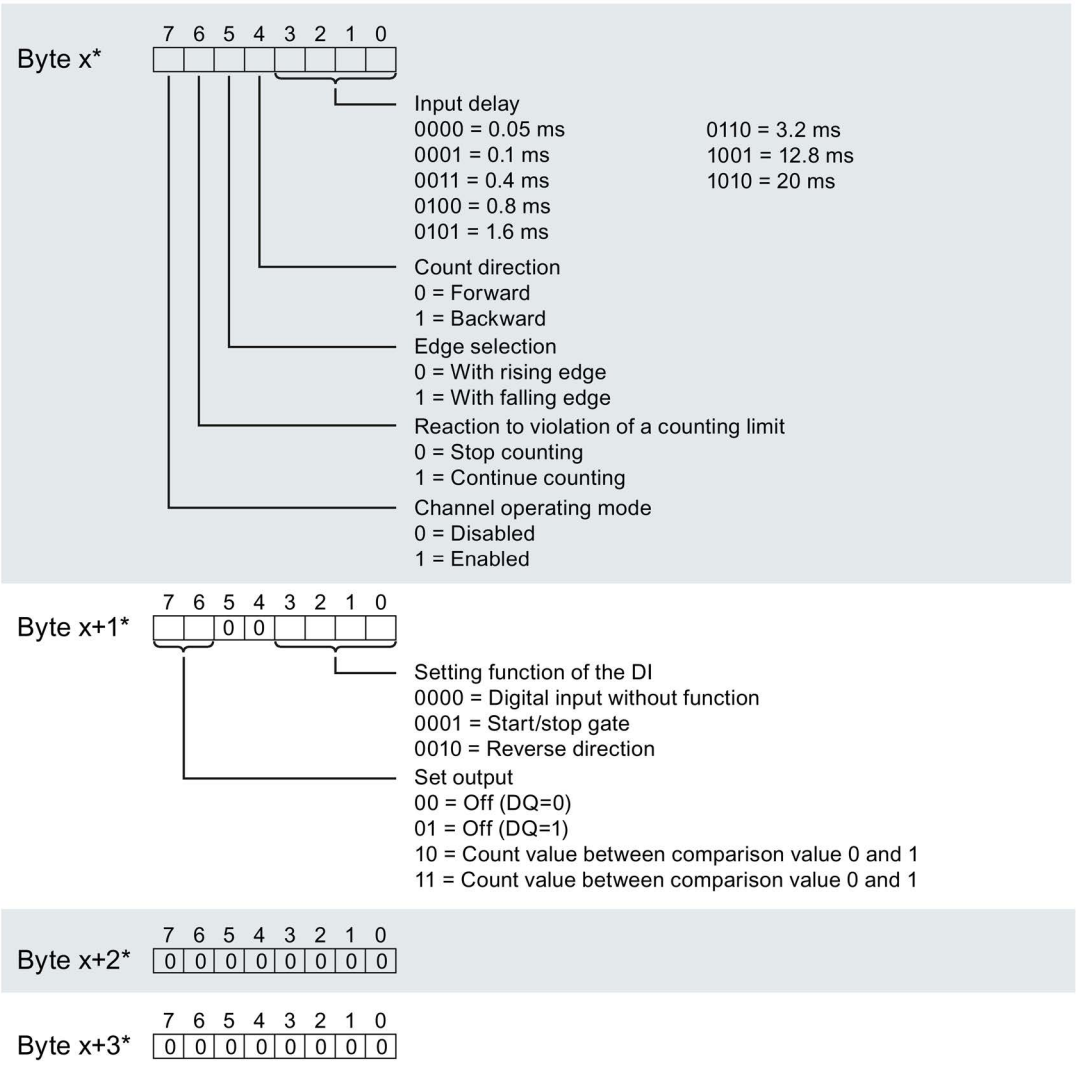


Figure A-11 Channel header information

Channel parameter block

The figure below shows the structure of the parameters for channels 0 to 3. You enable a parameter by setting the corresponding bit to "1".



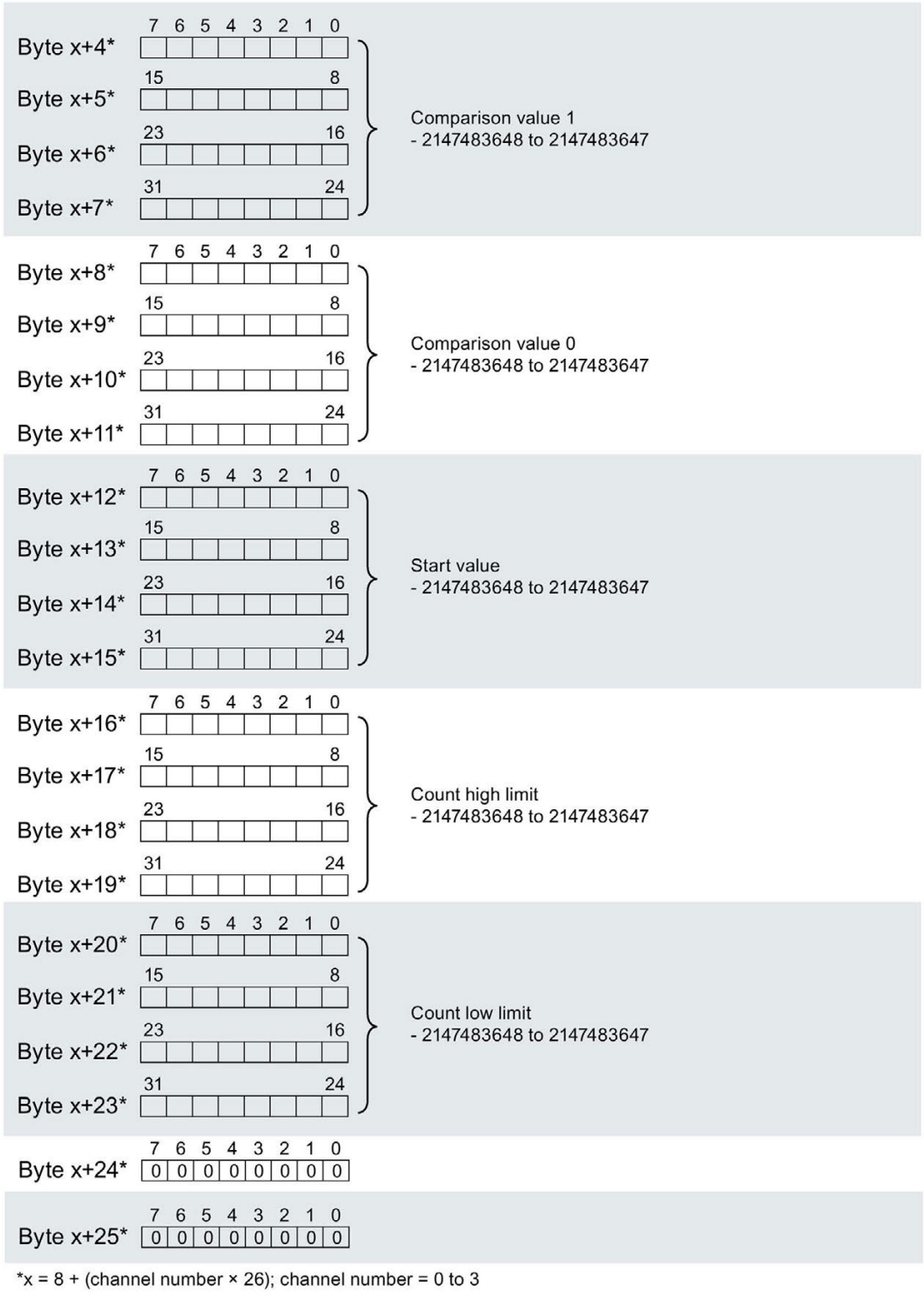


Figure A-12 Structure byte x to x+25 for the channels 0 to 3

A.3 Parameter assignment and structure of parameter data record for Oversampling operating mode

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Note

Changing parameters in RUN

If you change parameters in RUN mode, falsifications can occur in the input data.

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for the complete module

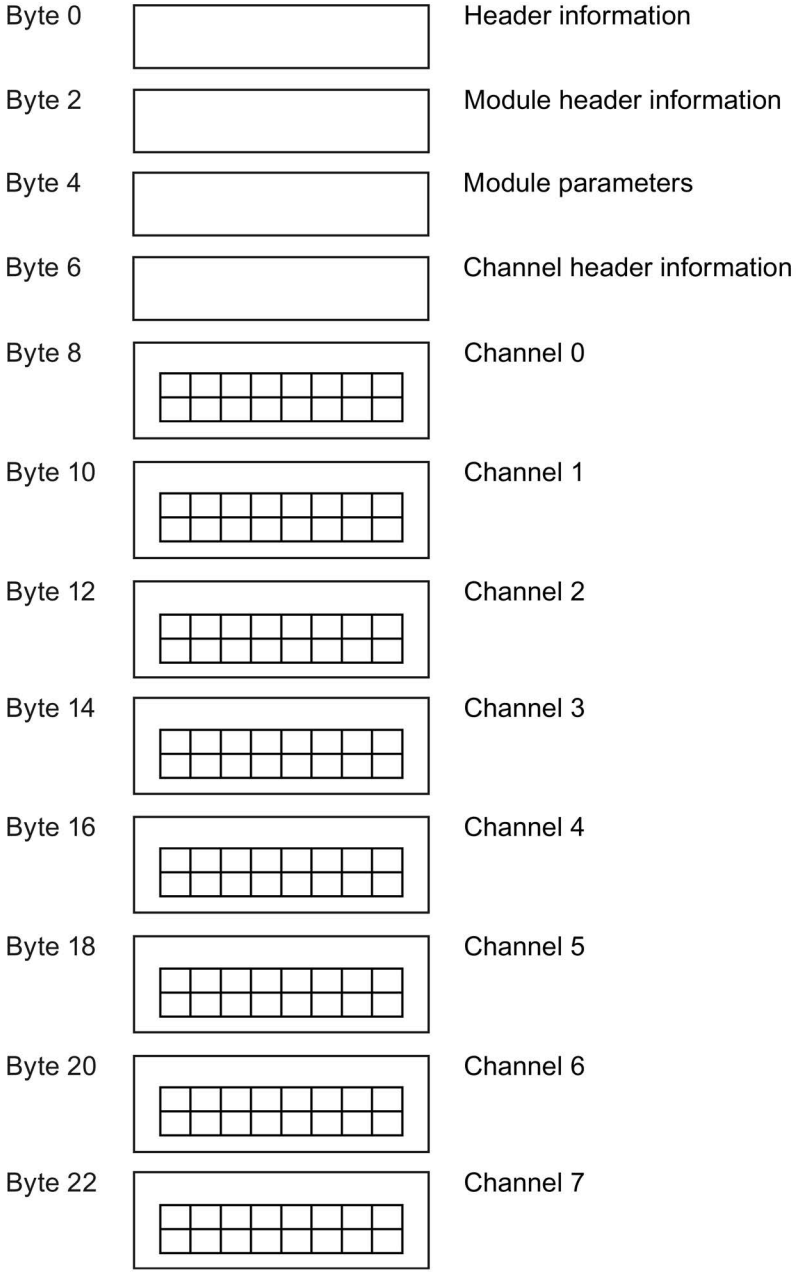


Figure A-13 Structure of data record 128 for the complete module

Header information

The figure below shows the structure of the header information.

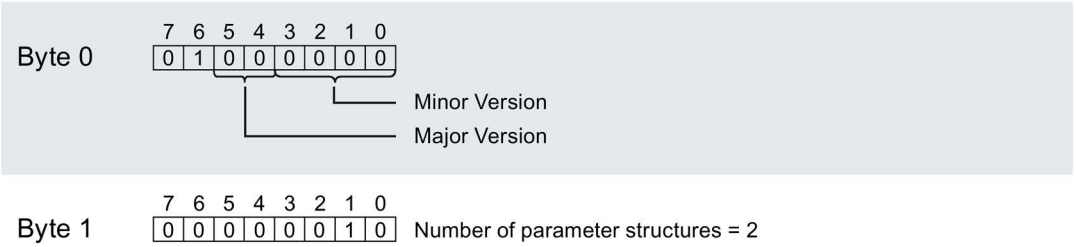


Figure A-14 Structure of the header information

Module header information

The figure below shows the structure of the module header information.

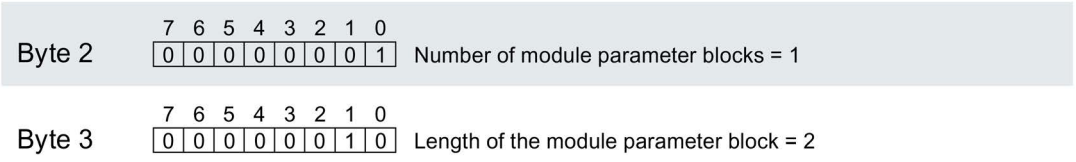


Figure A-15 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

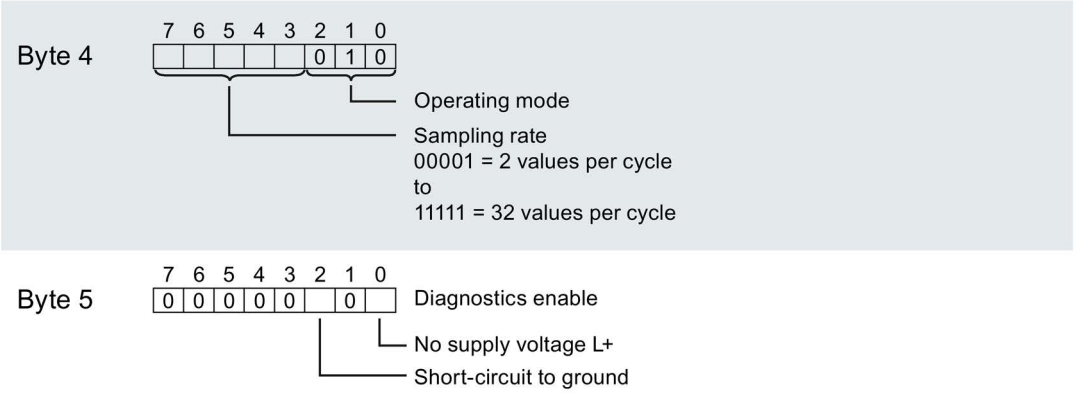


Figure A-16 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

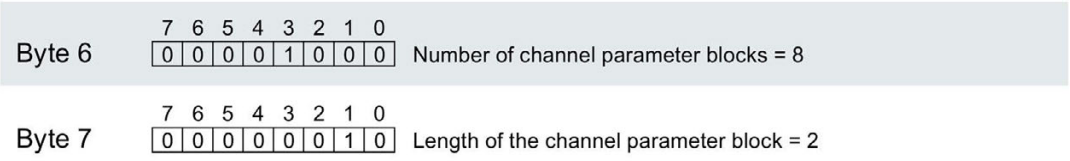
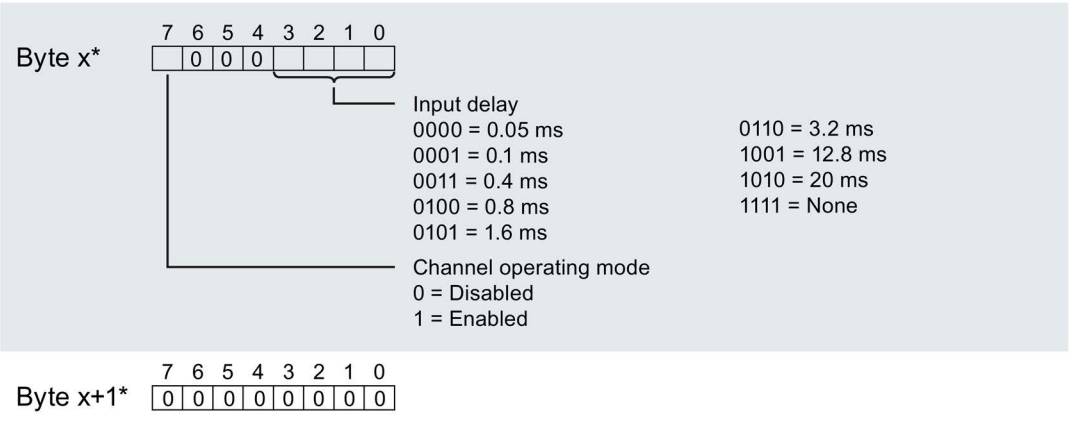


Figure A-17 Channel header information

Channel parameter block

The figure below shows the structure of the parameters for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".



*x = 8 + (channel number × 2); channel number = 0 to 7

Figure A-18 Structure byte x to x+1 for the channels 0 to 7

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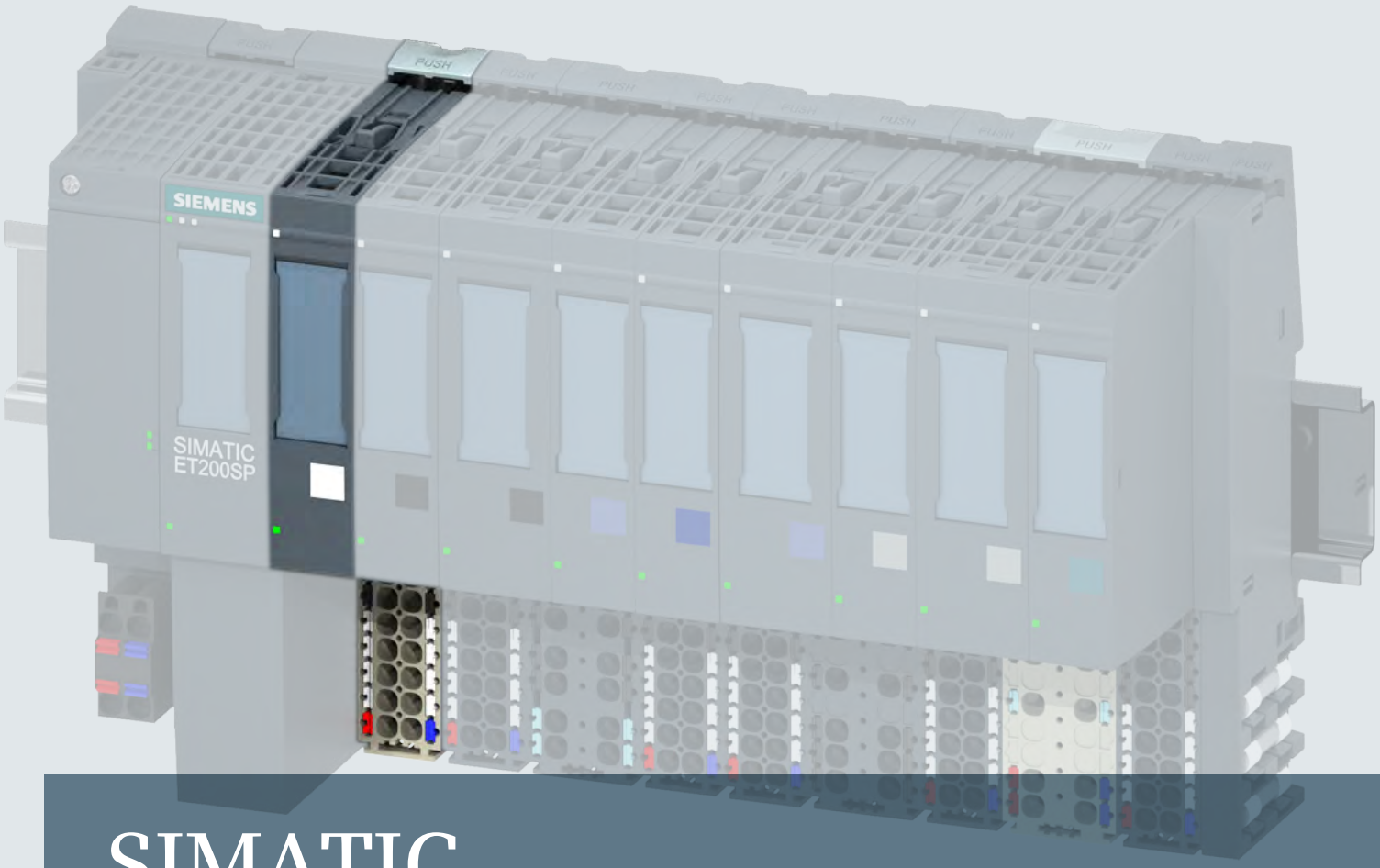

SIMATIC

ET 200SP

Digital input module DI 8x24VDC SRC BA (6ES7131-6BF60-0AA0)

Manual

Edition 02/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
DI 8x24VDC SRC BA
digital input module
(6ES7131-6BF60-0AA0)

Manual

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Parameter data record A

02/2014

A5E32855511-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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GERMANY

A5E32855511-AA
℗ 02/2014 Technical data subject to change

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of the system manual, function manuals and device manuals.

The STEP 7 information system (online help) also helps you to configure and program your automation system.

Overview of the documentation for digital input module DI 8×24VDC SRC BA

The following table lists additional documentation that you will need when using the DI 8x24VDC SRC BA digital input module.

Table 1- 1 Documentation for digital input module DI 8x24VDC SRC BA

Topic	Documentation	Most important contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Enhancements and special features of the ET 200SP Distributed I/O System	Product information Amendments to ET 200SP documentation (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All of the current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Part number

6ES7131-6BF60-0AA0

View of the module

Figure 2-1 View of the DI 8×24VDC SRC BA module

Properties

The module has the following technical properties:

- 8 digital inputs
- Source input (NPN, M reading)
- Supply voltage L+
- Configurable input delay 0.05 ms to 20 ms (per channel)
- Configurable diagnostics (per module)
- Suitable for connection of switches and 2-wire sensors according to IEC 61131, type 1 and 3

The module supports the following functions:

- Firmware update
- Identification data I&M0 to I&M3
- Parameter assignment in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

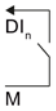
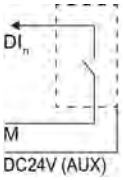
3

3.1 Pin assignment

General pin assignment

The following table shows the pin assignment for DI 8×24VDC SRC BA.

Table 3- 1 Pin assignment for DI 8×24VDC SRC BA

Pin assignment for DI 8×24VDC SRC BA (6ES7131-6BF60-0AA0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • M: Ground for sensor supply	A0	 CC02 6ES7193-6CP02-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	M	**10**	M			
11	M	**12**	M			
13	M	**14**	M			
15	M	**16**	M			
L+	24 V DC	**M**	M			
2-wire  						
3-wire  Only with BaseUnits with AUX connections (6ES7193-BU15-P16-A10-2D)						

[1] BaseUnit types that can be used are identified by the last two digits of the part number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of an ET 200SP station must be a light-colored BaseUnit. Keep this in mind also during the configuration.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

The figure below shows the block diagram of the DI 8x24VDC SRC BA.

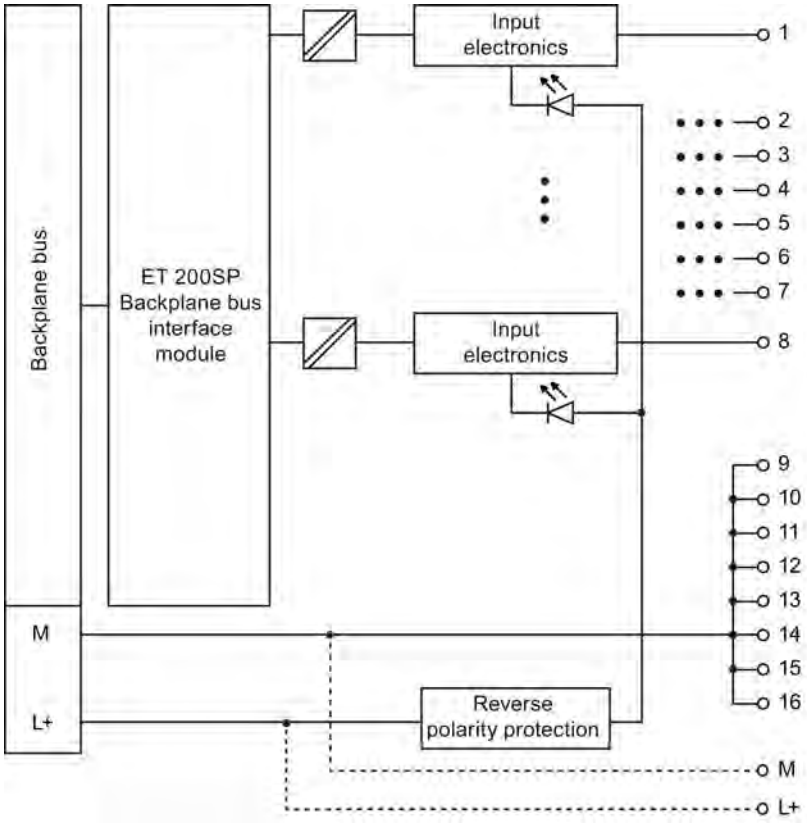


Figure 3-1 Block diagram DI 8×24VDC SRC BA

Parameters/address space

4

4.1 Parameters

DI 8×24VDC SRC BA parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 19)).

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP. The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 3 bytes.

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Operating mode

Determines whether a channel is activated or deactivated.

Input delay

Determines how high the input delay is for a channel.

Potential group

Specifies whether a BaseUnit with incoming voltage supply is located on this slot.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Address space of the digital input module DI 8×24VDC SRC BA

The figure below shows the assignment of the address space for DI 8×24VDC SRC BA.

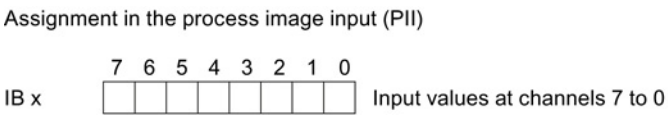


Figure 4-1 Address space of the digital input module DI 8×24VDC SRC BA

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC SRC BA.

① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The tables below explain the meaning of the Status and error displays. Remedial measures for diagnostics alarms can be found in section Diagnostics alarms (Page 15).

LED DIAG

Table 5- 1 Error display of the LED DIAG

LED DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

LED channel status

Table 5- 2 Status display of the LED channel status

LED channel status	Meaning
Off	Process signal = 0
On	Process signal = 1

LED PWR

Table 5- 3 Status display of the LED PWR

LED PWR	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The DI 8×24VDC SRC BA digital input module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following event:

- No supply voltage

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the LED DIAG flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8×24VDC SRC BA

	6ES7131-6BF60-0AA0
Product type designation	DI 8x24VDC SRC BA
General information	
Usable BaseUnits	BU type A0
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Encoder supply	
Number of outputs	8
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	1 bytes
Input	1 bytes
Digital inputs	
Number of inputs	8
Active low/Active high	Yes; reading m
Input characteristic curve acc. to IEC 61131, type 1	Yes
Input characteristic curve acc. to IEC 61131, type 2	No
Input characteristic curve acc. to IEC 61131, type 3	Yes
Pulse stretching	No

	6ES7131-6BF60-0AA0
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
for signal "0"	30 to -5V (reference potential is L+)
for signal "1"	-11 to -30V (reference potential is L+)
Input current	
for signal "1", typ.	6 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on cable length)
For interrupt inputs	
• Configurable	No
for counter/technological functions	
• Configurable	No
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	200 m
Encoders	
Supported encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	No
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green LED PWR
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red LED DIAG
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes

	6ES7131-6BF60-0AA0
Permissible potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Dimensional drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

The module parameters can be re-assigned in RUN (for example, the input delay of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics for the entire module.

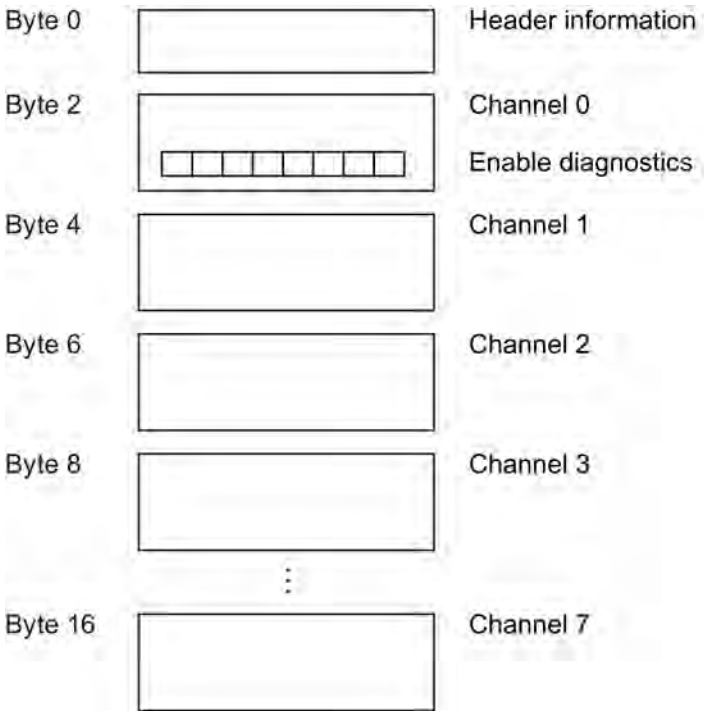


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

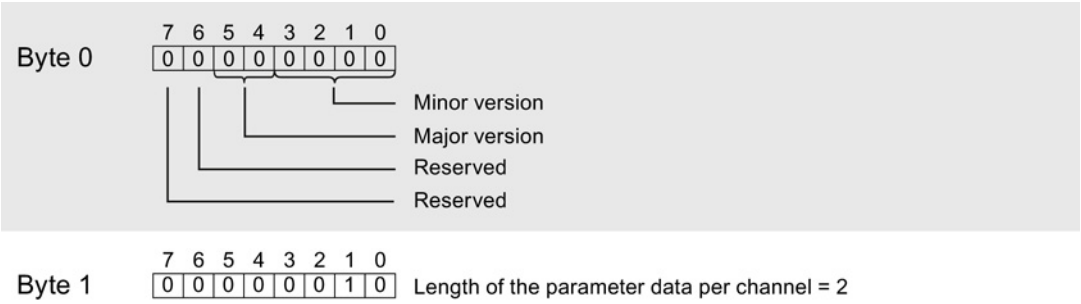


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".

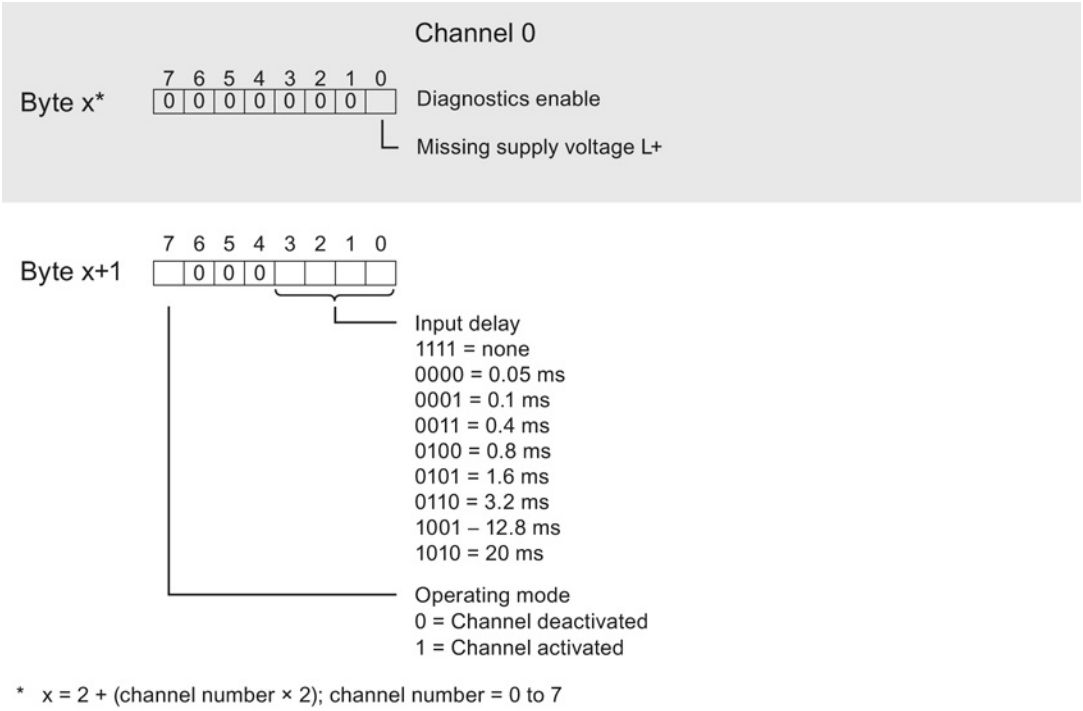


Figure A-3 Structure byte x to x+1 for the channels 0 to 7

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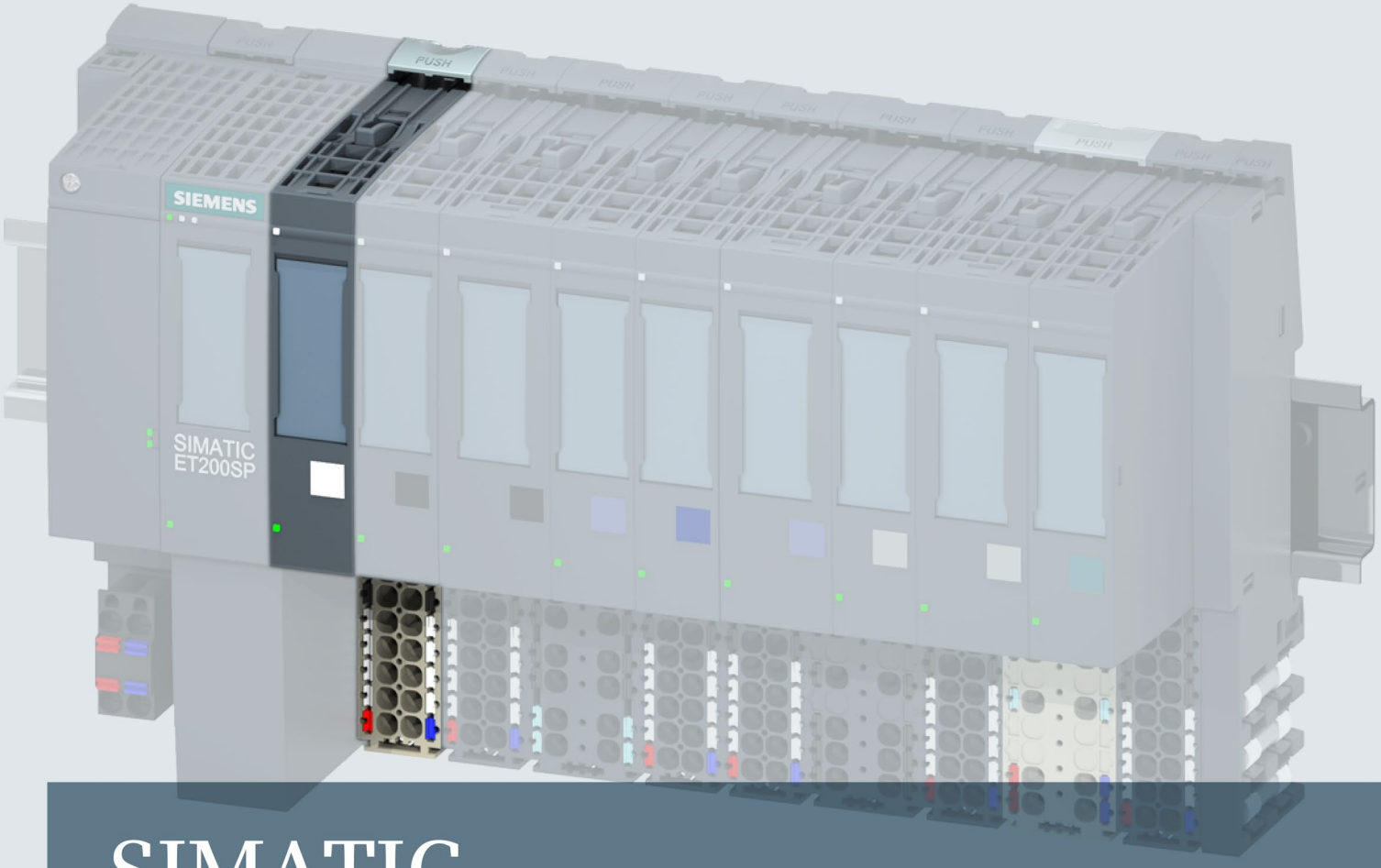

SIMATIC

ET 200SP

Digital input module DI 16x24VDC ST (6ES7131-6BH00-0BA0)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Digital input module
DI 16x24VDC ST
(6ES7131-6BH00-0BA0)

Manual

Preface

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Parameter data record A

12/2015

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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GERMANY

A5E03573442-AD
℗ 12/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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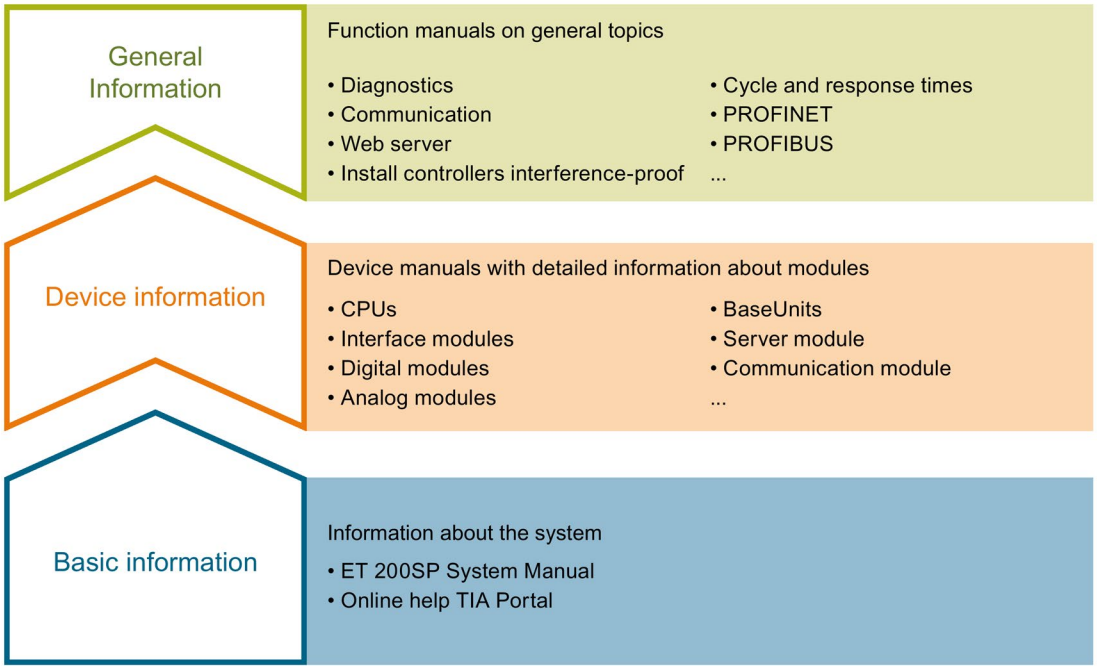
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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In doing so you can select:

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- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

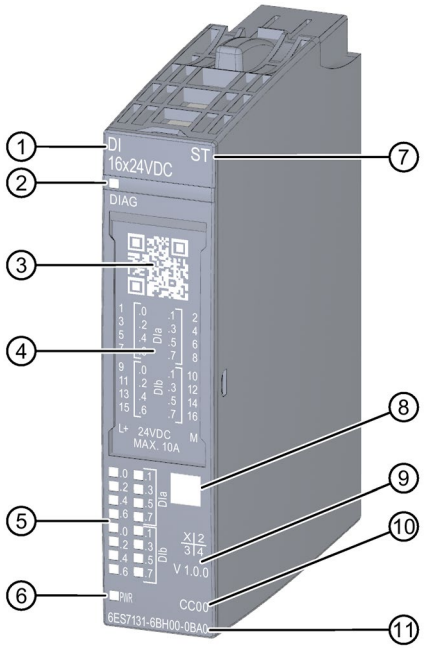
2.1 Properties

Article number

6ES7131-6BH00-0BA0 (packaging unit: 1 unit)

6ES7131-6BH00-2BA0 (packaging unit: 10 units)

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module DI 16×24VDC ST

Properties

The module has the following technical properties:

- Digital input module with 16 inputs
- Sink input, (PNP, P-reading)
- Supply voltage L+
- Configurable input delay 0.05 to 20 ms (per channel)
- Configurable diagnostics (per module)
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 3

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

Connecting

3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 16x24VDC ST module with the terminal assignments for a 1-wire connection.

Information on wiring the BaseUnit can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Note

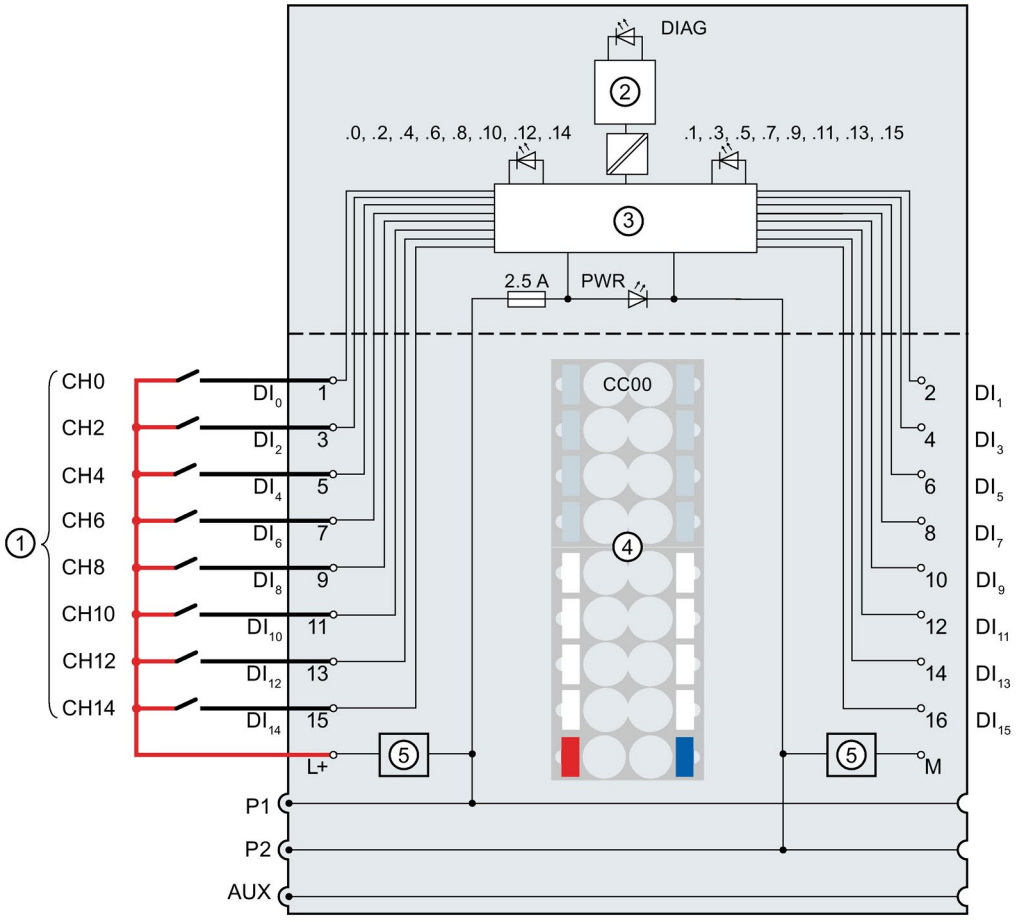
The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Note

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

Wiring: 1-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DI 16x24VDC ST on the BaseUnit BU type A0 without AUX terminals (1-wire connection).



①	1-wire connection	DI_n	Input signal, channel n
②	Backplane bus interface	L+	24 V DC (infeed only with light-colored BaseUnit)
③	Input electronics	M	Ground
④	Color-coded label with color code CC00 (optional)	DIAG	Error or diagnostics LED (green, red)
⑤	Filter connection supply voltage (only when light-colored BaseUnit is present)	.0 to .15	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)

Image 3-1 Wiring and block diagram for 1-wire connection of encoders

Parameters/address space

4

4.1 Parameters

Parameters for DI 16x24VDC ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of parameter data record (Page 24).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [2]
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics wire break[1]	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [2]
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] If you use a floating switch, you need to connect a resistor in parallel so that the wire break diagnostics is enabled in the open state (sensor resistance for the wire break diagnostics: 25 kΩ to 45 kΩ).

[2] Due to the limited number of parameters with a maximum of 244 bytes per ET 200SP station for a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

4.2 Declaration of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Wire break

Enabling diagnostics if the line to the encoder is interrupted.

Channel activated

Determines whether a channel is activated or deactivated.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of DI 16x24VDC ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DI 16x24VDC ST V1.0	X	X	X
1 x 16-channel without value status	DI 16x24VDC ST V1.1	---	X	X
1 x 16-channel with value status	DI 16x24VDC ST V1.1, QI	---	X	---

Evaluating the value status

An additional two bytes are allocated in the input address space if you enable the value status for the digital module. Bits 0 to 15 in these bytes are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DI 16×24VDC ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

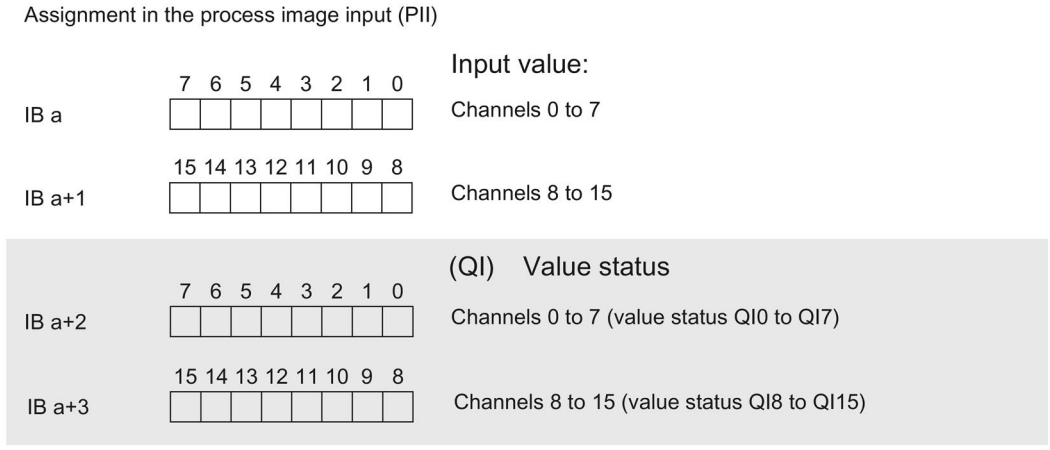


Image 4-1 Address space of the DI 16×24VDC ST with value status

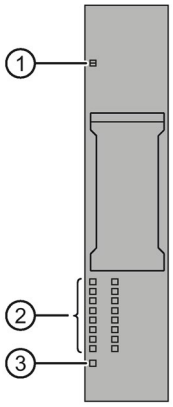
Interrupts/diagnostic alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the DI 16x24VDC ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostic messages (Page 20).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Process signal = 0
On	Process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The DI 16×24VDC ST digital input module supports diagnostic interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostic messages

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Wire break	6_H	Impedance of encoder circuit too high.	Use a different encoder type or modify the wiring, for example, use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor of between 25 and 45 kOhms to the encoder contacts
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read in process values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 16×24VDC ST

	6ES7131-6BH00-0BA0
General information	
Product type designation	ET 200SP, DI 16x24VDC ST, PU 1
Firmware version	V1.1
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 / -
PCS 7 can be configured/integrated as of version	V8.1 SP1
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DI	Yes
Counter	No
Oversampling	No
MSI	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	90 mA

	6ES7131-6BH00-0BA0
Encoder supply	
Short-circuit protection	No
24 V encoder supply	
24 V	No
Short-circuit protection	No
Power loss	
Power loss, typ.	1.7 W
Address area	
Address space per module	
Address space per module, max.	2 bytes; + 2 bytes for QI information
Digital inputs	
Number of inputs	16
Sinking/sourcing input	Yes; reading p
Input characteristic curve acc. to IEC 61131, type 1	Yes
Input characteristic curve acc. to IEC 61131, type 2	No
Input characteristic curve acc. to IEC 61131, type 3	Yes
Pulse stretching	No
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
For signal "0"	-30 ... +5 V
For signal "1"	+11 ... +30 V
Input current	
For signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on cable length)
• With "0" to "1", min.	0.05 ms
• With "0" to "1", max.	20 ms
• With "1" to "0", min.	0.05 ms
• With "1" to "0", max.	20 ms
For interrupt inputs	
• Configurable	No
for counters/technological functions	
• Configurable	No
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m

	6ES7131-6BH00-0BA0
Encoders	
Supported encoders	
2-wire sensor	Yes
• Permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostic information can be read	Yes
Diagnostics	Yes
Monitoring of the supply voltage	Yes
• Configurable	Yes
Monitoring of the encoder supply	No
Wire break	Yes; module by module
Short-circuit	No
Group error	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

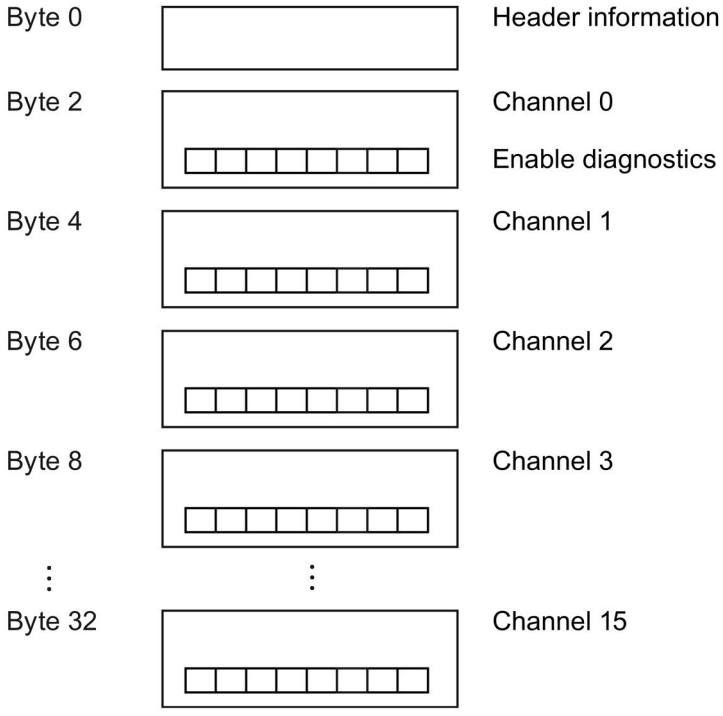


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

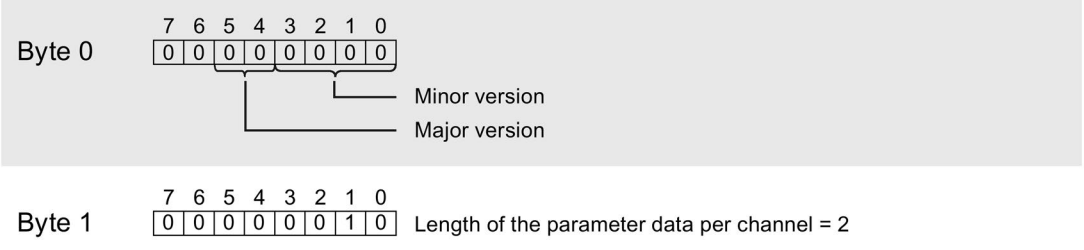
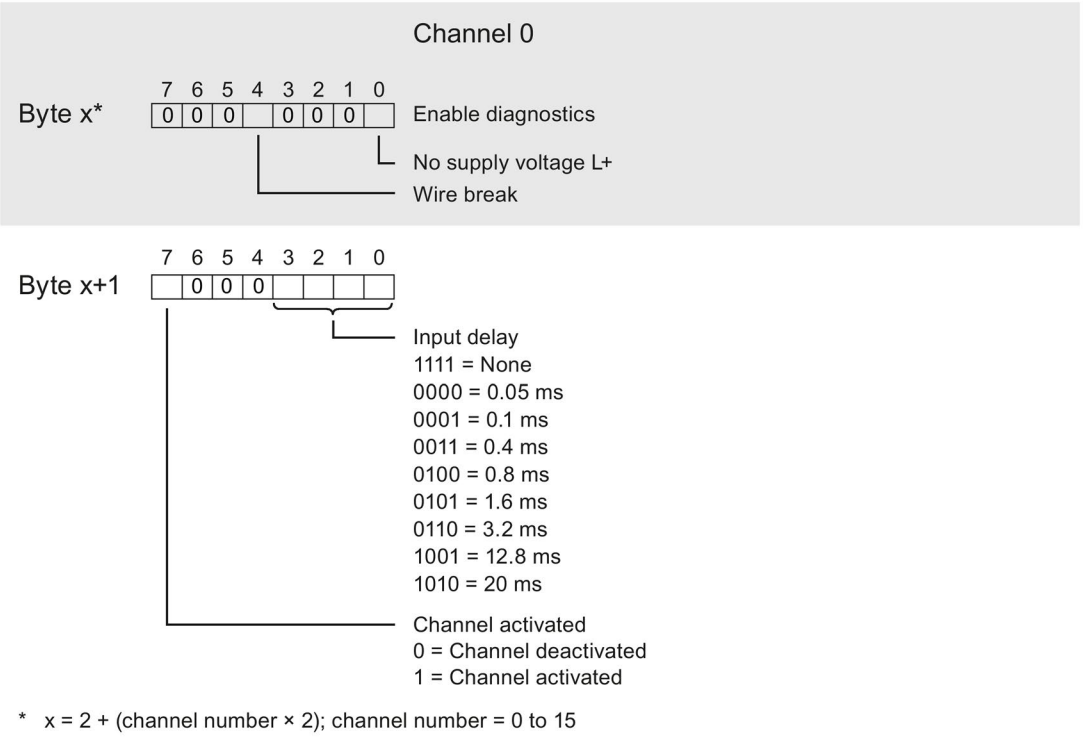


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 15.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 2); channel number = 0 to 15

Image A-3 Structure byte x to x+1 for the channels 0 to 15

Error transmitting the data record

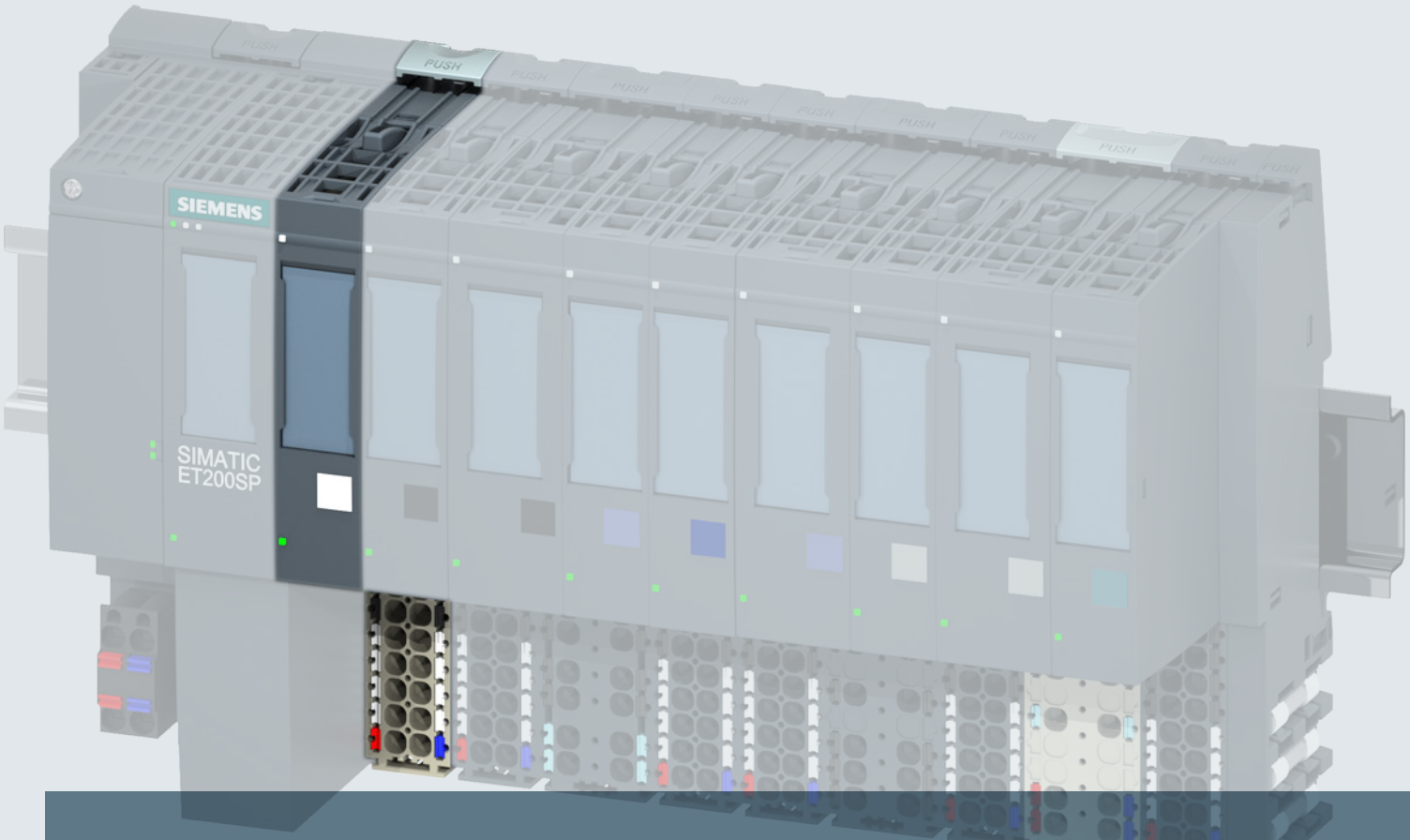
The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

SIEMENS



SIMATIC

ET 200SP

Digital input module DI 8xNAMUR (6ES7131-6TF00-0CA0)

Manual

Edition 02/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
DI 8xNAMUR HF
digital input module
(6ES7131-6TF00-0CA0)

Manual

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Interrupts/diagnostics alarms 5

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Parameter data record A

02/2014

A5E03894478-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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℗ 02/2014 Technical data subject to change

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Preface

Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Guide to documentation

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of a system manual, function manuals and product manuals.

The STEP 7 information system (online help) also supports you during the configuration and programming of your automation system.

Overview of documentation for digital input module DI 8×NAMUR HF

The following table shows additional documentation that you need for using the DI 8×NAMUR HF digital input module.

Table 1- 1 Documentation for the DI 8×NAMUR HF digital input module

Topic	Documentation	Key contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Amendments and special features of the ET 200SP I/O system	ET 200SP Product information (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or product manuals.

SIMATIC manuals

All current manuals for SIMATIC products are available to download free of charge on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Order number

6ES7131-6TF00-0CA0

View of the module

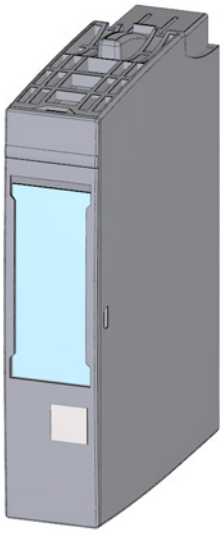


Figure 2-1 View of the DI 8×NAMUR HF module

Properties

The module has the following technical properties:

- 8 digital inputs each with a value status (quality information)
- 8.2 VDC sensor supply for individual connection and disconnection (PROFIenergy)
- Selectable diagnostics (per channel)
- Suitable for connecting NAMUR sensors and connected and unconnected mechanical contacts

The module supports the following technology functions:

- Pulse stretching
- Chatter monitoring
- Diagnostics for changeover contact sensor type

The module supports the following functions:

- Firmware update
- Identification data I&M0 to I&M3
- Reconfiguration in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories can be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

See also

ET 200SP Product information (http://support.automation.siemens.com/WW/view/en/73021864)

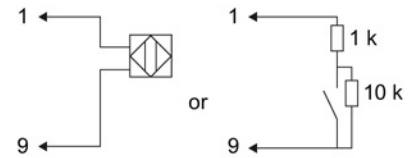
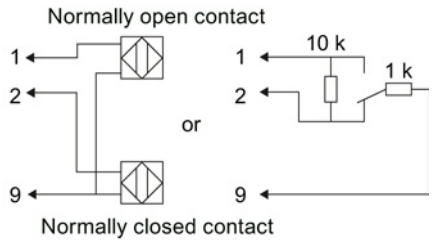
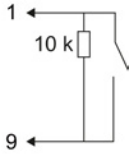
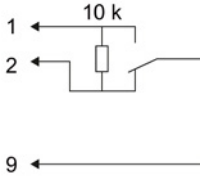
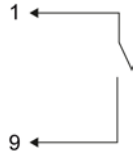
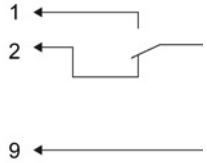
Wiring

3

3.1 Pin assignment

General pin assignment

Table 3- 1 Pin assignment for DI 8×NAMUR HF

<table>
<tr><th colspan="7">Pin assignment for DI 8×NAMUR HF (6ES7131-6TF00-0CA0)</th></tr>
<tr><th>Terminal</th><th>Assign-ment</th><th>Terminal</th><th>Assign-ment</th><th>Description</th><th>BaseUnit[1]</th><th>Color identification label (terminals 1 to 16)</th></tr>
<tr><td>1</td><td>DI_0</td><td>2</td><td>DI_1</td><td rowspan="9">• DI_n: Input signal, channel n
• U_{Sn}: Sensor supply, channel n</td><td rowspan="9">A0</td><td rowspan="9">
CC01
6ES7193-6CP01-2MA0</td></tr>
<tr><td>3</td><td>DI_2</td><td>4</td><td>DI_3</td></tr>
<tr><td>5</td><td>DI_4</td><td>6</td><td>DI_5</td></tr>
<tr><td>7</td><td>DI_6</td><td>8</td><td>DI_7</td></tr>
<tr><td>9</td><td>U_{S0}</td><td>10</td><td>U_{S1}</td></tr>
<tr><td>11</td><td>U_{S2}</td><td>12</td><td>U_{S3}</td></tr>
<tr><td>13</td><td>U_{S4}</td><td>14</td><td>U_{S5}</td></tr>
<tr><td>15</td><td>U_{S6}</td><td>16</td><td>U_{S7}</td></tr>
<tr><td>L+</td><td>24 VDC</td><td>M</td><td>M</td></tr>
<tr><td colspan="7">The figures below show the connections for input signal DI_0 for all sensor types.</td></tr>
<tr><td colspan="2">NAMUR sensors / IEC 60947-5-6 sensors
  </td><td colspan="2">NAMUR changeover contacts / IEC 60947-5-6 changeover contacts
  </td><td colspan="3">Single contact connected with 10 kΩ (mechanical normally open contact)
  </td></tr>
<tr><td colspan="2">Changeover contact connected with 10 kΩ (mechanical changeover contact)
  </td><td colspan="2">Single contact, unconnected (mechanical normally open contact with single contact)
  </td><td colspan="3">Changeover contact, unconnected (mechanical changeover contact)
  </td></tr>
</table>

[1] BaseUnit types that can be used are identified by the last two digits of the order number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Keep this in mind also during the configuration.

Firmware update

When updating the firmware, the L+ supply voltage must be applied to the module at the start and during the firmware update.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

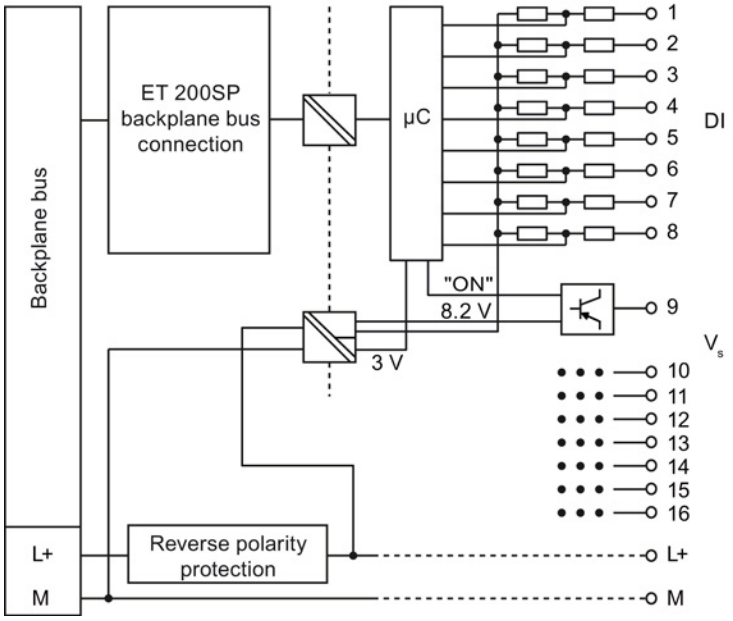


Figure 3-1 Block diagram DI 8×NAMUR HF

Parameters/address space

4

4.1 Parameters

DI 8xNAMUR HF parameters

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 33)).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Changing parameter settings in RUN	Effective range with configuration software, e.g. STEP 7 (TIA-Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Changeover error	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Chatter error	• Disable • Enable	Disable	Yes	Channel	-
Chatter monitoring: Monitoring window	• 0.5 s • 1 s to 100 s (can be set in 1 s-increments)	0.5 s	Yes	Channel	-
Chatter monitoring: Number of signal changes	• Deactivated • 2 to 32	Deactivated	Yes	Channel	-

Parameters	Value range	Default	Changing parameter settings in RUN	Effective range with configuration software, e.g. STEP 7 (TIA-Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupts	• Deactivated • Rising edge • Falling edge • Falling and rising edge	Deactivated	Yes	Channel	-
Sensor type	• Channel deactivated • NAMUR sensor • Single contact, unconnected • Single contact, connected with 10 kΩ • NAMUR changeover contact • Changeover contact, unconnected • Changeover contact, connected with 10 kΩ	NAMUR sensor	Yes	Channel	Channel
Pulse stretching	• None • 0.5 s • 1 s • 2 s	None	Yes	Channel	-
Inverted	• Disable • Enable	Disable	Yes	Channel	Channel
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

Changing parameter settings and effects on the technology functions

Reconfiguring a technology function resets its responses. Reconfiguring one technology function has no effect on other technology functions. Exception: Signal inversion and chatter monitoring, because an additional edge change is generated when signal inversion is disabled/enabled.

Technology functions

All technology functions, such as

- Pulse stretching
- Chatter monitoring
- Changeover errors
- Hardware interrupts

are executed only when there is an error-free signal (QI = 1). In other words, there is no diagnostics information on the channel (see also section Address space (Page 18)).

4.2 Explanation of parameters

Diagnostics: Missing supply voltage L+

The diagnostics alarm is enabled for missing or insufficient supply voltage L+.

Tip: To avoid a diagnostics overload, you should only enable "Diagnostics: Missing supply voltage" for an active channel.

Diagnostics: Short-circuit to ground

The diagnostics alarm is enabled if there is a short-circuit of the sensor supply to ground.

"Short-circuit to ground" diagnostics is available with the following sensor setting:

- NAMUR sensor
- NAMUR changeover contact

Diagnostics: Wire break

The diagnostics alarm is enabled if the line to the sensor is interrupted.

"Wire break" diagnostics is available with the following sensor setting:

- NAMUR sensor
- Single contact with 10 kΩ
- NAMUR changeover contact
- Changeover contact with 10 kΩ

Diagnostics: Changeover error

The diagnostics alarm is enabled when a changeover error occurs.

"Changeover error" diagnostics is available with the following sensor setting:

- NAMUR changeover contact
- Changeover contact, unconnected
- Changeover contact with 10 kΩ

Diagnostics: Chatter error

The diagnostics alarm is enabled when a chatter error occurs.

Chatter monitoring is a process control function for digital input signals. It detects and reports signal changes that are unexpected in process engineering, for example when an input signal fluctuates too often between "0" and "1". If signal characteristics like these occur, it is a sign that the sensors are faulty or that there are instabilities from a process engineering viewpoint.

Chatter monitoring: Monitoring window

Chatter monitoring: Setting of the monitoring window

Each input channel has a configurable monitoring window. The monitoring window is started the first time the input signal changes. If the input signal changes within the monitoring window more often than the configured number of signal changes, this is recognized as a chatter error. If no chatter error is detected within the monitoring window, the window is restarted at the next signal change.

Chatter monitoring: Number of signal changes

Chatter monitoring: Setting of the signal change

Settings for the tolerated number of signal changes during chatter monitoring within the monitoring window.

Number of signal changes = 0 deactivates the chatter monitoring function.

Hardware interrupts

Specifies whether the rising or falling edge or both edges trigger a hardware interrupt.

Sensor type

Specifies which sensor type is connected (see Table 3-1 Pin assignment for DI 8×NAMUR HF (Page 9)).

For the following sensor types

- NAMUR changeover contact
- Changeover contact, unconnected
- Changeover contact with 10 kΩ

the following applies: The normally open contact channel must be set according to the sensor type. The normally closed contact channel must be deactivated.

If "Channel deactivated" is shown, this means that the channel is not activated.

Pulse stretching

Sets whether and for how long pulse stretching is to take place.

Pulse stretching is a function for changing a digital input signal. A pulse at a digital input is extended to at least the configured length. If the input pulse is already longer than the configured length, then the pulse will not be changed.

Inverted

Specifies whether or not the input signal is to be inverted.

Inversion is only possible with the following sensor types:

- NAMUR sensor
- Single contact, unconnected
- Single contact with 10 kΩ

Potential group

Specifies that a BaseUnit with an incoming supply voltage is located in this slot (see ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

See also

Pin assignment (Page 9)

Pulse stretching (Page 16)

Diagnostics for changeover contact sensor type (Page 25)

4.3 Pulse stretching

Description

Pulse stretching is a function for changing a digital input signal. A pulse at a digital input is extended to at least the configured length. If the input pulse is already longer than the configured length, then the pulse will not be changed.

The pulse-stretched signal is the input signal for the hardware interrupt.

Principle of pulse stretching

The following figure uses examples to show if and how input pulses are changed.

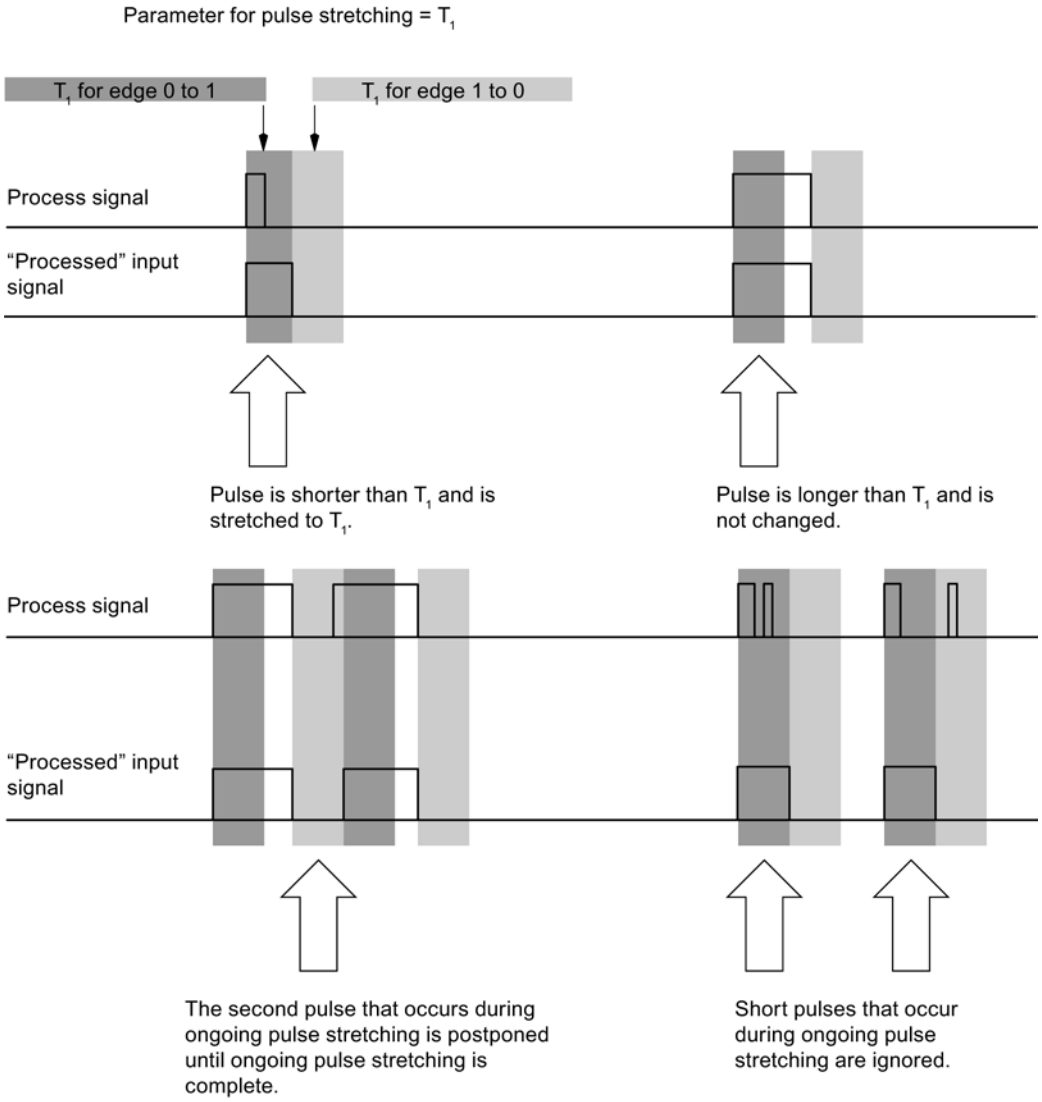


Figure 4-1 Principle of pulse stretching

Note

If you set pulse stretching for an input channel, this will also affect the chatter monitoring that is enabled for this channel. The "pulse-stretched" signal is the input signal for the chatter monitoring. You should therefore match the parameter settings for pulse stretching and chatter monitoring to one another. By selecting the appropriate values for the parameters you can adjust the functions optimally to your process.

Note

Pulse stretching in progress is reset in the event of an error in the value status (QI = 0, e.g. wire break).

4.4 Address space

Configuration options of the DI 8×NAMUR HF

Configuration with value status:

- DI 8×NAMUR HF QI

Evaluating the value status

As a result of configuration with value status (QI), an additional byte is allocated in the input address space. Each bit in this byte is assigned to a channel and returns information about the validity of the digital value.

Deactivated channels or channels that are not operating correctly return a value status of QI = 0.

With changeover contacts, the value status of a normally closed contact channel is always QI = 0. The validity of the signal must be checked on the normally open contact channel.

Address space of the digital input module DI 8×NAMUR HF

The following figure shows the assignment of address space for the DI 8×NAMUR HF with value status (Quality Information (QI)).

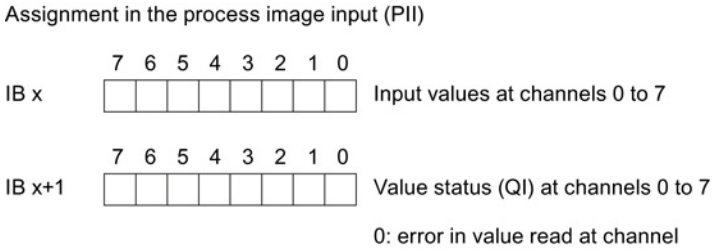


Figure 4-2 Address space of the DI 8×NAMUR HF digital input module with value status

Technology functions

All technology functions, such as

- Pulse stretching
- Chatter monitoring
- Changeover error
- Hardware interrupt

require a valid input signal that returns QI = 1 (no diagnostics detected). Otherwise, they will not run.

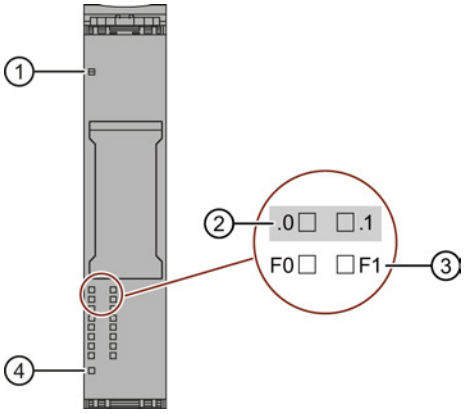
Interrupts/diagnostics alarms

5

5.1 Status and fault displays

LED displays

The figure below shows the LED displays (status and fault displays) of the DI 8×NAMUR HF.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 5-1 LED display

Meaning of the LEDs

The tables below explain the meaning of the status and fault displays. Corrective measures for diagnostics alarms can be found in chapter Diagnostics alarms (Page 24).

LED DIAG

Table 5- 1 LED DIAG fault display

LED DIAG	Meaning
Off	Supply voltage of the ET 200SP not OK
Flashing	Module not ready for operation (no parameters or invalid parameters assigned)
On	Module configured and no module diagnostics
Flashing	Module configured and module diagnostics

LED channel status/channel fault

The channel status LED shows the signal state of the user data of an input. If inversion is enabled, the channel status LED shows the inverted status of the signal applied to the terminal.

If there is a diagnostics event on the channel, the channel status LED is always off if diagnostics is enabled and therefore does not indicate the signal state of the user data of the input.

Table 5- 2 Channel status/channel fault LED status and fault display

LED		Meaning
Channel status	Channel fault	
Off	Off	Input returns "0" signal and no channel diagnostics or channel deactivated
On	Off	Input returns "1" signal and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (fault)

LED PWR

Table 5- 3 LED PWR status display

LED PWR	Meaning
□ Off	Supply voltage L+ is missing, is too low or polarity reversed
■ On	Supply voltage L+ present

5.2 Interrupts

Digital input module DI 8×NAMUR HF supports the following diagnostics and hardware interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- Short-circuit to ground
- Wire break
- Supply voltage missing
- Changeover error
- Chatter error

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Upon a rising edge (signal change from 0 to 1)
- Upon a falling edge (signal change from 1 to 0)

In the event of an interrupt, interrupt OBs run automatically in the CPU of the IO controller.

You will find detailed information on the event in the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

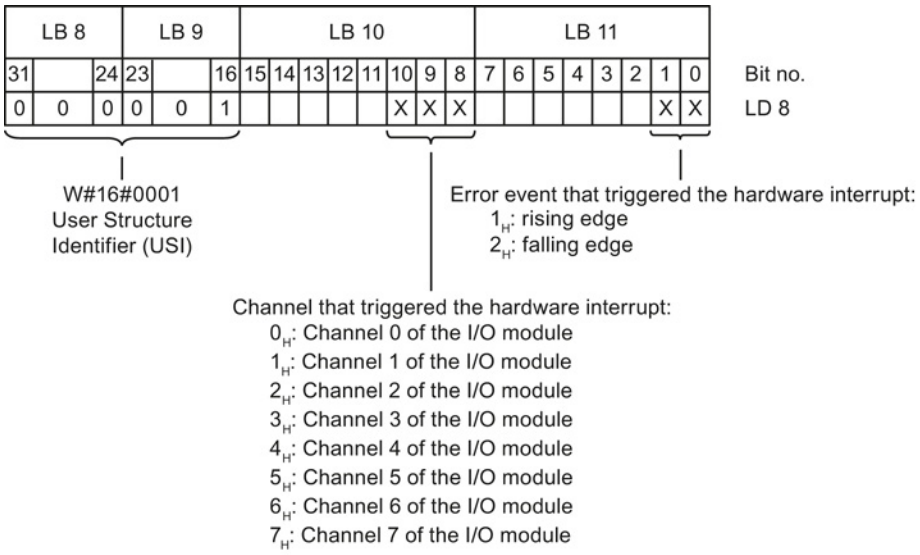


Figure 5-2 Organization block start information

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
The event that triggered the hardware interrupt follows.				
	Event	B#16#01	Rising edge	1
		B#16#02	Falling edge	

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the LED DIAG flashes on the module. Diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the fault codes with the user program.

Table 5- 5 Diagnostics alarms, meaning and corrective measures

Diagnostics alarm	Fault code	Meaning	Remedy
Short-circuit (NAMUR changeover contact and NAMUR sensor only) Tip: Check the normally open and normally closed contact channels of the NAMUR changeover contact.	1_H	Short-circuit in the signal line to the sensor	Correct the process wiring
		Sensor defective	Replace the sensor
		Wrong sensor type configured	Correct the parameter assignment
		Load impedance too low	Use a sensor with a higher impedance
Wire break (only NAMUR changeover contact, NAMUR sensor, sensor connected with 10 kΩ and single contact connected with 10 kΩ) Tip: Check the normally open and normally closed contact channels of the NAMUR changeover contact	6_H	Signal line to a sensor interrupted	Correct the process wiring
		Sensor defective	Replace the sensor
		Wrong sensor type configured	Correct the parameter assignment
		Load impedance too high	Use a different sensor type or modify the wiring, for example, using cables with a larger cross-section
		Channel not connected (open)	Disable diagnostics, connect sensor contacts
Fault	9_H	Sensor supply defective	Replace the module
		Hardware failure	
No load voltage	11_H	Supply voltage L+ missing or too low	Check supply voltage L+ on the BaseUnit Check BaseUnit type
External fault (changeover sensors only)	$1A_H$	Changeover error: Validity check between normally closed and normally open contact channel negative	Check process wiring, change sensor
Fault 1 in actuator/sensor = signal chatters	$1D_H$	Chatter error: Signal chatters: too many signal changes within the monitoring window If no further chattering of the input signal is detected within three monitoring windows, an outgoing diagnostics alarm is triggered. The status of the value of the current signal in the process image is set to "valid".	Verify the chatter monitoring parameters Check process wiring, if necessary change sensor
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or was canceled while running	Connect the supply voltage Restart the firmware update

5.4 Diagnostics for changeover contact sensor type

Diagnostics for changeover contact sensor type

With the changeover error diagnostics, the switchover between two input channels is checked. If there is a signal change in a changeover contact channel and there is no signal change at the other contact changeover channel after the tolerated switchover time, the diagnostics module returns a changeover error.

The tolerated switchover time between the two channels is set to the fixed value of 300 ms.

Changeover sensors are always assigned to two adjacent channels: The normally open contact channel should be set in accordance with the sensor type to channel 0, 2, 4, 6, and the respective corresponding normally closed contact channel 1, 3, 5, 7 deactivated.

Principle of changeover contact diagnostics

If the digital inputs of a channel group are configured as "changeover contacts", the module for this channel group carries out diagnostics for the changeover contact sensor type.

If the validity check is negative, the following applies:

- The module identifies the value status of the normally open contact channel as "invalid" (QI = "0"),
- The module creates a diagnostics entry for the normally open contact channel and
- A diagnostics interrupt is triggered if changeover error diagnostics is enabled.

The digital input signal and the value status are only updated for the normally open contact channel (channels 0, 2, 4, 6). The digital input signal is 0 and the value status is "invalid (QI = "0") for the normally closed contact channel (channels 1, 3, 5, 7). This channel is only used for a validity check of the sensor.

Please note the following special features for changeover contact diagnostics:

- If the normally open and normally closed contact signals are not plausible after 300 ms, a changeover error is output as diagnostics information.
- If there is already a fault (QI = 0, e.g. a wire break), the module will no longer perform diagnostics for changeover errors.
- There are different diagnostics options depending on the type of changeover contact (Dependencies when configuring with GSD files (Page 32)). Depending on the sensor type, a changeover error can have different causes.
  - In the case of connected changeover contacts, a changeover error may also be the result of a short-circuit (sensor is not defective; there is a short-circuit).
  - In the case of unconnected changeover contacts, a changeover error may also be the result of a wire break.
  - If a wire break or short-circuit can be detected with the particular sensor type but its diagnostics is not enabled, instead of the wire break or short-circuit diagnostics information, the changeover error diagnostics information is displayed if this is enabled.

Tip: Data records 0 to 7 and changeover sensor

Using the data records 1, 3, 5 and 7, you can configure a changeover sensor on an even channel (normally closed contact channel).

The corresponding normally open contact channel can be configured with the data records 0, 2, 4 and 6.

An even changeover contact channel must be followed by an odd, deactivated channel. Otherwise:

- you receive a parameter assignment error or
- the parameter assignment is rejected and the current parameter assignment retained.

Remedy: First, send data records 1, 3, 5 and 7 with deactivated, and then send data records 0, 2, 4 and 6 with changeover contact.

5.5 Chatter monitoring

Description

Chatter monitoring is a process control function for digital input signals. It detects and reports signal changes that are unexpected in process engineering, for example when an input signal fluctuates too often between "0" and "1". This period is known as the "monitoring window". If signal characteristics like these occur, it is a sign that the sensors are faulty or that there are instabilities from a process engineering viewpoint.

Activating chatter monitoring

You activate chatter monitoring by specifying a permitted number of input signal changes between "0" and "1" within the monitoring window. The number 0 deactivates the chatter monitoring function.

A chatter error detected by the chatter monitoring has a direct effect on the value status (QI).

Detecting a chatter error

Each input channel has a monitoring window that has been assigned parameters. The monitoring window is started the first time the input signal changes. If the input signal changes within the monitoring window more often than the configured number of signal changes, this is recognized as a chatter error. If no chatter error is detected within the monitoring window, the window is restarted at the next signal change.

Reporting a chatter error

If a chatter error occurs, the current signal status is entered in the process image and the value status of the signal is set to "invalid" (QI = 0). If "Chatter error" diagnostics is enabled, "Chatter error" is also entered as diagnostic information, triggering an incoming diagnostics interrupt.

You can evaluate and process the value status (QI) and the diagnostics information in the user program.

Resetting a chatter error

If no further chattering of the input signal is detected within three monitoring windows, an outgoing diagnostics interrupt is triggered. The status of the value of the current signal in the process image is set to "valid".

Note

Active chatter monitoring is reset if there is an error in the input signal (value status QI =0).

Principle

The following figure gives you another graphic illustration of the principle of chatter monitoring.

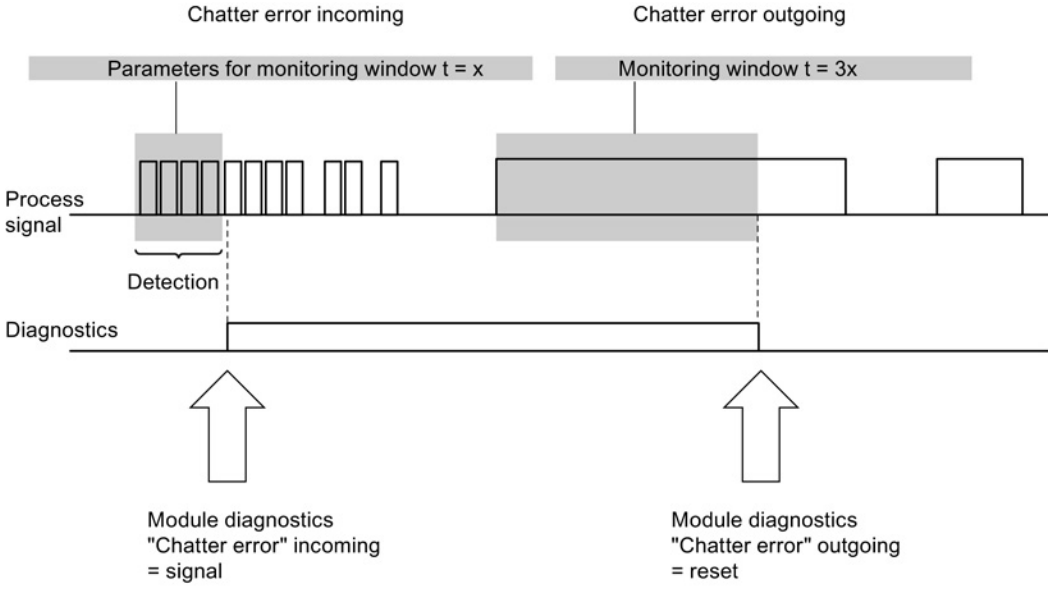


Figure 5-3 The principle of chatter monitoring

Chatter monitoring and "settling time" if a chatter error occurs

Does the monitoring time in the event of a fault restart as three monitoring windows if the signal continues to change?

The signal changes...	Result
once more often than set in the "Number of signal changes".	Monitoring time is restarted.
less often than set in the "Number of signal changes".	The monitoring time is not started again, in other words, the monitoring time runs once after a chatter error is detected. Even a change just before the time is up is tolerated.

Technical specifications

6

6.1 Technical specifications

DI 8×NAMUR HF technical specifications

	6ES7131-6TF00-0CA0
Product type designation	DI 8xNAMUR HF
General information	
Usable BaseUnits	BU type A0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	20.4 V
Valid range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Sensor supply	
Number of outputs	8
Output current	
Short-circuit protection	Yes
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Digital inputs	
Number of inputs	8
Digital inputs, configurable	Yes
Type	NAMUR
Pulse stretching	Yes; 0.5 s, 1 s, 2 s
Edge evaluation	Yes, rising edge, falling edge, edge change
Signal change chatter	Yes, 2 to 32 signal changes
Chatter monitoring window	Yes, 0.5 s, 1 s to 100 s in 1 s increments

	6ES7131-6TF00-0CA0
Input voltage	
Type of input voltage	DC
Rated value, DC	8.2 V
Input current	
For 10 k connected contact	
• For signal "0"	0.35 mA to 1.2 mA
• For signal "1"	2.1 to 7 mA
For unconnected contact	
• For signal "0", max. (permissible quiescent current)	0.5 mA
• For signal "1"	typ. 8 mA
For NAMUR sensors	
• For signal "0"	0.35 mA to 1.2 mA
• For signal "1"	2.1 to 7 mA
Input delay (for rated value of input voltage)	
Tolerated switchover time for changeover contacts	300 ms
For NAMUR inputs	
• with "0" to "1", max.	12 ms
• with "1" to "0", max.	12 ms
Cable length	
Cable length shielded, max.	200 m
Sensors	
Connectable sensors	
NAMUR sensor / changeover contact according to EN 60947	Yes
Single contact / changeover contact unconnected	Yes
Single contact / changeover contact connected with 10 kΩ	Yes
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes; channel-based
Hardware interrupt	Yes, selectable, channels 0 to 7
Diagnostics alarms	
Diagnostics information can be read	Yes
Monitoring of supply voltage	Yes
Wire break	Yes
Short-circuit	Yes
Group error	Yes

	6ES7131-6TF00-0CA0
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permissible potential difference	
Between different circuits	75 VDC / 60 VAC
Insulation	
Insulation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	32 g

NAMUR sensors and connected contacts

Monitoring for short-circuit and wire break only for NAMUR sensors and connected contacts. The response ranges of the diagnostics correspond to IEC 60947-5-6.

Dimension drawing

See manual BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Dependencies when configuring with GSD files

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other, see the tables below.

Configuring with a PROFINET GSD file

The table lists the diagnostics information and its dependencies on the sensor types for PROFINET.

Sensor type	Diagnostics information					
	Missing supply voltage L+	Short-circuit to ground	Wire break	Chatter error	Changeover error	Inversion
NAMUR sensor	×	×	×	×	-	×
Single contact, unconnected	×	-	-	×	-	×
Single contact, connected with 10 kΩ	×	-	×	×	-	×
NAMUR changeover contact	×	×	×	×	×	-
Changeover contact, unconnected	×	-	-	×	×	-
Changeover contact, connected with 10 kΩ	×	-	×	×	×	-

Configuring with a PROFIBUS GSD file

The table lists the diagnostics information and its dependencies on the sensor types for PROFIBUS.

Sensor type	Diagnostics information				
	Missing supply voltage L+	Short-circuit to ground	Wire break	Changeover error	Inversion
NAMUR sensor	×	×	×	-	×
Single contact, unconnected	×	-	-	-	×
Single contact, connected with 10 kΩ	×	-	×	-	×
NAMUR changeover contact	×	×	×	×	-
Changeover contact, unconnected	×	-	-	×	-
Changeover contact, connected with 10 kΩ	×	-	×	×	-

A.2 Parameter assignment and structure of parameter data record

The data record 128 of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can change the parameter assignment of the module in your user program regardless of its configuration. This means that you can use all the functions of the module even if you configured it using PROFIBUS GSD.

With data records 0 to 7, you can configure the individual channels.

Parameter assignment in the user program

You can change the parameters of the module in RUN (e.g. switch diagnostics on can be changed in RUN).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128 or data records 0 to 7. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 and data records 0 to 7

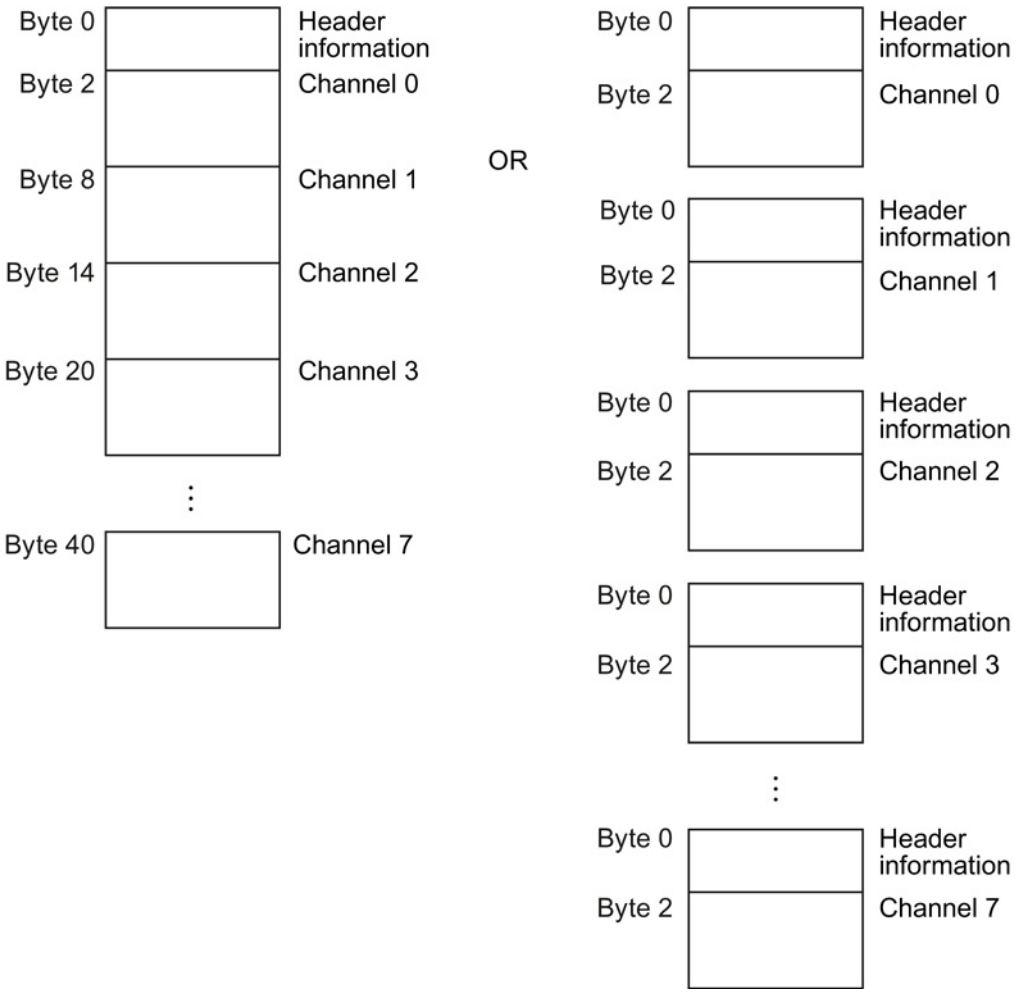


Figure A-1 Structure of data record 128 and data records 0 to 7

Header information

The figure below shows the structure of the header information.

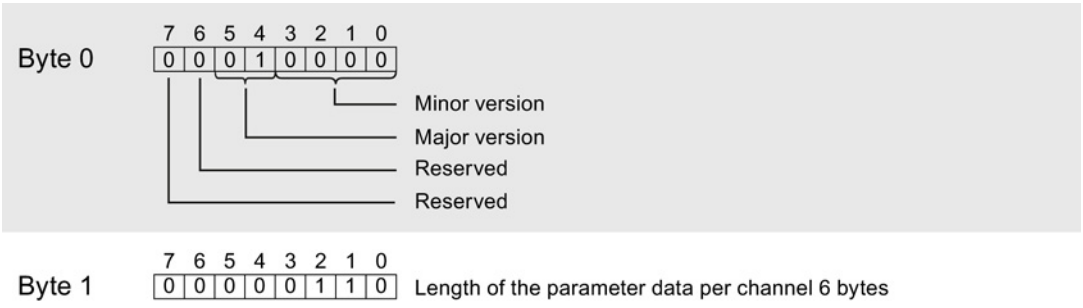
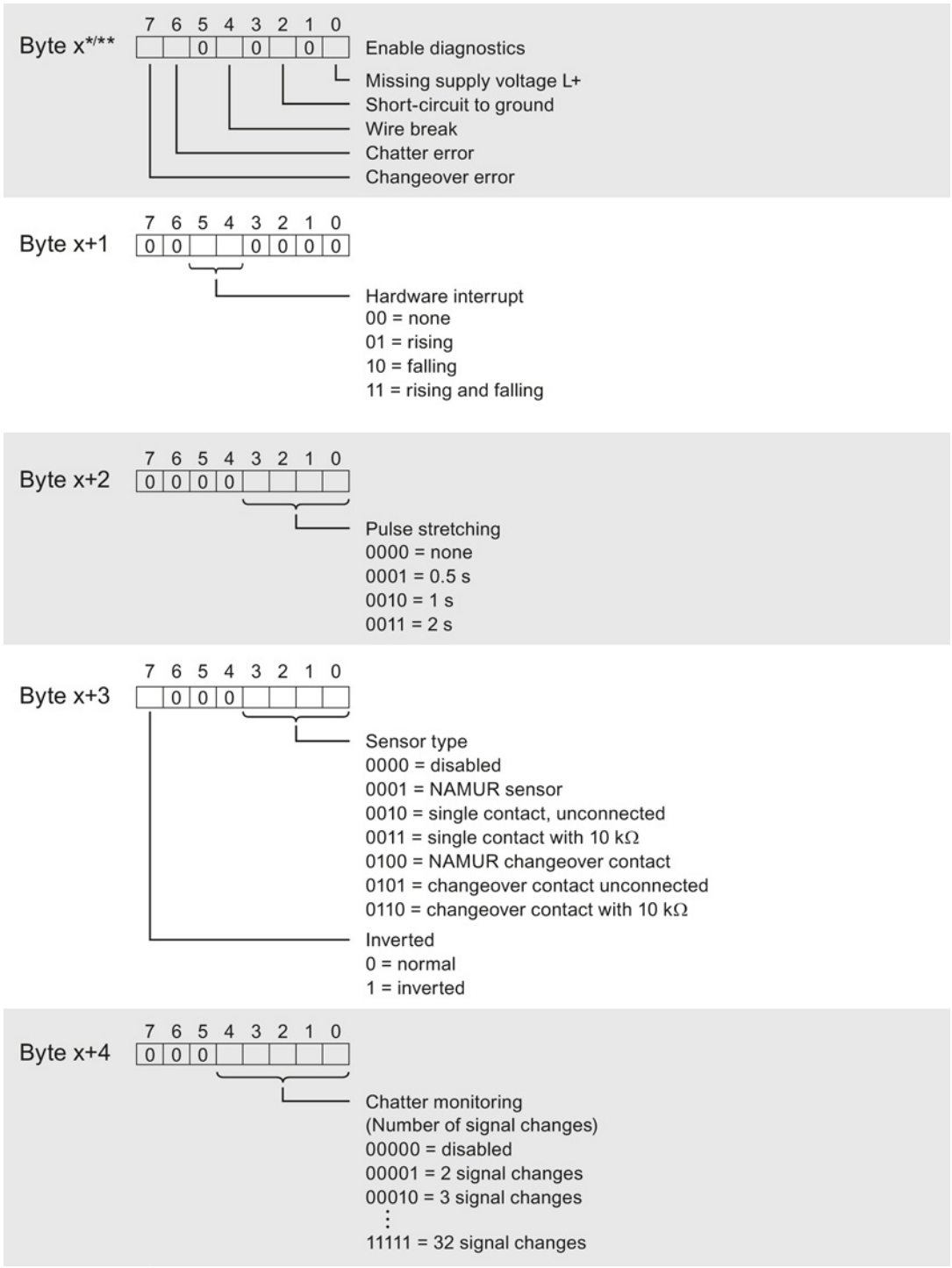
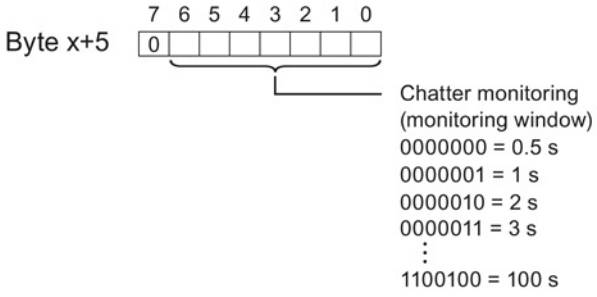


Figure A-2 DR 128 or DR 0 to 7: Bytes 0 and 1; header information

Parameters

The following figure shows the structure of the parameters for a channel. This structure also applies to channels 0 to 7.





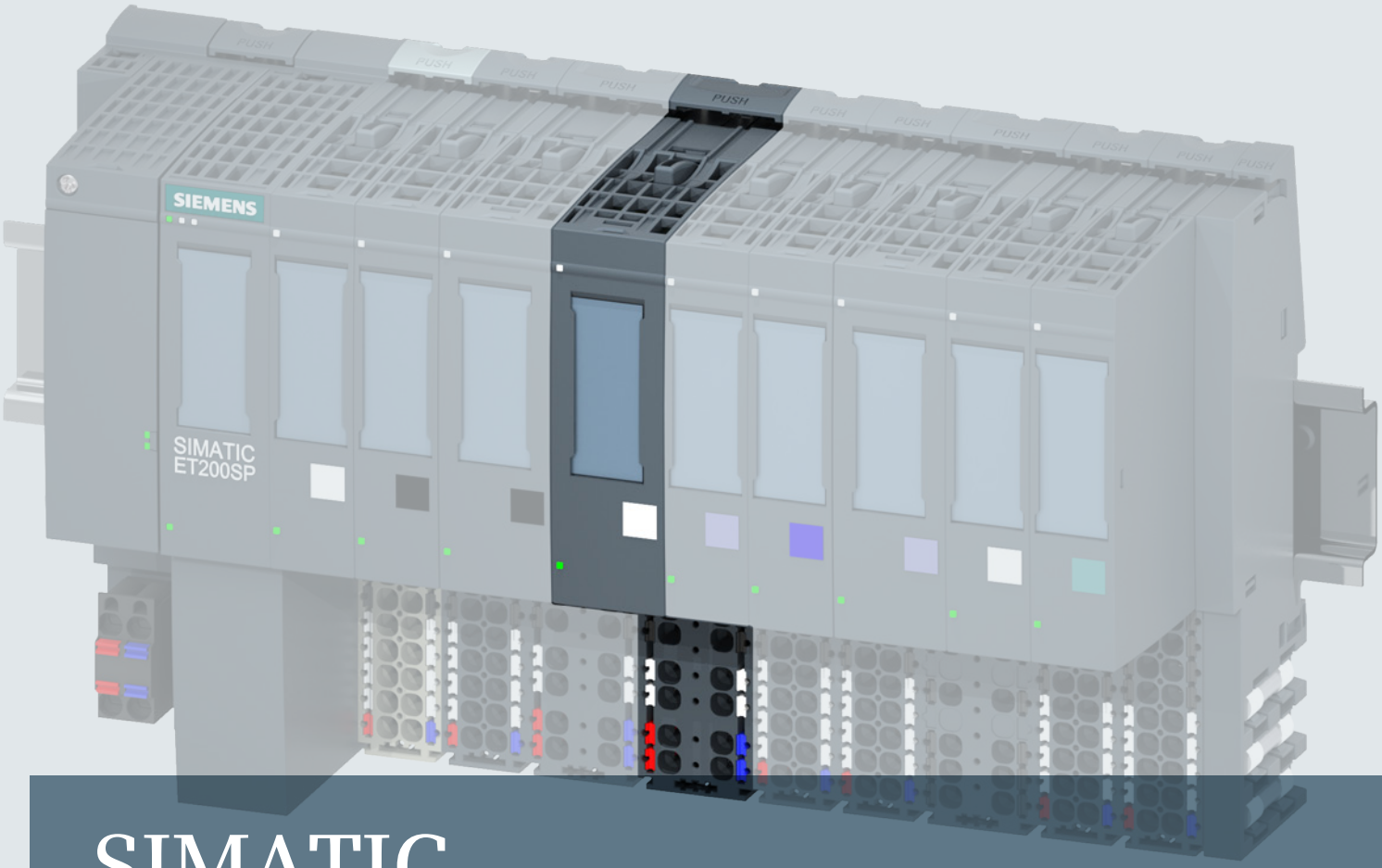
* x = 2 + (channel number × 6); channel number = 0 to 7 for DR 128
** x = 2 for DR 0 to DR 7

Figure A-3 DR 128 or DR 0 to 7: Byte x to x+5: Structure for channels 0 to 7

See also

Parameters (Page 11)

SIEMENS



SIMATIC

ET 200SP

Digital input module DI 4x120..230VAC ST (6ES7131-6FD00-0BB1)

Manual

Edition 02/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP DI 4x120..230VAC ST digital input module (6ES7131-6FD00-0BB1)

Manual

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Interrupts/diagnostics alarms 5

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02/2014

A5E32043398-AA

Legal information

Warning notice system

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

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indicates that death or severe personal injury **may** result if proper precautions are not taken.

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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GERMANY

A5E32043398-AA
℗ 02/2014 Technical data subject to change

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Preface

Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

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Guide to documentation

1

Introduction

The documentation for the SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of a system manual, function manuals and product manuals.

The STEP 7 information system (online help) also helps you to configure and program your automation system.

Overview of documentation for digital input module DI 4×120..230VAC ST

The following table lists additional documentation that you will need when using the DI 4×120..230VAC ST digital input module.

Table 1- 1 Documentation for the DI 4×120..230VAC ST digital input module

Topic	Documentation	Key content
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Amendments and special features of the ET 200SP I/O system	ET 200SP Product information (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All of the current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Order number

6ES7131-6FD00-0BB1

View of the module

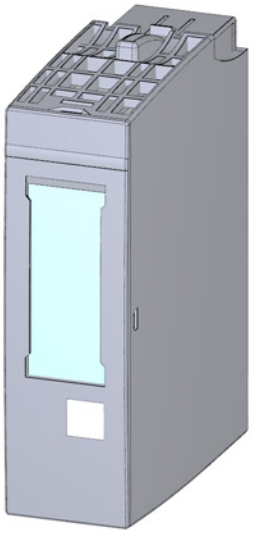


Figure 2-1 View of the DI 4×120..230VAC ST module

Properties

The module has the following technical properties:

- 4 digital inputs each with a value status (quality information)
- Supply voltage L+
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 3

The module supports the following functions:

- Firmware update
- Identification data I&M0 to I&M3
- Configuration in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

You can find additional information on the accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Terminal assignment

General pin assignment

NOTICE
Dangerous voltage: risk of death or serious injury
Prior to working on the system and module, always disconnect them from the power supply.

Note

Limiting overvoltage

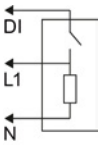
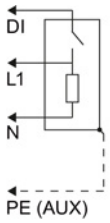
You must ensure overvoltage is limited to 1 kV for the encoder supply.

Note

Power limitation

To limit power, each input voltage must have a fuse with a maximum rating of 10 A tripping current. The fuse must be a quick-acting microfuse.

Table 3- 1 Pin assignment for DI 4×120..230VAC ST

Pin assignment for DI 4×120..230VAC ST (6ES7131-6FD00-0BB1)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 12)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • L1: Sensor supply 120 to 230 V AC • N: Neutral	B1	 CC41 6ES7193-6CP41-2MB0
3	DI_2	**4**	DI_3			
5	L1	**6**	L1			
7	L1	**8**	L1			
9	N	**10**	N			
11	N	**12**	N			
1L	120...230 V AC	**1N**	N			
2L	120...230 V AC	**2N**	N			
2-conductor 				3-wire 		4-wire 	

[1] BaseUnit types that can be used are identified by the last two digits of the order number. See also "ET 200SP distributed I/O system" system manual.

3.2 Block diagram

Block diagram

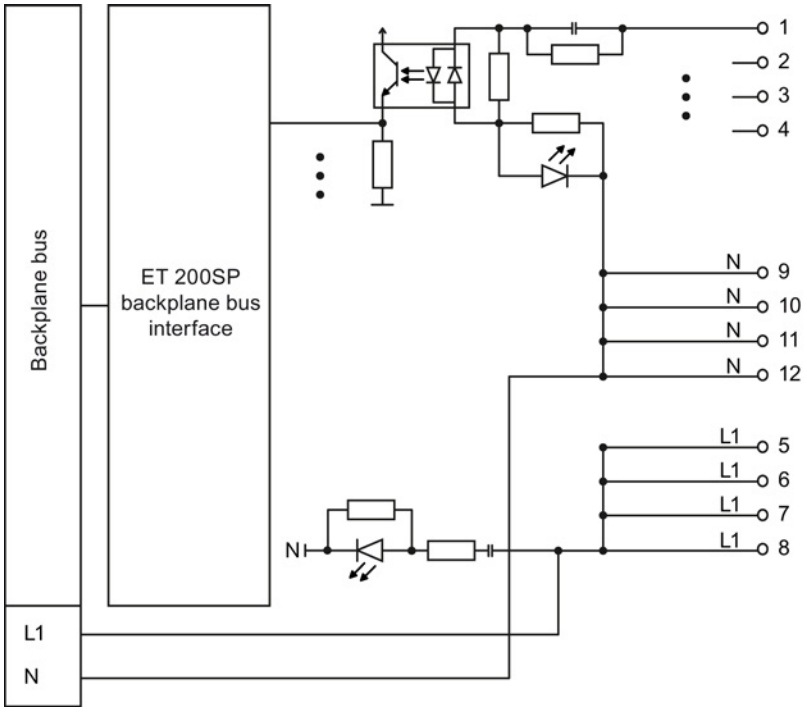


Figure 3-1 Block diagram DI 4x120...230VAC ST

Parameter assignment/addressing

4

4.1 Parameters

Parameters of the DI 4x120..230VAC ST

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When performing the configuration in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 20)).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Operating mode	• Channel activated • Channel deactivated	Channel activated	Yes	Channel	Channel

4.2 Explanation of parameters

Operating mode

Determines whether a channel is enabled or disabled.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Configuration options with the DI 4×120..230VAC ST

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Each bit in this byte is assigned to a channel and returns information on the validity of the digital value (0 = incorrect value).

Address space of the digital input module DI 4×120..230VAC ST

The following figure shows the assignment of address space for the DI 4×120..230VAC ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

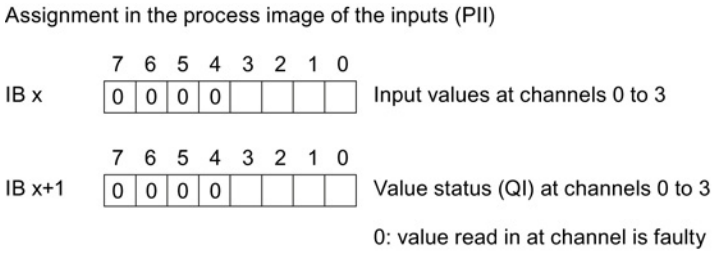


Figure 4-1 Address space of the DI 4×120..230VAC ST digital input module with value status

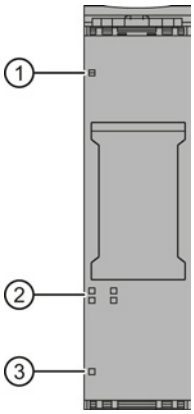
Interrupts/diagnostics alarms

5

5.1 Status and fault displays

LED displays

The figure below shows the LED displays (status and fault displays) of the DI 4x120..230VAC ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LEDs

The tables below explain the meaning of the Status and fault displays.

LED DIAG

Table 5- 1 LED DIAG fault display

LED DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashing	Module parameters not assigned
On	Module configured and no module diagnostics
Flashing	Module configured and module diagnostics

LED channel status

Table 5- 2 Channel status LED status and fault display

LED channel status	Meaning
Off	Process signal = 0
On	Process signal = 1

LED PWR

Table 5- 3 LED PWR status display

LED PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ present

5.2 Load voltage status

Load voltage status

The firmware of the module cannot detect the status of the load voltage.

If the "Load voltage status" function tied to the server module is used, a "1" is always displayed in the status bit for a slot with the DI 4×120..230VAC ST. Even when the load voltage is not applied.

Technical specifications

6

6.1 Technical specifications

DI 4×120..230VAC ST technical specifications

	6ES7131-6FD00-0BB1
General information	
Usable BaseUnits	BU type B1
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD as of revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Supply voltage	
Rated value (AC)	230 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	10 mA
Current consumption, max.	11 mA
Encoder supply	
Number of outputs	4
Output current	
up to 60 °C, max.	10 A
Short-circuit protection	No; install a fuse with 10A trigger current when using a type B1 BU
Power loss	
Power loss, typ.	1 W; active power, load voltage 230 V, all inputs wired with 230 V, 50 Hz
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Input	1 bytes

	6ES7131-6FD00-0BB1
Digital inputs	
Number of inputs	4
Active low/Active high	No
Input characteristic curve acc. to IEC 61131, type 3	Yes
Pulse stretching	No
Input voltage	
Type of input voltage	120/230 V AC (47 Hz to 63 Hz)
Rated value, AC	230 V
for signal "0"	0 to 40 V AC
for signal "1"	74 to 264 V AC
Input current	
for signal "1", typ.	10.8 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	No
• with "0" to "1", min.	1.5 ms
• with "0" to "1", max.	4 ms
• with "1" to "0", min.	10 ms
• with "1" to "0", max.	10 ms
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Encoders	
Supported encoders	
2-wire sensor	Yes
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	No
Hardware interrupt	No
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green LED PWR
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red LED DIAG

	6ES7131-6FD00-0BB1
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Insulation	
Insulation tested with	2545 V DC 2 s (routine test)
Dimensions	
Width	20 mm
Weights	
Weight, approx.	36 g

Dimensional drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

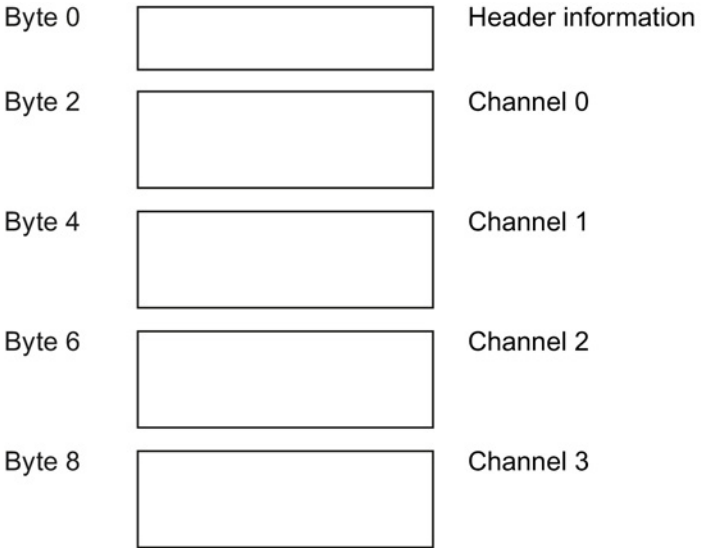


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

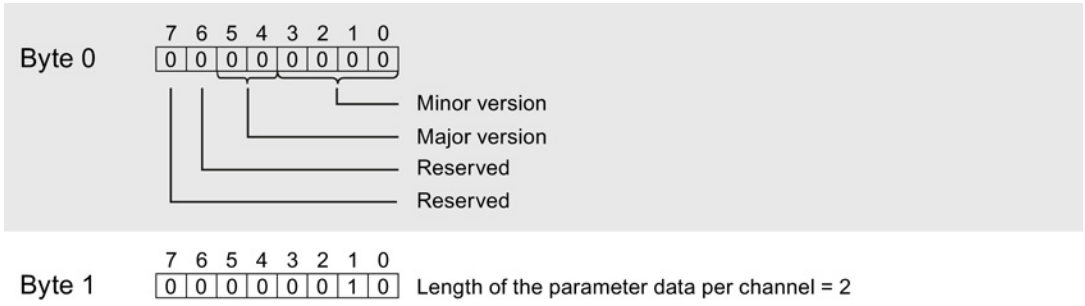


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

Figure A-3 Structure byte x to x+1 for the channels 0 to 3

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Digital output module DQ 8x24VDC/0.5A BA (6ES7132-6BF00-0AA0)

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Manual

Preface

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12/2015

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 12/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

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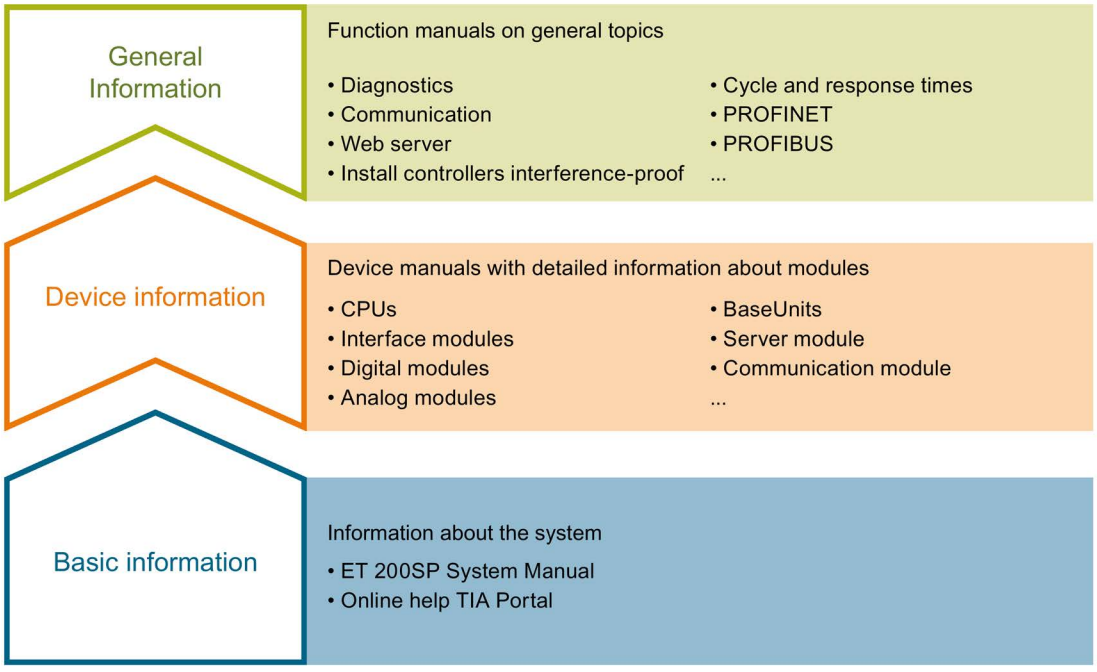
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

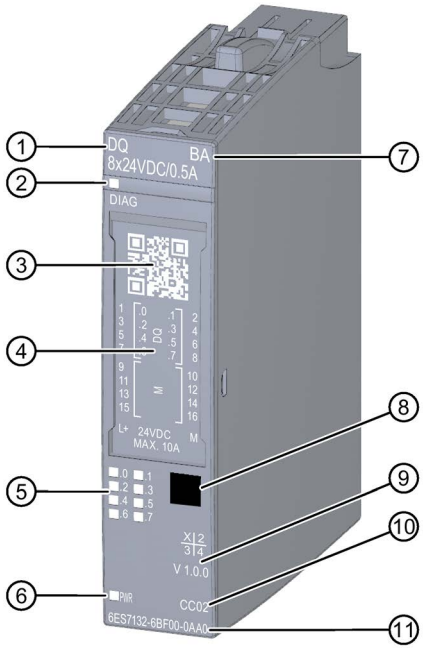
2.1 Properties

Article number

6ES7132-6BF00-0AA0 (packaging unit: 1 unit)

6ES7132-6BF00-2AA0 (packaging unit: 10 units)

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module DQ 8×24VDC/0.5A BA

Properties

The module has the following technical properties:

- Digital output module with 8 outputs
- Supply voltage L+
- Output current 0.5 A (per channel)
- Source output (PNP, P-switching)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 8x24VDC/0.5A BA module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnit in the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Note

- The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

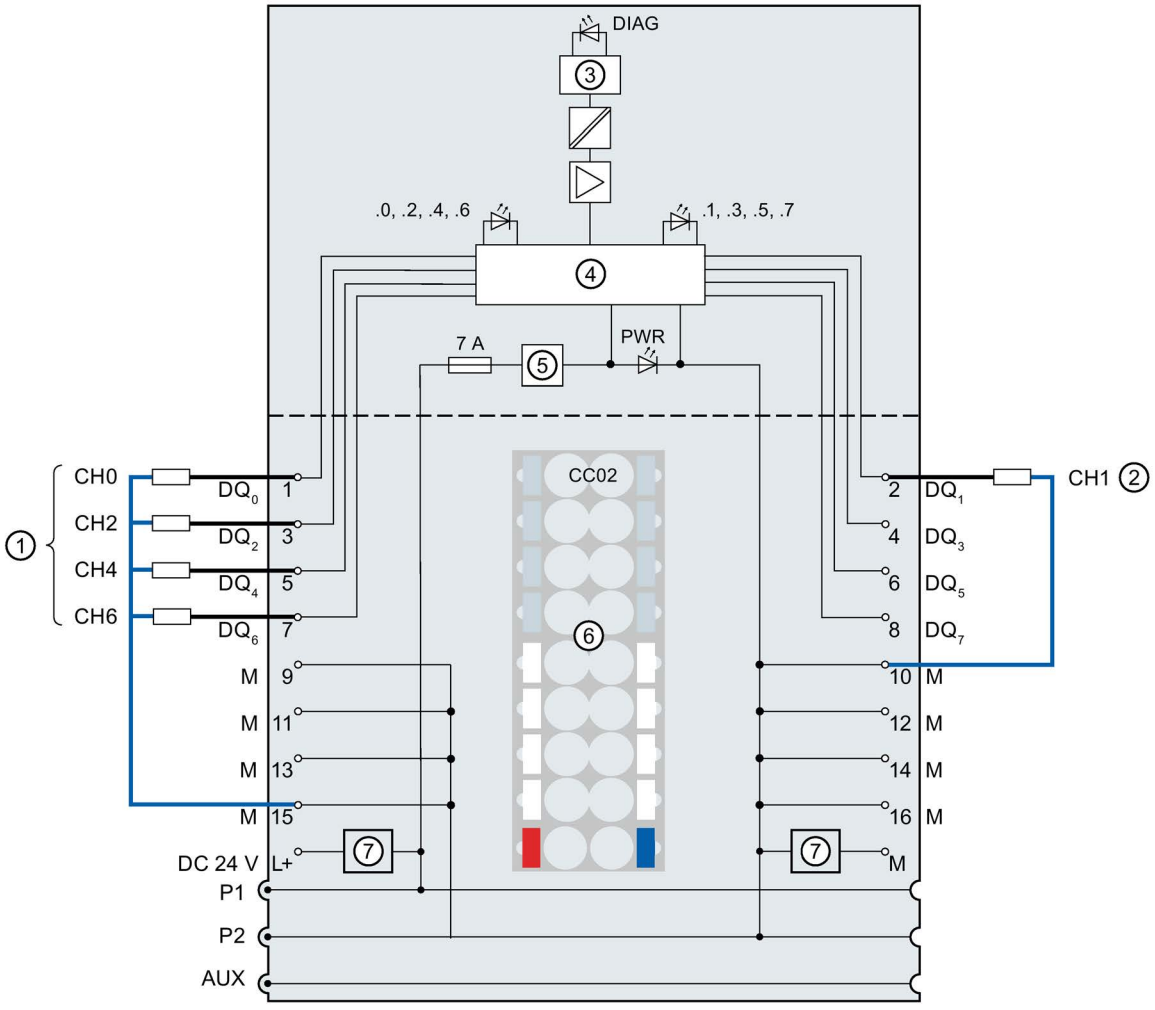
Note

Cross circuit at output

Be aware that voltage from a cross-circuit at the output can feed L+ to modules.

Wiring: 1 and 2-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A BA on the BaseUnit BU type A0 without AUX terminals (1- and 2-wire connection).

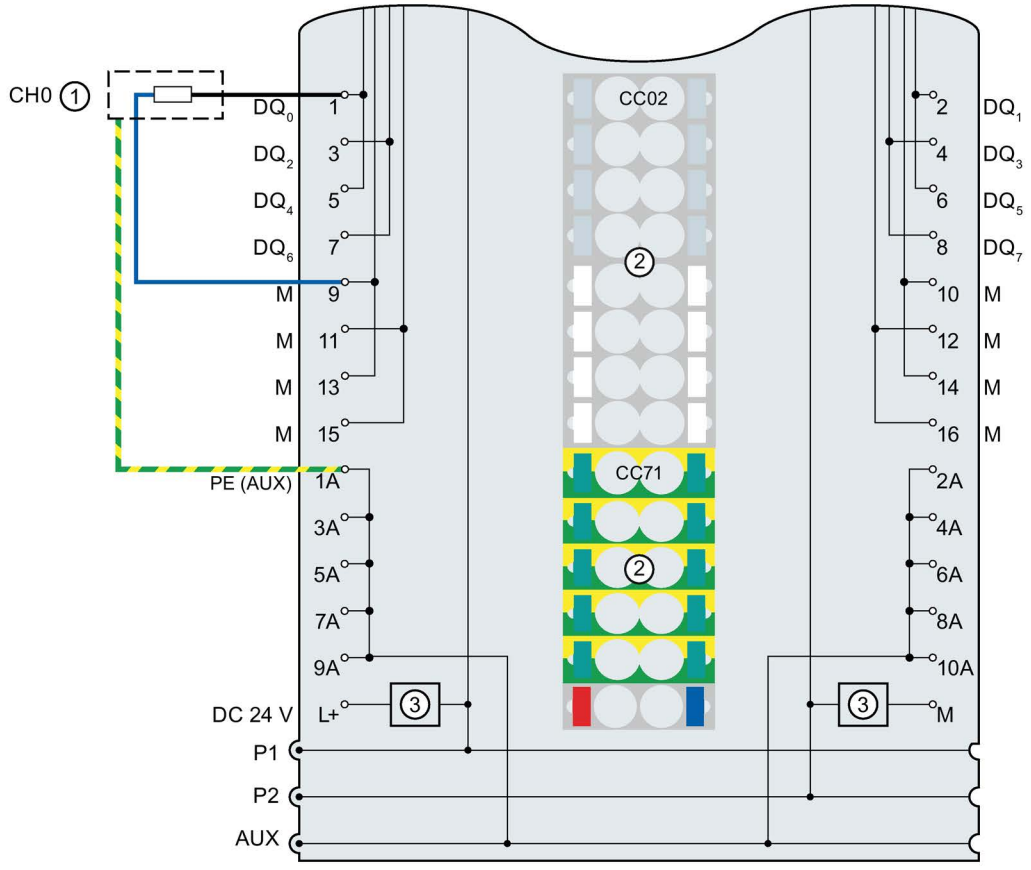


①	1-wire connection	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
②	2-wire connection	M	Ground
③	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Output electronics	DQ_n	Output signal, channel n
⑤	Polarity reversal protection	DIAG	Error or diagnostics LED (green, red)
⑥	Color-coded label with color code CC02 (optional)	.0 to .7	Channel status LED (green)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	PWR	Power LED (green)

Image 3-1 Block diagram and terminal assignment for 1- and 2-wire connection of actuators

Wiring: 3-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A BA on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection	1 A to 10 A	AUX terminals
②	Color-coded labels with color codes CC02 and CC71 (optional)	PE (AUX)	Protective conductor connection
③	Filter connection supply voltage (only when light-colored BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
DQ_n	Output signal, channel n	M	Ground
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Image 3-2 Terminal assignment for 3-wire connection of actuators

Parameters/address space

4

4.1 Parameters

Parameters for DQ 8x24VDC/0.5A BA

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 23).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Enable • Disable	Disable	Yes	Module	Module
Channel activated	• Enable • Disable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

4.2 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Address space

Address space of the digital output module DQ 8x24VDC 0.5A BA

The following figure shows the assignment of the address space for the DQ 8×24VDC/0.5A BA.

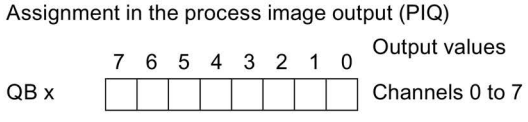


Image 4-1 Address space of the DQ 8×24VDC/0.5A BA

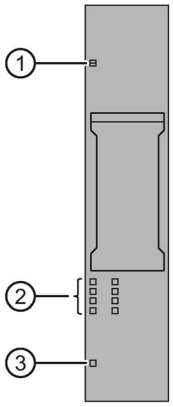
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the DQ 8x24VDC/0.5A BA.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 18).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated and process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The DQ 8×24VDC/0.5A BA digital output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 8×24VDC/0.5A BA

	6ES7132-6BF00-0AA0
General information	
Product type designation	ET 200SP, DQ 8x24VDC/0.5A BA, PU 1
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC02
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 / -
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	45 mA; without load
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W

	6ES7132-6BF00-0AA0
Address area	
Address space per module	
Address space per module, max.	1 byte
Hardware configuration	
Automatic coding	
• Mechanical coding element:	Yes
Selection of BaseUnit for connection versions	
1-wire connection	BU type A0
2-wire connection	BU type A0
3-wire connection	BU type A0 with AUX terminals
4-wire connection	No
Digital outputs	
Number of outputs	8
Sinking output	No
Sourcing output	Yes
Short-circuit protection	Yes
• Response threshold, typ.	0.7 to 1.7 A
Limitation of inductive shutdown voltage to	Typ. L+ (-53 V)
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	0.5 A
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ
Output current	
For signal "1" rated value	0.5 A
For signal "0" residual current, max.	1 mA
Output delay with resistive load	
"0" to "1", max.	100 µs; with rated load
"1" to "0", max.	150 µs; with rated load
Parallel connection of two outputs	
For increased performance	No
For redundant control of a load	Yes; for each module
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	2 Hz
With lamp load, max.	10 Hz
Total current of the outputs	
Current per channel, max.	0.5 A
Current per module, max.	4 A

	6ES7132-6BF00-0AA0
Total current of the outputs (per module)	
Horizontal installation	
• Up to 60 °C, max.	4 A
Vertical installation	
• Up to 50 °C, max.	4 A
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	No
Short-circuit	No
Group error	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

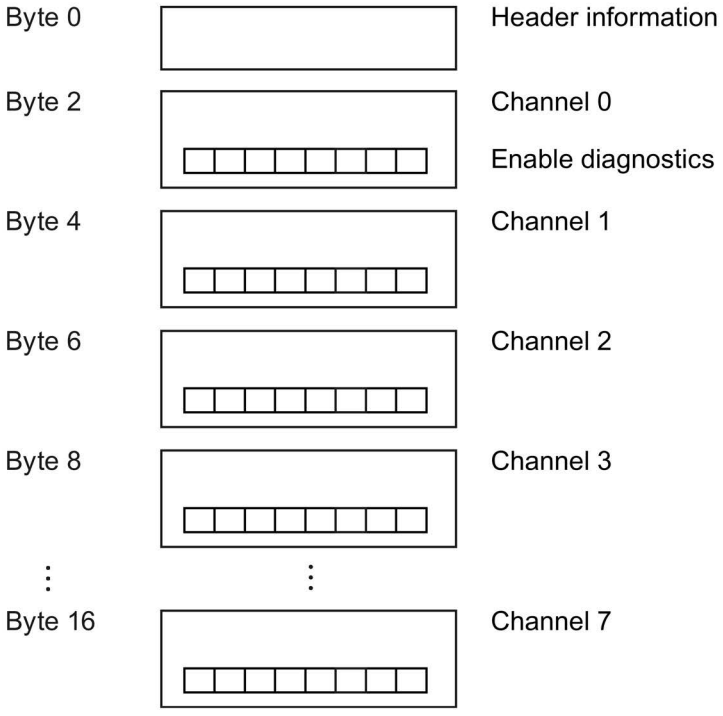


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

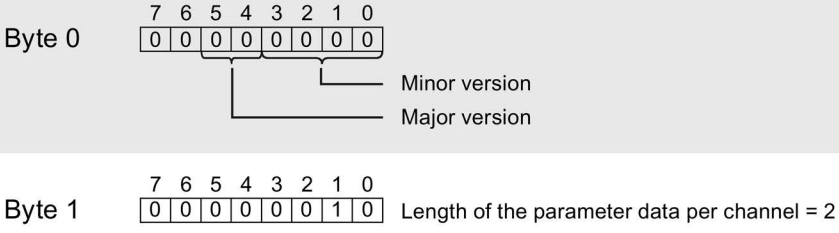


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

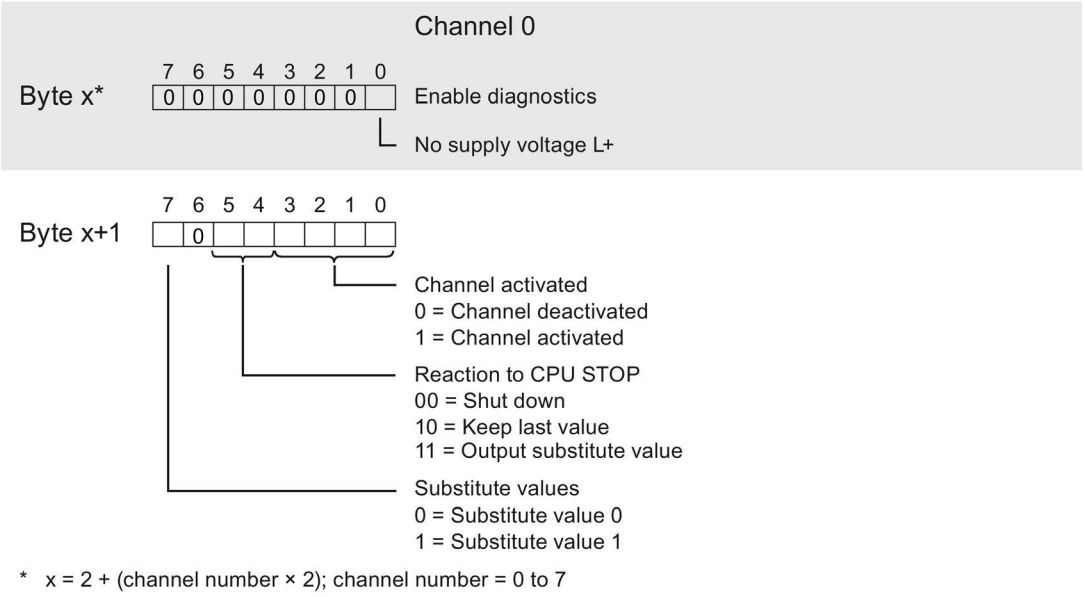


Image A-3 Structure byte x to x+1 for the channels 0 to 7

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

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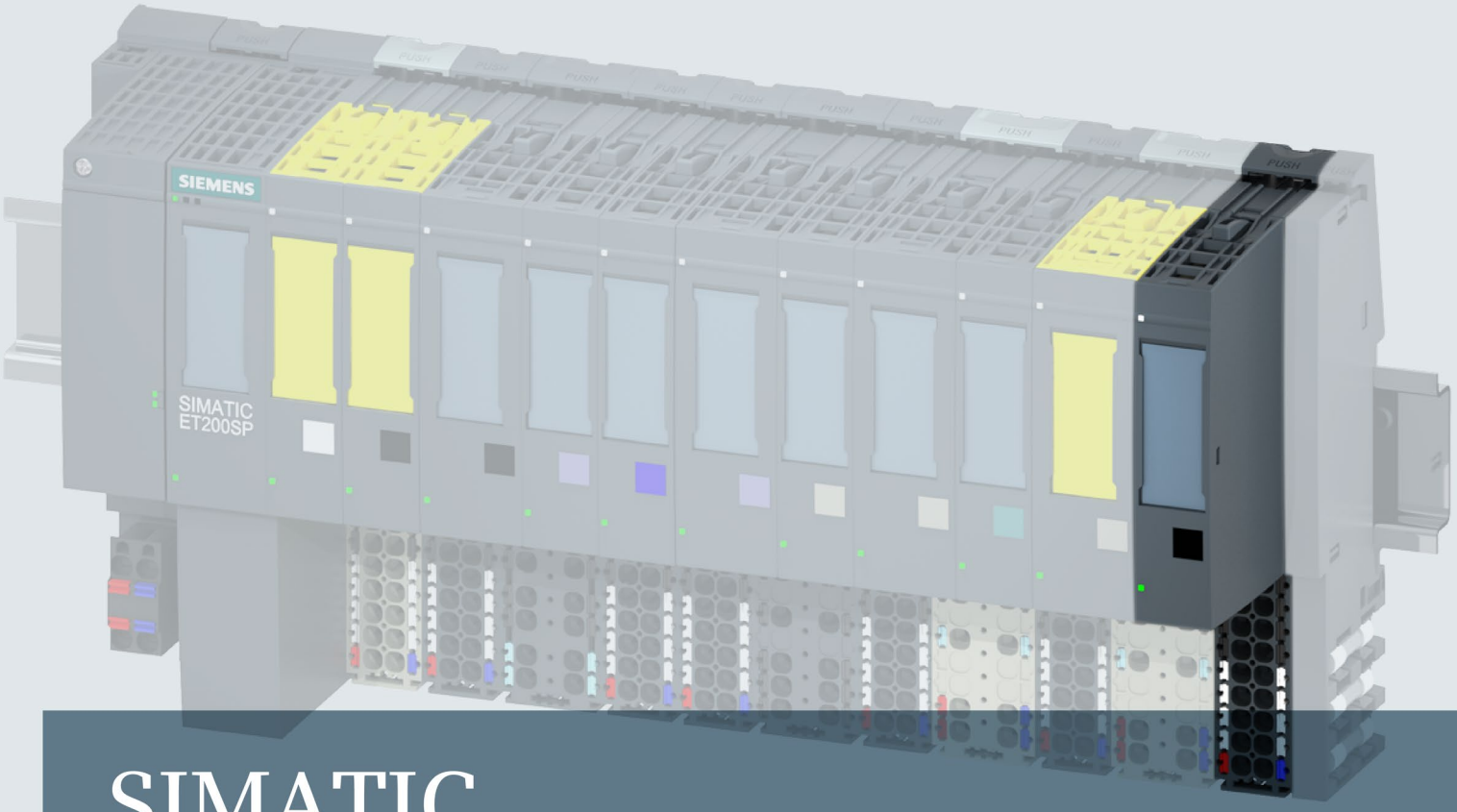

SIMATIC

ET 200SP

Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD20-0BA0)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Digital output module
DQ 4x24VDC/2A ST
(6ES7132-6BD20-0BA0)

Manual

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Parameters/address space 4

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Technical specifications 6

Parameter data record A

12/2015
A5E03574516-AD

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 12/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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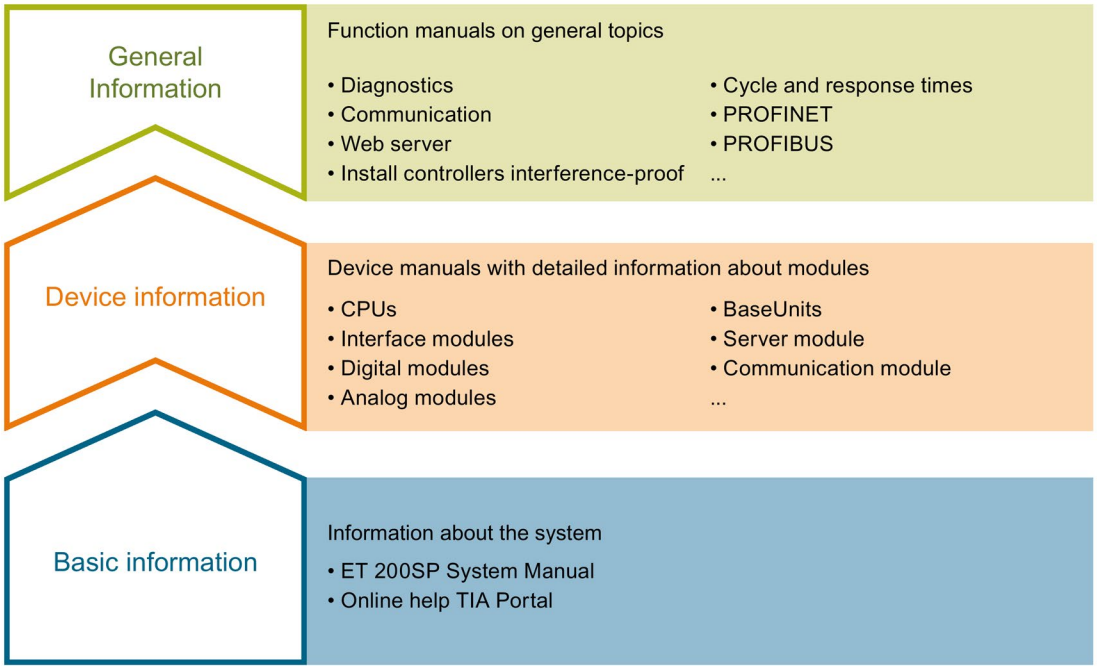
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

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In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

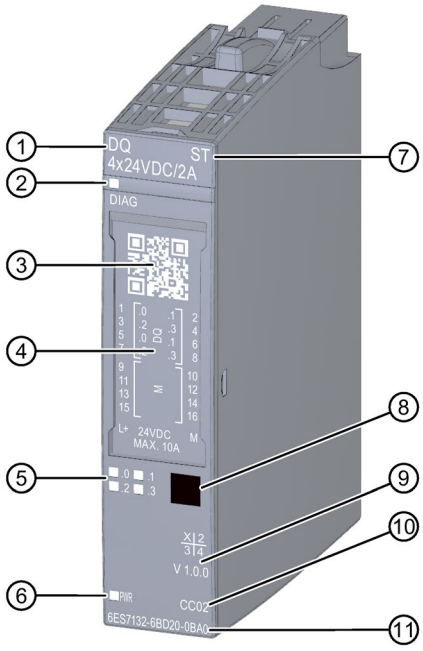
2.1 Properties

Article number

6ES7132-6BD20-0BA0 (packaging unit: 1 unit)

6ES7132-6BD20-2BA0 (packaging unit: 10 units)

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module DQ 4×24VDC/2A ST

Properties

The module has the following technical properties:

- Digital output module with 4 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 2 A (per channel)
- Total current 8 A (per module) (see derating: Technical specifications (Page 22))
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 4x24VDC/2A ST module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection. You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnits in the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Note

- The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Note

The fuse integrated in BaseUnit type A1 may be triggered in the digital output module, rendering the terminals unusable.

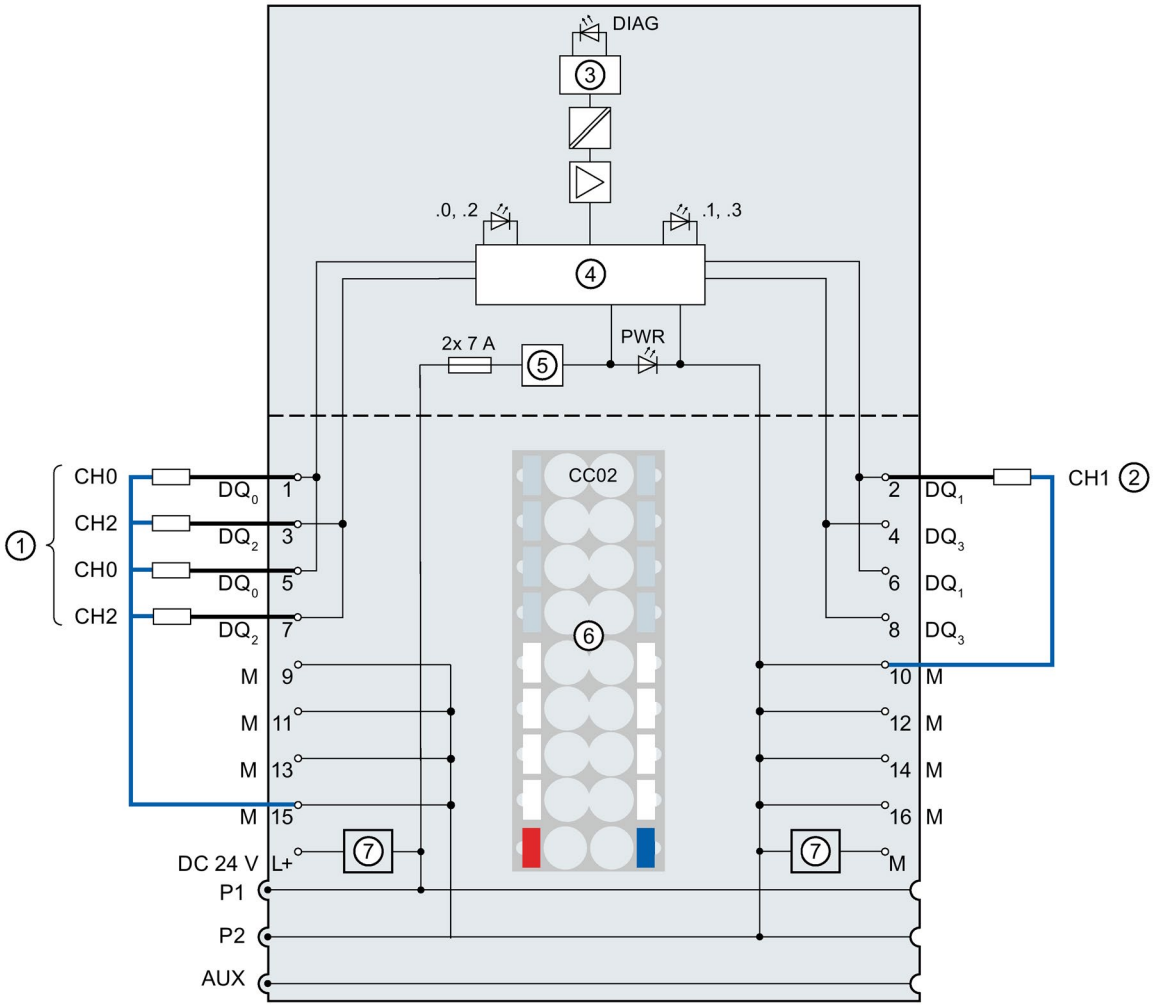
Note

Cross circuit at output

Be aware that voltage from a cross-circuit at the output can feed L+ to modules.

Wiring: 1 and 2-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 4×24VDC/2A ST on the BaseUnit BU type A0 without AUX terminals (1- and 2-wire connection).

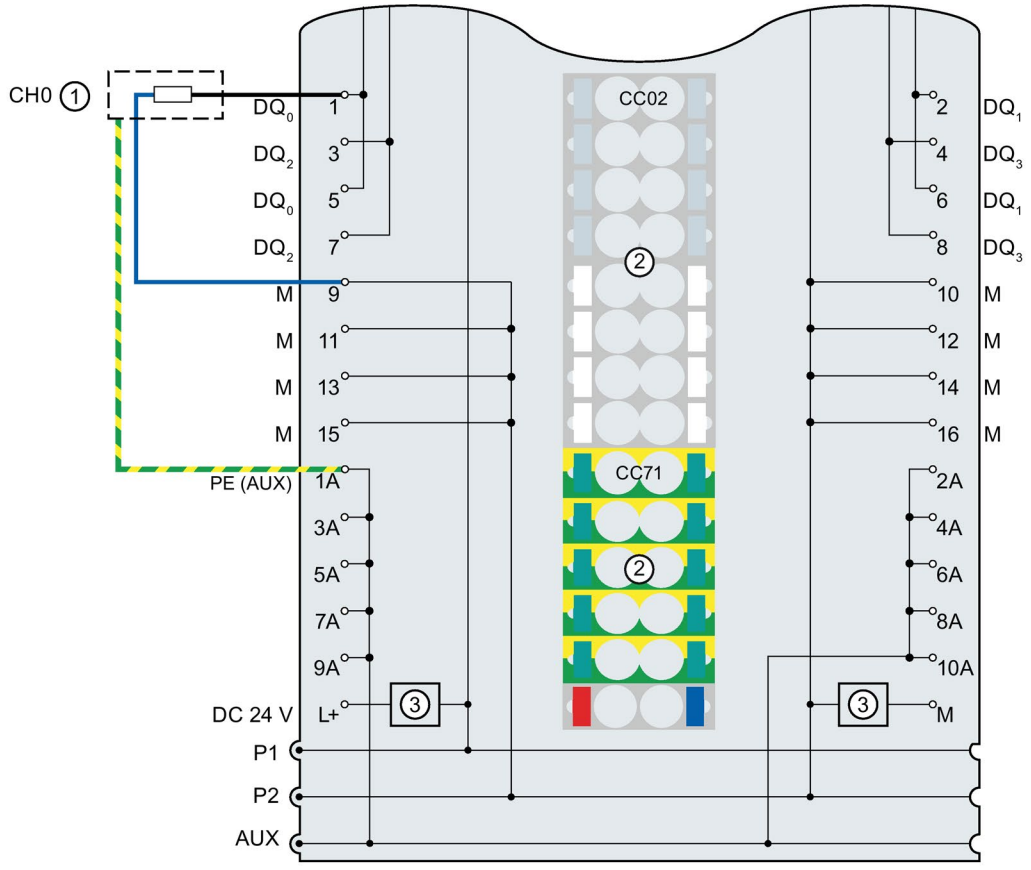


①	1-wire connection	DQ_n	Output signal, channel n
②	2-wire connection	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
③	Backplane bus interface	M	Ground
④	Output electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Polarity reversal protection	DIAG	Error or diagnostics LED (green, red)
⑥	Color-coded label with color code CC02 (optional)	.0 to .3	Channel status LED (green)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	PWR	Power LED (green)

Image 3-1 Block diagram and terminal assignment for 1- and 2-wire connection of actuators

Wiring: 3-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 4×24VDC/2A ST on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection	1 A to 10 A	AUX terminals
②	Color-coded labels with color codes CC02 and CC71 (optional)	PE (AUX)	Protective conductor connection
③	Filter connection supply voltage (only when light-colored BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
DQ_n	Output signal, channel n	M	Ground
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Image 3-2 Terminal assignment for 3-wire connection of actuators

Parameters/address space

4

4.1 Parameters

Parameters for DQ 4x24VDC/2A ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 27).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Enable • Disable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Enable • Disable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to L+	• Enable • Disable	Disable	Yes	Module	Module
Diagnostics: Wire break	• Enable • Disable	Disable	Yes	Module	Module
Channel activated	• Enable • Disable	Enable	Yes	Channel	Channel

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

Note

If one of the two parameters "Diagnostics: Short-circuit to L+" or "Diagnostics: Wire break" is enabled and one of these diagnostics occurs, the affected channel is switched off to avoid triggering an undefined load. Note that a diagnostic interrupt can only be generated when diagnostics are enabled. [1]

[1] as of module revision 06

4.2 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP / substitute value

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 4x24VDC/2A ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	DQ 4x24VDC/2A ST V1.0	X	X	X
1 x 4-channel without value status	DQ 4x24VDC/2A ST V1.1	X	X	X
1 x 4-channel with value status	DQ 4x24VDC/2A ST V1.1, QI	X	X	---

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DQ 4×24VDC/2A ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

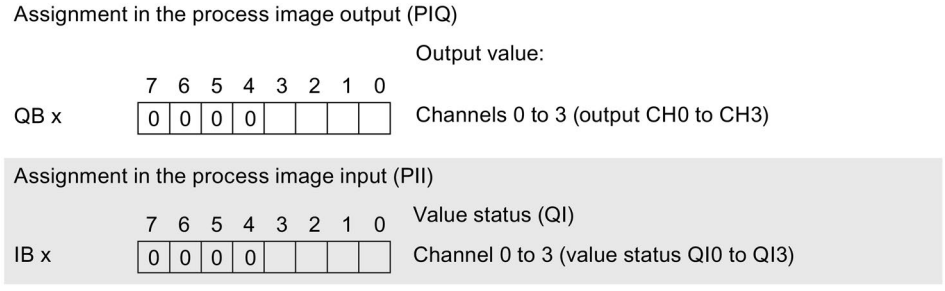


Image 4-1 Address space of the DQ 4×24VDC/2A ST with value status

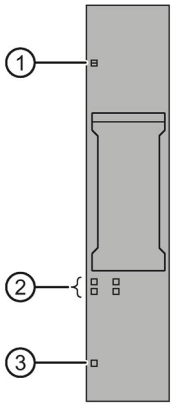
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the DQ 4x24VDC/2A ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 20).

DIAG LED

Table 5- 1 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ on	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Channel deactivated or activated and process signal = 0
■ on	Channel activated and process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

5.2 Interrupts

The DQ 4×24VDC/2A ST digital output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Note

You can connect 2 actuators per output.

The diagnostics of the two actuators influenced each other in the case of duplicate wiring.

This means:

- a wire break is only signaled if both actuators are affected
- a single short-circuit affects both actuators

Note

Parallel connection of two outputs

For parallel connection of two outputs for redundant control of a load, the channel diagnostics "Short-circuit to L+" and "Wire break" must be deactivated.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	• Short-circuit of actuator supply to ground • Short-circuit of actuator supply to L+	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 4×24VDC/2A ST

	6ES7132-6BD20-0BA0
General information	
Product type designation	ET 200SP, DQ 4x24VDC/2A ST, PU 1
Firmware version	V1.1
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC02
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V11 SP2 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PCS 7 can be configured/integrated as of version	V8.1 SP1
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	60 mA; no load
Output voltage	
Rated value (DC)	24 V

	6ES7132-6BD20-0BA0
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Digital outputs	
Number of outputs	4
Sinking output	No
Sourcing output	Yes
Short-circuit protection	Yes
• Response threshold, typ.	2.8 ... 5.2 A
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	10 W
Load resistance range	
Low limit	12 Ω
High limit	3400 Ω
Output current	
For signal "1" rated value	2 A
For signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
"0" to "1", typ.	50 µs
"0" to "1", max.	50 µs
"1" to "0", typ.	100 µs
"1" to "0", max.	100 µs
Parallel connection of two outputs	
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	2 Hz
With lamp load, max.	10 Hz
Total current of the outputs	
Current per channel, max.	2 A
Current per module, max.	8 A

	6ES7132-6BD20-0BA0
Total current of the outputs (per module)	
Horizontal installation	
• Up to 30 °C, max.	8 A
• Up to 40 °C, max.	8 A
• Up to 50 °C, max.	6 A
• Up to 60 °C, max.	4 A
Vertical installation	
• Up to 30 °C, max.	8 A
• Up to 40 °C, max.	6 A
• Up to 50 °C, max.	4 A
• Up to 60 °C, max.	4 A
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	Yes; module by module
Short-circuit	Yes; module by module
Group error	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	30 g

Safety-related shutdown

Note

The digital output module DQ 4x24VDC/2A ST supports safety-related shutdown in connection with a fail-safe power module F-PM-E 24VDC/8A PPM ST:

- SIL according to IEC 61508: 2
- Highest attainable safety class in safety mode, performance level according to EN ISO 13849-1: d

Residual current for signal state "0"

Note

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current does not depend on the setting for the Diagnostics: Wire break parameter.

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

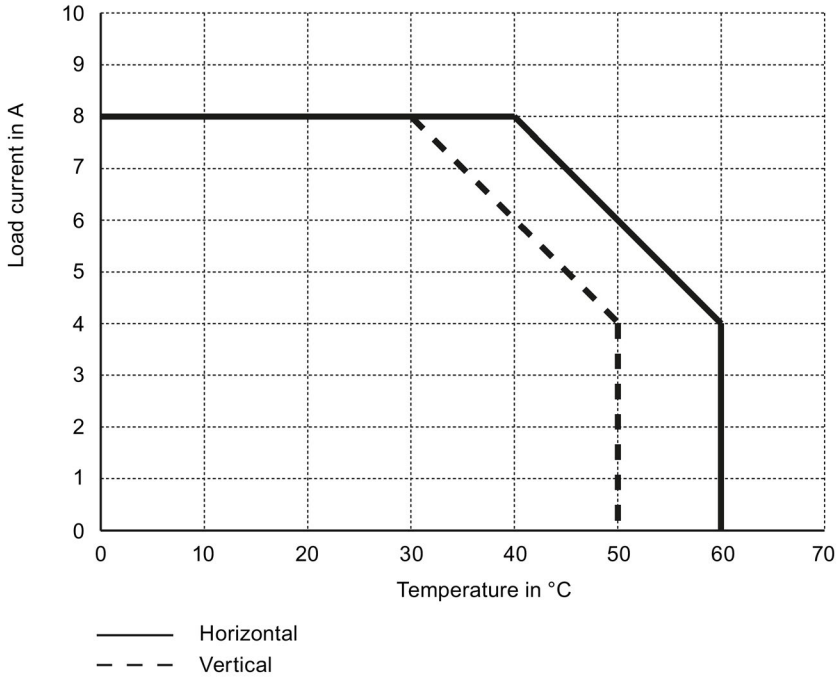


Image 6-1 Load current for mounting position

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

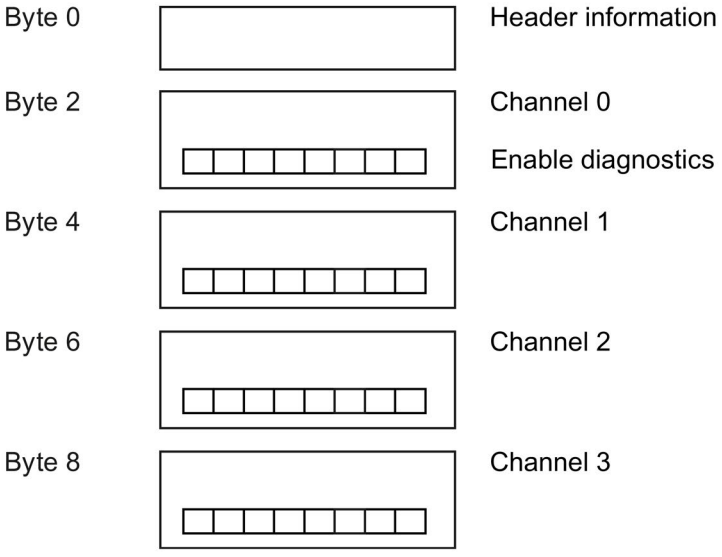


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

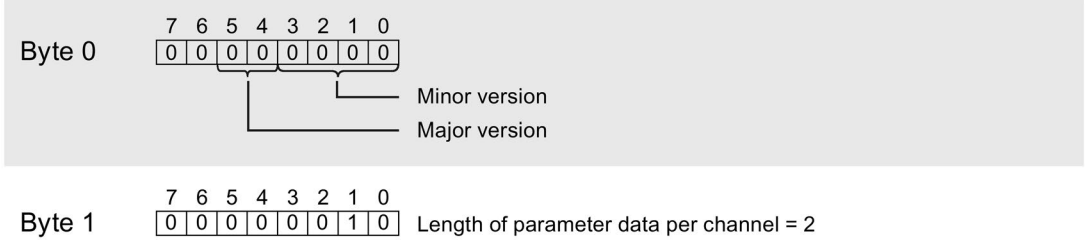


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

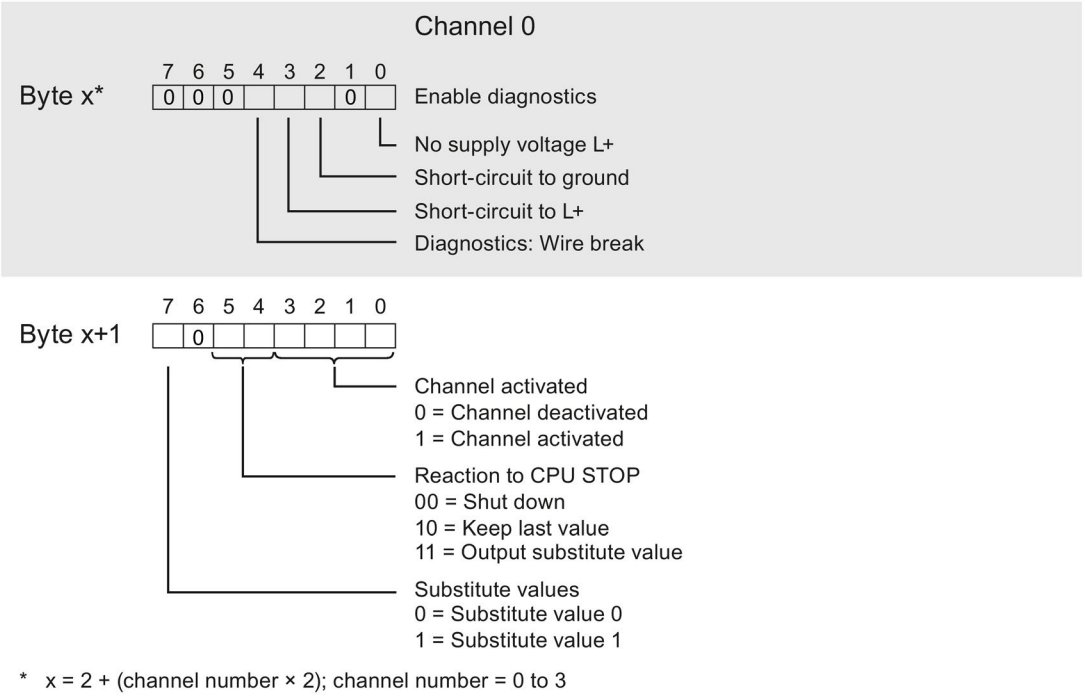


Image A-3 Structure byte x to x+1 for the channels 0 to 3

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

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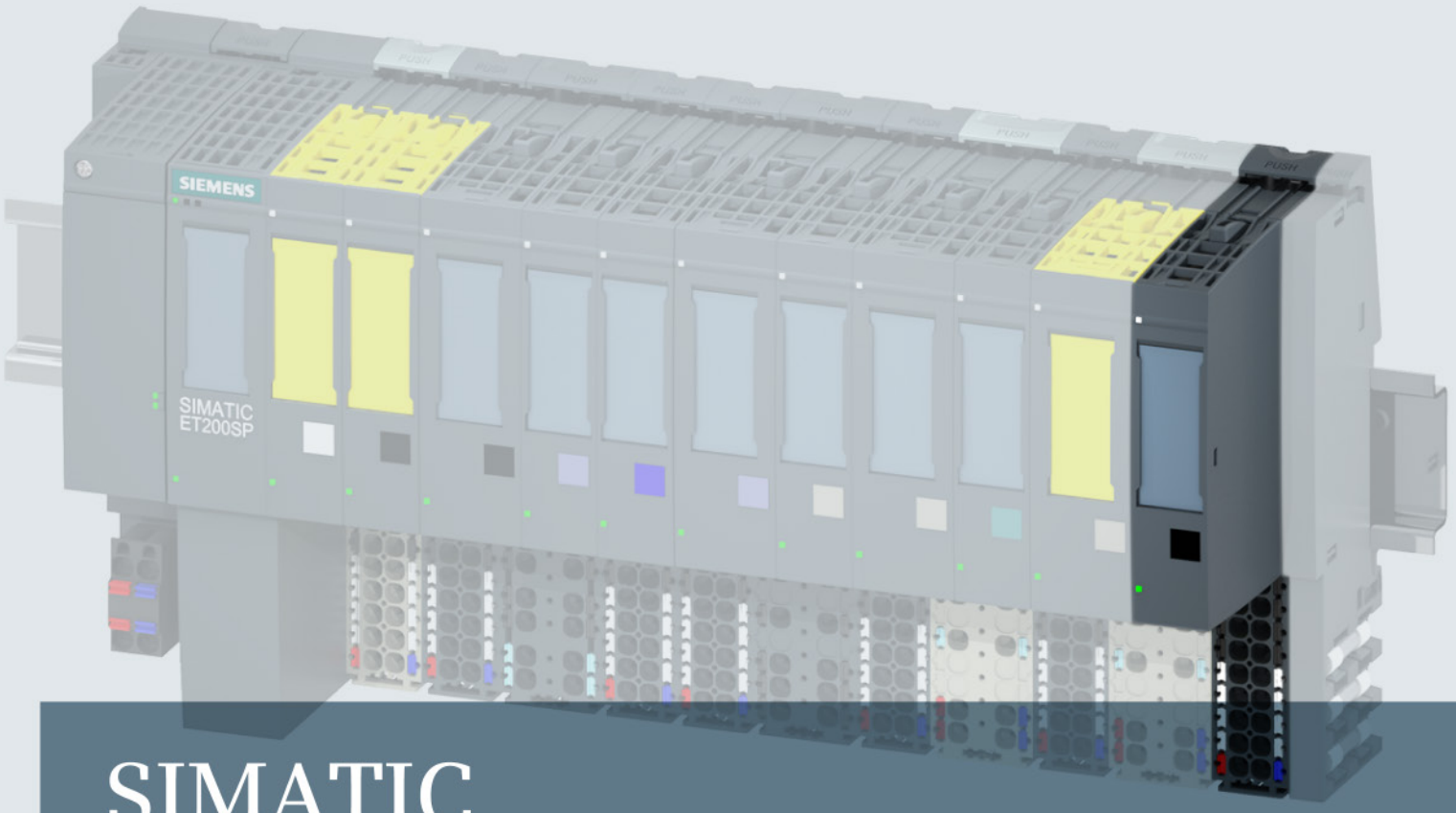

SIMATIC

ET 200SP

Digital output module DQ 8x24VDC/0.5A ST (6ES7132-6BF00-0BA0)

Manual

Edition 07/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Digital output module
DQ 8x24VDC/0.5A ST
(6ES7132-6BF00-0BA0)

Manual

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Parameter data record A

07/2014

A5E03574575-AC

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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GERMANY

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℗ 07/2014 Subject to change

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Preface

Purpose of the documentation

This device manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that relate generally to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you when commissioning the ET 200SP distributed I/O system.

Conventions

Please pay particular attention to notes highlighted as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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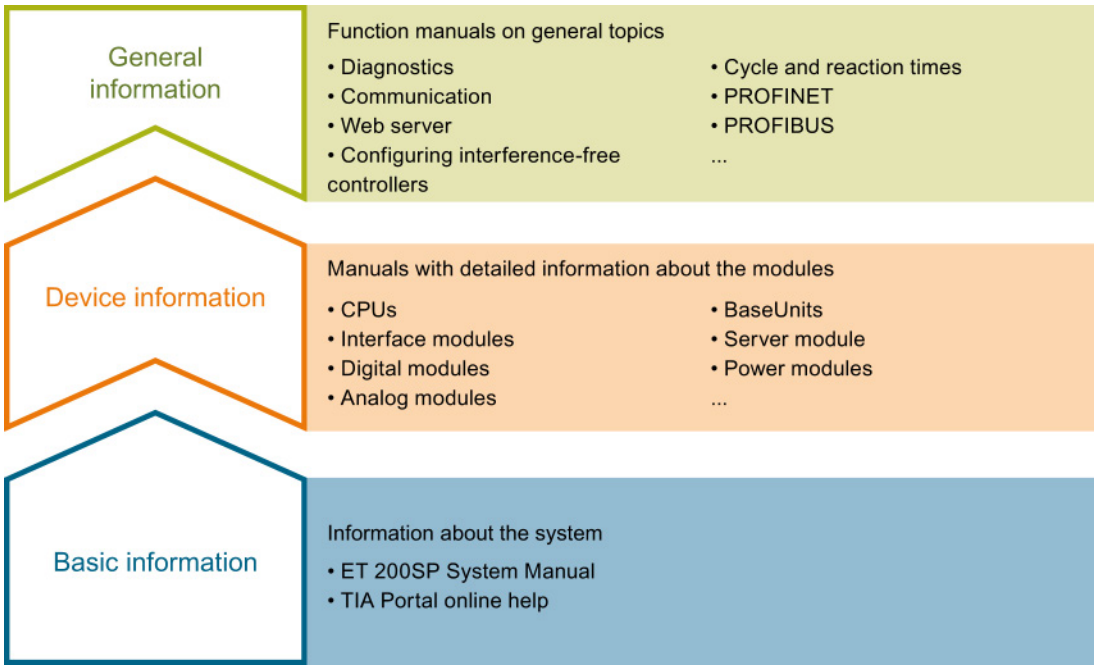
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC distributed I/O system. ET 200SP. The STEP 7 online help supports you in the configuration and programming.

Device information

Manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics, technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

Product overview

2

2.1 Properties

Article number

6ES7132-6BF00-0BA0

View of the module

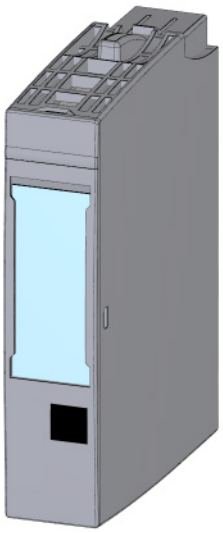


Figure 2-1 View of the module DQ 8×24VDC/0.5A ST

Properties

The module has the following technical properties:

- Digital output module with 8 outputs
- Supply voltage L+
- Output current 0.5 A per channel
- Source output (PNP)
- Module-oriented selectable diagnostics
- Substitute value output

- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

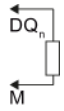
Wiring up

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment

<table>
<tr><th colspan="7">Terminal assignment for DQ 8×24VDC/0.5A ST (6ES7132-6BF00-0BA0)</th></tr>
<tr><th>Terminal</th><th>Assignment</th><th>Terminal</th><th>Assignment</th><th>Explanation</th><th>BaseUnit[1]</th><th>Color identification label (terminals 1 to 16)</th></tr>
<tr><td>1</td><td>DQ_0</td><td>2</td><td>DQ_1</td><td rowspan="9">• DQ_n: Output signal, channel n
• M: Ground</td><td rowspan="9">A0</td><td rowspan="9">
CC02
6ES7193-6CP02-2MA0</td></tr>
<tr><td>3</td><td>DQ_2</td><td>4</td><td>DQ_3</td></tr>
<tr><td>5</td><td>DQ_4</td><td>6</td><td>DQ_5</td></tr>
<tr><td>7</td><td>DQ_6</td><td>8</td><td>DQ_7</td></tr>
<tr><td>9</td><td>M</td><td>10</td><td>M</td></tr>
<tr><td>11</td><td>M</td><td>12</td><td>M</td></tr>
<tr><td>13</td><td>M</td><td>14</td><td>M</td></tr>
<tr><td>15</td><td>M</td><td>16</td><td>M</td></tr>
<tr><td>L+</td><td>24 VDC</td><td>M</td><td>M</td></tr>
<tr><td colspan="7">2-wire
 
</td></tr>
</table>

[1] Usable BaseUnit types, can be identified by the last two digits of the article number.

Note

The first BaseUnit of an ET 200SP station must be a light-colored BaseUnit. Also keep this in mind during the configuration.

You will find additional information on the BaseUnit types in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Schematic circuit diagram

Schematic circuit diagram

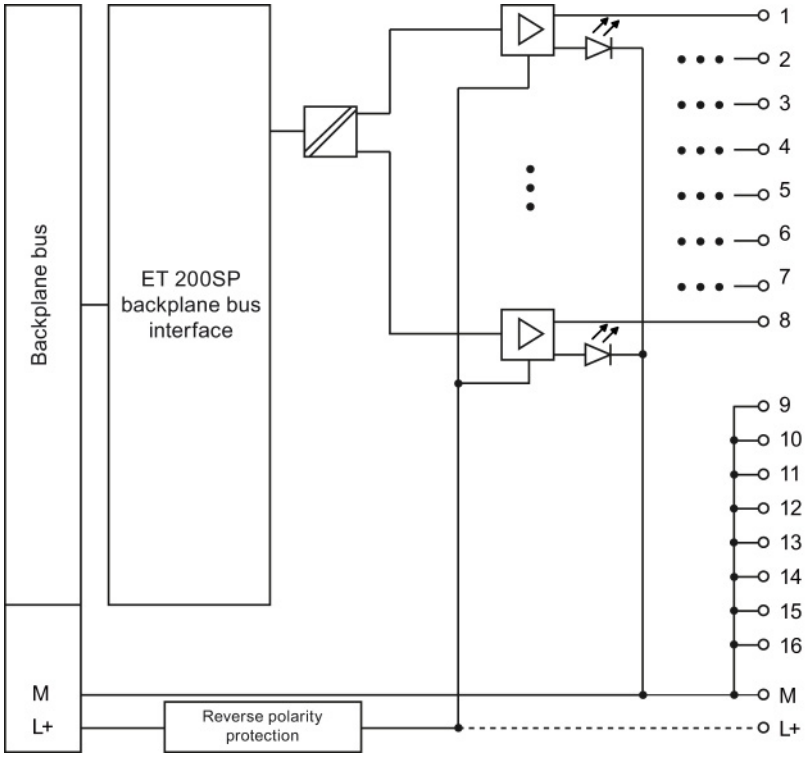


Figure 3-1 Block diagram DQ 8×24VDC/0.5A ST

Parameters/address space

4

4.1 Parameters

Parameters for DQ 8x24VDC/0.5A ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Auto-Hotspot.

The following parameter settings are possible:

Table 4- 1 Settable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Enable • Disable	Disable	yes	Module	Module
Diagnostics Short-circuit to ground	• Enable • Disable	Disable	yes	Module	Module
Diagnostics Short-circuit to L+	• Enable • Disable	Disable	yes	Module	Module
Diagnostics Wire break	• Enable • Disable	Disable	yes	Module	Module
Operating mode	• Channel disabled • Channel enabled	Channel enabled	yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	yes	Channel	Module

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Substitute value	• 0 • 1	0	yes	Channel	Channel
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	no	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 16 bytes.

4.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Diagnostics wire break

Enabling of the diagnostics if the line to the actuator is broken.

Operating mode

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP / substitute value

Specifies the behavior of the module if the CPU changes to STOP.

Potential group

Specifies that a BaseUnit with voltage supply feed-in is located in this slot (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

4.3 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 7 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DQ 8×24VDC/0.5A ST with value status (Quality Information (QI)).
The addresses for the value status are only available if the value status is enabled.

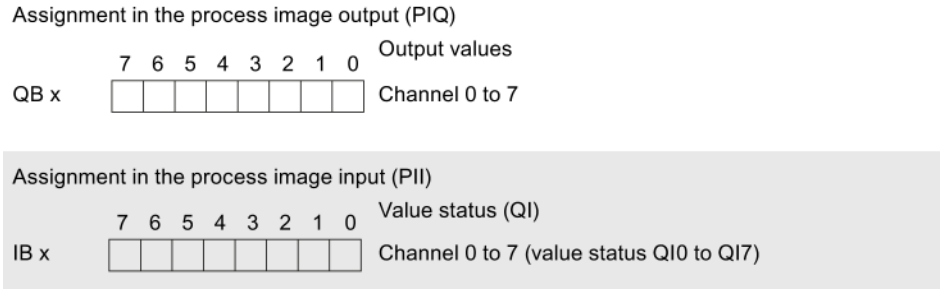


Figure 4-1 Address space of the DQ 8×24VDC/0.5A ST with value status

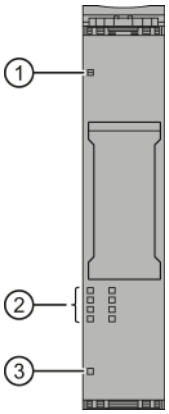
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the DQ 8x24VDC/0.5A ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 19).

DIAG LED

Table 5- 1 DIAG LED fault/error display

DIAG LED	Meaning
off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
on	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
off	Channel deactivated or activated and process signal = 0
on	Channel activated and process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
off	No supply voltage L+
on	Supply voltage L+ present

5.2 Interrupts

The digital output module DQ 8×24VDC/0.5A ST supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit
- Wire break
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update
Short-circuit	1_H	• Short-circuit of actuator supply to ground • Short-circuit of actuator supply to L+	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high.	Use a different actuator type or wire differently, e.g. use cables with a larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of DQ 8×24VDC/0.5A ST

	6ES7132-6BF00-0BA0
Product type designation	DQ 8x24VDC/0.5A ST
General information	
Firmware version	V1.1
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC02
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V11 SP2 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	35 mA; no load
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information

	6ES7132-6BF00-0BA0
Hardware configuration	
Fieldbus connection via separate transceiver	Yes
Digital outputs	
Number of outputs	8
Sourcing output	Yes
Short-circuit protection	
• Response threshold, typ.	0.7 to 1.3 A
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	0.5 A
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ
Output current	
For signal "1" rated value	0.5 A
For signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
"0" to "1", max.	50 µs; with rated load
"1" to "0", max.	100 µs; with rated load
Parallel switching of 2 outputs	
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	2 Hz
With lamp load, max.	10 Hz
Total current of the outputs	
Max. current per module	4 A
Total current of the outputs (per module)	
Horizontal installation	
• up to 60 °C, max.	4 A
Vertical installation	
• up to 50 °C, max.	4 A
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes

	6ES7132-6BF00-0BA0
Diagnostics alarms	
Monitoring of supply voltage	Yes
Wire break	Yes
Short-circuit	Yes
Group error	Yes
Diagnostics display LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic isolation)
Insulation	
Insulation tested with	707 VDC (type test)
Degree of protection and protection class	
IP (rear)	IP20
Standards, approvals, certificates	
Highest safety class achievable in safety mode	
Performance level according to EN ISO 13849-1:2008	d (conditional use of an F-PM-E)
SIL according to IEC 61508:2010	2 (conditional use of an F-PM-E)
Use in hazardous areas	
Explosion protection category for gas	ATEX II 3 G Ex nA IIC T4 Gc
Associated equipment (Ex ia)	No
Associated equipment (Ex ib)	No
Environmental conditions	
Operating temperature	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Residual current for signal state "0"

Note

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current depends on the setting for the Diagnostics: Wire break parameter.

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 contains the diagnostics for the entire module.

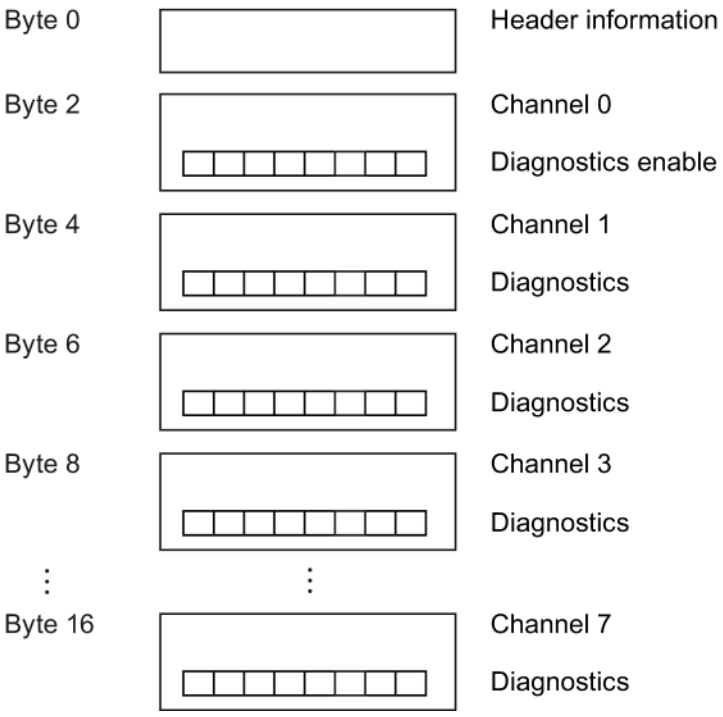


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

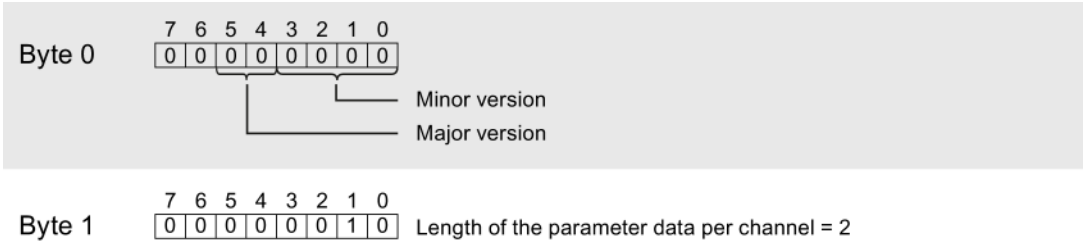


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

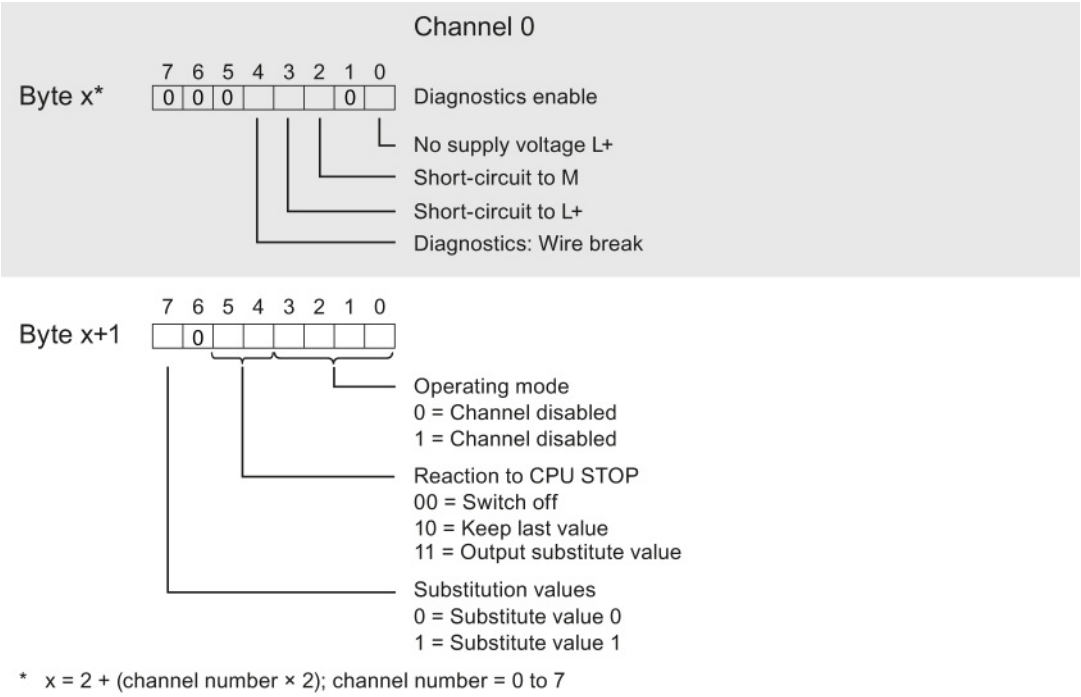
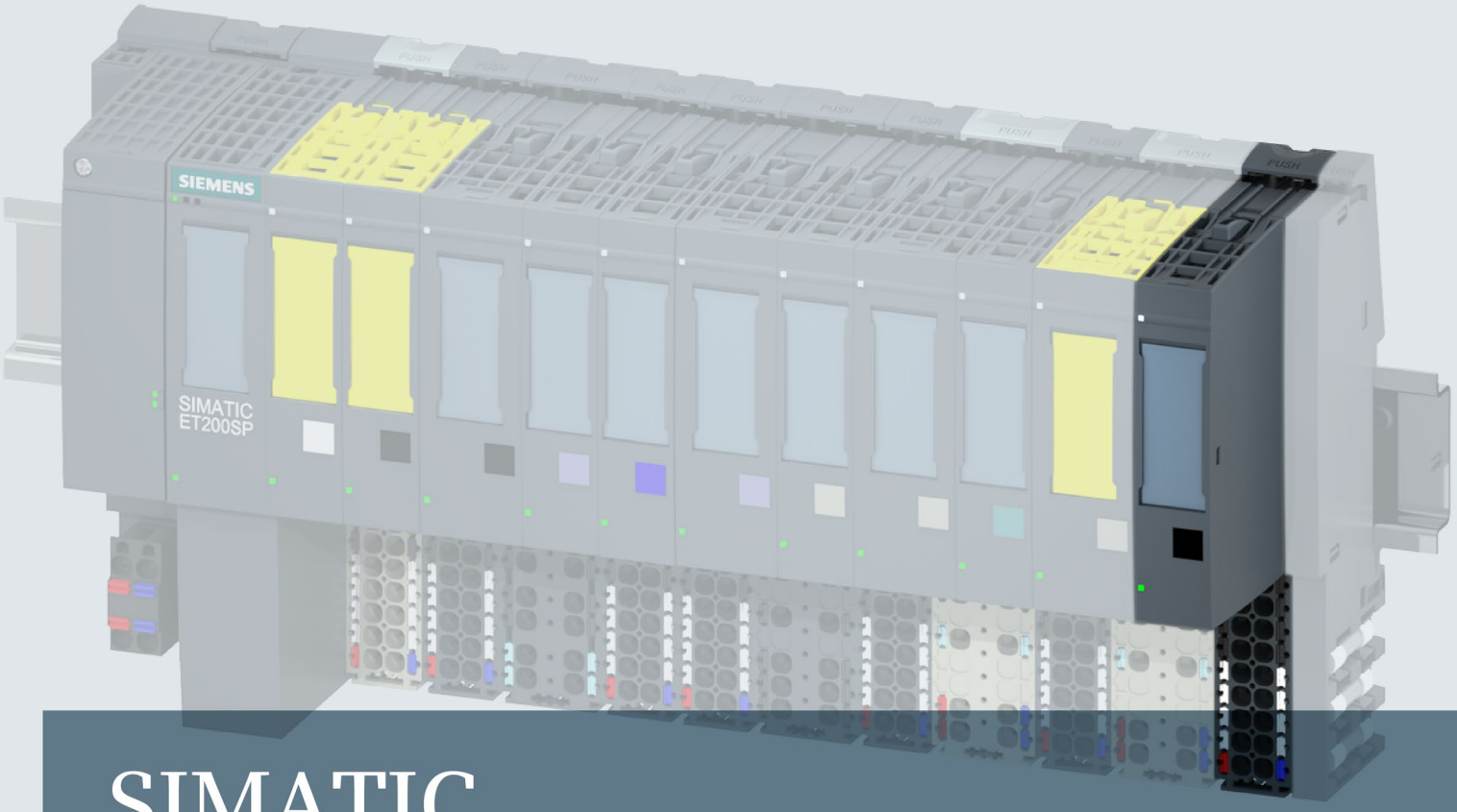


Figure A-3 Structure byte x to x+1 for the channels 0 to 7

SIEMENS



SIMATIC

ET 200SP

Digital output module DQ 8x24VDC/0.5A HF (6ES7132-6BF00-0CA0)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Digital output module
DQ 8x24VDC/0.5A HF
(6ES7132-6BF00-0CA0)

Manual

Preface

Documentation guide 1

Product overview 2

Wiring 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

12/2015

A5E03576680-AD

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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GERMANY

A5E03576680-AD
℗ 12/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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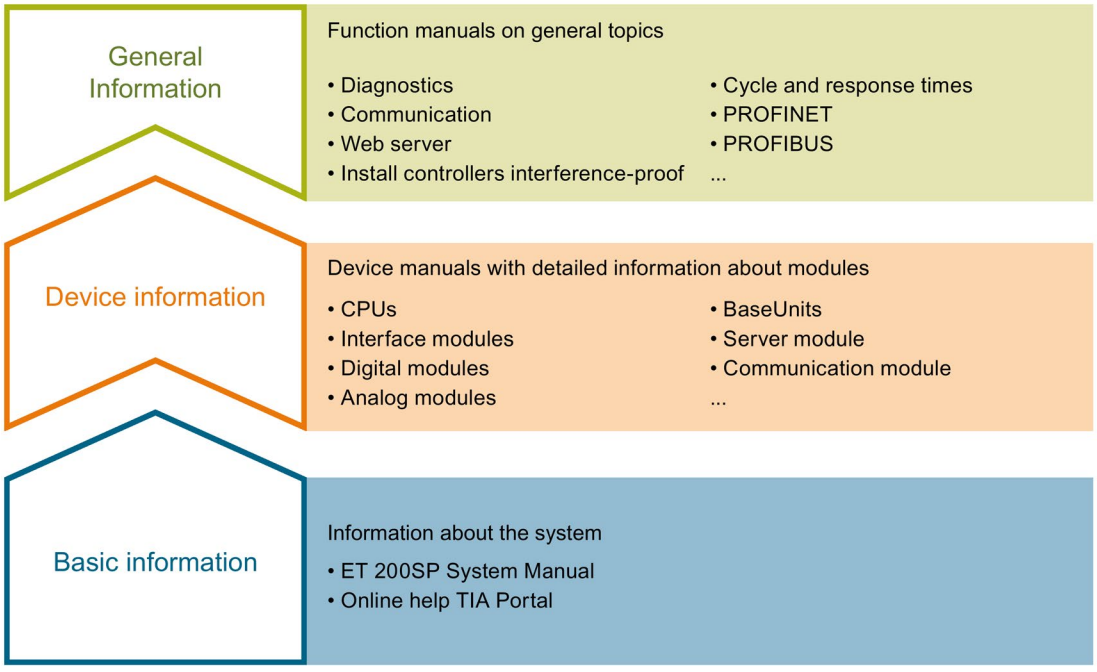
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

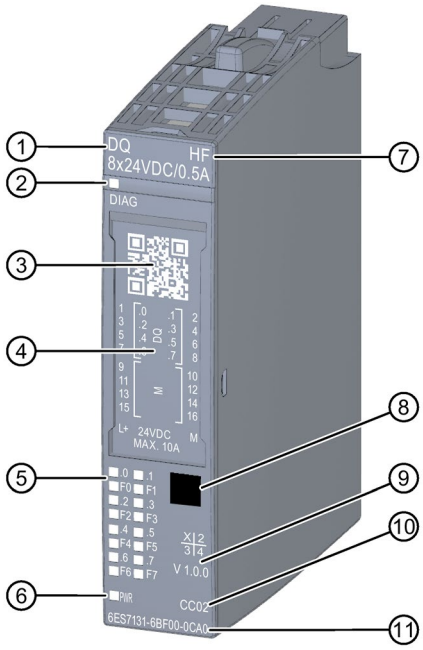
2

2.1 Properties

Article number

6ES7132-6BF00-0CA0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module DQ 8×24VDC/0,5A HF

Properties

The module has the following technical properties:

- Digital output module with 8 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 0.5 A (per channel)
- Configurable diagnostics (per channel)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0
Isochronous mode	1	V1.1.0
Module-internal Shared Output (MSO)	1	V1.2.0
Configurable submodules/ submodules for Shared Device	1	V2.0.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/91696622).

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 8x24VDC/0.5A HF module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnit in the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Note

- The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

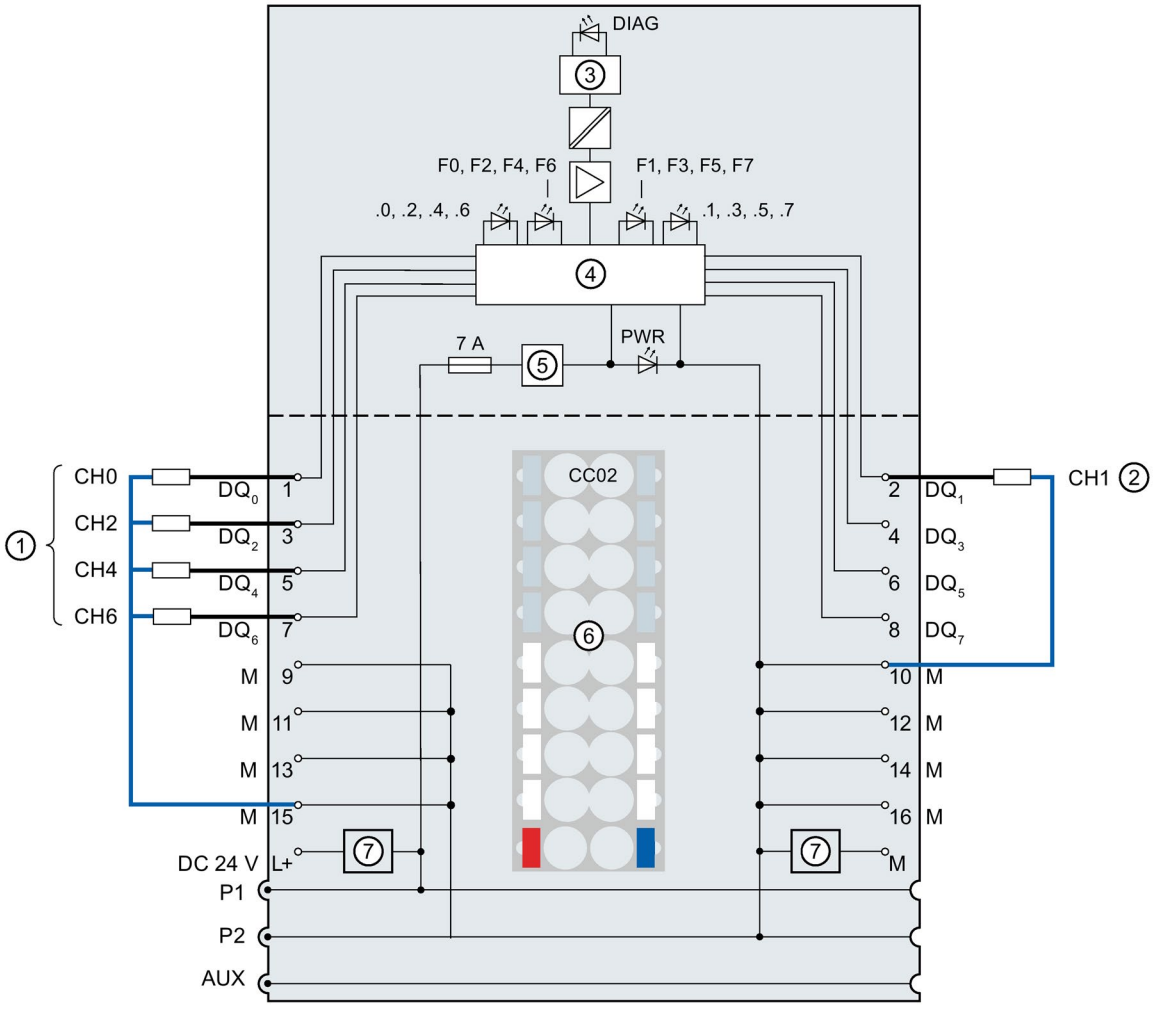
Note

Cross circuit at output

Be aware that voltage from a cross-circuit at the output can feed L+ to modules.

Wiring: 1 and 2-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A HF on the BaseUnit BU type A0 without AUX terminals (1- and 2-wire connection).

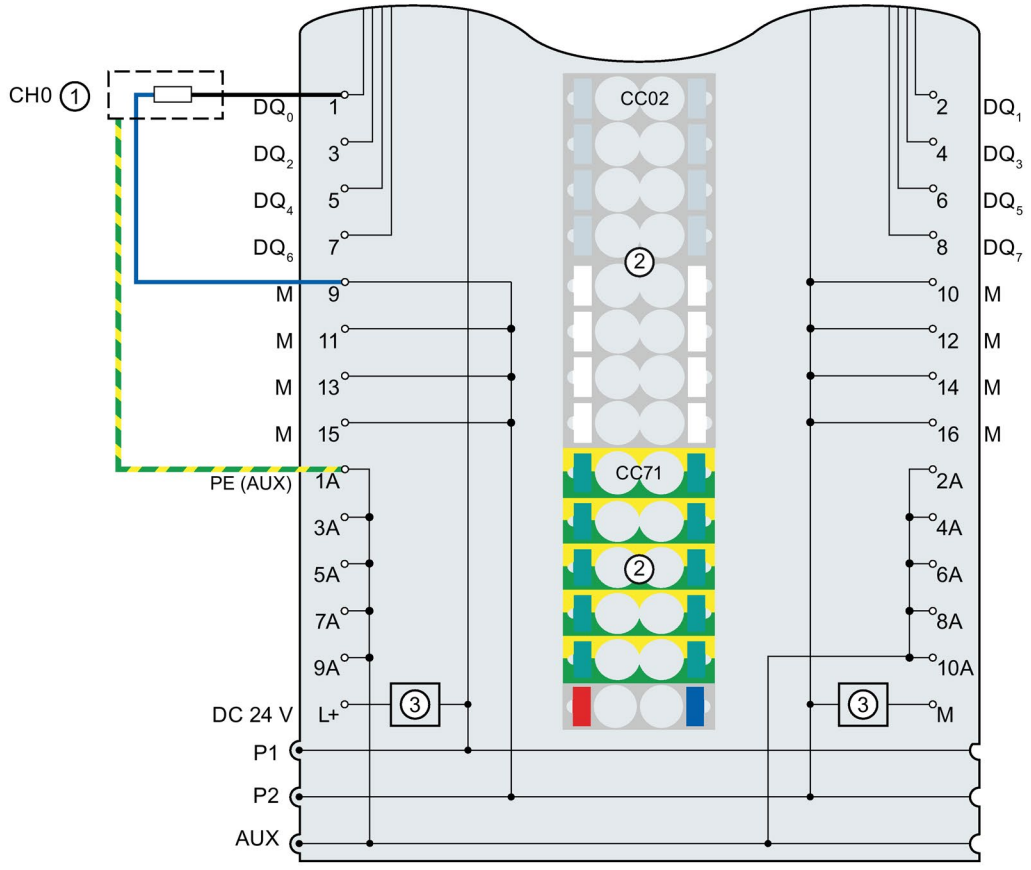


①	1-wire connection	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
②	2-wire connection	M	Ground
③	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Output electronics	DQ_n	Output signal, channel n
⑤	Polarity reversal protection	DIAG	Error or diagnostics LED (green, red)
⑥	Color-coded label with color code CC02 (optional)	.0 to .7	Channel status LED (green)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0 to F7	Channel fault LED (red)
		PWR	Power LED (green)

Image 3-1 Block diagram and terminal assignment for 1- and 2-wire connection of actuators

Wiring: 3-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A HF on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection	1 A to 10 A	AUX terminals
②	Color-coded labels with color codes CC02 and CC71 (optional)	PE (AUX)	Protective conductor connection
③	Filter connection supply voltage (only when light-colored BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
DQ_n	Output signal, channel n	M	Ground
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Image 3-2 Terminal assignment for 3-wire connection of actuators

Parameters/address space

4

4.1 Parameters

GSD file parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 32)).

Table 4- 1 Parameters for DQ 8x24VDC/0.5A HF (GSD file)

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to L	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Reaction to CPU STOP [1]	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP. The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign these parameters using data records 64 to 71 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 7 bytes.

Note

If one of the two parameters "Diagnostics: Short-circuit to L+" or "Diagnostics: Wire break" is enabled and one of these diagnostics occurs, the affected channel is switched off to avoid triggering an undefined load. Note that a diagnostic interrupt can only be generated when diagnostics are enabled. [1]

[1] as of module revision 05

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

See system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 8x24VDC/0.5A HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x24VDC/0.5A HF V1.0	X	X	X
1 x 8-channel without value status	DQ 8x24VDC/0.5A HF V1.1	X	X	X
1 x 8-channel with value status	DQ 8x24VDC/0.5A HF V1.1, QI	X	X	---
1 x 8-channel without value status	DQ 8x24VDC/0.5A HF V1.2	X	X	X
1 x 8-channel with value status	DQ 8x24VDC/0.5A HF V1.2, QI	X	X	---
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x24VDC/0.5A HF V1.2, MSO	X	X	---
1 x 8-channel without value status	DQ 8x24VDC/0.5A HF V2.0	---	X	X
1 x 8-channel with value status	DQ 8x24VDC/0.5A HF V2.0, QI	---	X	---
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x24VDC/0.5A HF V2.0, MSO	---	X	---
2 x 4-channel without value status	DQ 8x24VDC/0.5A HF V2.0, S.2	---	X	---
2 x 4-channel with value status	DQ 8x24VDC/0.5A HF V2.0, S.2 QI	---	X	---
4 x 2-channel without value status	DQ 8x24VDC/0.5A HF V2.0, S.4	---	X	---
4 x 2-channel with value status	DQ 8x24VDC/0.5A HF V2.0, S.4 QI	---	X	---

Note

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

2 x 4- / 4 x 2-channel configuration

For the configuration, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a Shared Device.

The number of usable submodules is dependent on the interface module used. Read the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DQ 8x24VDC/0.5A HF QI
- DQ 8x24VDC/0.5A HF MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF

The figure below shows the address space assignment for configuration as a 1 x 8-channel module without value status

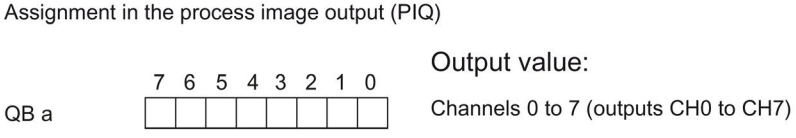


Image 4-1 Address space for configuration as 8-channel DQ 8x24VDC/0.5A HF, QI without value status

Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF, QI

The following figure shows the assignment of the address space for the configuration as 1 x 8-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

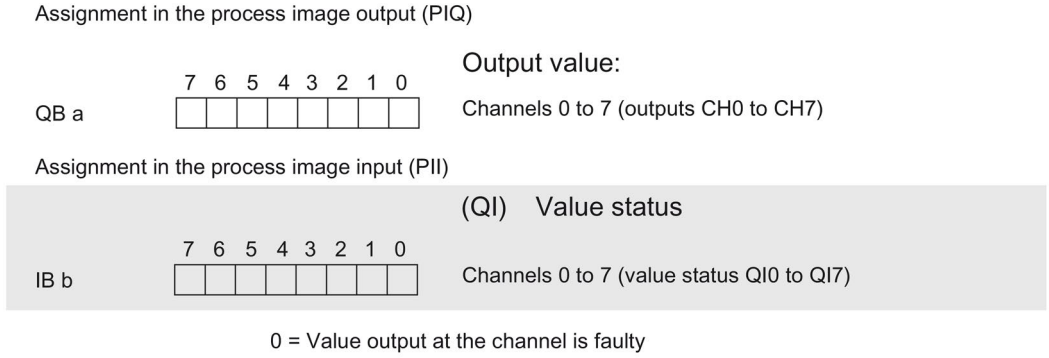


Image 4-2 Address space for configuration as 8-channel DQ 8x24VDC/0.5A HF, QI with value status

Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF, MSO

For the configuration as a 1 x 8-channel module (module-internal Shared Output, MSO), channels 0 to 7 of the module are copied to up to four submodules. Channels 0 to 7 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 7.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 7.

Value status (Quality Information,QI)

The meaning of the value status depends on the submodule on which it occurs.

For the 1st submodule (=basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status.

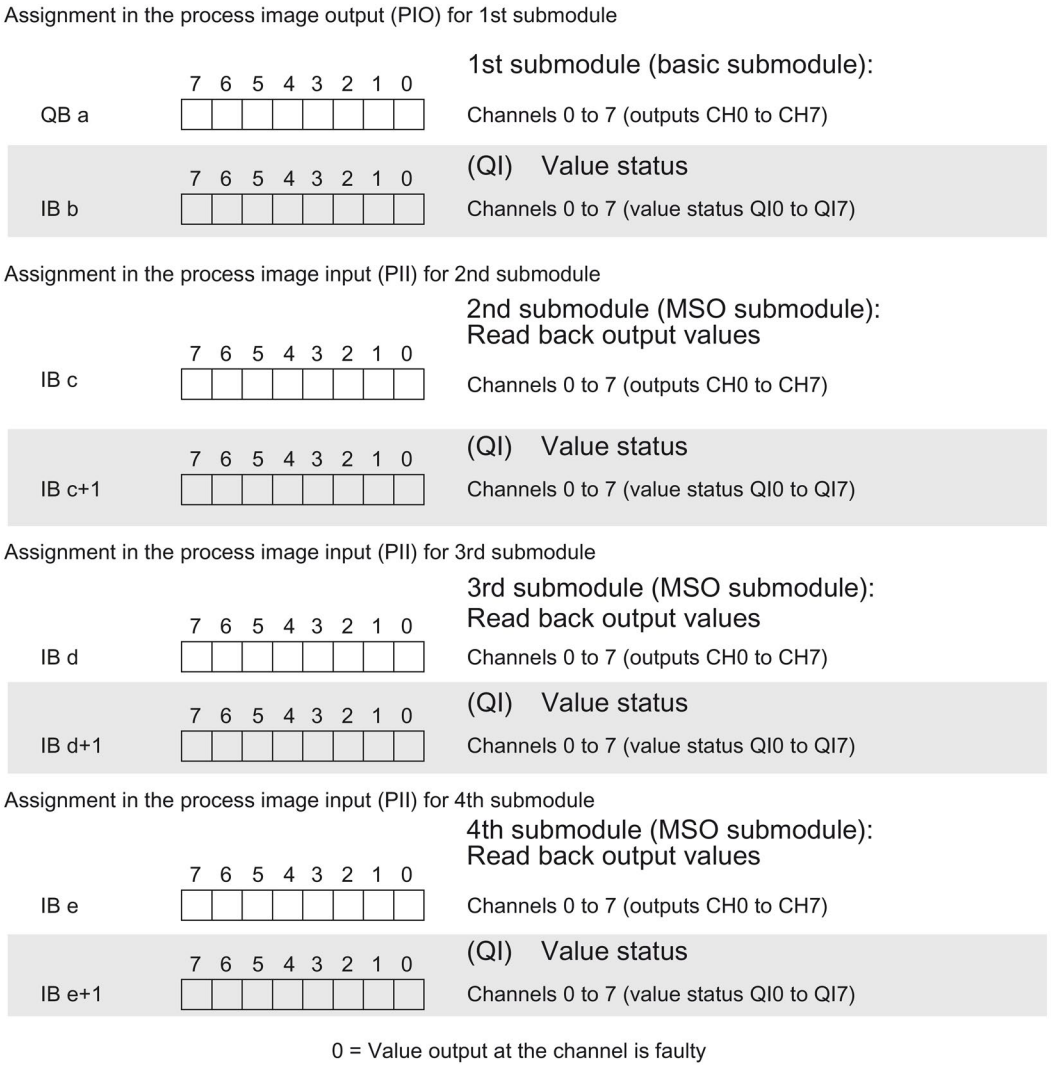


Image 4-3 Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF MSO with value status

Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V2.0, S.2

The figure below shows the address space assignment for configuration as a 2 x 4-channel module without value status.

Each of the two submodules has a freely assignable start address.

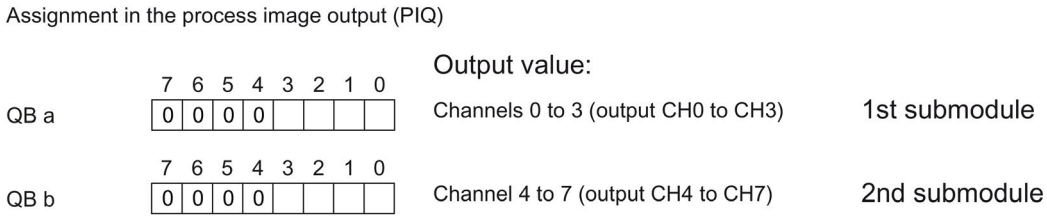


Image 4-4 Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V2.0, S.2 without value status

Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V2.0, S.2 QI

The figure below shows the address space assignment for configuration as a 2 x 4-channel module with value status.

Each of the two submodules has a freely assignable start address.

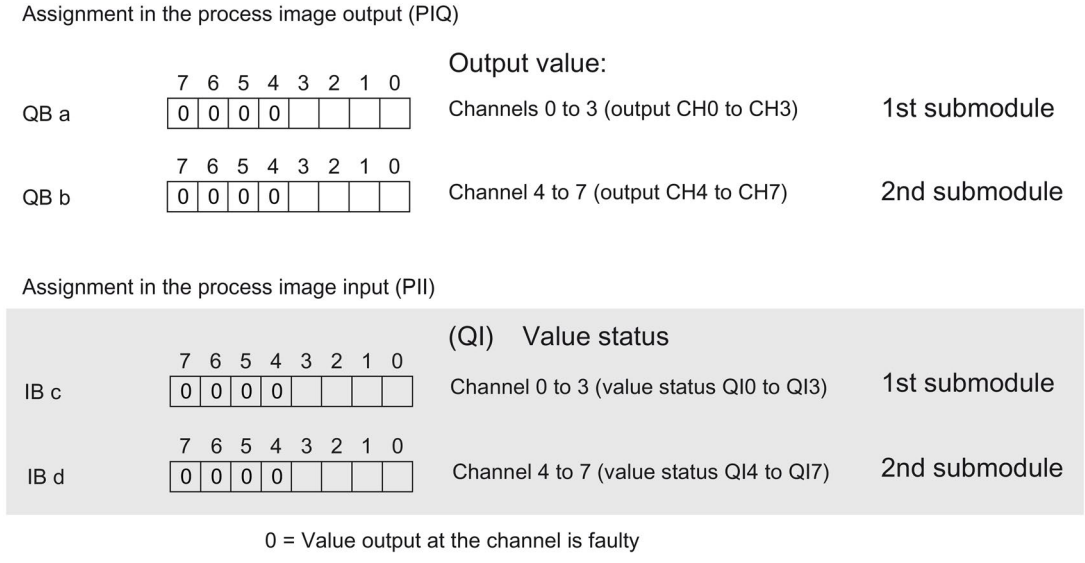


Image 4-5 Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V2.0, S.2 QI with value status

Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V2.0, S.4

The figure below shows the address space assignment for configuration as a 4 x 2-channel module without value status.

Each of the four submodules has a freely assignable start address.

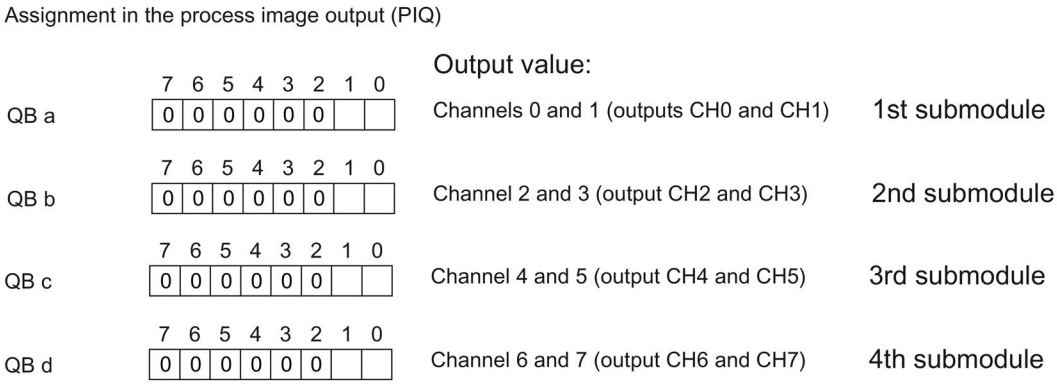


Image 4-6 Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V2.0, S.4 without value status

Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V2.0, S.4 QI

The figure below shows the address space assignment for configuration as a 4 x 2-channel module with value status.

Each of the four submodules has a freely assignable start address.

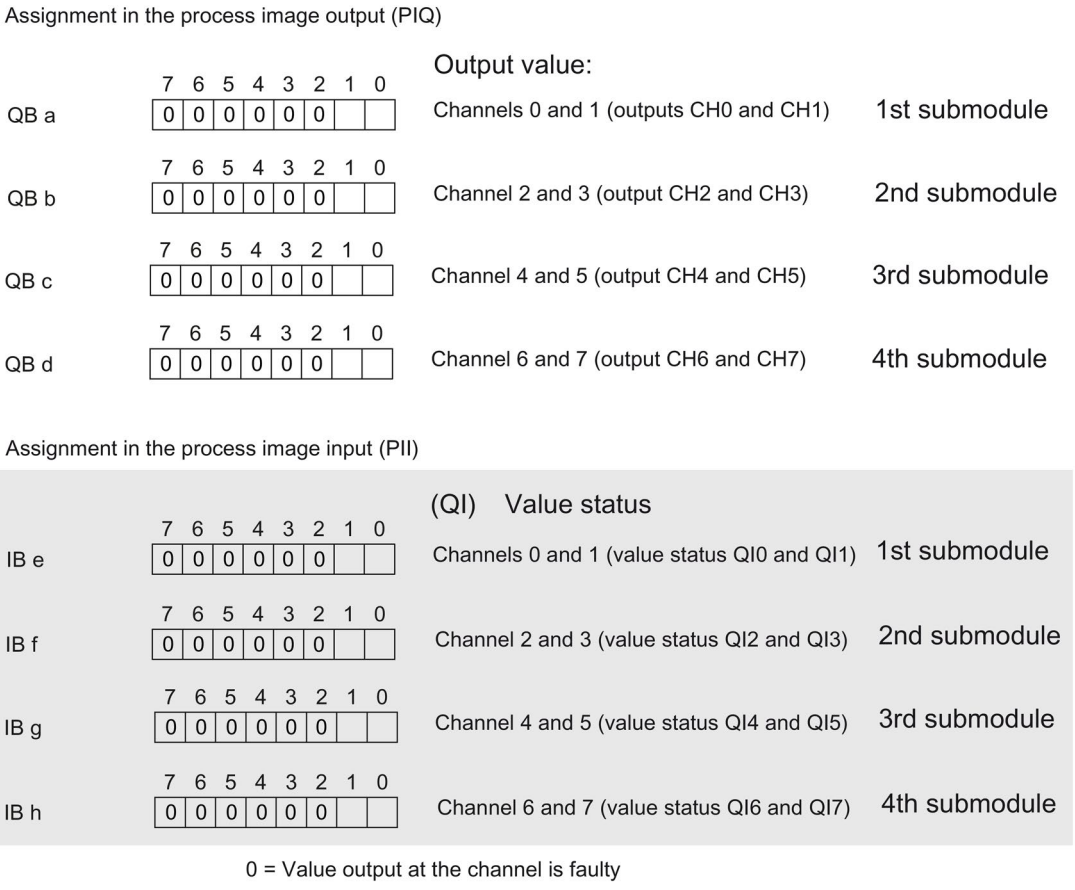


Image 4-7 Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V2.0, S.4 QI with value status

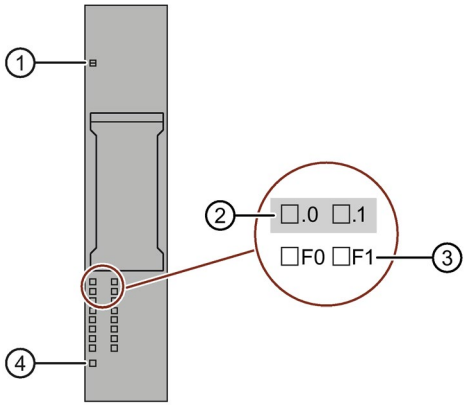
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DQ 8x24VDC/0.5A HF:



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Image 5-1 LED displays

Meaning of the LEDs

The tables below explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 26).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ On	Module parameters assigned and no module/channel diagnostics
☼ Flashes	Module parameters assigned and module/channel diagnostics

LED channel status/channel error

Table 5- 2 Status / error display of the LED channel status / channel error

LED channel status	LED channel error	Meaning
☐ Off	☐ Off	Channel deactivated or process signal = 0 and no channel diagnostics
■ On	☐ Off	Channel activated and process signal = 1 and no channel diagnostics
☐ Off	■ On	Channel activated and channel diagnostics

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
☐ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The DQ 8×24VDC/0.5A HF digital output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Note

Parallel connection of two outputs

For parallel connection of two outputs for redundant control of a load, the channel diagnostics "Short-circuit to L+" and "Wire break" must be deactivated.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	• Short-circuit of actuator supply to ground [1] • Short-circuit of actuator supply to L+ [2]	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, for example, use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

[1] only in switched state (output value 1)

[2] only in non-switched state (output value 0)

Note

In case of a short-circuit of the actuator supply to L+ at the activated channel, load distributions can occur which result in wire break diagnostics.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 8×24VDC/0.5A HF

	6ES7132-6BF00-0CA0
General information	
Product type designation	ET 200SP, DQ 8x24VDC/0,5A HF, PU 1
Firmware version	V2.0
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC02
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 / -
STEP 7 can be configured/integrated as of version	V5.5 / -
PCS 7 can be configured/integrated as of version	V8.1 SP1
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W

	6ES7132-6BF00-0CA0
Address area	
Address space per module	
Address space per module, max.	8 bytes; 2 channels per submodule + QI information
Digital outputs	
Number of outputs	8
Sinking output	No
Sourcing output	Yes
Short-circuit protection	
• Response threshold, typ.	0.7 to 1.3 A
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	0.5 A
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ
Output current	
For signal "1" rated value	0.5 A
For signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
"0" to "1", typ.	50 µs
"1" to "0", typ.	100 µs
Parallel connection of two outputs	
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	2 Hz
With lamp load, max.	10 Hz
Total current of the outputs	
Current per channel, max.	0.5 A
Current per module, max.	4 A
Total current of the outputs (per module)	
Horizontal installation	
• Up to 60 °C, max.	4 A
Vertical installation	
• Up to 50 °C, max.	4 A
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m

	6ES7132-6BF00-0CA0
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	48 µs
Bus cycle time (TDP), min.	500 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	Yes; channel-based
Short-circuit	Yes; channel-based
Group error	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	30 g

Safety-related shutdown

Note

The digital output module DQ 8x24VDC/0.5A HF supports safety-related shutdown in connection with a fail-safe power module F-PM-E 24VDC/8A PPM ST:

- SIL according to IEC 61508: 2
- Highest attainable safety class in safety mode, performance level according to EN ISO 13849-1: d

Residual current for signal state "0"

Note

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current does not depend on the setting for the Diagnostics: Wire break parameter.

Dimension drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

With data records 64 to 71, you can configure individual channels.

Parameter assignment in the user program

You can reassign the module parameters in RUN (e.g. "Switch on diagnostics" can be changed in RUN).

Changing parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128 or data records 64 to 71. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Data record structure

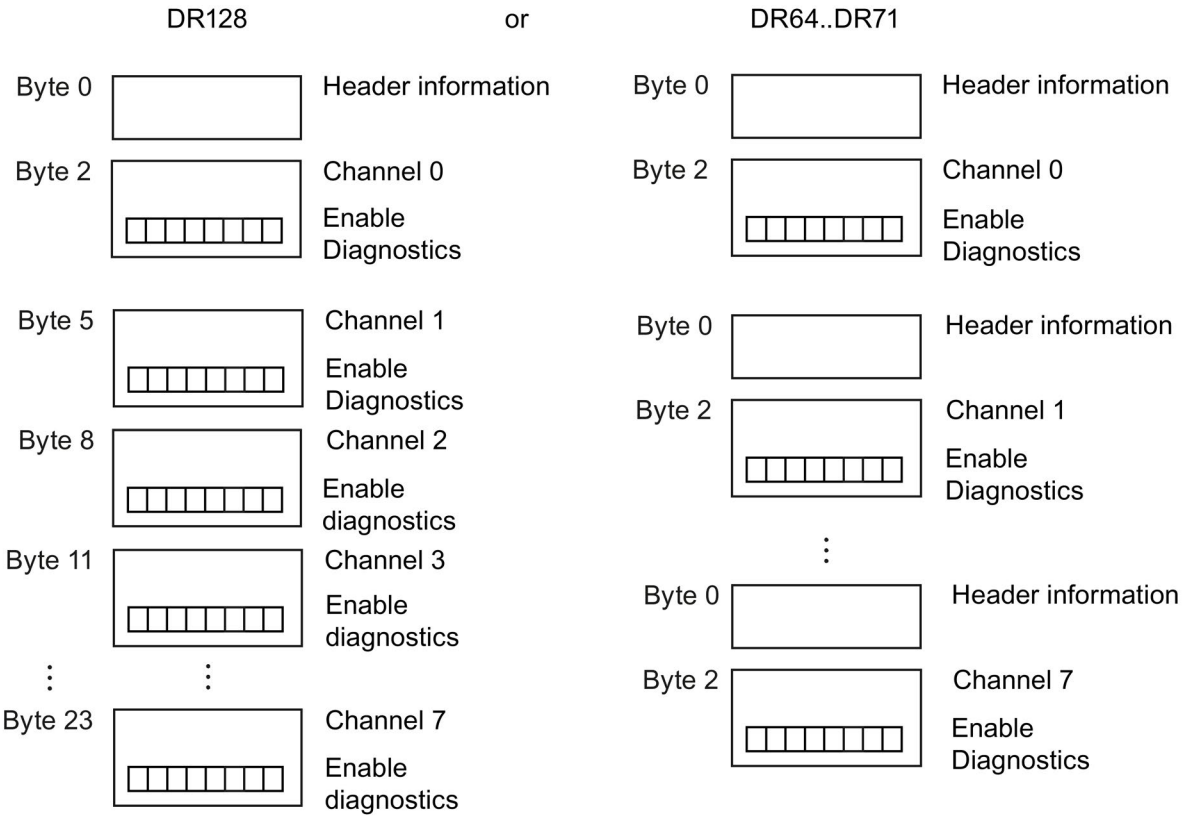


Image A-1 Structure of data record 128 or data records 64 to 71

Header information

The figure below shows the structure of the header information.

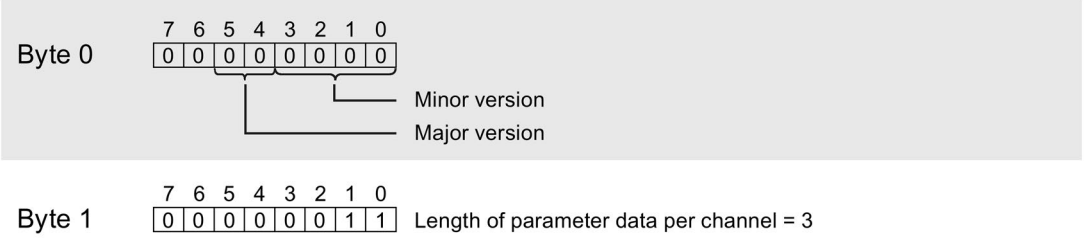
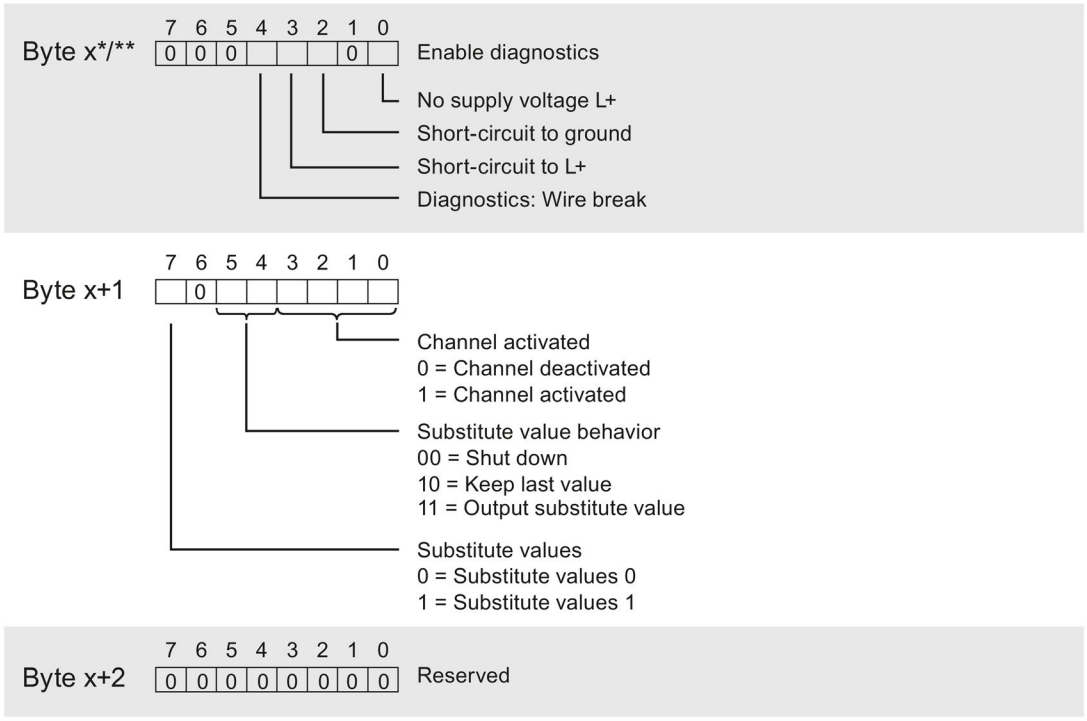


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 3); channel number = 0 to 7 for DR 128
** x =2 for DR 64 to DR 71

Image A-3 Structure of byte x to x+2 for channels 0 to 7

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

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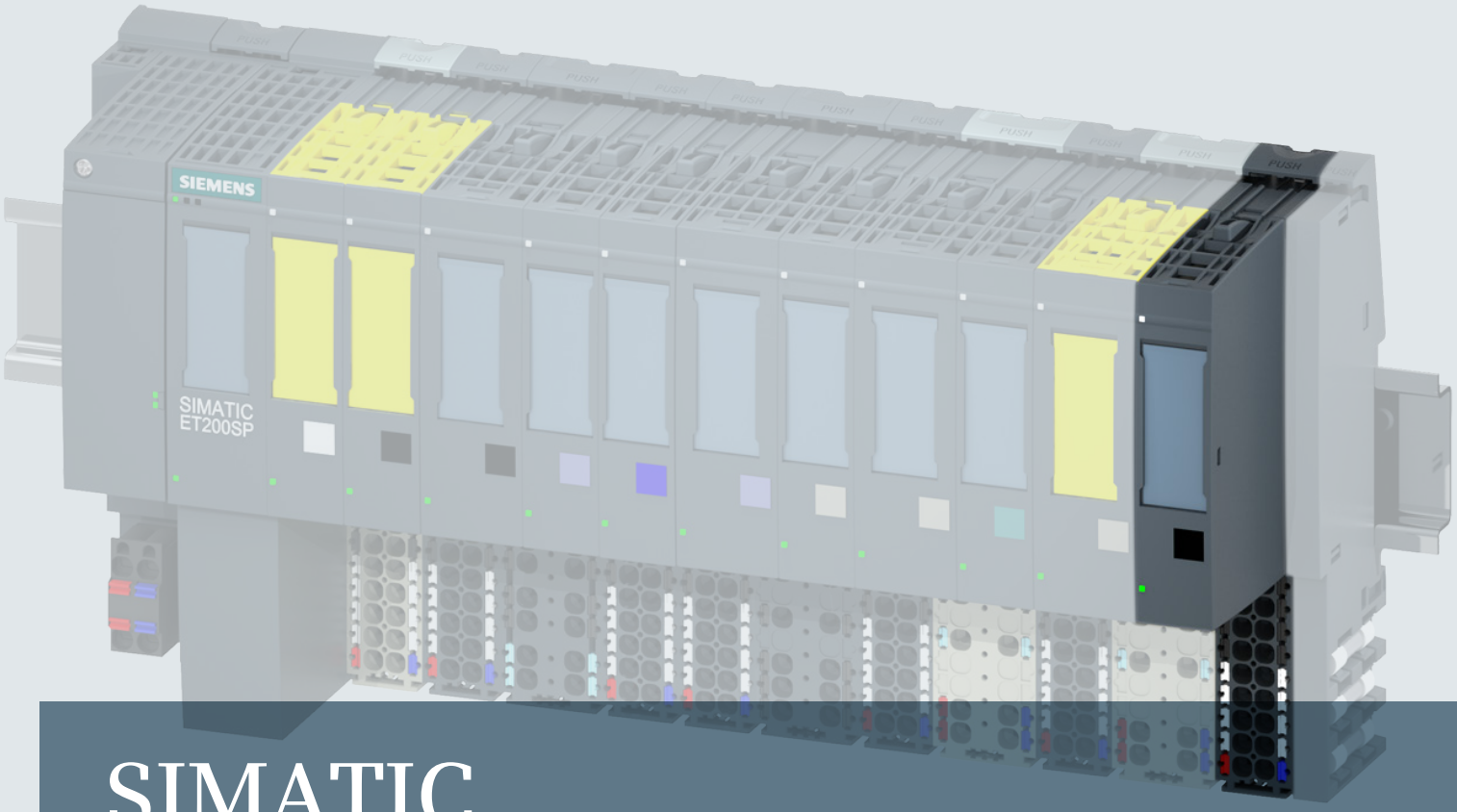

SIMATIC

ET 200SP

Digital output module DQ 8x24VDC/0,5A SNK BA (6ES7132-6BF60-0AA0)

Manual

Edition 02/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
DQ 8x24VDC/0,5A SNK BA digital output module (6ES7132-6BF60-0AA0)

Manual

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Parameters/address space 4

Interrupts/diagnostics alarms 5

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Parameter data record A

02/2014

A5E32855878-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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Note the following:

⚠WARNING

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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A5E32855878-AA
℗ 02/2014 Technical data subject to change

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of the system manual, function manuals and device manuals.

The STEP 7 information system (online help) also helps you to configure and program your automation system.

Overview of the documentation for digital output module DQ 8×24VDC/0,5A SNK BA

The table below lists additional documentation that you will need when using the DQ 8×24VDC/0,5A SNK BA digital output module.

Table 1- 1 Documentation for digital output module DQ 8×24VDC/0,5A SNK BA

Topic	Documentation	Most important contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Enhancements and special features of the ET 200SP Distributed I/O System	Product information Amendments to ET 200SP documentation (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All of the current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Part number

6ES7132-6BF60-0AA0

View of the module

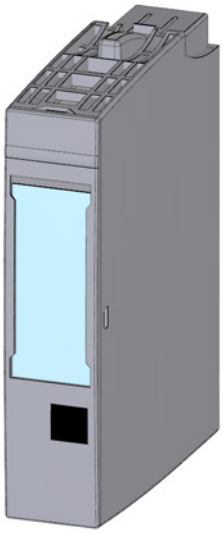


Figure 2-1 View of the DQ 8×24VDC/0,5A SNK BA module

Properties

The module has the following technical properties:

- 8 digital outputs
- Sink output (NPN, M switching)
- Supply voltage L+
- Output current 0.5 A (per channel)
- Configurable diagnostics (per module)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

- Firmware update
- Identification data I&M0 to I&M3
- Parameter assignment in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

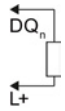
3

3.1 Pin assignment

General pin assignment

The following table shows the pin assignment for DQ 8×24VDC/0,5A SNK BA.

Table 3- 1 Pin assignment for DQ 8×24VDC/0,5A SNK BA

Pin assignment for DQ 8×24VDC/0,5A SNK BA (6ES7132-6BF00-0BA0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DQ_0	**2**	DQ_1	• DQ_n: Output signal, channel n • L+: Actuator supply	A0	 CC01 6ES7193-6CP01-2MA0
3	DQ_2	**4**	DQ_3			
5	DQ_4	**6**	DQ_5			
7	DQ_6	**8**	DQ_7			
9	L+	**10**	L+			
11	L+	**12**	L+			
13	L+	**14**	L+			
15	L+	**16**	L+			
L+	24 V DC	**M**	M			
2-wire 						

[1] BaseUnit types that can be used are identified by the last two digits of the part number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of an ET 200SP station must be a light-colored BaseUnit. Keep this in mind also during the configuration.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

The figure below shows the block diagram of the DQ 8x24VDC/0,5A SNK BA.

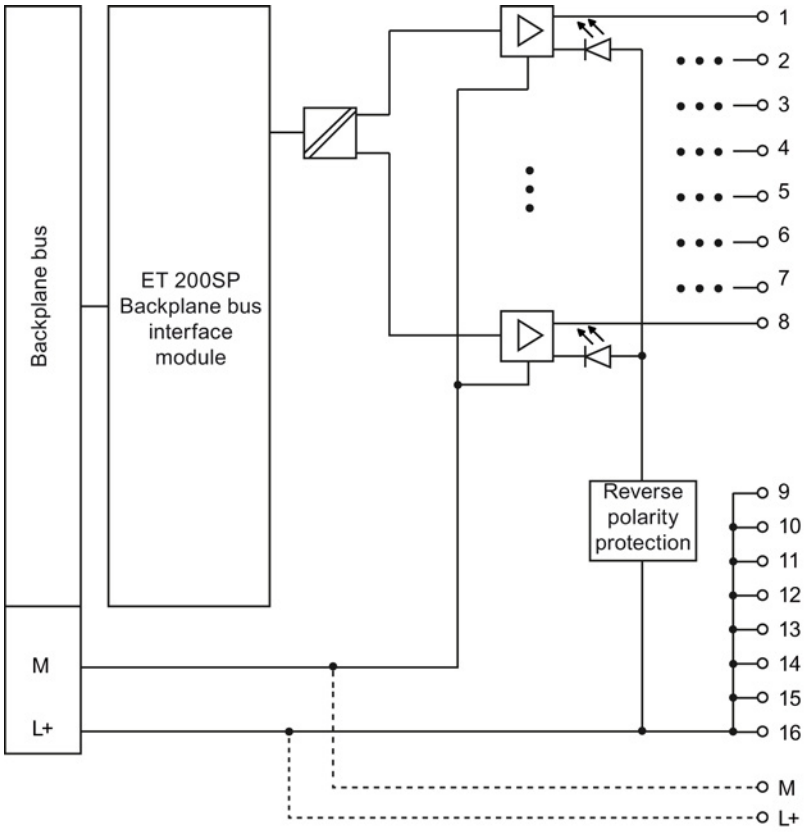


Figure 3-1 Block diagram DQ 8×24VDC/0,5A SNK BA

Parameters/address space

4

4.1 Parameters

DQ 8x24VDC/0,5A SNK BA parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 18)).

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module (reaction) Channel (substitute value)
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP. The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 4 bytes.

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Operating mode

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

Specifies whether a BaseUnit with incoming voltage supply is located on this slot.

Principle

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Address space of the digital output module DQ 8×24VDC/0,5A SNK BA

The figure below shows the assignment of the address space for DQ 8×24VDC/0,5A SNK BA.

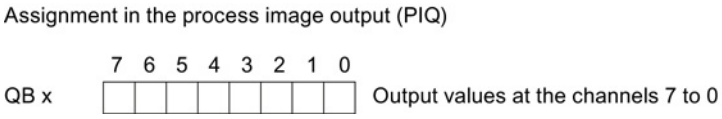


Figure 4-1 Address space of the digital output module DQ 8×24VDC/0,5A SNK BA

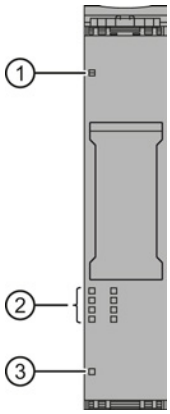
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DQ 8x24VDC/0,5A SNK BA.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED displays

Meaning of the LED displays

The tables below explain the meaning of the Status and error displays. Remedial measures for diagnostics alarms can be found in section Diagnostics alarms (Page 14).

LED DIAG

Table 5- 1 Error display of the LED DIAG

LED DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

LED channel status

Table 5- 2 Status display of the LED channel status

LED channel status	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated and process signal = 1

LED PWR

Table 5- 3 Status display of the LED PWR

LED PWR	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The DQ 8×24VDC/0,5A SNK BA digital output module supports diagnostics alarms.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following event:

- No supply voltage

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the LED DIAG flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 8×24VDC/0,5A SNK BA

	6ES7132-6BF60-0AA0
Product type designation	DQ 8x24VDC/0,5A SNK BA
General information	
Usable BaseUnits	BU type A0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Operating mode	
Multi-output	No
Oversampling	No
MSI	No
MSO	No
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	1 bytes
Output	1 bytes

	6ES7132-6BF60-0AA0
Digital outputs	
Number of outputs	8
Switching to M potential	Yes
Short-circuit protection	Yes
• Response threshold, typ.	1.5 A
Wire-break detection	No
Limitation of inductive shutdown voltage to	Typ. 47V
Controlling a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	0.5 A
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	3400 Ω
Output current	
for signal "1" rated value	0.5 A
for signal "0" residual current, max.	5 µA
Output delay with resistive load	
"0" to "1", max.	300 µs
"1" to "0", max.	600 µs
Parallel switching of 2 outputs	
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	0.5 Hz
With lamp load, max.	10 Hz
Total current of the outputs	
Max. current per channel	0.5 A
Max. current per module	4 A
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green LED PWR
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red LED DIAG

	6ES7132-6BF60-0AA0
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Permissible potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	30 g

Dimensional drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You have the option to re-configure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics for the entire module.

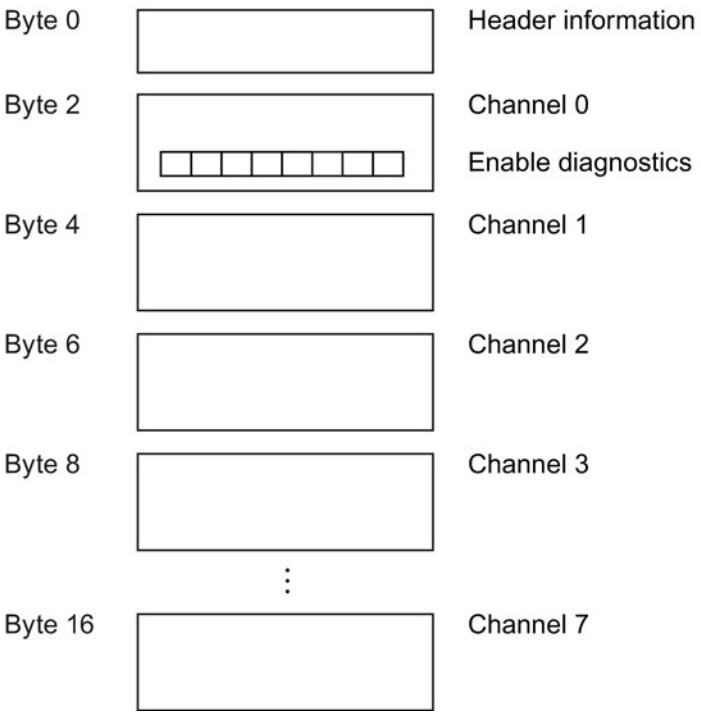


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

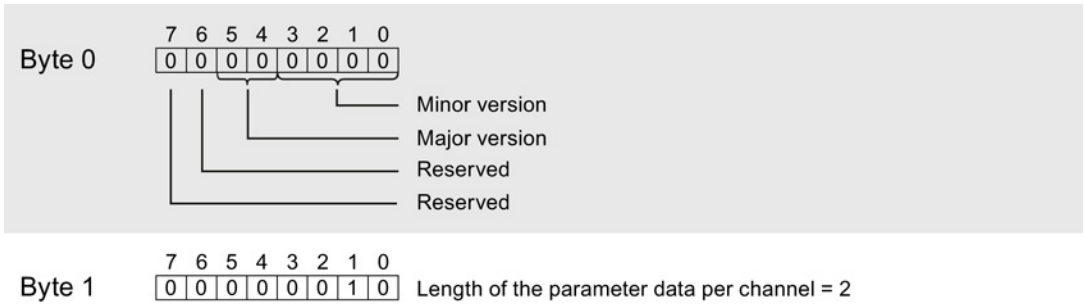


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".

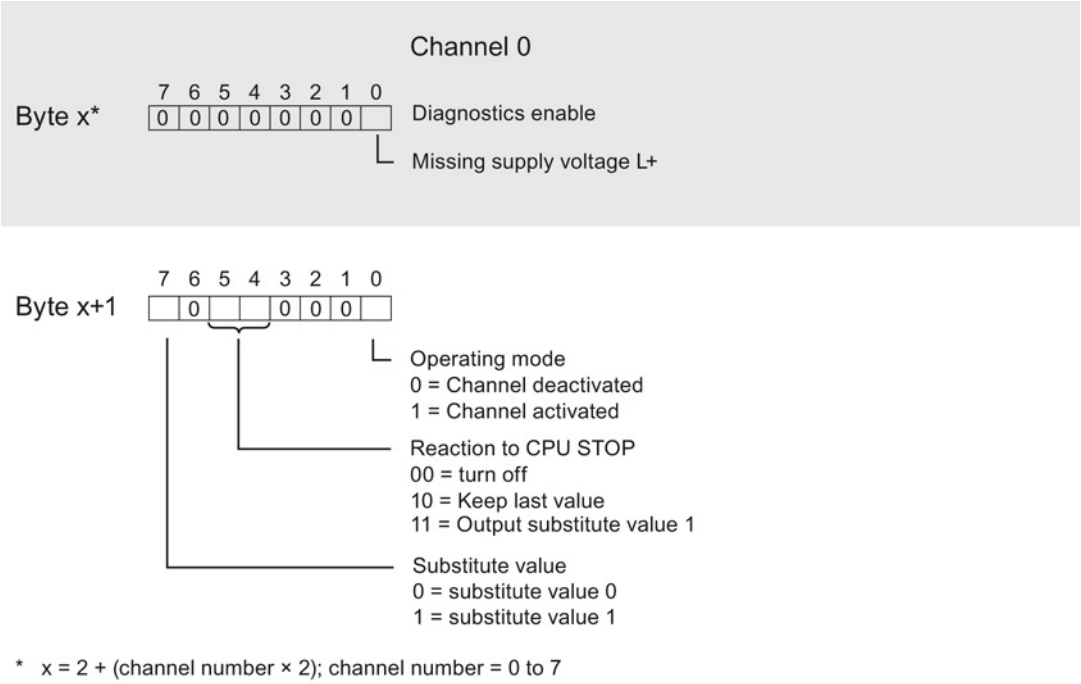


Figure A-3 Structure byte x to x+1 for the channels 0 to 7

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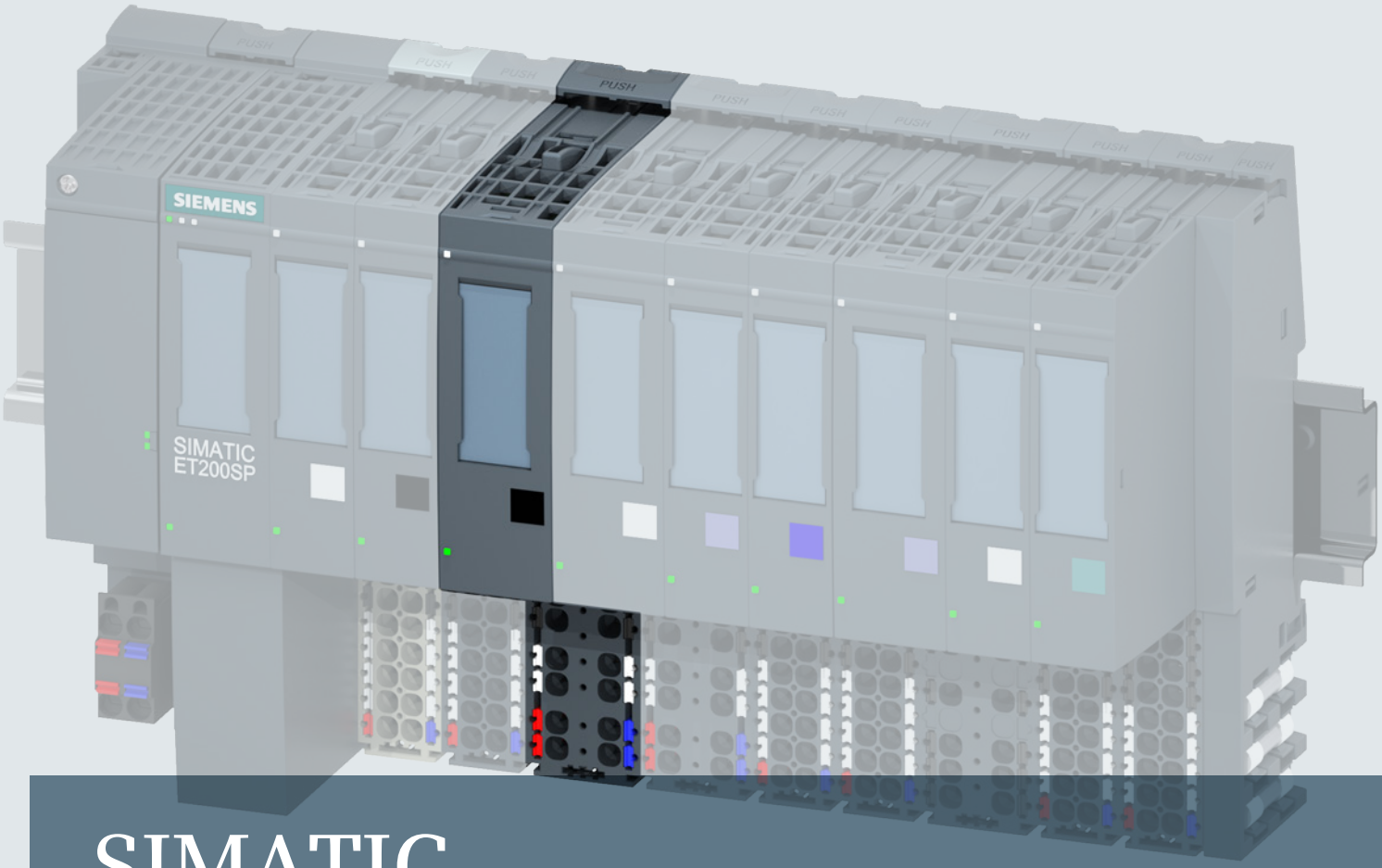

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ET 200SP

Digital output module DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)

Manual

Edition 02/2014

Answers for industry.

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ET 200SP
DQ 4x24..230VAC/2A ST digital output module (6ES7132-6FD00-0BB1)

Manual

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02/2014

A5E32043575-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 02/2014 Technical data subject to change

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Preface

Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Guide to documentation

1

Introduction

The documentation for the SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of a system manual, function manuals and product manuals.

The STEP 7 information system (online help) also helps you to configure and program your automation system.

Overview of the documentation for digital output module DQ 4×24..230VAC/2A ST

The table below lists additional documentation that you will need when using the DQ 4×24..230VAC/2A ST digital output module.

Table 1- 1 Documentation for digital output module DQ 4×24..230VAC/2A ST

Topic	Documentation	Key content
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
System diagnostics	Function manual Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Amendments and special features of the ET 200SP I/O system	ET 200SP Product information (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All of the current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Order number

6ES7132-6FD00-0BB1

View of the module

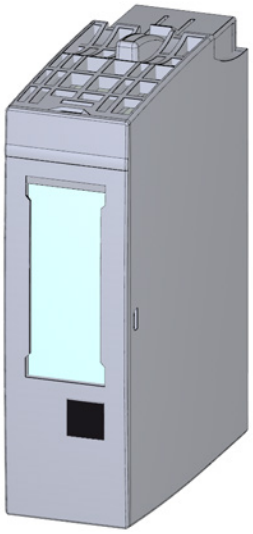


Figure 2-1 View of the DQ 4×24..230VAC/2A ST module

Properties

The module has the following technical properties:

- 4 digital outputs each with a value status (quality information)
- Supply voltage L+
- Switches in zero point
- Output current 2 A per channel
- Total current 8 A (per module)
- Assignable substitute values (per channel)
- Substitute values (per channel)
- Suitable for solenoid valves, AC contactors, and indicator lights

The module supports the following functions:

- Firmware update
- Identification data I&M0 to I&M3
- Configuration in RUN
- PROFIenergy

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label

You can find additional information on the accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Terminal assignment

General pin assignment

NOTICE
Dangerous voltage. Risk of death or serious injury.
Prior to working on the system and module, always disconnect them from the power supply.

Note

Limiting overvoltage

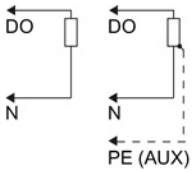
You must ensure overvoltage is limited to 1 kV for the encoder supply.

Note

Power limitation

To limit power, each input voltage must have a fuse with a maximum rating of 10 A tripping current. The fuse must be a quick-acting microfuse.

Table 3- 1 Pin assignment for DQ 4×24..230VAC/2A ST

Pin assignment for DQ 4×24..230VAC/2A ST (6ES7132-6FD00-0BB1)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 12)**
1	DQ_0	**2**	DQ_1	• DQn: Output signal, channel n • L1: Encoder supply 24 to 230 V AC[2, 3] • N: Neutral [2]	B1	 CC41 6ES7193-6CP41-2MB0
3	DQ_2	**4**	DQ_3			
5	L1	**6**	L1			
7	L1	**8**	L1			
9	N	**10**	N			
11	N	**12**	N			
1L	24...230 V AC	**1N**	N			
2L	24...230 V AC	**2N**	N			
Connection examples 						

1 BaseUnit types that can be used are identified by the last two digits of the order number. See also "ET 200SP distributed I/O system" system manual.

2 L1, N: Supply terminals for the I/O module on this BU only

3 max. load current: max. permitted module current, depending on temperature derating, minus the total output current in the application

No pin for

The digital output is not suitable for alternating current loads.

3.2 Block diagram

Block diagram

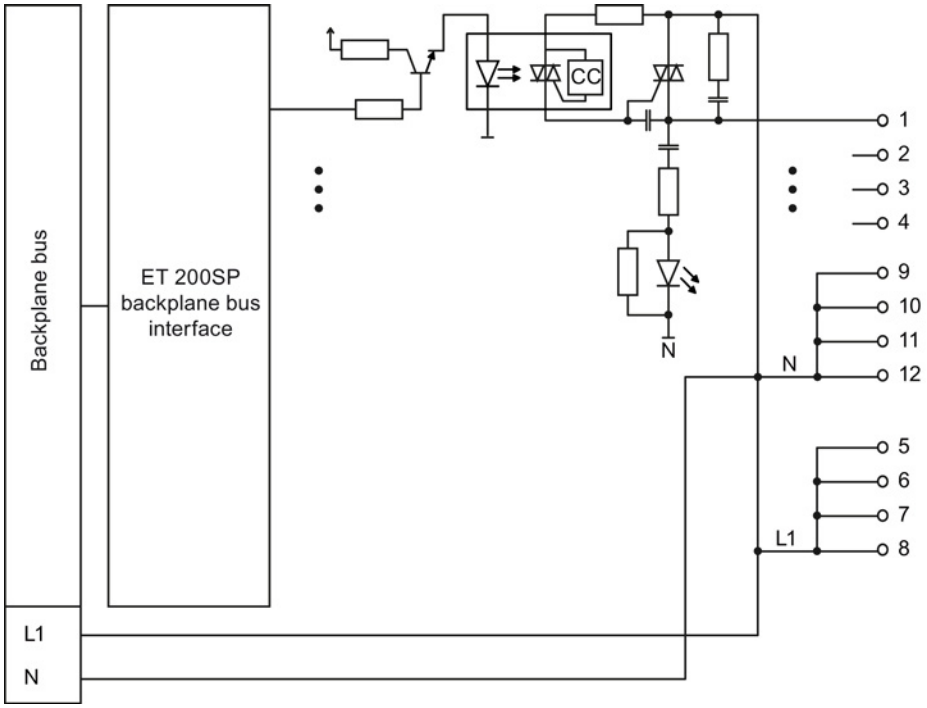


Figure 3-1 Block diagram DQ 4×24..230VAC/2A ST

Parameter assignment/addressing

4

4.1 Parameters

DQ 4×24..230VAC/2A ST parameters

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When performing the configuration in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 21)).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Operating mode	• Channel activated • Channel deactivated	Channel activated	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module

[1] Only for configuration using the PROFIBUS GSD file; does not affect configuration with STEP 7 using HSP: As the number of parameters with PROFIBUS GSD configuration is limited to a maximum of 244 bytes per ET 200SP station, the configuration options are limited. If required, however, you can still set this parameter using data record 128 as described in the column "GSD file PROFINET IO" (see the table above). The parameter length of the I/O module is 3 bytes.

4.2 Explanation of parameters

Operating mode

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Configuration options with the DQ 4×24..230VAC/2A ST

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Each bit in this byte is assigned to a channel and returns information on the validity of the digital value (0 = incorrect value).

Address space of the digital output module DQ 4×24..230VAC/2A ST

The following figure shows the assignment of address space for the DQ 4×24..230VAC/2A ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

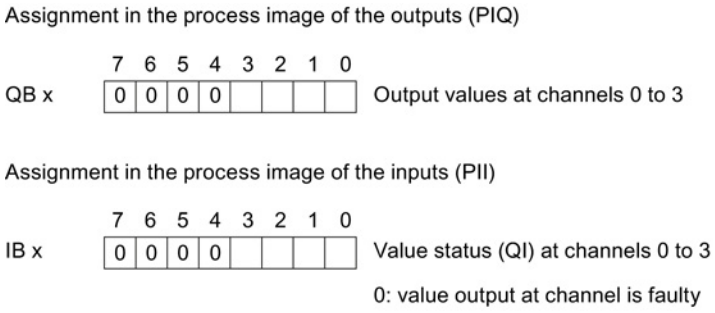


Figure 4-1 Address space of the DQ 4×24..230VAC/2A ST digital output module with value status

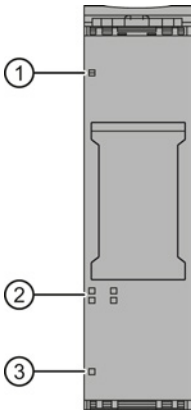
Interrupts/diagnostics alarms

5

5.1 Status and fault displays

LED displays

The figure below shows the LED displays (status and fault displays) of the DQ 4×24..230VAC/2A ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LEDs

The tables below explain the meaning of the status and fault displays.

LED DIAG

Table 5- 1 LED DIAG fault display

LED DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashing	Module parameters not assigned
On	Module configured and no module diagnostics
Flashing	Module configured and module diagnostics

LED channel status

Table 5- 2 LED channel status display

LED channel status	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated and process signal = 1

LED PWR

Table 5- 3 LED PWR status display

LED PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ present

5.2 Load voltage status

Load voltage status

The firmware of the module cannot detect the status of the load voltage.

If the "Load voltage status" function tied to the server module is used, a "1" is always displayed in the status bit for a slot with the DQ 4×24..230VAC/2A ST. Even when the load voltage is not applied.

The state of the load voltage at the terminal does not impact the PROFIenegy behavior.

Technical specifications

6

6.1 Technical specifications

DQ 4×24...230VAC/2A ST technical specifications

	6ES7132-6FD00-0BB1
General information	
Usable BaseUnits	BU type B1
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD as of revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Supply voltage	
Rated value (AC)	230 V
Input current	
Current consumption (rated value)	11.5 mA
Current consumption, max.	13 mA
Power loss	
Power loss, typ.	9 W; active power, load voltage 230 V, all outputs loaded with 2 A, 50 Hz
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Output	1 bytes
Digital outputs	
Number of outputs	4
Switching to M potential	No
Switching to P potential	Yes
Short-circuit protection	No; install a fuse with 10A trigger current when using a type B1 BU
Wire-break detection	No
Overload protection	No; install a fuse with 10A trigger current when using a type B1 BU
Limitation of inductive shutdown voltage to	Install overvoltage protection when using a type B1 BU
Controlling a digital input	Yes

	6ES7132-6FD00-0BB1
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	100 W
Output voltage	
for signal "1", min.	20.4 V
Output current	
for signal "1" rated value	2 A
for signal "1" permissible range, min.	10 mA
For signal "1" permitted range, max.	2 A
for signal "0" residual current, max.	460 µA
Output delay with resistive load	
"0" to "1", max.	10 ms
"1" to "0", max.	10 ms
Parallel switching of 2 outputs	
For logical operations	No
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	10 Hz
With inductive load, max.	0.5 Hz
With lamp load, max.	1 Hz
Total current of the outputs	
Max. current per channel	2 A
Max. current per module	8 A
Total current of the outputs (per module)	
Horizontal installation	
• up to 40 °C, max.	8 A
• up to 50 °C, max.	6 A
• up to 60 °C, max.	4 A
Vertical installation	
• up to 30 °C, max.	8 A
• up to 40 °C, max.	6 A
• up to 50 °C, max.	4 A
Output current per channel	
Horizontal installation	
• up to 60 °C, max.	2 A
Vertical installation	
• up to 50 °C, max.	2 A
Triac outputs	
Size of motor starter according to NEMA, max.	5

	6ES7132-6FD00-0BB1
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	No
Diagnostics indicator LED	
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red LED DIAG
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Insulation	
Insulation tested with	2545 V DC 2 s (routine test)
Dimensions	
Width	20 mm
Weights	
Weight, approx.	50 g

Dimensional drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

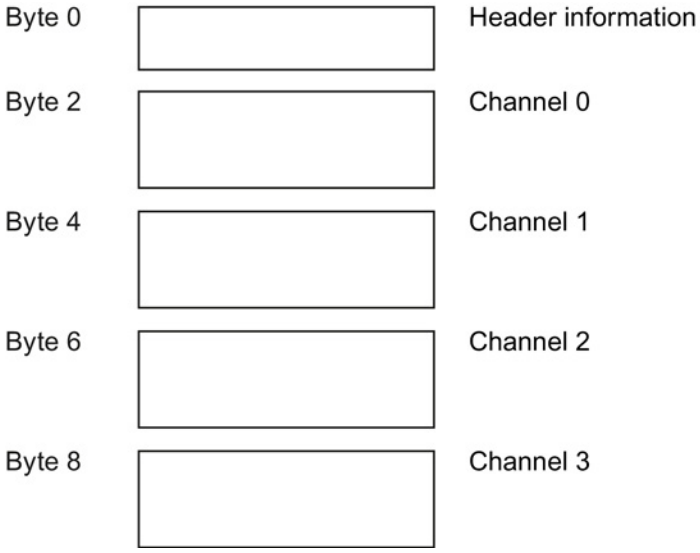


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

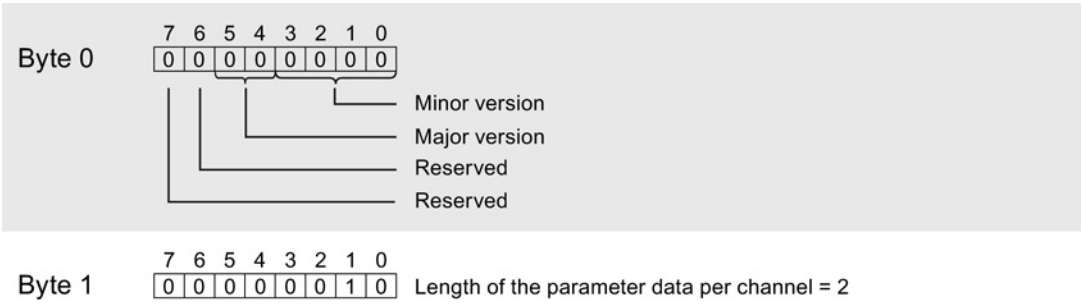


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

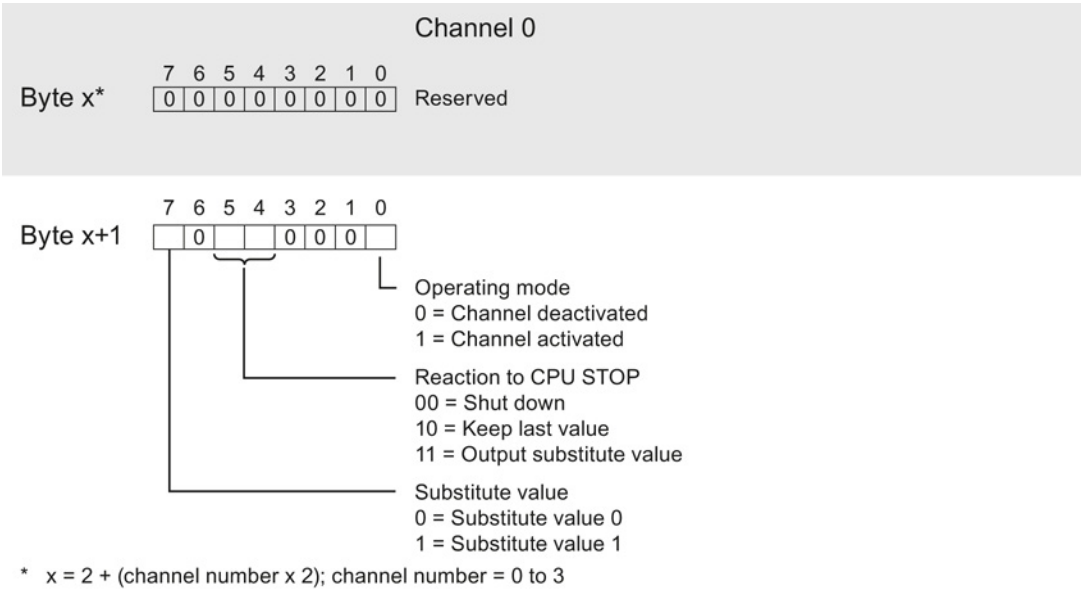


Figure A-3 Structure byte x to x+1 for the channels 0 to 3

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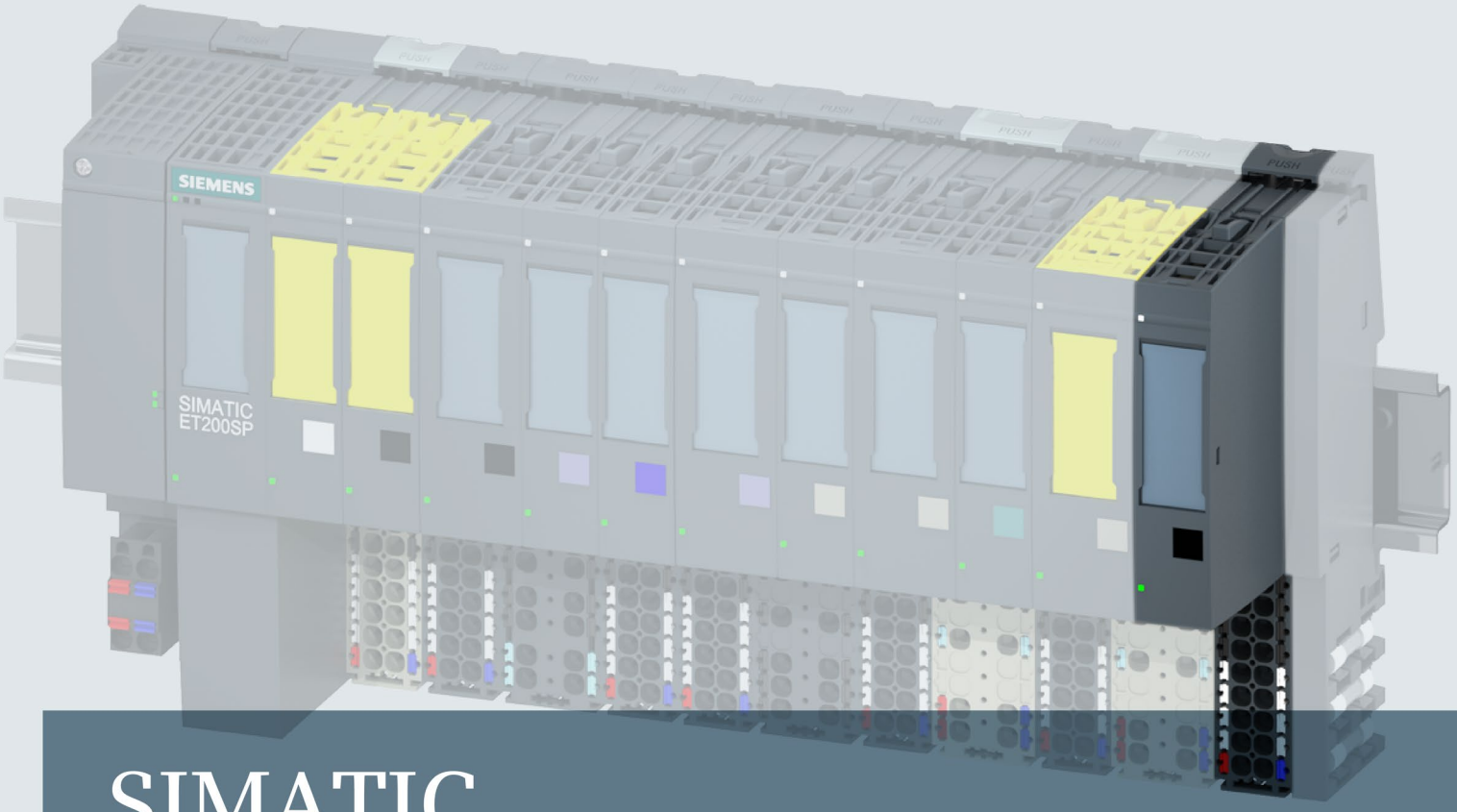

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ET 200SP

Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD20-0CA0)

Manual

Edition 12/2015

Answers for industry.

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ET 200SP
Digital output module
DQ 4x24VDC/2A HF
(6ES7132-6BF20-0CA0)

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Parameter data record A

12/2015

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

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indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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A5E32855695-AC
℗ 12/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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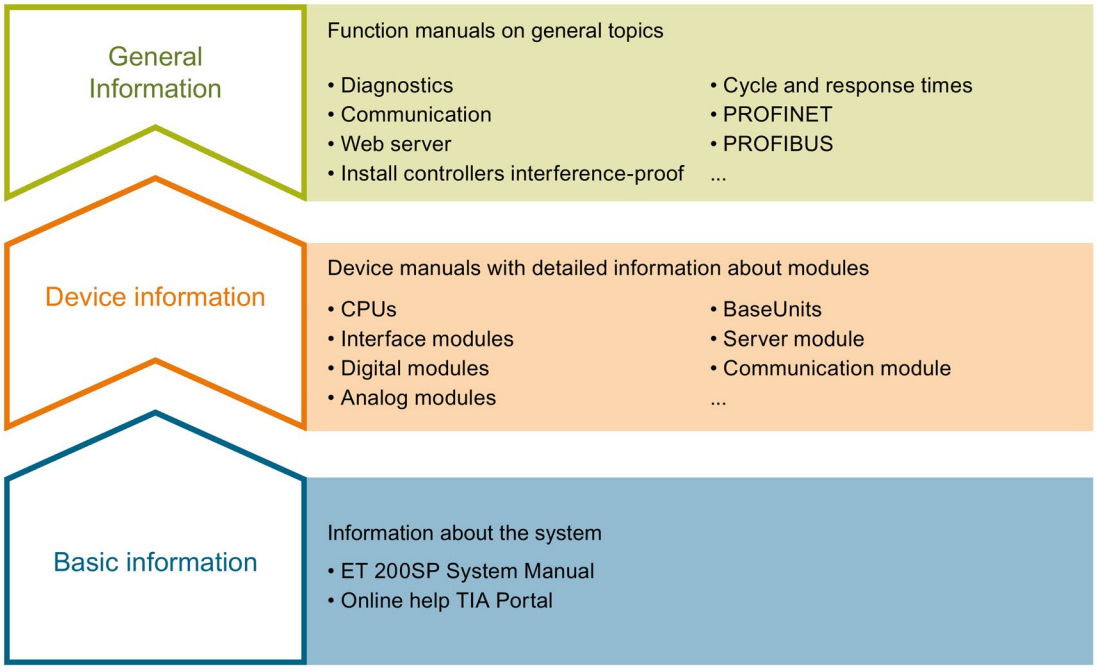
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

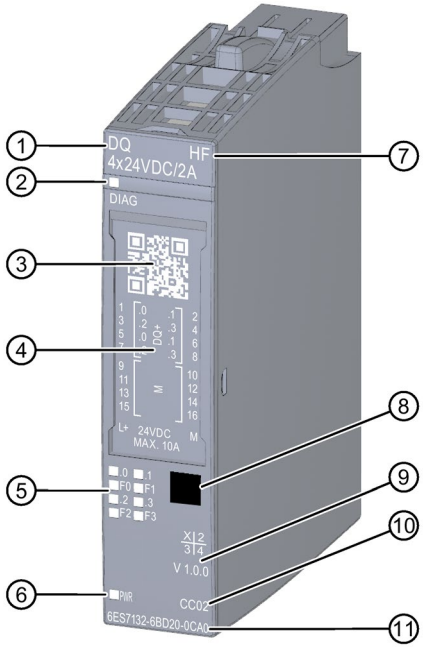
2

2.1 Properties

Article number

6ES7132-6BD20-0CA0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status/channel fault
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module DQ 4×24VDC/2A HF

Properties

The module has the following technical properties:

- Digital output module with 4 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 2 A (per channel)
- Configurable diagnostics (per channel)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status
- Isochronous mode
- Module-internal Shared Output (MSO)

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Configurable submodules/ submodules for shared device	1	V2.0.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manualET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 4x24VDC/2A HF module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection. You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnits in the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Note

- The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

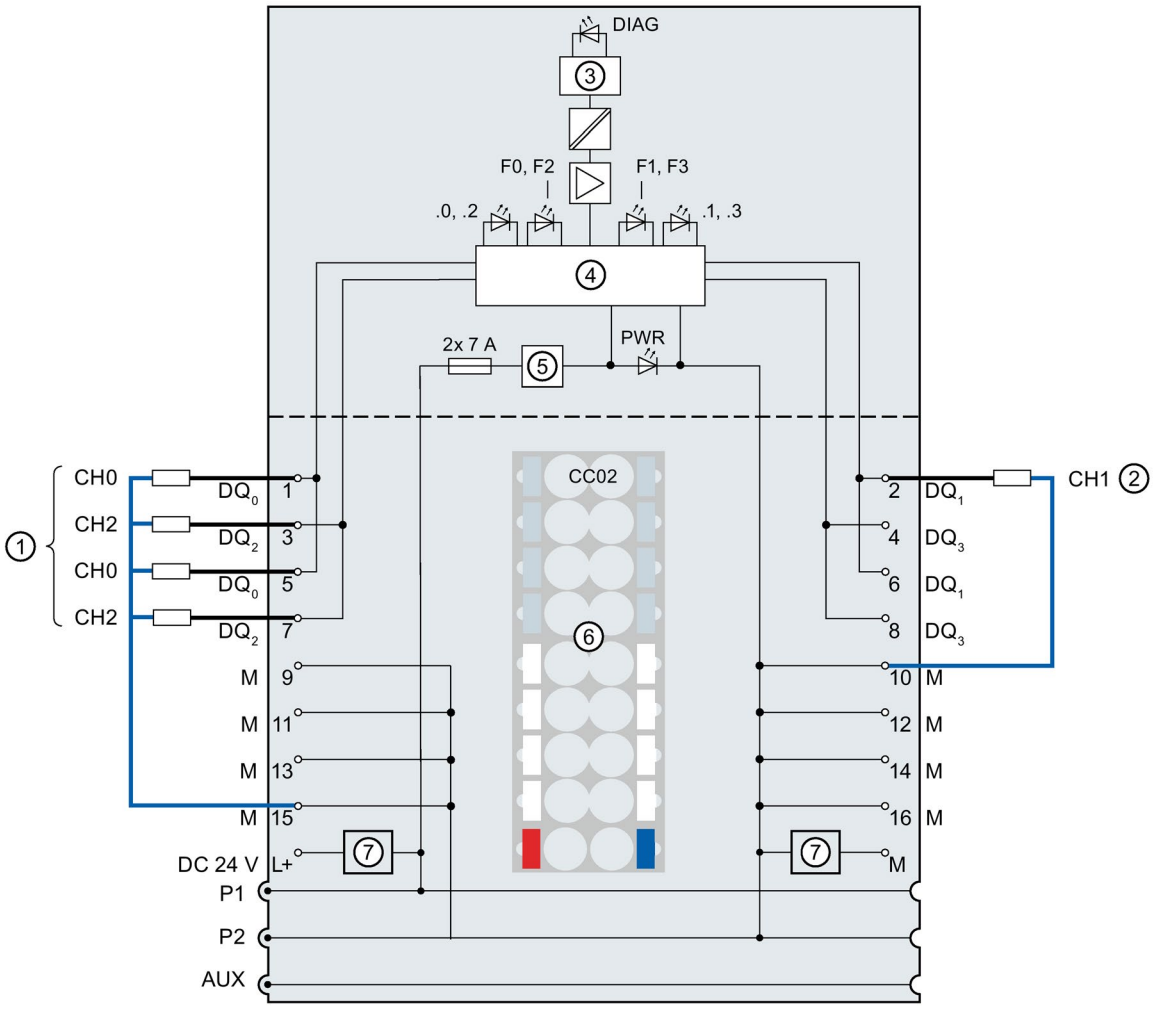
Note

Cross circuit at output

Be aware that voltage from a cross-circuit at the output can feed L+ to modules.

Wiring: 1 and 2-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 4×24VDC/2A HF on the BaseUnit BU type A0 without AUX terminals (1- and 2-wire connection).

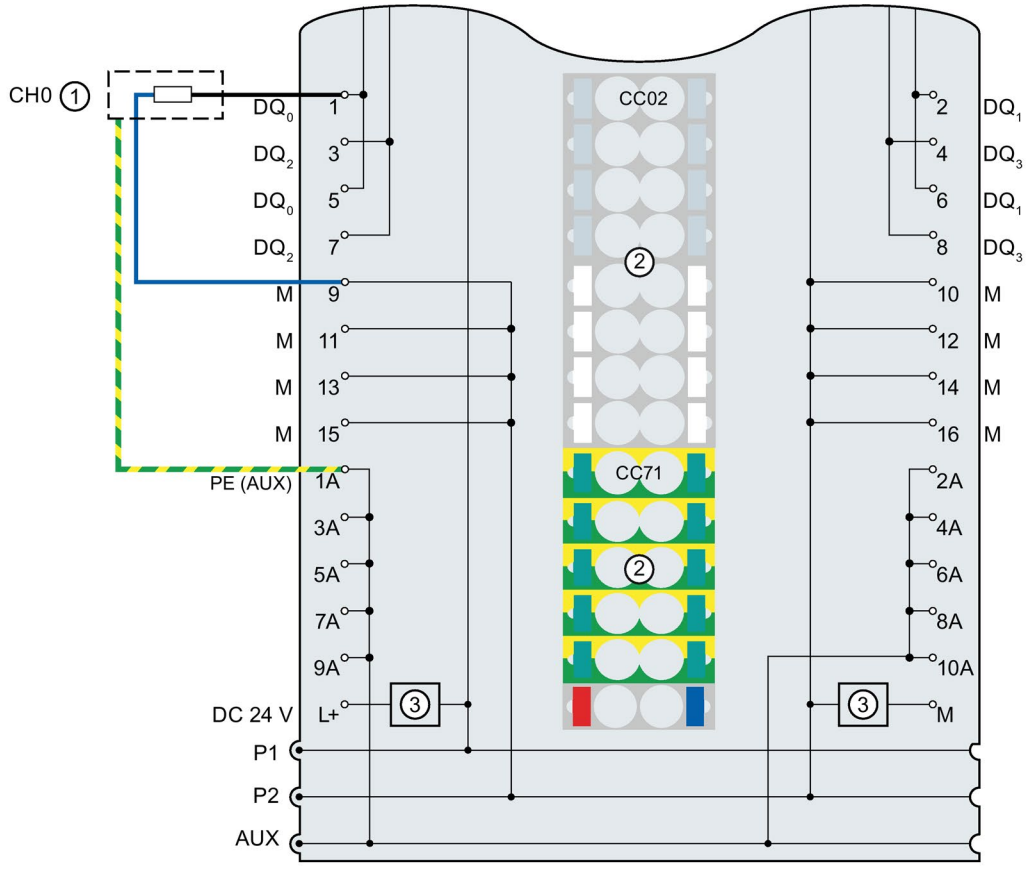


①	1-wire connection	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
②	2-wire connection	M	Ground
③	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Output electronics	DIAG	Error or diagnostics LED (green, red)
⑤	Polarity reversal protection	.0 to .3	Channel status LED (green)
⑥	Color-coded label with color code CC02 (optional)	F0 to F3	Channel fault LED (red)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	PWR	Power LED (green)
DQ_n	Output signal, channel n		

Image 3-1 Block diagram and terminal assignment for 1- and 2-wire connection of actuators

Wiring: 3-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 4×24VDC/2A HF on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection	1 A to 10 A	AUX terminals
②	Color-coded labels with color codes CC02 and CC71 (optional)	PE (AUX)	Protective conductor connection
③	Filter connection supply voltage (only when light-colored BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
DQ_n	Output signal, channel n	M	Ground
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Image 3-2 Terminal assignment for 3-wire connection of actuators

Parameters/address space

4

4.1 Parameters

Parameters of the DQ 4x24VDC/2A HF

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 31)).

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Parameter reassignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to L+	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

Parameter	Range of values	Default	Parameter reassignment in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP. The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign the parameters using data records 64 to 67 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 7 bytes.

Note

If one of the two parameters "Diagnostics: Short-circuit to L+" or "Diagnostics: Wire break" is enabled and one of these diagnostics occurs, the affected channel is switched off to avoid triggering an undefined load. Note that a diagnostic interrupt can only be generated when diagnostics are enabled. [1]

[1] as of module revision 04

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 4×24VDC/2A HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. When you configure the module by means of the GSD file, the configuration is available under different abbreviations/module names. The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Abbreviation/module name in the GSD file	Configuration software, e.g. STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	DQ 4×24VDC/2A HF V1.0	X	X	X
1 x 4-channel with value status	DQ 4×24VDC/2A HF V1.0, QI	X	X	---
1 x 4-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 4×24VDC/2A HF V1.0, MSO	X	X	---
1 x 4-channel without value status	DQ 4×24VDC/2A HF V2.0	---	X	---
1 x 4-channel with value status	DQ 4×24VDC/2A HF V2.0, QI	---	X	X
1 x 4-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 4×24VDC/2A HF V2. 0, MSO	---	X	---
2 x 2-channel without value status	DQ 4×24VDC/2A HF V2.0, S.2	---	X	---
2 x 2-channel with value status	DQ 4×24VDC/2A HF V2.0, S.2 QI	---	X	---

Note

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

2 x 2-channel configuration

For the configuration, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a Shared Device.

The number of usable submodules is dependent on the interface module used. Read the information in the manual for the particular interface module.

Value status (quality information, QI)

The value status is always activated for the following module names:

- DQ 4×24VDC/2A HF QI
- DQ 4×24VDC/2A HF MSO

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0

The figure below shows the address space assignment for configuration as a 4-channel module without value status.

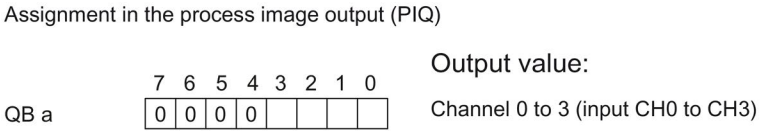


Image 4-1 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF, QI without value status

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0, QI

The following figure shows the assignment of the address space for the configuration as a 4-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

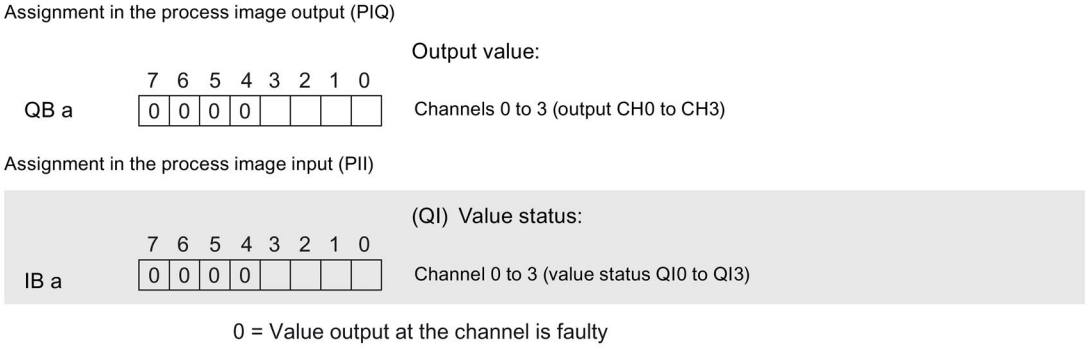


Image 4-2 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF, QI with value status

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0, MSO

For the configuration as a 1 x 4-channel module (module-internal shared output, MSO), channels 0 to 3 of the module are copied to up to four submodules. Channels 0 to 3 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 3.
- The IO controller to which submodule 2, 3, or 4 is assigned has read access to outputs 0 to 3.

Value status (Quality Information,QI)

The meaning of the value status depends on the submodule on which it occurs.

For the 1st submodule (= basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (= MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status.

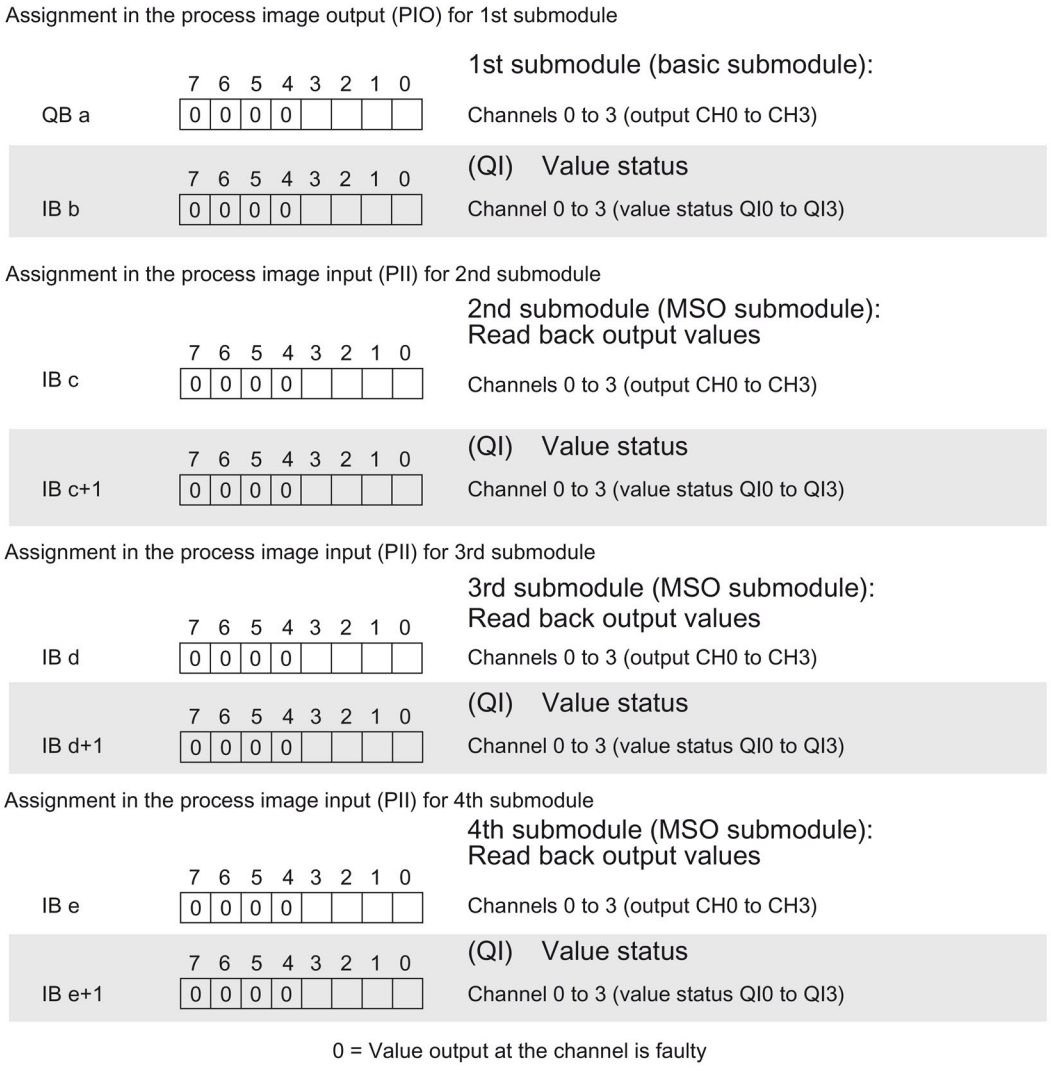


Image 4-3 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF, MSO with value status

Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF, S.2

The figure below shows the address space assignment for configuration as a 2 x 2-channel module without value status.

Each of the two submodules has a freely assignable start address.

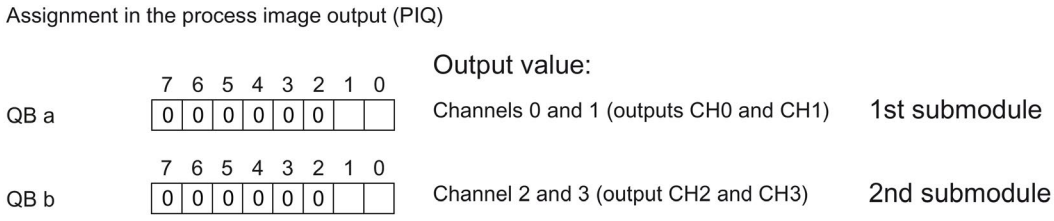


Image 4-4 Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF, S.2 without value status

Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF, S.2 QI

The figure below shows the address space assignment for configuration as a 2 x 2-channel module with value status.

Each of the two submodules has a freely assignable start address.

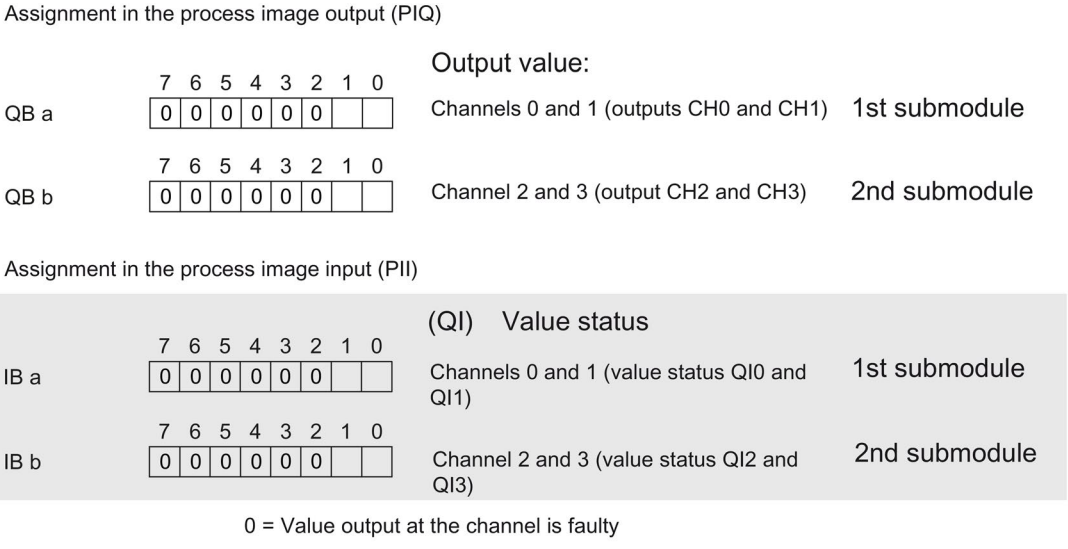


Image 4-5 Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF V2.0, S.2 QI with value status

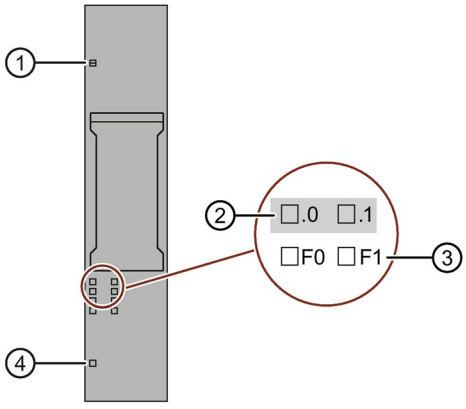
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DQ 4x24VDC/2A HF.



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The tables below explain the meaning of the Status and error displays. Remedial measures for diagnostics alarms can be found in section Diagnostics alarms (Page 24).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
▫ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module/channel diagnostics
☼ Flashes	Module parameters assigned and module/channel diagnostics

LED channel status/channel error

Table 5- 2 Status / error display of the LED channel status / channel error

Channel status LED	LED channel error	Meaning
▫ Off	▫ Off	Channel deactivated or process signal = 0
■ On	▫ Off	Channel activated and no channel diagnostics
▫ Off	■ On	Channel activated and channel diagnostics

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
▫ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The DQ 4×24VDC/2A HF digital output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Note

You can connect 2 actuators per output.

The diagnostics of the two actuators influenced each other in the case of duplicate wiring.

This means:

- a wire break is only signaled if both actuators are affected
- a single short-circuit affects both actuators

Note

Parallel connection of two outputs

For parallel connection of two outputs for redundant control of a load, the channel diagnostics "Short-circuit to L+" and "Wire break" must be deactivated.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Short-circuit	1_H	• Short-circuit of actuator supply to ground [1] • Short-circuit of actuator supply to L+ [2]	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, for example, use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

[1] only in switched state (output value 1)

[2] only in non-switched state (output value 0)

Note

In case of a short-circuit of the actuator supply to L+ at the activated channel, load distributions can occur which result in wire break diagnostics.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 4×24VDC/2A HF

	6ES7132-6BD20-0CA0
General information	
Product type designation	ET 200SP, DQ 4x24VDC/2A HF, PU 1
Firmware version	V2.0
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC02
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 / -
STEP 7 can be configured/integrated as of version	V5.5 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W

	6ES7132-6BD20-0CA0
Address area	
Address space per module	
Address space per module, max.	4 bytes; 2 channels per submodule + QI information
Digital outputs	
Number of outputs	4
Sinking output	No
Sourcing output	Yes
Short-circuit protection	Yes
• Response threshold, typ.	2.8 ... 5.2 A
Limitation of inductive shutdown voltage to	L+ -(37 to 41V)
Control of a digital input	Yes; minimum current consumption 7 mA
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	10 W
Load resistance range	
Low limit	12 Ω
High limit	3400 Ω
Output current	
For signal "1" rated value	2 A
For signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
"0" to "1", typ.	50 µs
"1" to "0", typ.	100 µs
Parallel connection of two outputs	
For increased performance	No
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	2 Hz
With lamp load, max.	10 Hz
Total current of the outputs	
Current per channel, max.	2 A
Current per module, max.	8 A
Total current of the outputs (per module)	
Horizontal installation	
• Up to 40 °C, max.	8 A
• Up to 50 °C, max.	6 A
• Up to 60 °C, max.	4 A
Vertical installation	
• Up to 30 °C, max.	8 A
• Up to 40 °C, max.	6 A
• Up to 50 °C, max.	4 A

	6ES7132-6BD20-0CA0
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Bus cycle time (TDP), min.	500 µs
Jitter, max.	8 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	Yes; channel-based
Short-circuit	Yes; channel-based
Group error	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	30 g

Safety-related shutdown

Note

The digital output module DQ 4x24VDC/2A HF supports safety-related shutdown in connection with a fail-safe power module F-PM-E 24VDC/8A PPM ST:

- SIL according to IEC 61508: 2
- Highest attainable safety class in safety mode, performance level according to EN ISO 13849-1: d

Residual current for signal state "0"

Note

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current does not depend on the setting for the Diagnostics: Wire break parameter.

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

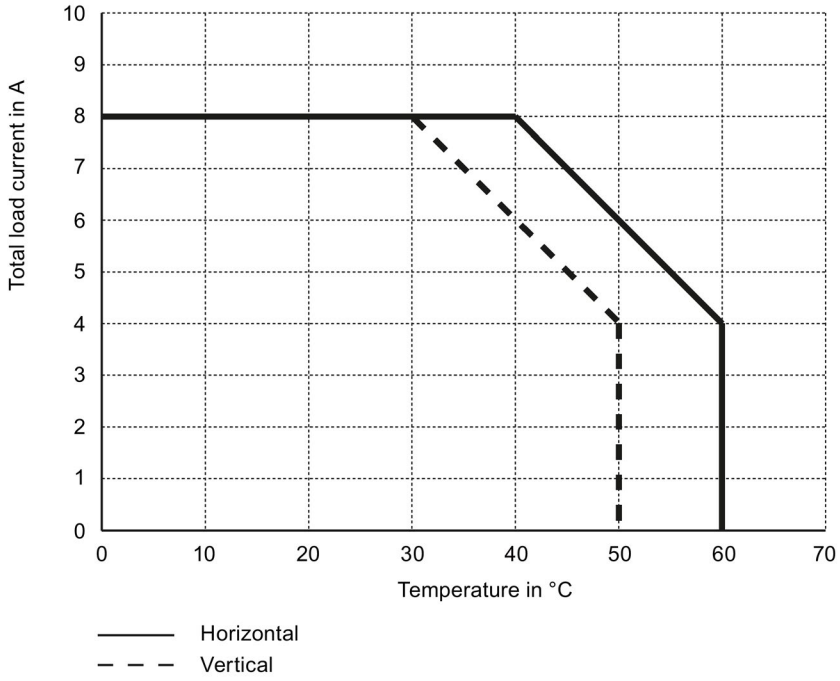


Image 6-1 Load current for mounting position

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

You can configure the individual channels with data records 64 to 67.

Parameter assignment in the user program

You can reassign the module parameters in RUN (e.g. "Switch on diagnostics" can be changed in RUN).

Changing parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128 or data records 64 to 67. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Data record structure

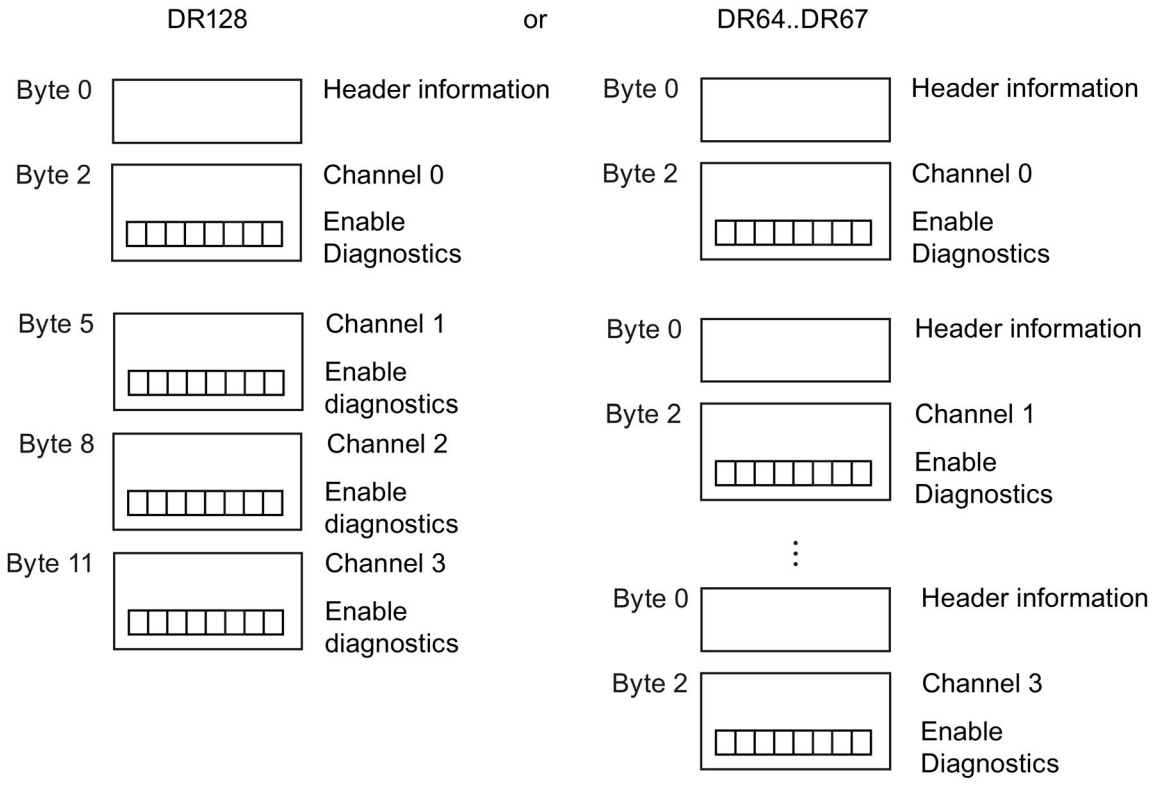


Image A-1 Structure of data record 128 or data records 64 to 67

Header information

The figure below shows the structure of the header information.

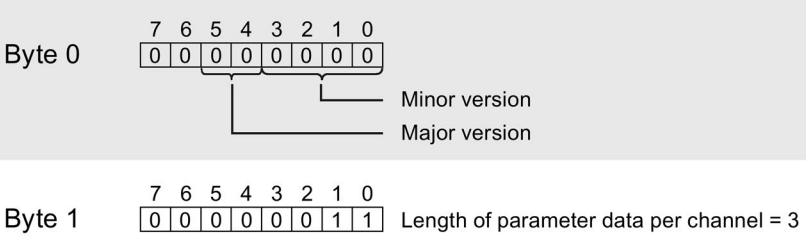
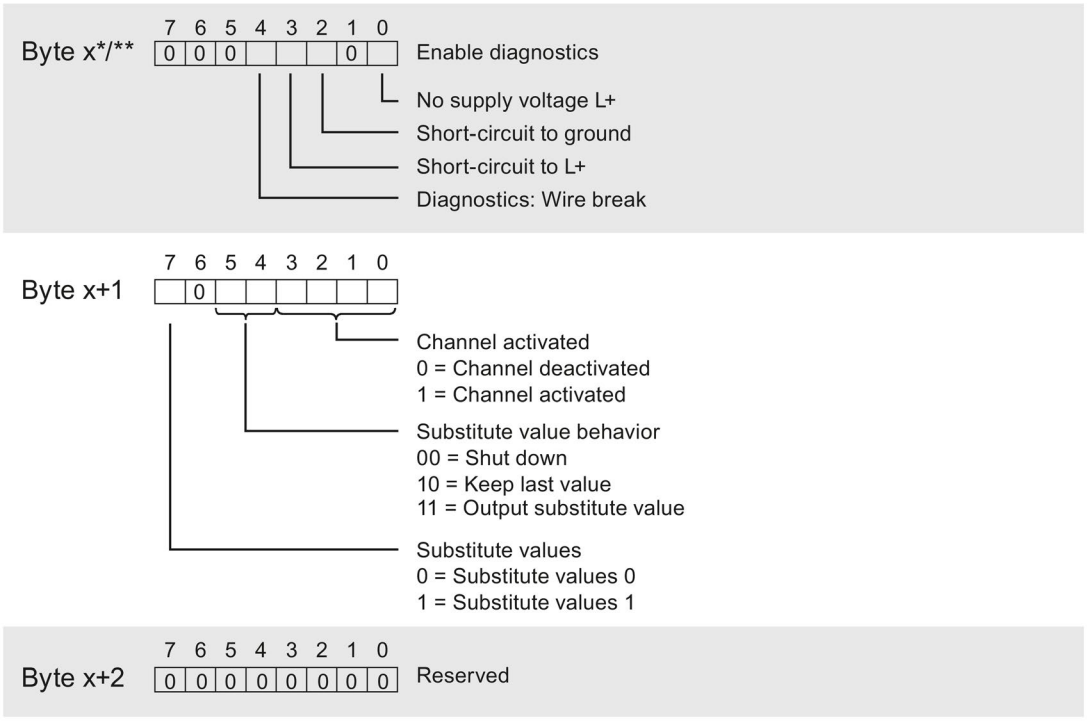


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 3); channel number = 0 to 3 for DR 128
** x =2 for DR 64 to DR 67

Image A-3 Structure of byte x to x+2 for channels 0 to 3

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

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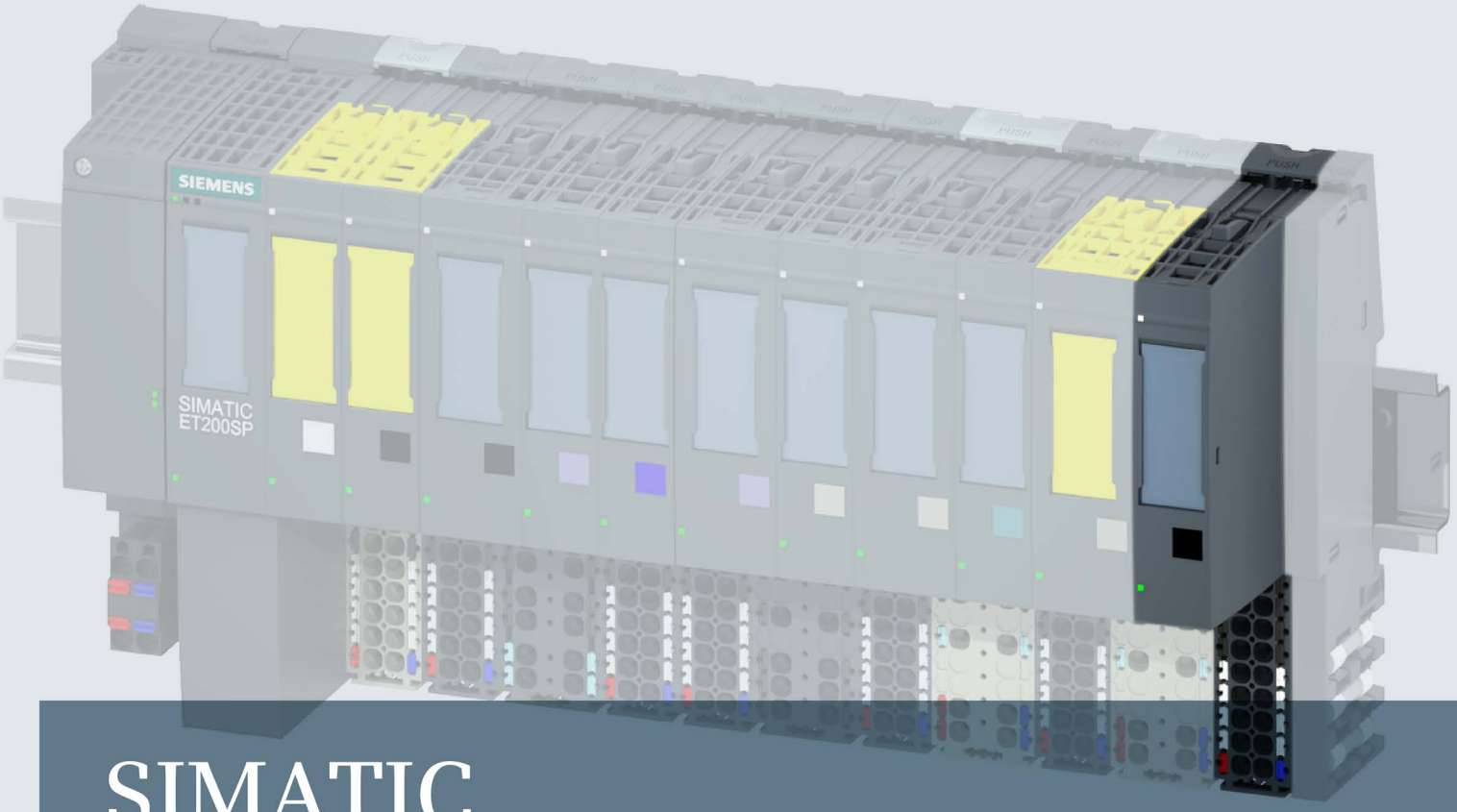

SIMATIC

ET 200SP

Digital output module DQ 4x24VDC/2A HS (6ES7132-6BD20-0DA0)

Manual

Edition 09/2016

siemens.com

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SIMATIC

ET 200SP
Digital output module
DQ 4x24VDC/2A HS
(6ES7132-6BD20-0DA0)

Manual

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Parameter data record A

09/2016

A5E32855695-AB

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

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⚠ WARNING

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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A5E32855695-AB
℗ 09/2016 Subject to change

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Preface

Purpose of the documentation

This manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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A Parameter data record **41**

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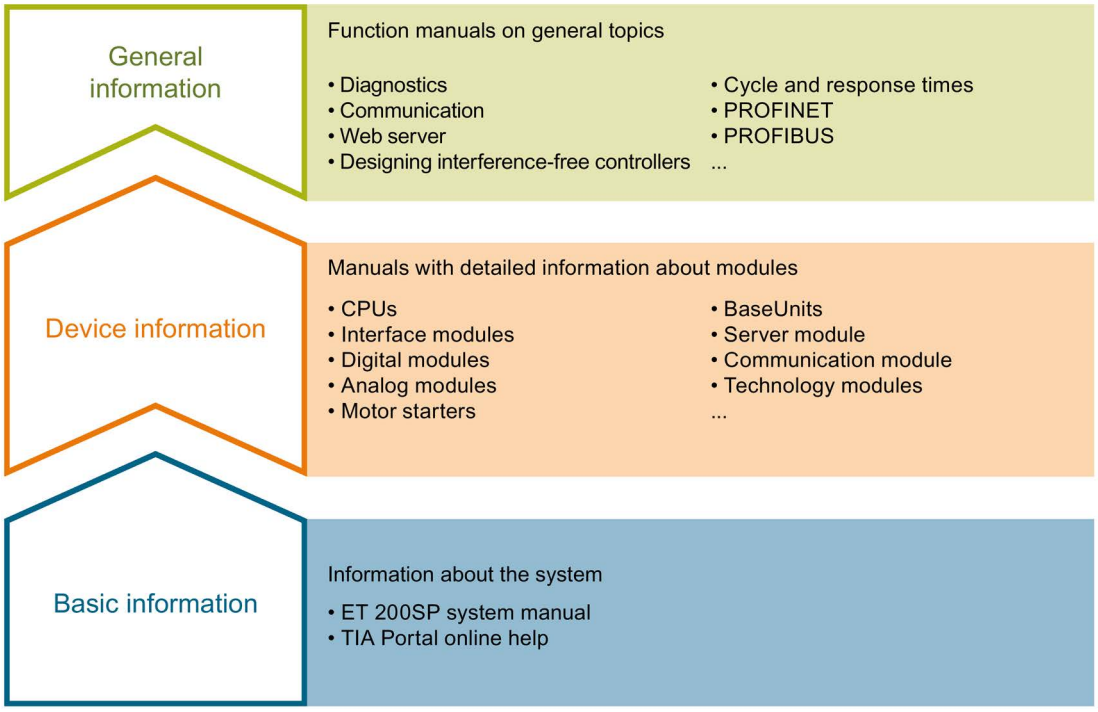
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

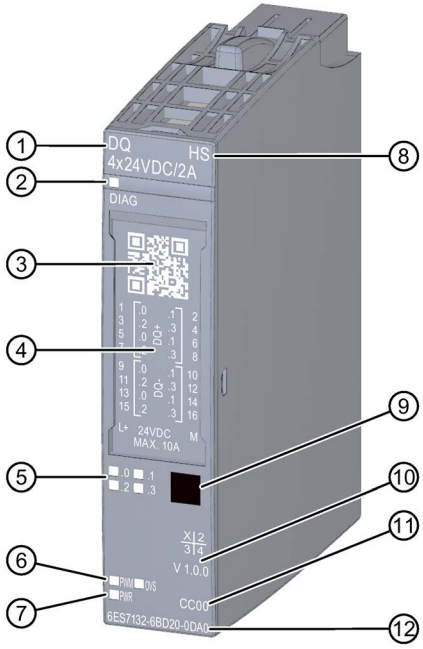
2

2.1 Properties

Article number

6ES7132-6BD20-0DA0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LEDs for operating mode
⑦ LED for supply voltage
⑧ Function class
⑨ Color coding module type
⑩ Function and firmware version
⑪ Color code for selecting the color identification labels
⑫ Article number

Figure 2-1 View of the DQ 4×24VDC/2A HS module

Properties

The module has the following technical properties:

- Digital output module with 4 outputs (push-pull)
- Source output (PNP, sourcing output)
- Supply voltage L+
- Output current 2 A (per channel)
- Configurable substitute values (per channel)
- Configurable diagnostics (per module)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy
- Value status
- Isochronous mode
- Oversampling
- Valve control
- Pulse width modulation

You can configure the module with STEP 7 and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 4x24VDC/2A HS module with the terminal assignments for a 2-wire and 3-wire connection in the three operating modes DQ, pulse width modulation and oversampling.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

You can connect 2 actuators per output.

Note

Cross circuit at output

Be aware that voltage from a cross circuit at the output can feed L+ to modules.

Note

- The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.
- The connection of actuators with 1-wire connection is not permitted.

Note

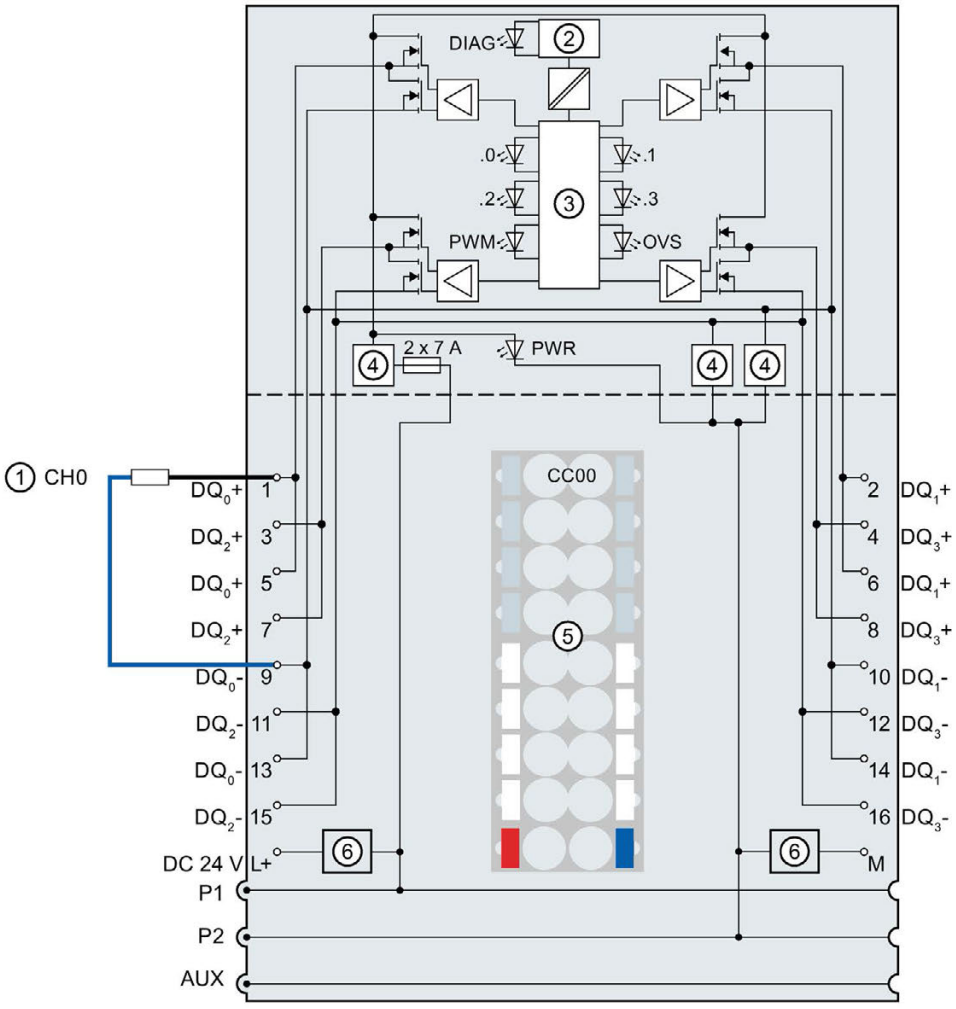
You may use and combine the different wiring options for all channels.

Note

Outputs DQ_n- must not be connected with ground.

Connection: 2-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 without AUX terminals (2-wire connection).

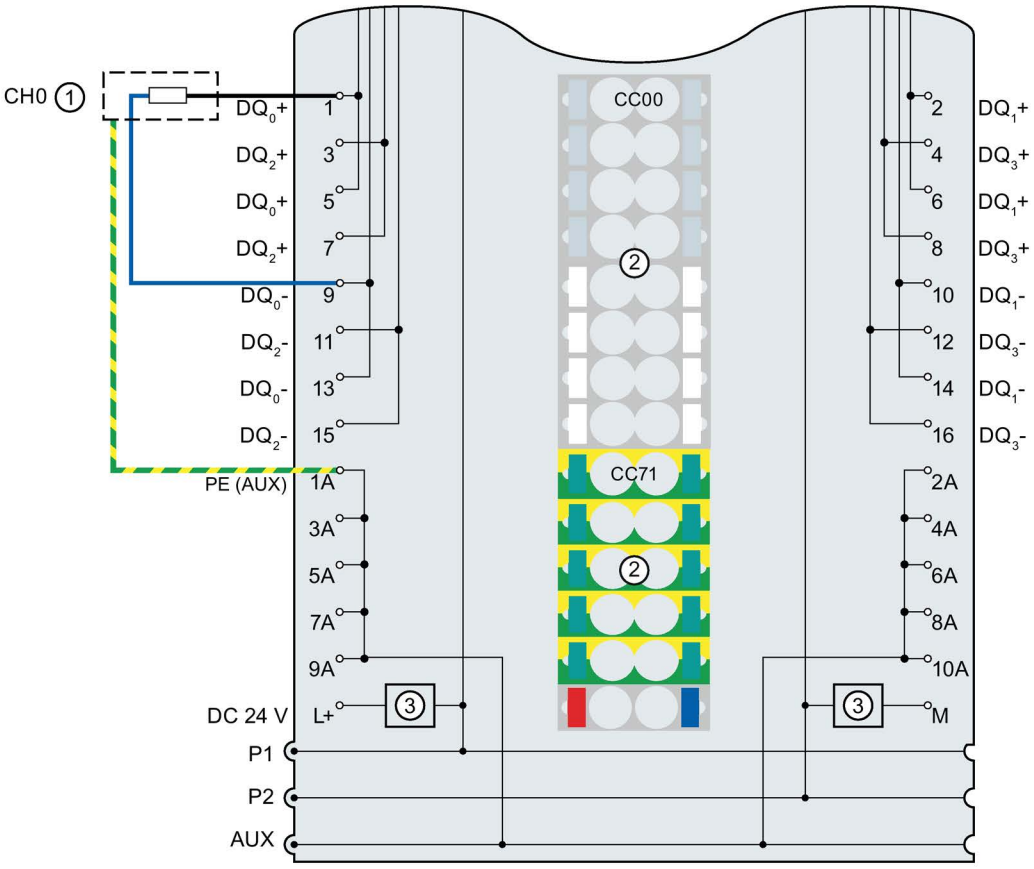


①	2-wire connection	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
②	Backplane bus interface	M	Ground
③	Control unit	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Polarity reversal protection	DIAG	Error or Diagnostics LED (green, red)
⑤	Color identification label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)	PWM	Pulse width modulation LED (green)
DQ_n+	Output signal, channel n	OVS	Oversampling LED (green)
DQ_n-	Reference output signal, channel n	PWR	Power LED (green)

Figure 3-1 Block diagram and terminal assignment for 2-wire connection of actuators

Connection: 3-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 with AUX terminals (3-wire connection).



①	3-wire connection	1 A to 10 A	AUX terminals
②	Color identification labels CCxx (optional)	PE (AUX)	Protective conductor connection
③	Filter connection supply voltage (only when light-colored BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
DQ_n+	Output signal, channel n	M	Ground
DQ_n-	Reference output signal, channel n	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Figure 3-2 Terminal assignment for 3-wire connection of actuators

Parameters/address space

4

4.1 Parameters

DQ 4×24VDC/2A HS parameters

The effective range of the parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of the parameter data record (Page 41).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file) [3]

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Operating mode	• Normal operation DQ (valve control)/Oversampling [2] • Pulse width modulation	Normal operation DQ (valve control)\Oversampling	No	Module	Module [1]
Output rate	Normal operation and pulse width modulation: • 1 sample / cycle Oversampling: • 2 sample / cycle • 4 sample / cycle • ... • 32 sample / cycle	1 sample / cycle	No	Module	Module [1]
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module [1]

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: Short-circuit	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Module	Module [1]
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel [1]
Reaction to CPU STOP	• Turn off • Keep last value Normal operation/Oversampling • Output substitute value 1 Pulse width modulation • Output substitute value	Turn off	Yes	Channel	Module [1]
Holding time valve control	• Off • 10 ms • 20 ms • ... • 10 s	500 ms	Yes	Channel	Channel [1]
Pulse width modulation duty factor	• Off • 0.1% • 0.2% • ... • 100%	100%	Yes	Channel	Channel [1]
Pulse width modulation time period	• Off • 0.20 ms • 0.40 ms • 0.93 ms • 1.33 ms • 4.27 ms • 10.67 ms • 21.33 ms • 34.13 ms • 59.73 ms	Off	Yes	Channel	Channel [1]

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Substitute value duty factor (for pulse width modulation)	• Off • 0.1% • 0.2% • ... • 100%	Off	Yes	Channel	Channel [1]
Potential group	• Use potential group of the left module (dark BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module [1]

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 15 bytes.

[2] Valve control is a special function of normal operation.

[3] Oversampling is not supported with GSD files.

4.2 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated. If you configure using a GSD file, you decide the module operating mode by selecting the module name in the GSD file.

- Normal operation as digital output module
  - Valve control is a special function of normal operation, see section Normal operation/Valve control (Page 20).
- Pulse width modulation, see section Pulse width modulation (Page 22)
- Oversampling, see section Oversampling (Page 25)

See section Address space (Page 27).

Output rate

Specifies the number of subcycles per isochronous data cycle.
See section Oversampling (Page 25).

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the permitted value range of the duty factor is exceeded during pulse width modulation.
See section Pulse width modulation (Page 22).

Channel activated

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Holding time valve control

Specifies the time which must expire before the pulse width modulated output signal is output in the next possible data cycle.
See section Normal operation/Valve control (Page 20).

Pulse width modulation duty factor

Specifies the pulse/pause duty factor for the activated pulse width modulation with valve control.
See section Normal operation/Valve control (Page 20).

Pulse width modulation time period

Specifies the frequency of the pulse width modulation.
See section Normal operation/Valve control (Page 20) and section Pulse width modulation (Page 22).

Substitute value duty factor

Specifies the pulse/pause duty factor of the pulse width modulation if there is a CPU STOP.
See section Pulse width modulation (Page 22).

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always begins with an I/O module that is plugged into a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Normal operation/Valve control

Normal operation

"Normal operation" refers to the function of the DQ 4×24VDC/2A HS as digital output module.

Valve control is a special function of normal operation.

Valve control function

You use valve control to switch to a smaller "holding current" after tightening the valve (locked-rotor current). You do this by activating a pulse width modulation (see section Pulse width modulation (Page 22)).

With a 0 → 1 transition of the digital channel, the configured holding time is started. After it has expired, the pulse/pause duty factor is activated as pulse width modulation. The actuating signal is output digitally as a pulse sequence of on and off pulses.

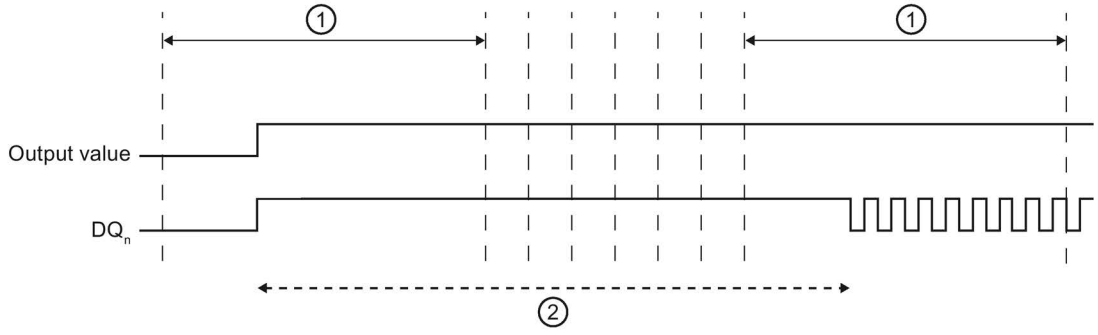
Configuration

You configure valve control with the following parameters:

- "Normal operation" operating mode
- Holding time valve control
- Pulse width modulation duty factor
- Pulse width modulation time period

Chronological sequence

The figure below shows the chronological sequence for valve control. The pulse width modulation is activated in the next possible data cycle.



① Data cycle
② Holding time valve control

Figure 4-1 Valve control

"Pulse width modulation time period" parameter

You use the "Pulse width modulation time period" parameter to specify the frequency of the pulse width modulation activated for valve control (see section Pulse width modulation (Page 22)).

Note: When this is parameter is set to "Off", the DQ 4×24VDC/2A HS is in normal operation without valve control.

"Pulse width modulation duty factor" parameter

You use the "Pulse width modulation duty factor" parameter (0 to 1000) to specify the pulse/pause duty factor of the activated pulse width modulation within the configured time period.

Note: Unlike in the "Pulse width modulation" operating mode, the duty factor cannot be updated cyclically depending on the output value from the user program in normal operation with valve control.

Derating

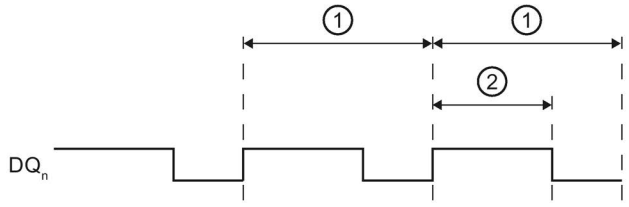
See the information on derating of the module in the section Derating of the DQ 4x24VDC/2A HS (Page 38).

4.4 Pulse width modulation

Function

You can operate the module in the "Pulse width modulation" operating mode. In this operating mode, the four outputs only provide a pulse-width modulated output signal.

The digital channel is activated with a pulse/pause duty factor that is updated cyclically depending on the output value from the user program. The actuating signal is output digitally as a pulse sequence of on and off pulses.



① Time period T; frequency of the pulse width modulation: f = 1/T

② Pulse duration (duty factor)

Figure 4-2 Pulse width modulation

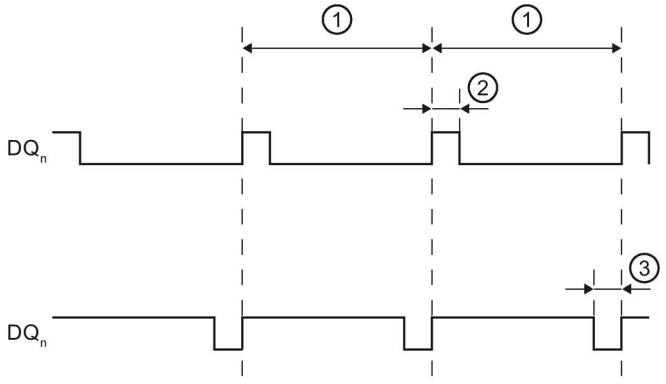
Configuration

You configure the pulse width modulation with the following parameters:

- "Pulse width modulation" operating mode
- Pulse width modulation time period
- Substitute value duty factor
- Diagnostics: Overflow

Chronological sequence

The output value (0 to 1000) is written from the user program to the output word of the channel. The module maps this value by means of the output characteristic and the values for minimum pulse duration and minimum pulse pause to the configured time period and thus determines the pulse/pause duty factor (the pulse duration) of the pulse width modulation.

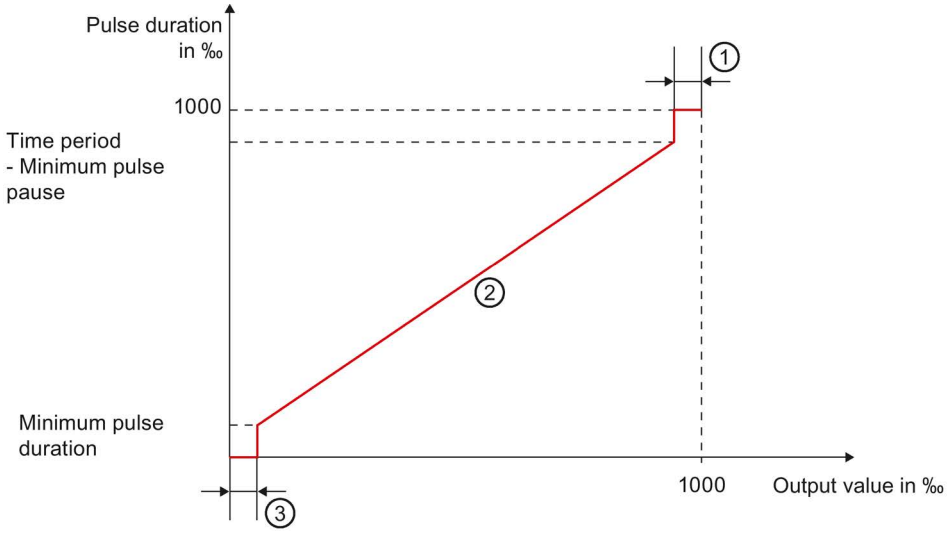


① Time period T
② Minimum pulse duration
③ Minimum pulse pause

Figure 4-3 Minimum pulse duration and minimum pulse pause

The minimum pulse duration and the minimum pulse pause are at least 2 µs each, which means:

- Any pulse duration that is shorter than the minimum pulse duration will be suppressed
- Any pulse duration that is longer than the time period minus minimum pulse duration is reduced to 100% (≙ output value 1000)



① Minimum pulse pause
② Output characteristic
③ Minimum pulse duration

Figure 4-4 Output characteristic of the pulse duration

The following values apply when determining the pulse/pause duty factor of the pulse width modulation:

Table 4- 2 Determining the pulse/pause duty factor of the pulse width modulation

Time period parameter	Frequency	Output value in the user program (‰)	Pulse/pause duty factor at output terminal DQ_n (‰)
0.20 ms	5000 Hz	0...9	0
		10...990	10...990
		991...1000	1000
0.40 ms	2500 Hz	0...4	0
		5...995	5...995
		996...1000	1000
0.93 ms	1071 Hz	0...2	0
		3...997	3...997
		998...1000	1000
1.33 ms	750 Hz	0, 1	0
		2...998	2...998
		999, 1000	1000
4.27 ms	234 Hz	0...1000	0...1000

Time period parameter	Frequency	Output value in the user program (‰)	Pulse/pause duty factor at output terminal DQ_n (‰)
10.67 ms	94 Hz	0...1000	0...1000
21.33 ms	47 Hz	0...1000	0...1000
34.13 ms	29 Hz	0...1000	0...1000
59.73 ms	17 Hz	0...1000	0...1000

Example

When you configure a channel with 5000 Hz (≙ 200 µs) and the user program writes the value 3 to the output word of the channel, this value is converted to 0 by the module: The channel is permanently 0.

"Diagnostics: Overflow" parameter

You use the "Diagnostics: Overflow" parameter to enable the diagnostics if the permitted value range of the duty factor is exceeded, which means an output value > 1000 from the user program is written to the output word of the channel.

"Substitute value duty factor" parameter

You use the "Substitute value duty factor" parameter (0 to 1000) to specify the pulse/pause duty factor of the pulse width modulation in the case of a CPU STOP.

Derating

See the information on derating of the module in the section Derating of the DQ 4x24VDC/2A HS (Page 38).

4.5 Oversampling

Function

Oversampling is the output of data in constant bus cycle segments (sub-cycles), whereby n sub-cycles correspond to one PROFINET bus cycle. A data packet is transmitted from the controller to the module, which outputs the packet in n constant bus sub-cycles.

Oversampling is useful whenever you require output of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With oversampling, a PROFINET bus cycle is divided into constant bus sub-cycles:

- Each sub-cycle returns a 4-bit output value.
- A sub-cycle is at least 100 µs long.
- Sub-cycles are possible in increments of 2 to 32 (only even numbers). The following applies here: Isochronous data cycle / number of sub-cycles ≥ permitted sub-cycle duration (100 µs).

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameters:

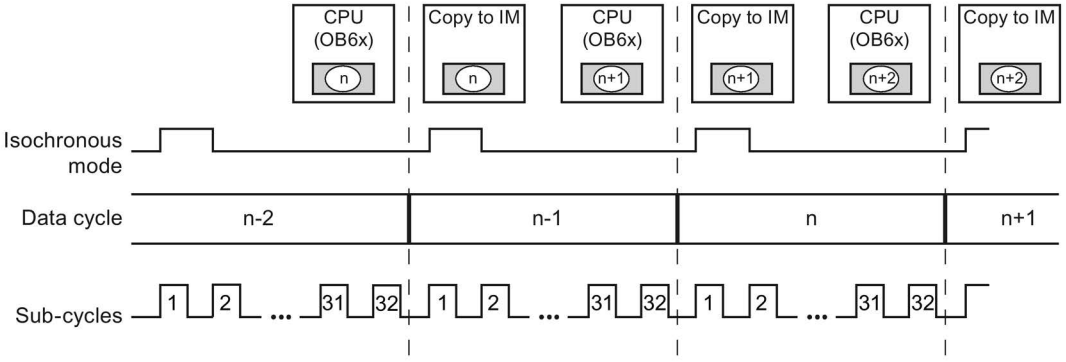
- "Oversampling" operating mode
- Output rate

Note

Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. Make sure that the output of data in the module is synchronized with the user program of the CPU.

Chronological sequence

The figure below shows the chronological sequence for oversampling. The output data present in the CPU is output in the data cycle after the next one, distributed across the sub-cycles which are generated on the actual module.



n	Output values from bus cycle n
Sub-cycle	4 bit x 32 (max) each = max. 16 bytes output data per data cycle

Figure 4-5 Oversampling

Derating

See the information on derating of the module in the section Derating of the DQ 4x24VDC/2A HS (Page 38).

4.6 Address space

The module can be configured differently in STEP 7; see table below. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 4×24VDC/2A HS

You can configure the module with STEP 7 or with a GSD file. When you configure the module by means of the GSD file, the configuration is available under different short designations/module names. The following configurations are possible:

Table 4- 3 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. STEP 7		
		Can be integrated in the hardware catalog STEP 7, as of V13 SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel normal operation without value status	DQ 4×24VDC/2A HS	x	x	x
1 x 4-channel normal operation with value status	DQ 4×24VDC/2A HS QI	x	x	-
1 x 4-channel with pulse width modulation	DQ 4×24VDC/2A HS PWM	x	x	x
1 x 4-channel with oversampling	-	x	-	-

Overview of operating modes, functions and parameters

The table below provides an overview of:

- The dependencies between the operating modes of the module and associated technical functions
- The required parameter assignment for the respective operating mode

Table 4- 4 Operating modes, functions and parameters of the DQ 4×24VDC/2A HS

Function/Parameter assignment	Operating mode			
	Normal operation	Valve control in normal operation	Pulse width modulation	Oversampling
Function				
Isochronous mode	Yes, optional	Yes, optional	No	Yes, required
• Shortest send clock	125 µs	125 µs	-	250 µs
Oversampling	No	No	No	Yes
• Number of oversampling levels (output rate)	-	-	-	2 to 32
• Shortest sub-cycle (= shortest sample time)	-	-	-	100 µs
Value status (QI)	x	x	-	-
Data length	1 byte	1 byte	8 bytes	16 bytes
Parameter assignment				
Holding time valve control	-	x	-	-
Pulse width modulation duty factor	-	x	-	-
Pulse width modulation time period	-	x	x	-
Substitute value duty factor	-	-	x	-

Value status (quality information, QI)

The value status is always activated for the following module names in the GSD file:

- DQ 4×24VDC/2A HS (...) **QI**

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in this byte are each assigned to one channel. They provide information about the validity of the digital value.

- Bit =1: No fault is present on the channel.
- Bit =0: Channel is disabled or there is a fault/error on the module.

If an error on a channel occurs with this module, the value status for all channels is 0.

Address space for configuration as 4-channel DQ 4×24VDC/2A HS

The figure below shows the assignment of the address space for the configuration as a 4-channel module with value status (normal operation without/with valve control). The addresses for the value status are only available if the value status is enabled.

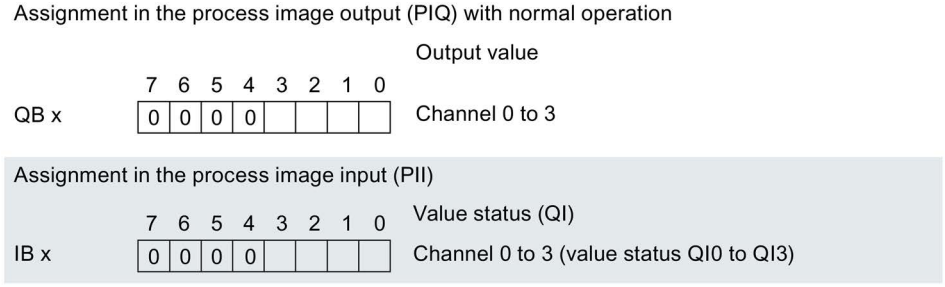


Figure 4-6 Address space for configuration as 4-channel DQ 4×24VDC/2A HS with value status

Address space for configuration with pulse width modulation

The figure below shows the address space allocation for the configuration with pulse width modulation.

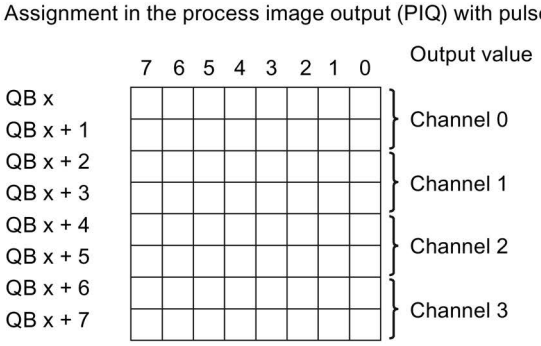


Figure 4-7 Address space of the DQ 4×24VDC/2A HS with pulse width modulation

Address space for configuration with oversampling

The figure below shows the address space allocation for the configuration with oversampling.

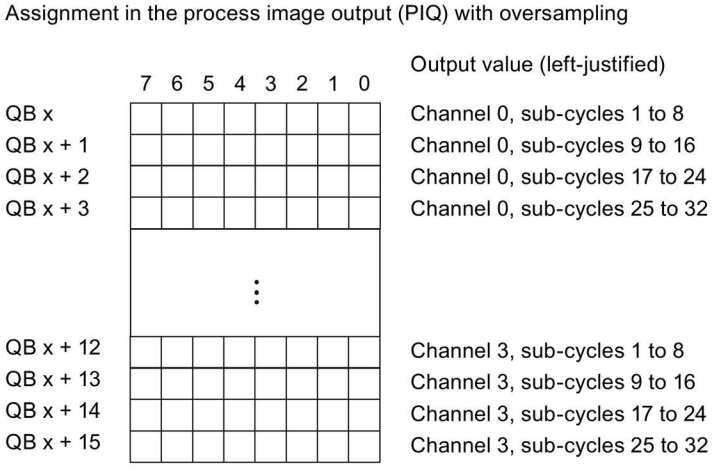


Figure 4-8 Address space of the DQ 4×24VDC/2A HS with oversampling

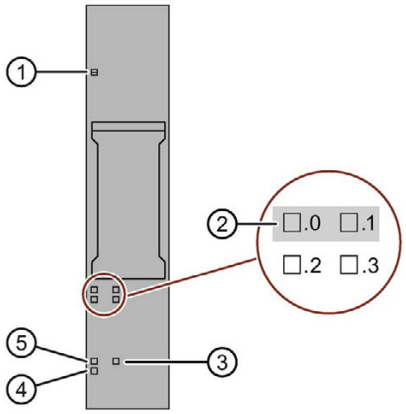
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the location of the LED displays of the DQ 4×24VDC/2A HS.



① DIAG (green/red)
② Channel status (green)
③ Oversampling mode (green)
④ PWR (green)
⑤ Pulse width modulation operating mode (green)

Figure 5-1 LED displays

Meaning of the LEDs

The following tables contain the meaning of the Status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 34).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated or process signal = 0
On	Channel activated and process signal = 1

Oversampling LED

Table 5- 3 Status display of the oversampling LED

Oversampling LED	Meaning
Off	Oversampling operating mode disabled
On	Oversampling operating mode enabled

PWR LED

Table 5- 4 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

Pulse width modulation (PWM) LED

Table 5- 5 Status display of the pulse width modulation LED

PWM LED	Meaning
□ Off	Pulse width modulation operating mode disabled
■ On	Pulse width modulation operating mode enabled

5.2 Interrupts

The DQ 4×24VDC/2A HS digital output module supports diagnostics interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Overtemperature
- High limit violated
- Parameter assignment error
- No load voltage
- Communications error
- Channel temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Note

You can connect 2 actuators per output.

The diagnostics of the two actuators influence each other in the case of duplicate wiring. This means that a single short-circuit affects both actuators.

Table 5- 6 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Short-circuit [1] [2]	1_H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	5_H	The module has detected that the maximum permitted module temperature has been exceeded. All channels of the module are switched to high resistance. The module is then restarted.	Correct the process wiring
High limit violated	7_H	The permitted value range of the duty factor has been exceeded.	Correct the output value (0 to 1000)
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Communications error	13_H	Module is defective.	Replace the module.
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read out any process values or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

[1] The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

[2] If the short-circuit persists, the module heats up. This may trigger temperature monitoring with overtemperature diagnostic interrupt.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 4×24VDC/2A HS

	6ES7132-6BD20-0DA0
Product type designation	ET 200SP, DQ 4x24VDC/2A High Speed
General information	
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	Yes; valve control
PWM	Yes
Oversampling	Yes
MSO	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	50 mA; no load
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	2.5 W; with 24 V, 25 °C, DQ mode, 2 A per channel

	6ES7132-6BD20-0DA0
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Input	1 byte; with QI
Output	16 bytes; max., in oversampling operating mode
Digital outputs	
Number of outputs	4
Sinking output	No
Sourcing output	Yes; push-pull output
Short-circuit protection	Yes
• Response threshold, typ.	6 A
Limitation of inductive shutdown voltage to	M (-1 V)
Control of a digital input	No
Digital output functions, configurable	
PWM output	Yes
• Number, max.	4
• Time period, configurable	Yes; 0 ms; 0.2 ms; 0.4 ms; 0.93 ms; 1.33 ms; 4.27 ms; 10.67 ms; 21.33 ms; 34.13 ms; 59.73 ms
• Resolution of the on-load factor	0.1%
Digital output with oversampling	Yes
• Number, max.	4
• Values per cycle, max.	32
• Resolution, min.	100 µs
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	10 W
Load resistance range	
Low limit	12 Ω
High limit	3400 Ω
Output current	
For signal "1" rated value	2 A
For signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
"0" to "1", max.	1 µs
"1" to "0", max.	1 µs
Parallel switching of 2 outputs	
For increased performance	No
Switching frequency	
With resistive load, max.	5 kHz
With inductive load, max.	5 kHz
With lamp load, max.	5 kHz

	6ES7132-6BD20-0DA0
Total current of outputs	
Current per module, max.	8 A
Total current of outputs (per module)	
Horizontal installation	
• up to 30 °C, max.	8 A; DQ mode
• up to 40 °C, max.	6.9 A; DQ mode
• up to 50 °C, max.	4.7 A; DQ mode
• up to 60 °C, max.	2.5 A; DQ mode
Vertical installation	
• up to 30 °C, max.	7.2 A; DQ mode
• up to 40 °C, max.	5.6 A; DQ mode
• up to 50 °C, max.	4 A; DQ mode
Cable length	
Shielded, max.	50 m
Unshielded, max.	50 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes; DQ and OVS operating mode only
Bus cycle time (TDP), min.	125 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Short-circuit	Yes
Diagnostics display LED	
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

6.2 Derating of the DQ 4x24VDC/2A HS

Maximum permitted output current depending on the frequency

The figure below shows the maximum permitted output current per channel depending on the frequency.

You must take this characteristic into consideration for all operating modes of the module.

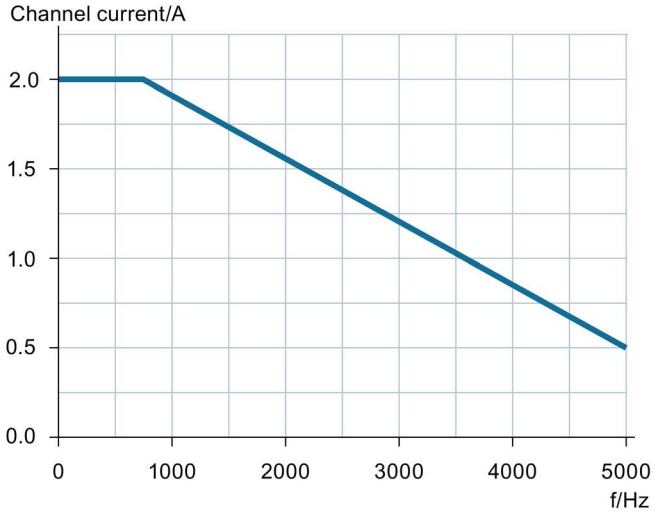


Figure 6-1 Derating of the DQ 4×24VDC/2A HS depending on the frequency

Maximum permitted output current depending on the ambient temperature

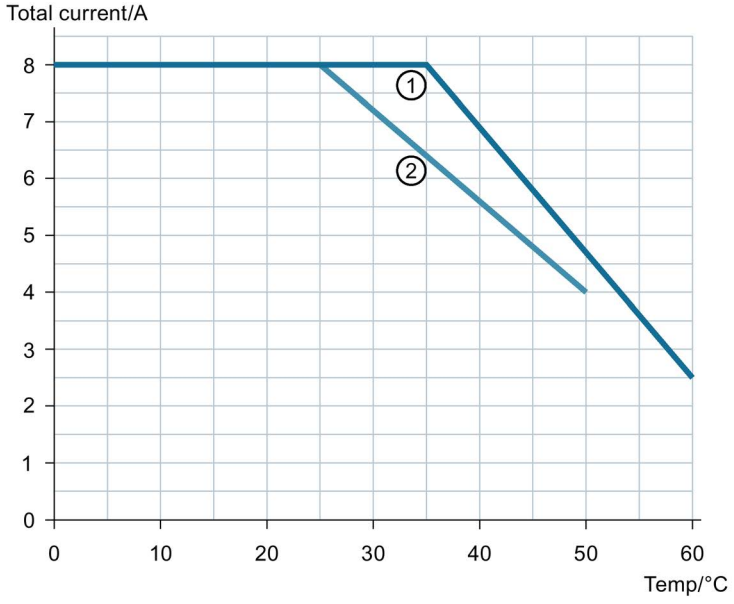
In addition to the dependency of the maximum permitted output current on the frequency, you also have to take into consideration the dependency on the ambient temperature. Depending on the configured module operating mode, there is an additional "DQ" or "PWM" derating. The table below shows the dependencies of derating version and module operating mode:

Table 6- 1 Additional derating versions of the DQ 4×24VDC/2A HS

Derating version	Operating mode			
	Normal operation	Valve control in normal operation	Pulse width modulation	Oversampling
DQ derating	×	-	-	×
PWM derating	-	×	×	-

DQ derating

The figure below shows the maximum permitted total current depending on the ambient temperature for the DQ derating.

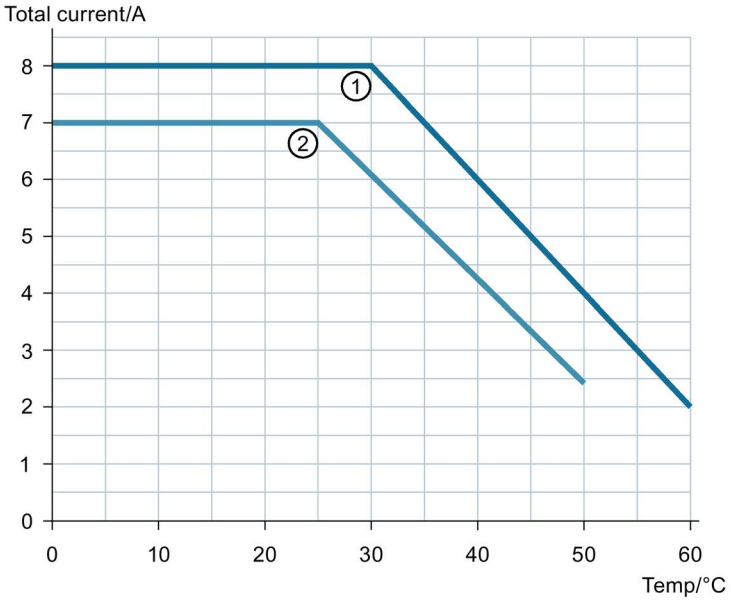


① Horizontal installation position
② Vertical installation position

Figure 6-2 Additional DQ derating depending on the ambient temperature

PWM derating

The figure below shows the maximum permitted total current depending on the ambient temperature for the PWM derating.



① Horizontal installation position
② Vertical installation position

Figure 6-3 Additional PWM derating depending on the ambient temperature

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module parameter settings can be changed in RUN. The time period of selected channels can, for example, be changed in RUN in the "Pulse width modulation" operating mode without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

Note

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

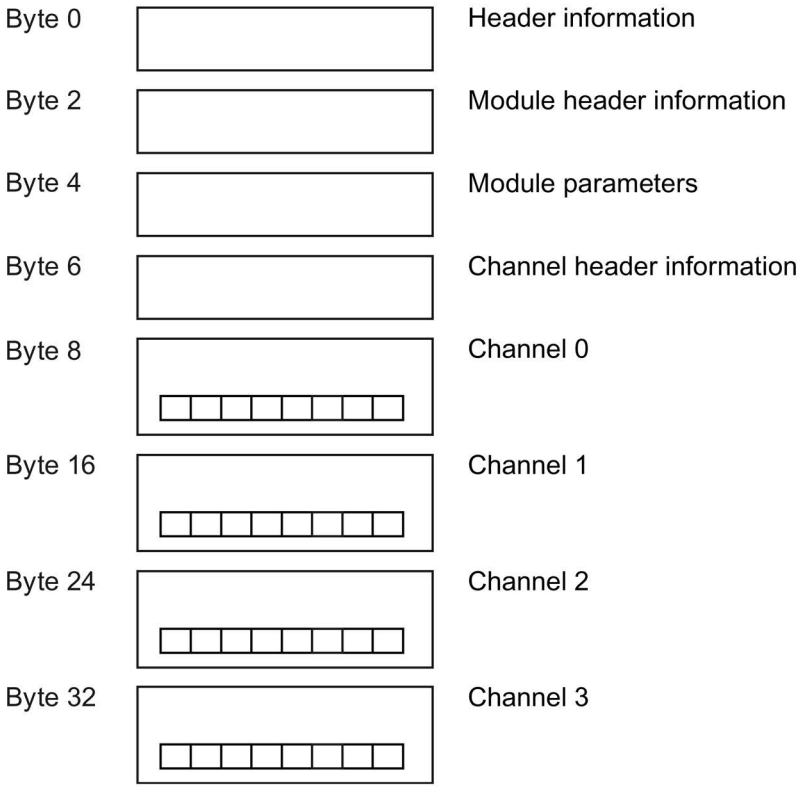


Figure A-1 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

Figure A-2 Header information

Module header information

The figure below shows the structure of the module header information.

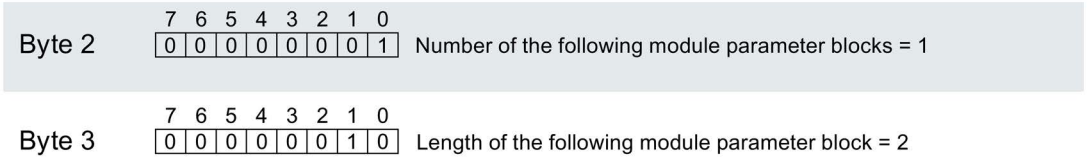


Figure A-3 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 3.

Enable a parameter by setting the corresponding bit to "1".

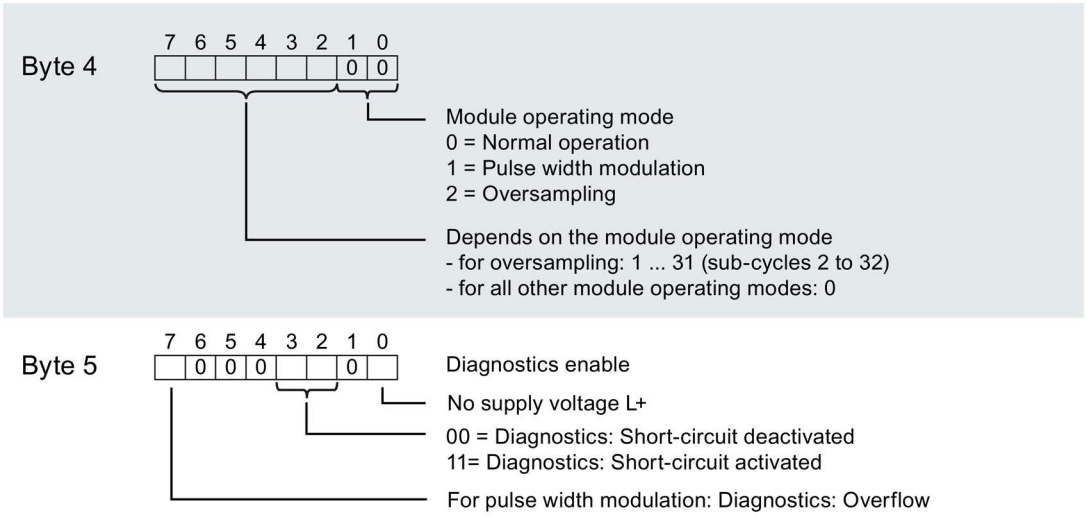


Figure A-4 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

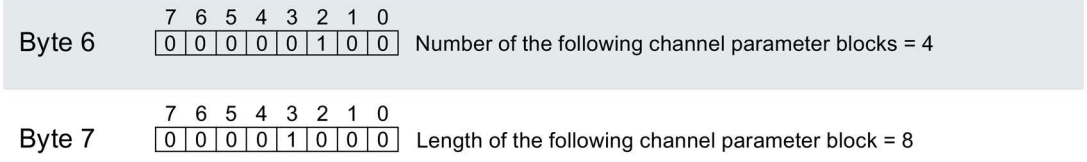
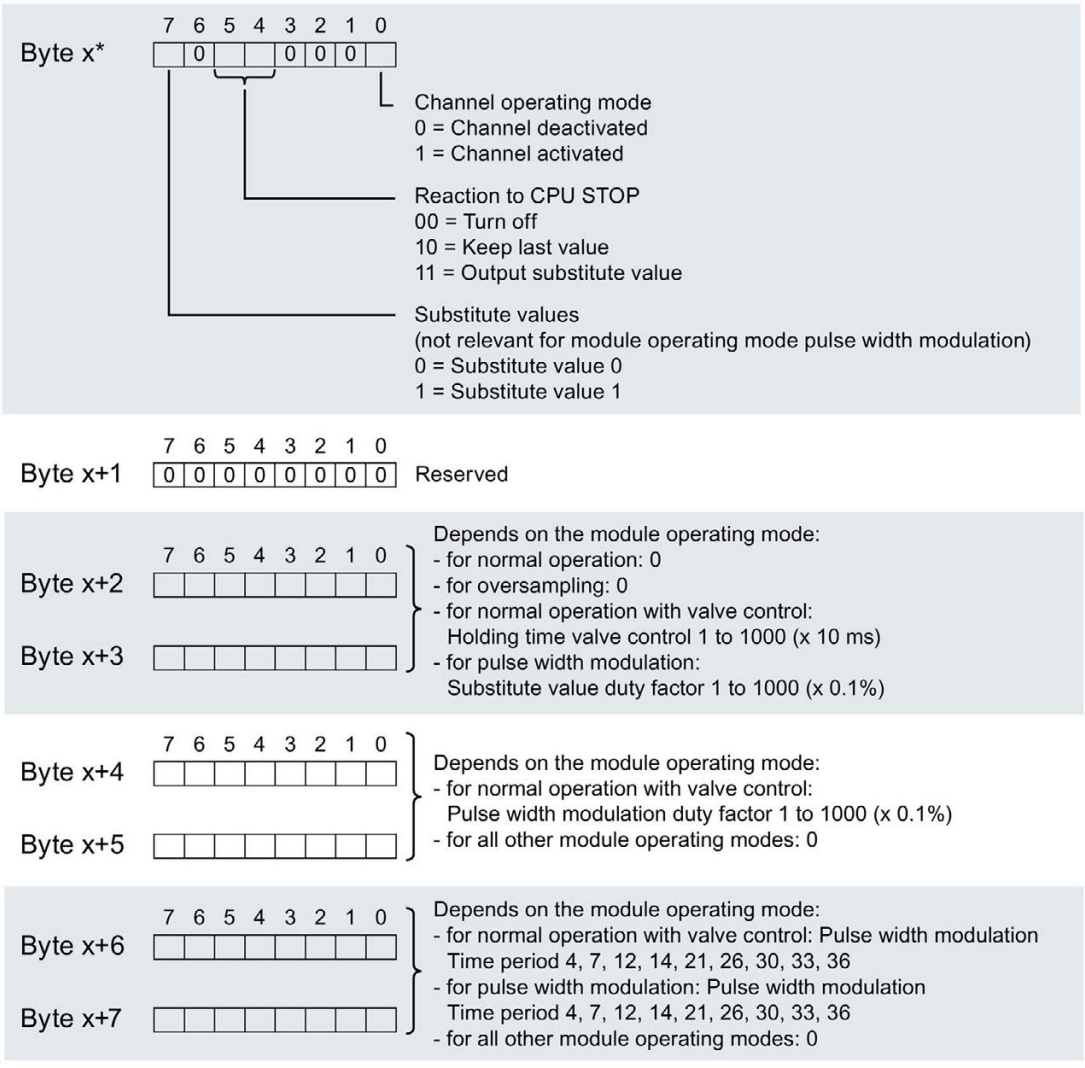


Figure A-5 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".



* x = 8 + (channel number × 8); channel number = 0 to 3

Figure A-6 Structure of byte x to x+7 for channels 0 to 3

Codes for time period of the pulse width modulation

The table below contains the codes for the time period of the pulse width modulation of the digital output module. You must enter these codes in bytes x+6 and x+7 of the channel parameter block of data record 128 (see previous figure).

Table A- 1 Codes for output range

Value	Time period	Code
4	0.20 ms	0000 0100
7	0.40 ms	0000 0111
12	0.93 ms	0000 1100
14	1.33 ms	0000 1110
21	4.27 ms	0001 0101
26	10.67 ms	0001 1010
30	21.33 ms	0001 1110
33	34.13 ms	0010 0001
36	59.73 ms	0010 0100

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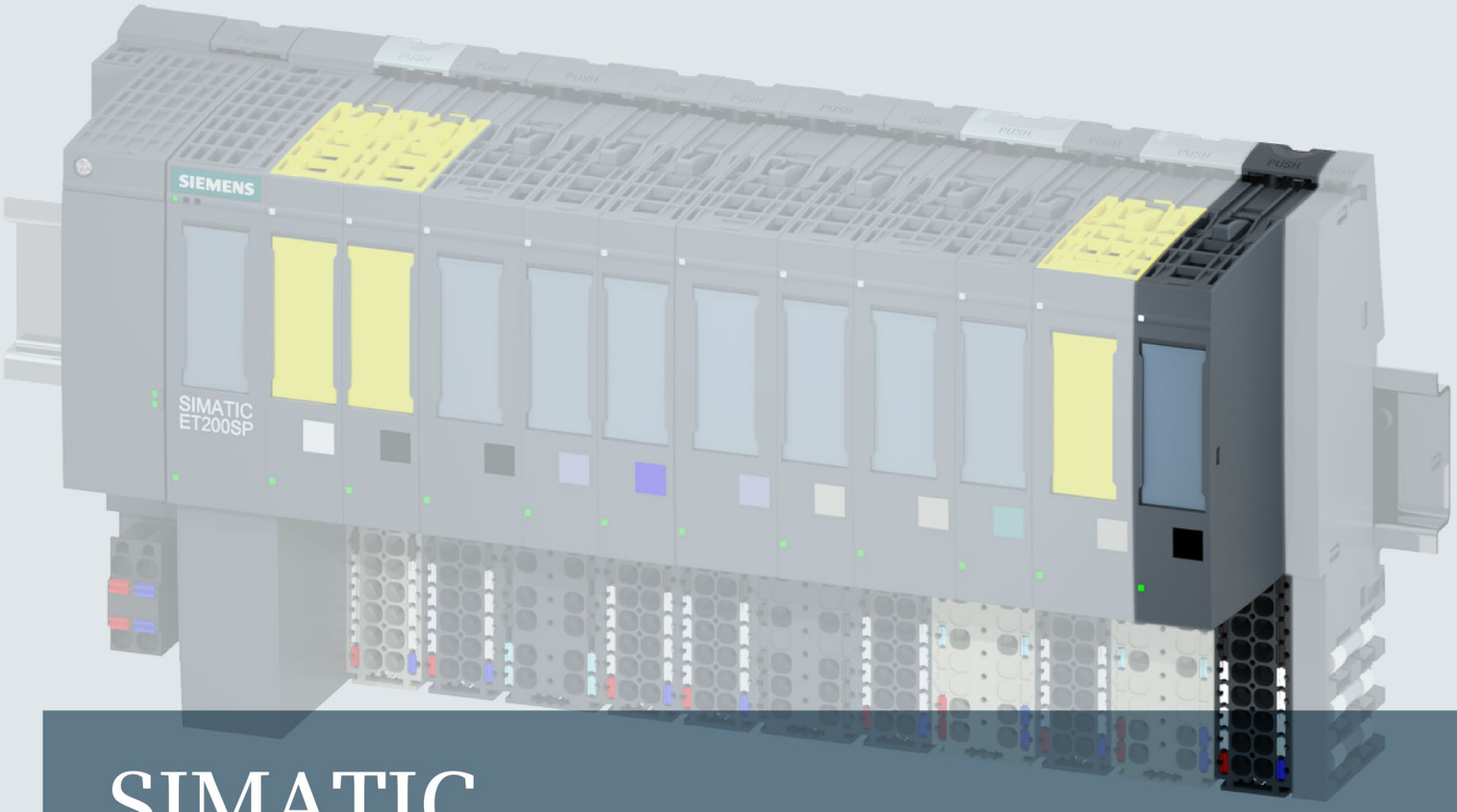

SIMATIC

ET 200SP

Digital output module DQ 16x24VDC/0.5A ST (6ES7132-6BH00-0BA0)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Digital output module
DQ 16x24VDC/0.5A ST
(6ES7132-6BH00-0BA0)

Manual

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Parameter data record A

12/2015

A5E03574420-AC

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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GERMANY

A5E03574420-AC
℗ 12/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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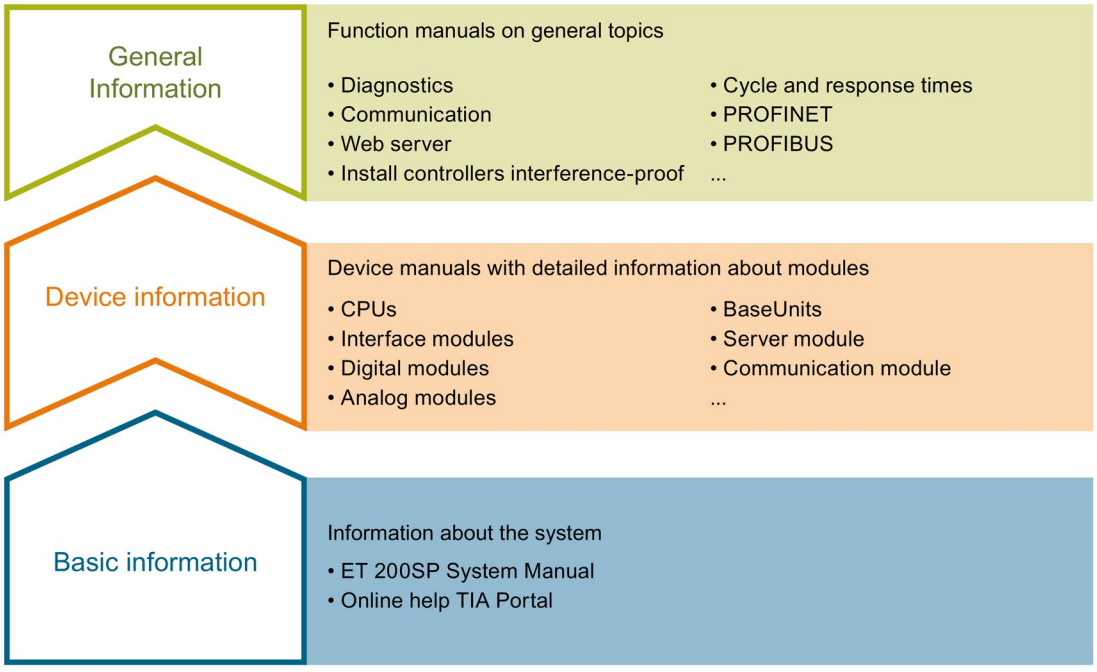
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

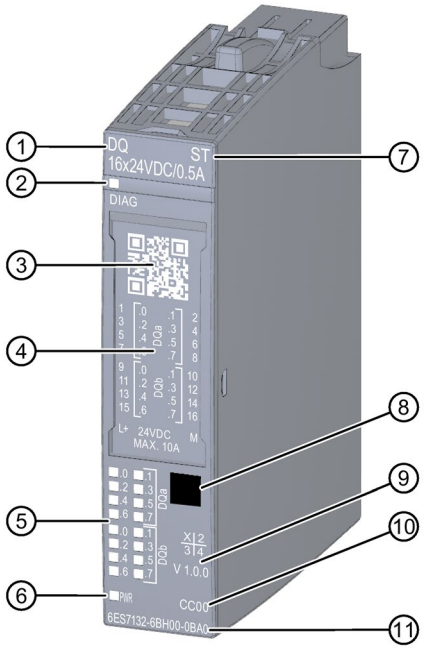
2.1 Properties

Article number

6ES7132-6BH00-0BA0 (packaging unit: 1 unit)

6ES7132-6BH00-2BA0 (packaging unit: 10 units)

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module DQ 16×24VDC/0.5A ST

Properties

The module has the following technical properties:

- Digital output module with 16 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 0.5 A (per channel), total current max. 8 A
  (see derating: Technical specifications (Page 22))
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manualET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

Connecting

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 16×24VDC/0.5A ST module with the terminal assignments for a 1-wire connection.

You can find information on wiring the BaseUnit in the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Note

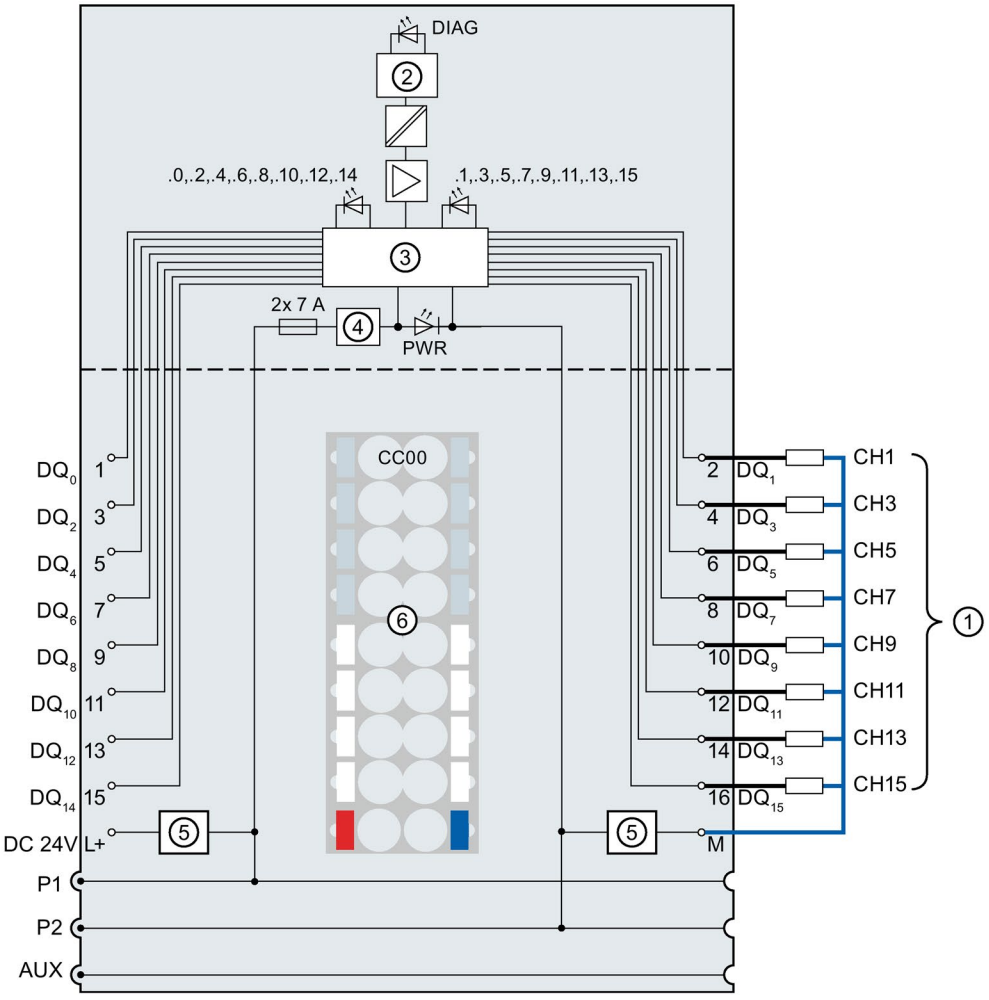
The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Note

The fuse integrated in BaseUnit type A1 may be triggered in the digital output module, rendering the terminals unusable.
Make sure that you only use digital output modules with BaseUnit type A0 during commissioning.

Wiring: 1-wire connection of actuators

The following figure shows the block diagram and an example for the terminal assignment of the digital output module DQ 16×24VDC/0.5A ST on the BaseUnit BU type A0 (1-wire connection).



①	1-wire connection	DQ_n	Output signal, channel n
②	Backplane bus interface	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
③	Output electronics	M	Ground
④	Polarity reversal protection	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Supply voltage filter circuit (only available with light BaseUnit)	DIAG	Diagnostics LED (green, red)
⑥	Color-coded label with color code CC00 (optional)	.0 to .15	Channel status LED (green)
		PWR	Power LED (green)

Image 3-1 Wiring and block diagram for 1-wire connection of actuators

Parameters/address space

4

4.1 Parameters

Parameters for DQ 16x24VDC/0.5A ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of parameter data record (Page 27).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Enable • Disable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Enable • Disable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to L+	• Enable • Disable	Disable	Yes	Module	Module
Diagnostics: Wire break	• Enable • Disable	Disable	Yes	Module	Module
Channel activated	• Enable • Disable	Enable	Yes	Channel	Channel

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 6 bytes.

Note

If one of the two parameters "Diagnostics: Short-circuit to L+" or "Diagnostics: Wire break" is enabled and one of these diagnostics occurs, the affected channel is switched off to avoid triggering an undefined load. Note that a diagnostic interrupt can only be generated when diagnostics are enabled. [1]

[1] as of module revision 05

4.2 Declaration of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP / substitute value

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 16x24VDC/0.5A ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DQ 16x24VDC/0.5A ST V1.0	X	X	X
1 x 16-channel without value status	DQ 16x24VDC/0.5A ST V1.1	---	X	X
1 x 16-channel with value status	DQ 16x24VDC/0.5A ST V1.1, QI	---	X	---

Evaluating the value status

An additional two bytes are allocated in the input address space if you enable the value status for the digital module. Bits 0 to 15 in these bytes are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DQ 16×24VDC/0.5A ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

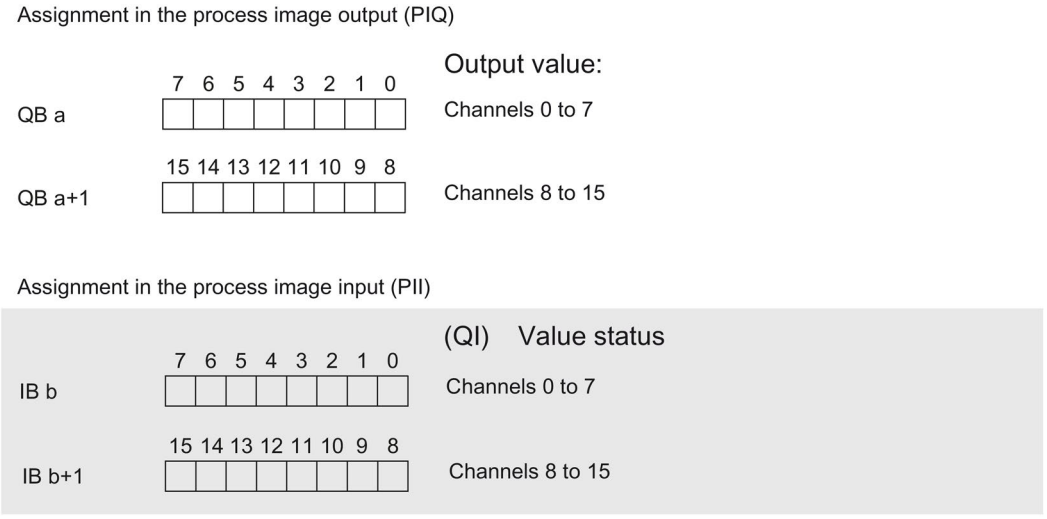


Image 4-1 Address space of DQ 16×24VDC/0.5A ST with value status

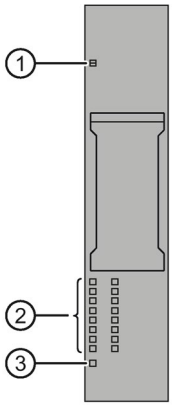
Interrupts/diagnostic alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the DQ 16x24VDC/0.5A ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in chapter Diagnostic messages (Page 21).

DIAG LED

Table 5- 1 DIAG LED fault display

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashing	Module not configured
On	Module configured and no module diagnostics
Flashing	Module configured and module diagnostics

LED channel status

Table 5- 2 LED channel status display

LED channel status	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated and process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ present

5.2 Interrupts

The digital output module DQ 16×24VDC/0.5A ST supports diagnostic interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostic messages

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Note

Parallel connection of two outputs

For parallel connection of two outputs for redundant control of a load, the channel diagnostics "Short-circuit to L+" and "Wire break" must be deactivated.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	• Short-circuit of actuator supply to ground • Short-circuit of actuator supply to L+	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	• Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 16×24VDC/0.5A ST

	6ES7132-6BH00-0BA0
General information	
Product type designation	ET 200SP, DQ 16x24VDC/0.5A ST, PU 1
Firmware version	V1.1
• FW update possible	Yes
Usable BaseUnits	BU type A0
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 / -
PCS 7 can be configured/integrated as of version	V8.1 SP1
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	60 mA; no load
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W

	6ES7132-6BH00-0BA0
Address area	
Address space per module	
Address space per module, max.	2 bytes; + 2 bytes for QI information
Digital outputs	
Number of outputs	16
Sinking output	No
Sourcing output	Yes
Short-circuit protection	Yes
• Response threshold, typ.	0.7 to 1.3 A
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	0.5 A
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ
Output current	
For signal "1" rated value	0.5 A
For signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
"0" to "1", typ.	50 µs
"1" to "0", typ.	100 µs
Parallel connection of two outputs	
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	100 Hz
With inductive load, max.	2 Hz
With lamp load, max.	10 Hz
Total current of the outputs	
Current per channel, max.	0.5 A
Current per module, max.	8 A
Total current of the outputs (per module)	
Horizontal installation	
• Up to 40 °C, max.	8 A
• Up to 50 °C, max.	6 A
• Up to 60 °C, max.	4 A
Vertical installation	
• Up to 30 °C, max.	8 A
• Up to 40 °C, max.	6 A
• Up to 50 °C, max.	4 A

	6ES7132-6BH00-0BA0
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	Yes; module by module
Short-circuit	Yes; module by module
Group error	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	28 g

Safety-related shutdown

Note

The digital output module DQ 16x24VDC/0.5A ST supports safety-related shutdown in connection with a fail-safe power module F-PM-E 24VDC/8A PPM ST:

- SIL according to IEC 61508: 2
- Highest attainable safety class in safety mode, performance level according to EN ISO 13849-1: d

Residual current for signal state "0"

Note

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current does not depend on the setting for the Diagnostics: Wire break parameter.

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

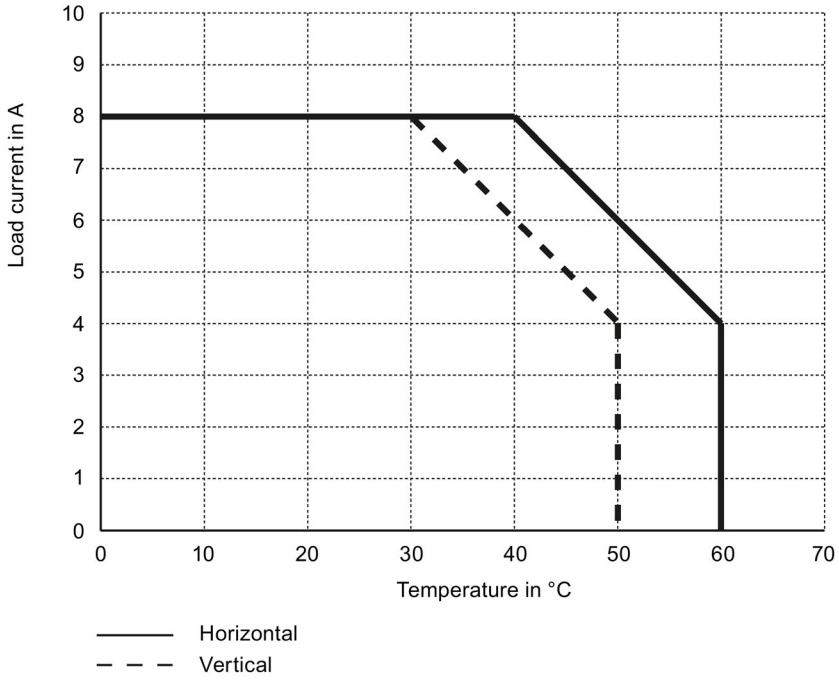


Image 6-1 Load current for mounting position

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

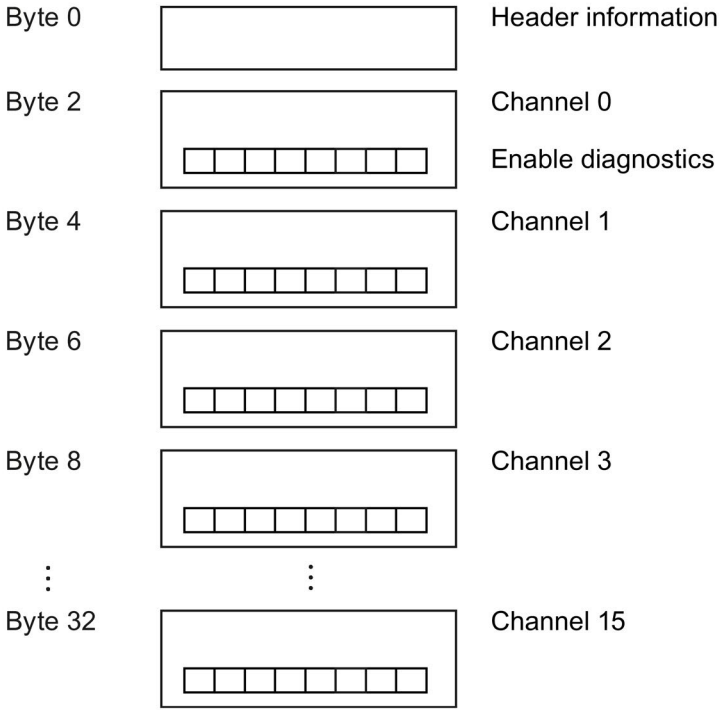


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

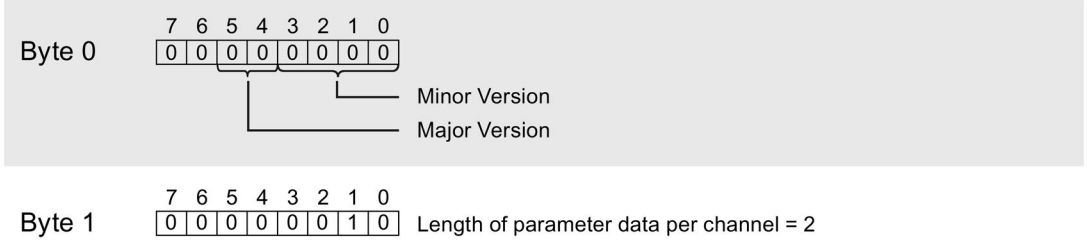
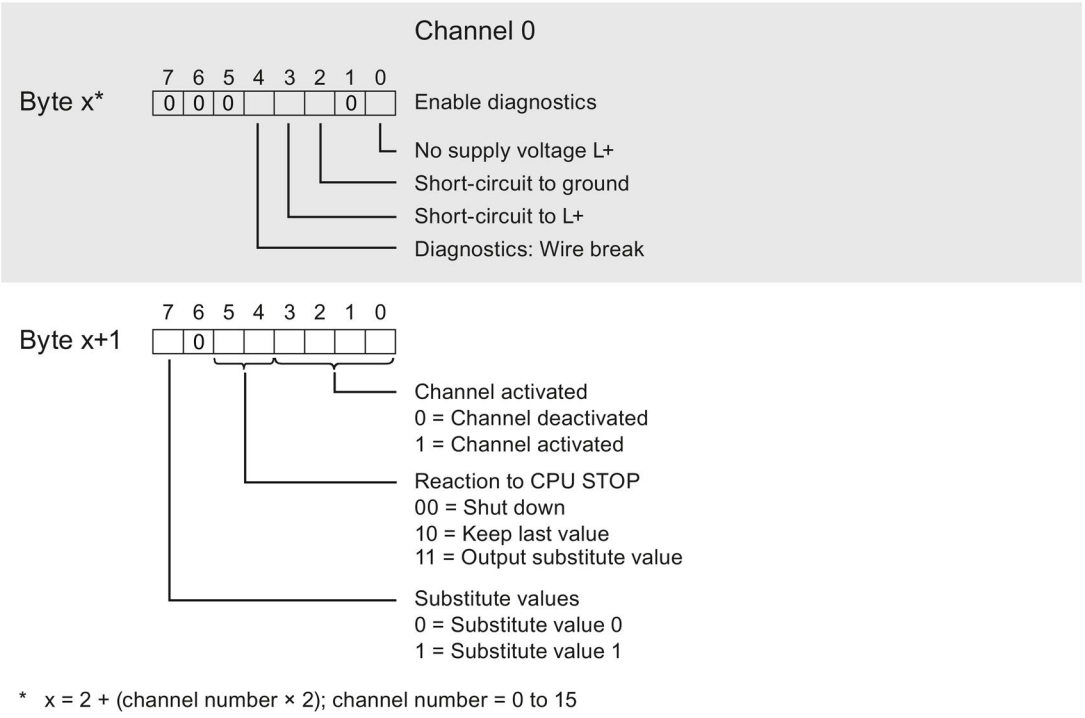


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 15.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 2); channel number = 0 to 15

Image A-3 Structure byte x to x+1 for the channels 0 to 15

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

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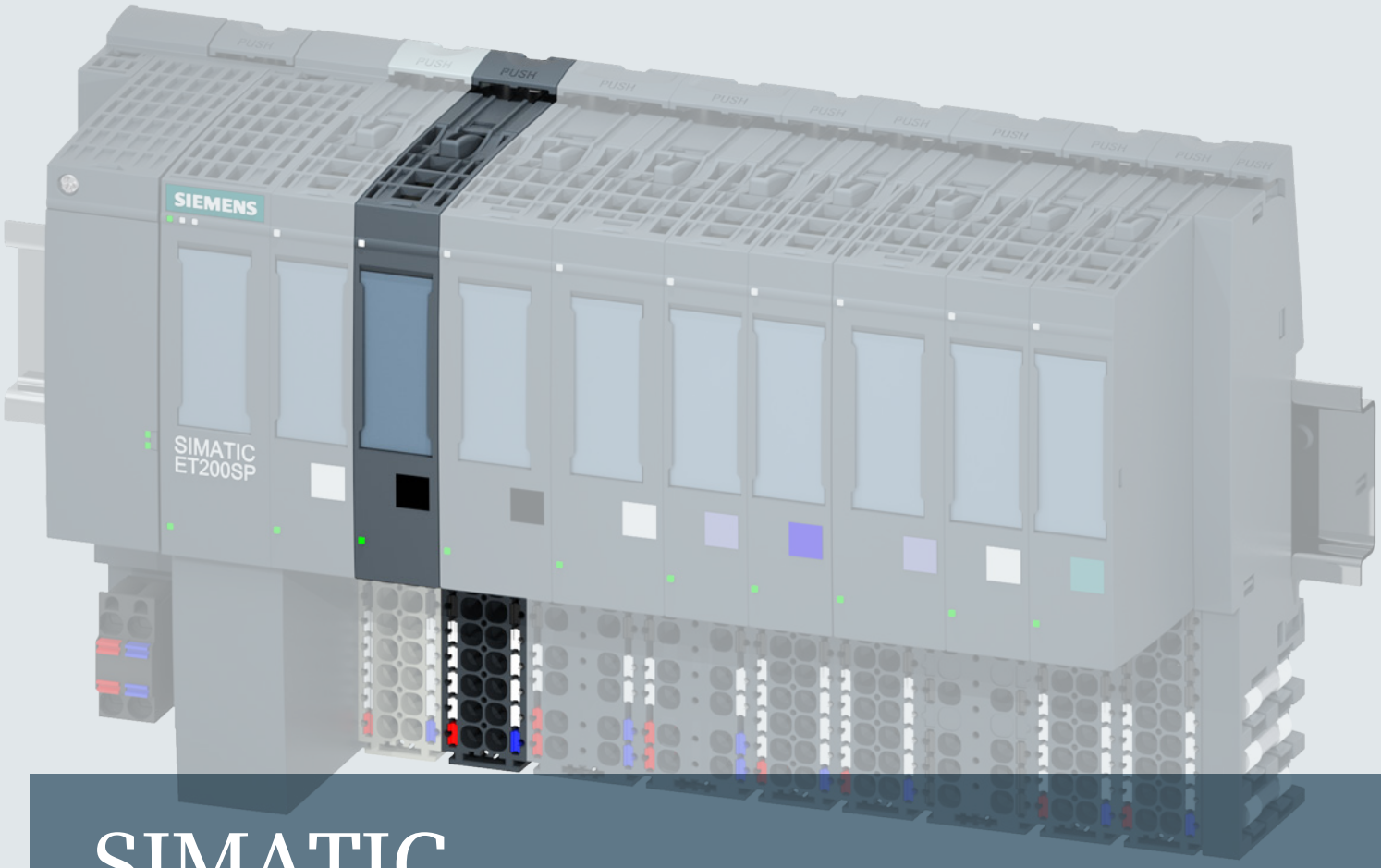

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ET 200SP

Digital output module RQ 4x24VUC/2A CO ST (6ES7132-6GD50-0BA0)

Manual

Edition 02/2014

Answers for industry.

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ET 200SP
RQ 4x24VUC/2A CO ST
Digital Output Module
(6ES7132-6GD50-0BA0)

Manual

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Parameter data record A

02/2014

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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A5E32855952-AA
℗ 02/2014 Technical data subject to change

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers topics relating to your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of the system manual, function manuals and device manuals.

The STEP 7 information system (online help) also helps you to configure and program your automation system.

Overview of the documentation for digital output module RQ 4×24VUC/2A CO ST

The table below lists additional documentation that you will need when using the RQ 4×24VUC/2A CO ST digital output module.

Table 1- 1 Documentation for digital output module RQ 4×24VUC/2A CO ST

Topic	Documentation	Most important contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Enhancements and special features of the ET 200SP Distributed I/O System	Product information Amendments to ET 200SP documentation (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or other manuals.

SIMATIC manuals

All of the current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Part number

6ES7132-6GD50-0BA0

View of the module

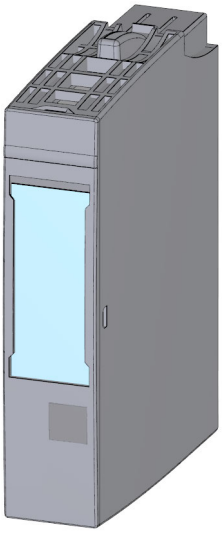


Figure 2-1 View of the RQ 4×24VUC/2A CO ST module

Properties

The module has the following technical properties:

- 4 digital outputs with floating relay changeover contacts
- Supply voltage L+
- Output current per output 2 A
- Normally open contact (NO: normally open) and normally closed contact (NC: normally closed)
- Assignable substitute values (per channel)
- Configurable diagnostics (per module)
- Suitable for resistive load

The module supports the following functions:

- Firmware update
- Identification data I&M0 to I&M3
- Parameter assignment in RUN
- PROFIenergy

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

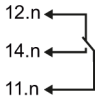
3

3.1 Pin assignment

General pin assignment

The following table shows the pin assignment for RQ 4x24VUC/2A CO ST.

Table 3- 1 Pin assignment for RQ 4×24VUC/2A CO ST

Pin assignment for RQ 4×24VUC/2A CO ST (6ES7132-6GD50-0BA0)						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	12.0	**2**	12.1	• 11.n: Common contact • 12.n: Normally closed contact • 14.n: Normally open contact • n: Channel	A0	---
3	12.2	**4**	12.3			
5	14.0	**6**	14.1			
7	14.2	**8**	14.3			
9	11.0	**10**	11.1			
11	11.2	**12**	11.3			
13	RES	**14**	RES			
15	RES	**16**	RES			
L+	24 V DC	**M**	M			
Changeover contact 						

[1] BaseUnit types that can be used are identified by the last two digits of the part number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Keep this in mind also during the configuration

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

The figure below shows the block diagram of the RQ 4x24VUC/2A CO ST.

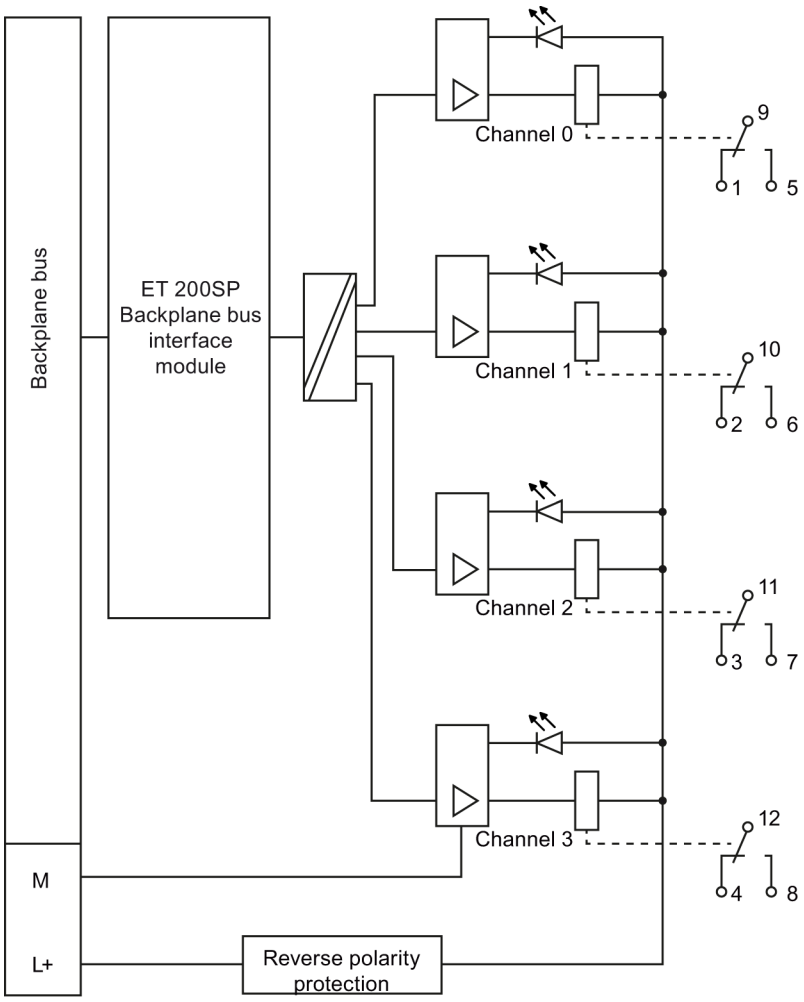


Figure 3-1 Block diagram RQ 4×24VUC/2A CO ST

Parameters/address space

4

4.1 Parameters

RQ 4x24VUC/2A CO ST parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record).

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Enable • Disable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP. The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 4 bytes.

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Operating mode

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Address space of the digital output module RQ 4×24VUC/2A CO ST

The figure below shows the assignment of the address space for RQ 4×24VUC/2A CO ST.

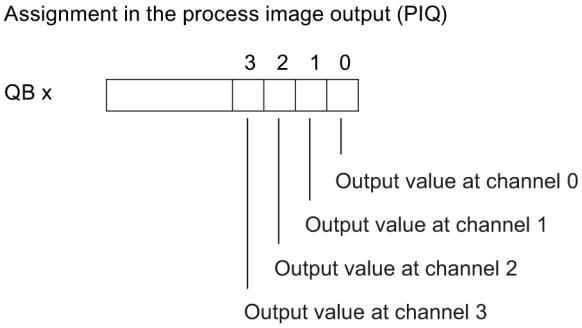


Figure 4-1 Address space of the digital output module RQ 4×24VUC/2A CO ST

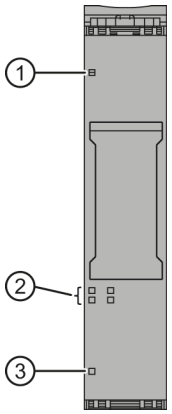
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the RQ 4x24VUC/2A CO ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The tables below explain the meaning of the status and error displays. Remedial measures for diagnostics alarms can be found in section Diagnostics alarms (Page 14).

LED DIAG

Table 5- 1 Error display of the LED DIAG

LED DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module not ready for operation (no parameters assigned)
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

LED channel status

Table 5- 2 Status display of the LED channel status

LED channel status	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated

LED PWR

Table 5- 3 Status display of the LED PWR

LED PWR	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The RQ 4×24VUC/2A CO ST digital output module supports diagnostics alarms.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following event:

- No supply voltage

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the LED DIAG flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the potential group • Check BaseUnit

Technical specifications

6

6.1 Technical specifications

Technical specifications of the RQ 4×24VUC/2A CO ST

	6ES7132-6GD50-0BA0
Product type designation	RQ 4x24VUC/2A CO ST
General information	
Usable BaseUnits	BU type A0
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Input current	
Current consumption (rated value)	50 mA
Current consumption, max.	60 mA
Power loss	
Power loss, typ.	1.2 W
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Digital outputs	
Parallel switching of 2 outputs	
For increased performance	No
Switching frequency	
With resistive load, max.	2 Hz
Total current of the outputs	
Max. current per module	8 A
Relay outputs	
Number of relay outputs	4

	6ES7132-6GD50-0BA0
Rated input voltage of relay coil L+ (DC)	24 V
Current consumption of relays (coil current of all relays), max.	40 mA
Switching capacity of the contacts	
• With resistive load, max.	2 A
• Thermal continuous current, max.	2 A
• Rated switching voltage (DC)	24 V
• Rated switching voltage (AC)	24 V
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	200 m
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostic interrupt	Yes
Diagnostics alarms	
Monitoring of supply voltage	Yes
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green LED PWR
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red LED DIAG
Electrical isolation	
Electrical isolation channels	
Between the channels	Yes
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permissible potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	30 g

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

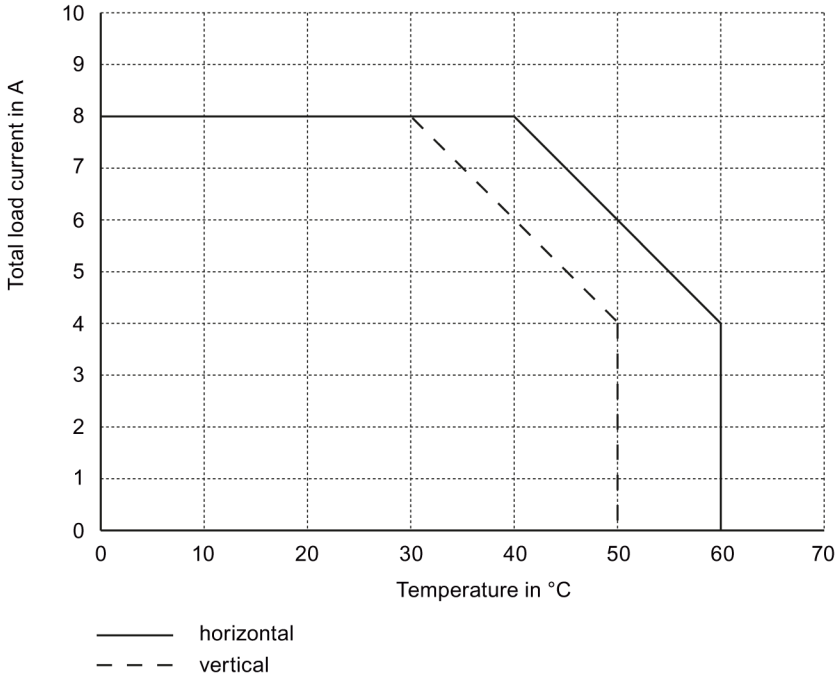


Figure 6-1 Load current for mounting position

Dimensional drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You have the option to re-configure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

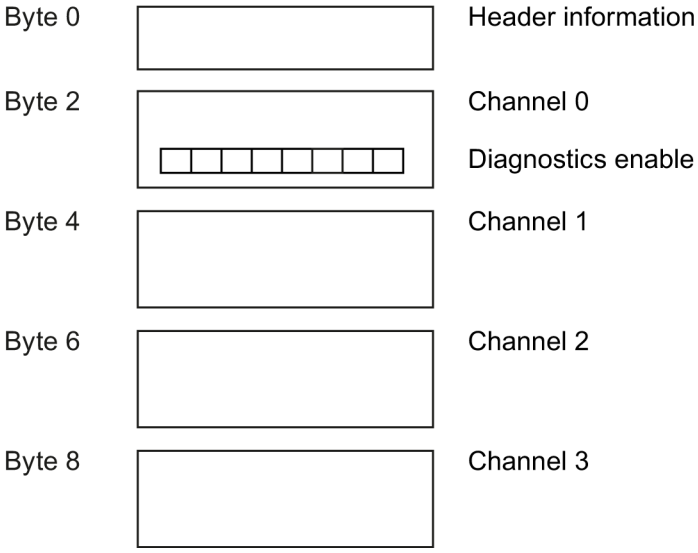


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

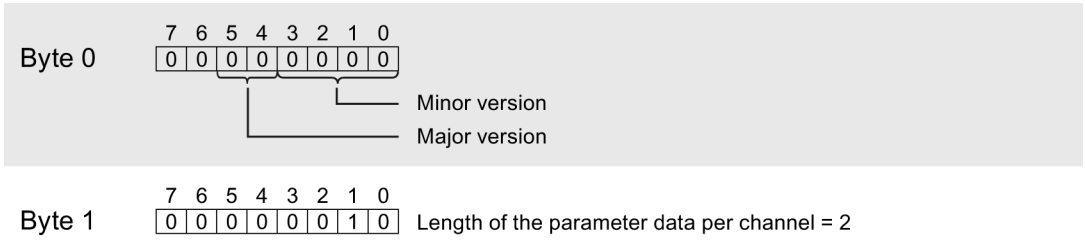
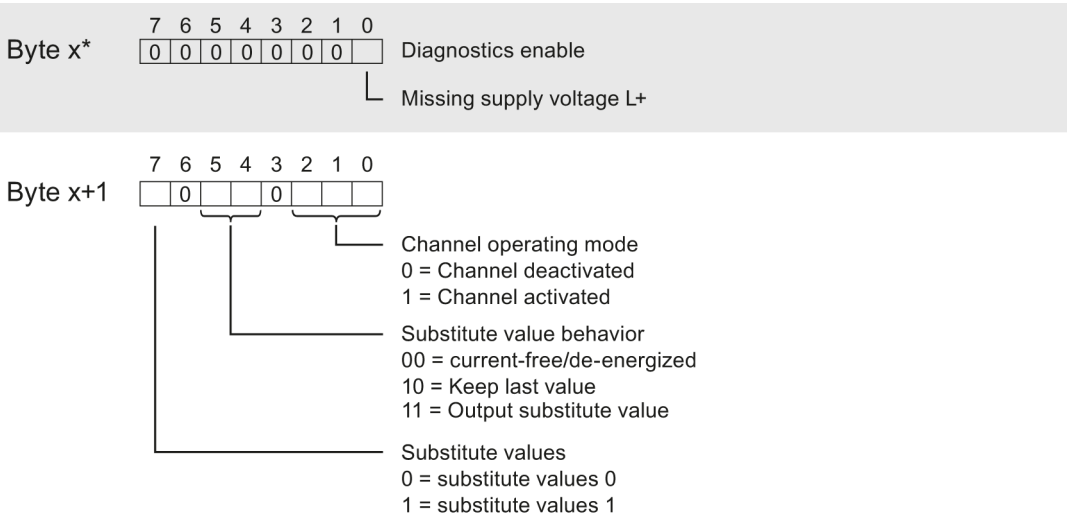


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

Enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 2); channel number = 0 to 3

Figure A-3 Structure byte x to x+1 for the channels 0 to 3

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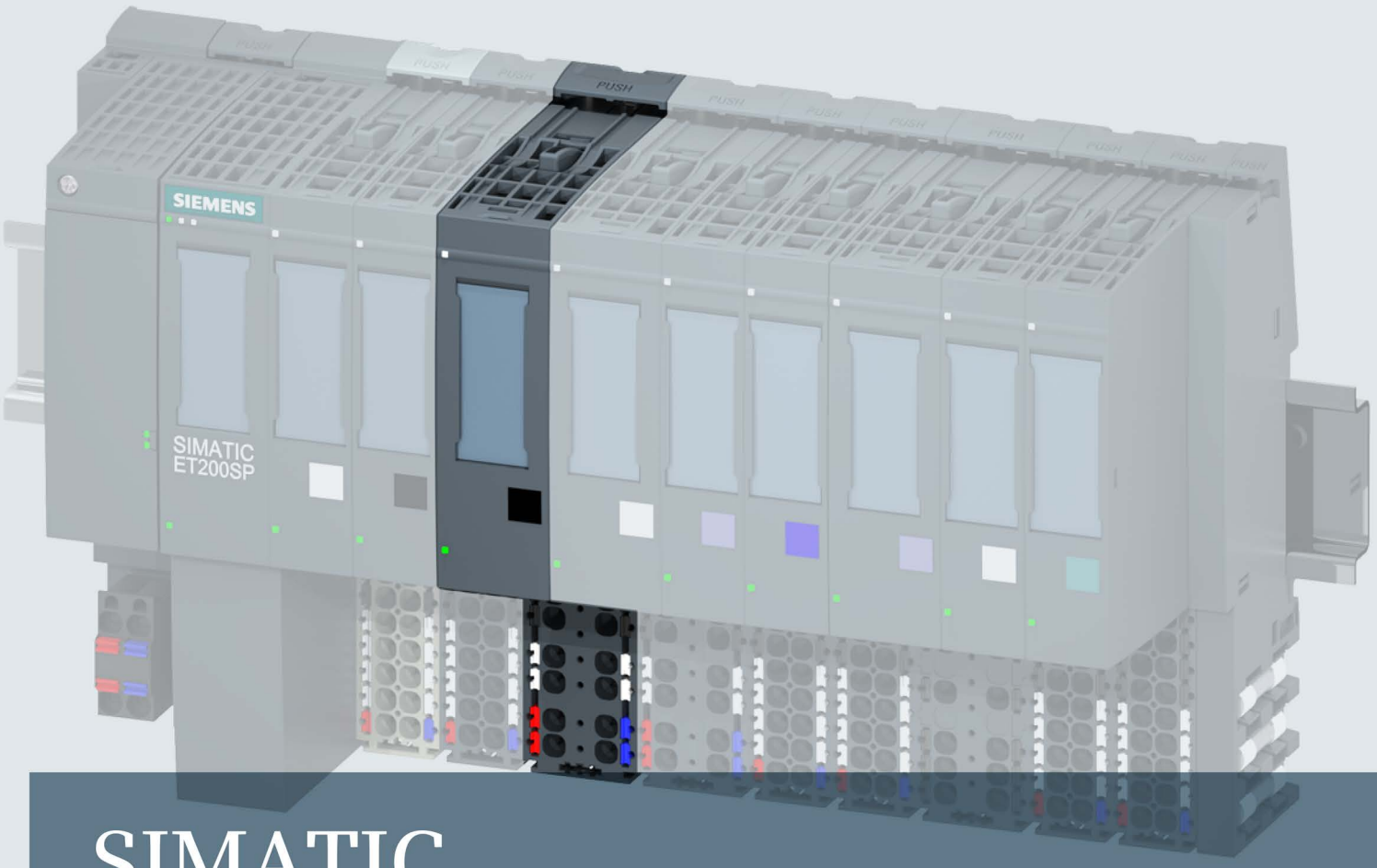

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Digital output module RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB1)

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Parameter assignment and structure of the parameter data record A

03/2015

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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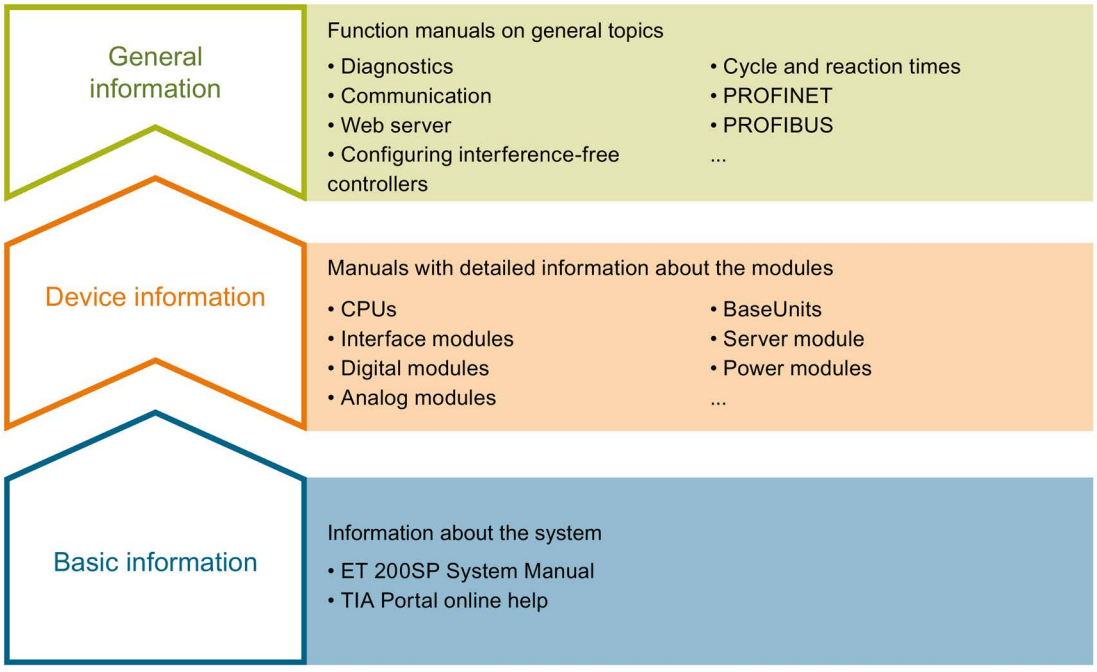
A.1 Parameter assignment and structure of the parameter data record 24

Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

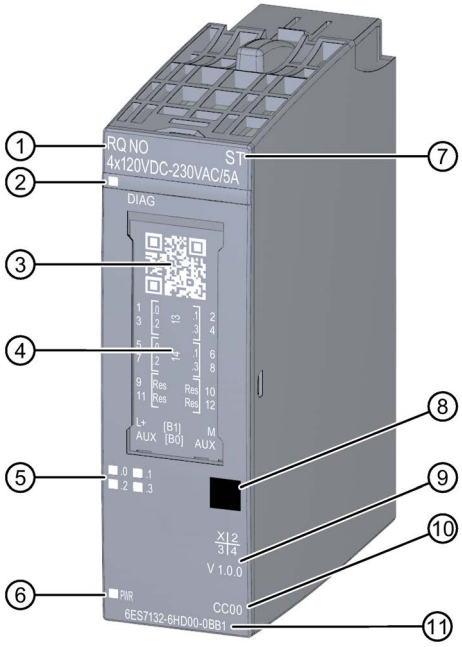
2

2.1 Properties

Article number

6ES7132-6HD00-0BB1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-1 View of the RQ 4×120VDC-230VAC/5A NO ST module

Properties

The module has the following technical properties:

- Digital output module with 4 floating relay outputs
- Supply voltage L+
- Output current per output 5 A
- Normally open contact (NO: normally open)
- Configurable diagnostics (per module)
- Substitute value output
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Note

The I/O module RQ 4×120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB1) replaces the predecessor module with order number 6ES7132-6HD00-0BB0 and also supports the BaseUnit BU type B1 (2-wire connection of actuators).

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the RQ 4x120VDC-230VAC/5A NO ST module with the terminal assignments for 2-wire and 3-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

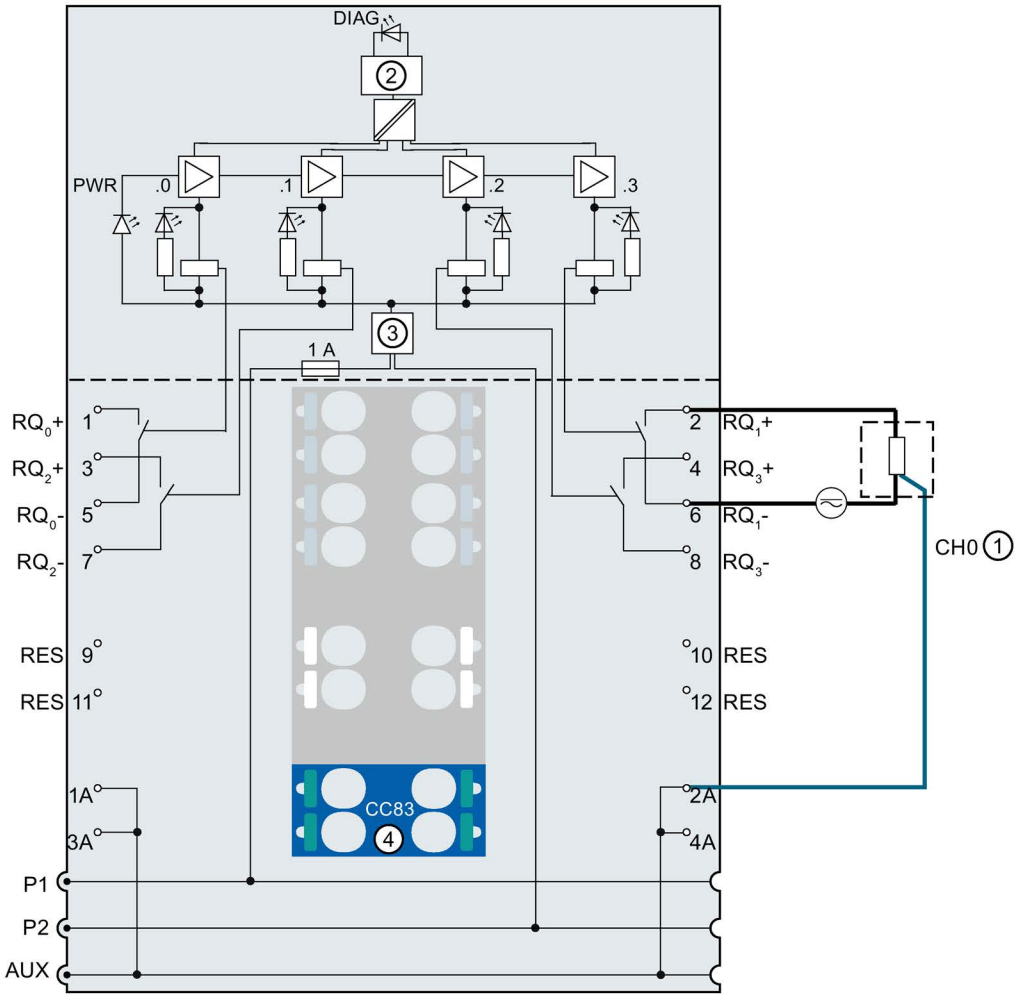
You may use and combine the different wiring options for all channels.

Note

The relay contacts of the module can only switch identical voltage potential. The AUX terminals can only be used with an associated identical voltage or PE.

Connection: 3-wire connection of actuators

The following figure shows the block diagram and an example for the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO ST on the BaseUnit BU type B0.

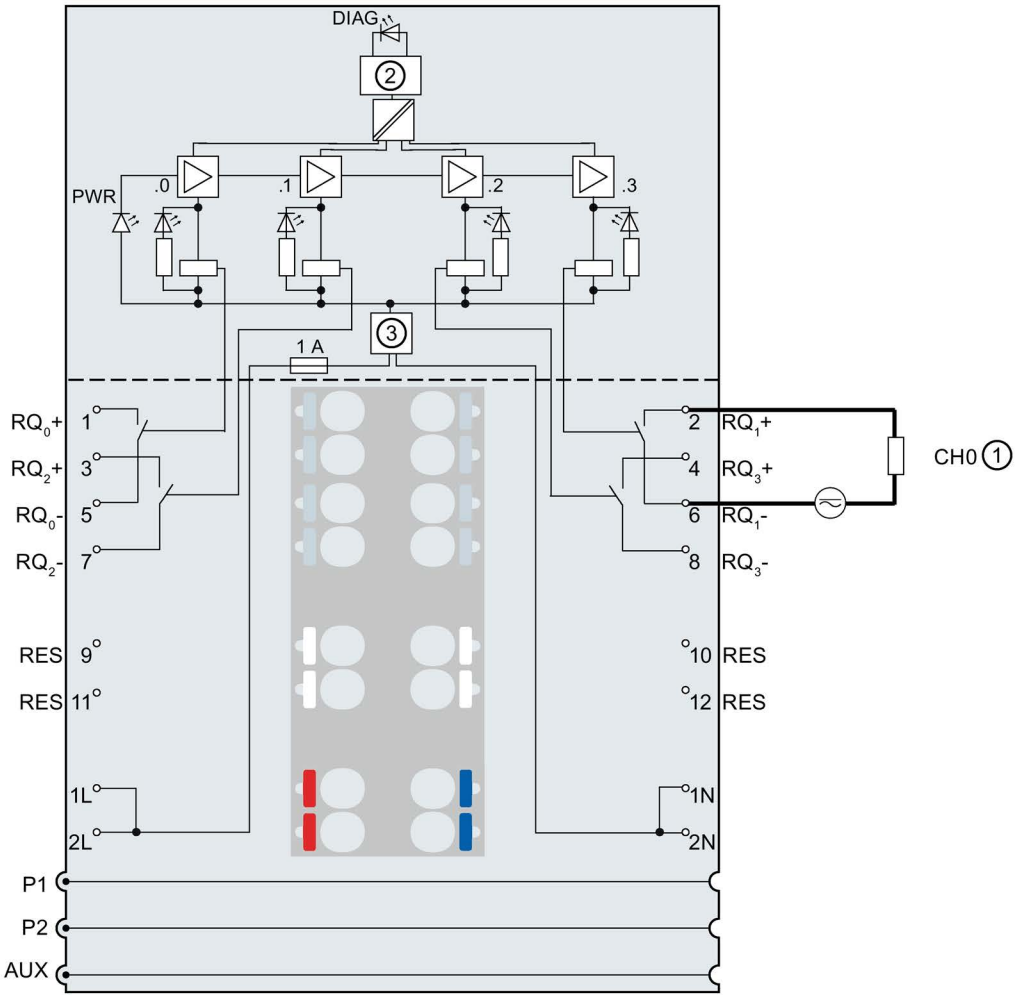


①	3-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	1A to 4A	AUX terminals (freely usable up to 230 V AC)
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
④	Color identification label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
RQ_n+, RQ_n-	Channel n	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 3-1 Wiring and block diagram for 3-wire connection of actuators

Connection: 2-wire connection of actuators

The following figure shows the block diagram and an example for the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO ST on the BaseUnit BU type B1.



①	2-wire connection	1L, 2L	Supply voltage 24 V DC
②	Backplane bus interface	1N, 2N	Neutral conductor supply voltage
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
RQ_n+, RQ_n-	Channel n	.0, .1, .2, .3	Channel status LED (green)
RES	Reserve, must remain unused for future function extensions	PWR	Power LED (green)
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)

Figure 3-2 Wiring and block diagram for 2-wire connection of actuators

Parameters/address space

4

4.1 Parameters

Parameters for RQ 4x120VDC-230VAC/5A NO ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 24).

The following parameter settings are possible:

Table 4- 1 Settable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Enable • Disable	Disable	yes	Module	Module
Operating mode	• Channel disabled • Channel enabled	Channel enabled	yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	yes	Channel	Module
Substitute value	• 0 • 1	0	yes	Channel	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 8 bytes.

4.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Operating mode

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP / substitute value

Specifies the behavior of the module if the CPU changes to STOP.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the RQ 4×120VDC-230VAC/5A NO ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

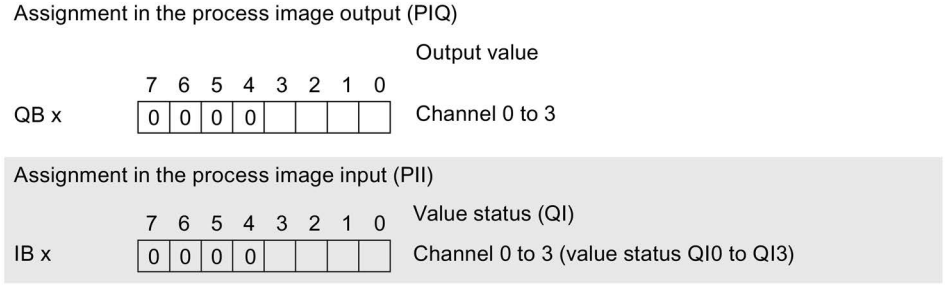


Figure 4-1 Address space of RQ 4×120VDC-230VAC/5A NO ST with value status

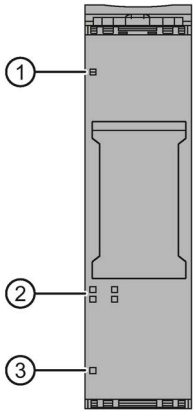
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the RQ 4x120VDC-230VAC/5A NO ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 18).

DIAG LED

Table 5- 1 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ on	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Channel deactivated or activated and process signal = 0
■ on	Channel activated and process signal = 1

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

5.2 Interrupts

The RQ 4×120VDC-230VAC/5A NO ST digital output module supports diagnostic interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the RQ 4×120VDC-230VAC/5A NO ST

	6ES7132-6HD00-0BB1
Product type designation	RQ 4x120VDC-230VAC/5A NO ST
General information	
Firmware version	V1.1
• FW update possible	Yes
Usable BaseUnits	BU type B0, B1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	100 mA; no load
Power loss	
Power loss, typ.	1.5 W

	6ES7132-6HD00-0BB1
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Input	1 byte; with QI
Output	1 bytes
Digital outputs	
Number of outputs	4
Short-circuit protection	No
Switching frequency	
With resistive load, max.	2 Hz
With inductive load, max.	0.5 Hz
With lamp load, max.	2 Hz
Total current of outputs	
Current per module, max.	20 A
Relay outputs	
Number of relay outputs	4
Rated input voltage of relay coil L+ (DC)	24 V
Current consumption of relays (coil current of all relays), max.	40 mA
External fuse for relay outputs	Yes, with 6 A
Switching capacity of the contacts	
• Thermal continuous current, max.	5 A; max. 1 385 VA, 150 W
• Switched current, min.	100 mA; 5 V DC
Cable length	
Shielded, max.	1000 m
Unshielded, max.	200 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red DIAG LED

	6ES7132-6HD00-0BB1
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between channels and backplane bus/supply voltage	240 V AC
Between backplane bus and supply voltage	75 V DC/60 V AC
Insulation	
Insulation tested with	2 500 V DC (type test)
Tested with	
Between channels and backplane bus/supply voltage	2500 V DC
Between backplane bus and supply voltage	707 V DC (type test)
Dimensions	
Width	20 mm
Weights	
Weight, approx.	40 g

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

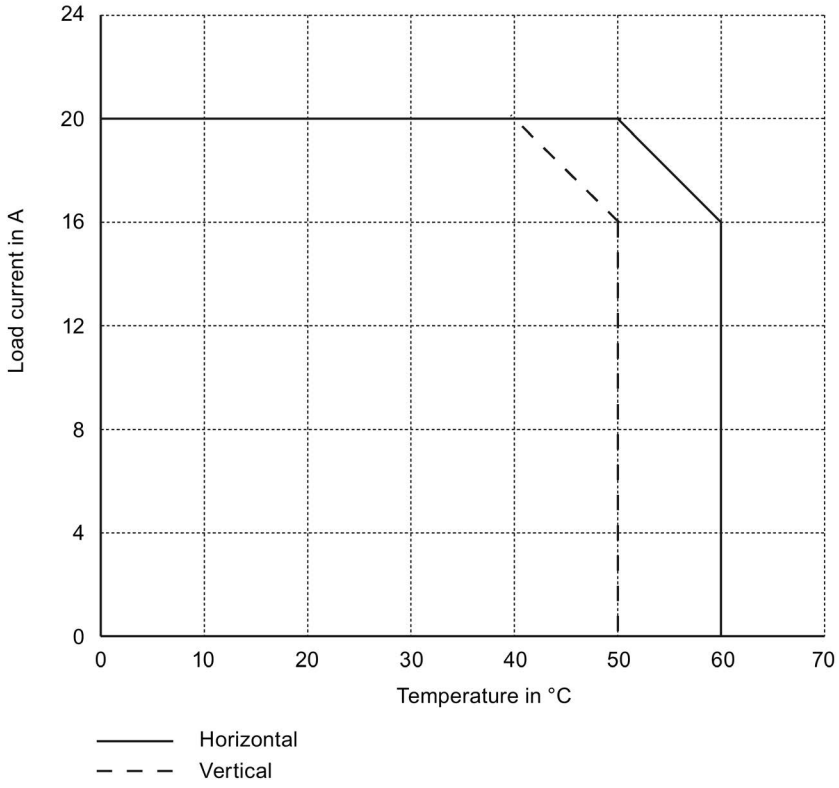


Figure 6-1 Load current and mounting position

Dimension drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

6.2 Switching cycles

Switching capacity and lifetime of the contacts

With an external protective circuit, the contacts will last longer than specified in the table. This table shows the switching capacity and lifetime of the relay contacts:

Table 6- 1 Switching capacity and lifetime of the relay contacts

Resistive load	Voltage	Current	Switching cycles (typical)
For resistive load	24 VDC	5.0 A	0.1 million
		4.0 A	0.2 million
		2.0 A	0.5 million
		1.0 A	1.6 million
		0.5 A	4 million
		0.1 A	7 million
	60 VDC	0.5 A	1.6 million
	120 VDC	0.2 A	1.6 million
	48 VAC	2.0 A	1.6 million
	60 VAC	2.0 A	1.2 million
	120 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
	230 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	24 VDC	2.0 A	0.1 million
		1.0 A	0.2 million
		0.5 A	0.5 million
	60 VDC	0.5 A	0.2 million
	120 VDC	0.2 A	0.5 million
	48 VAC	1.0 A	0.7 million
	60 VAC	1.0 A	0.5 million
	120 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million
		0.1 A	2 million
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	230 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million

Parameter assignment and structure of the parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

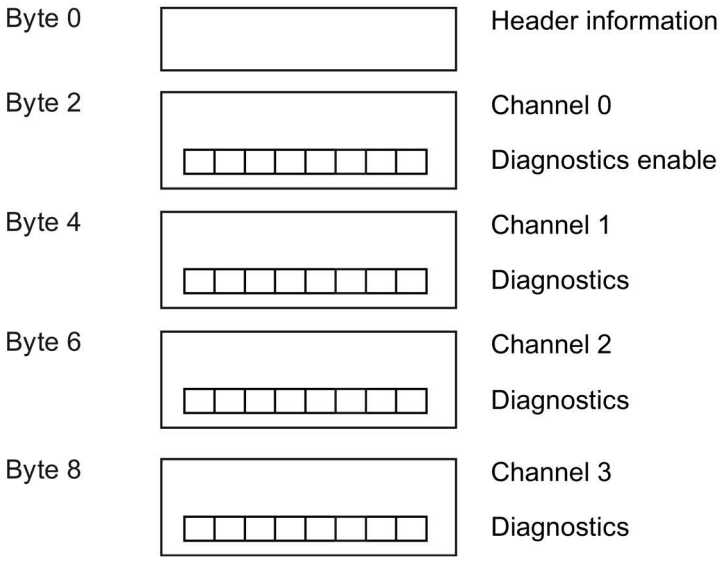


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

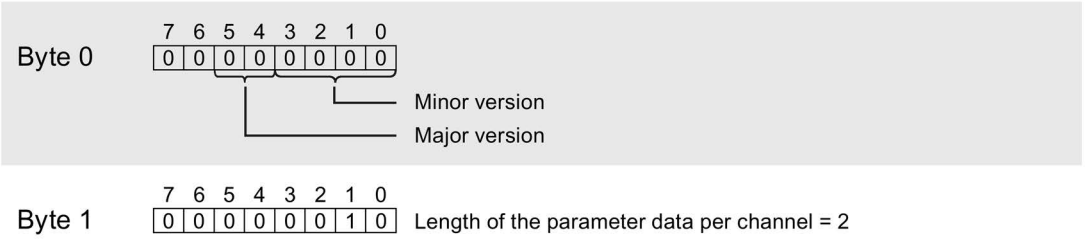
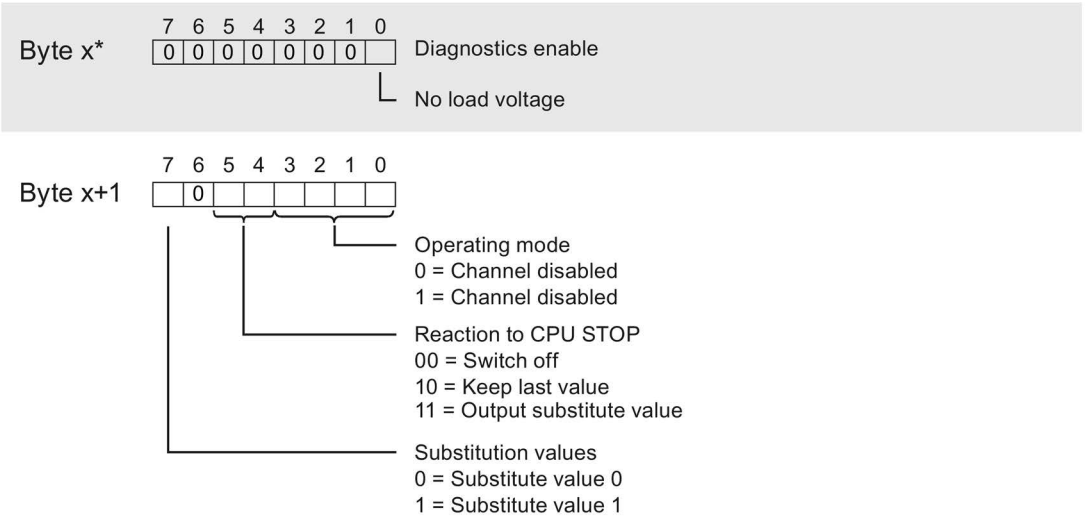


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 2); channel number = 0 to 3

Figure A-3 Structure byte x to x+1 for the channels 0 to 3

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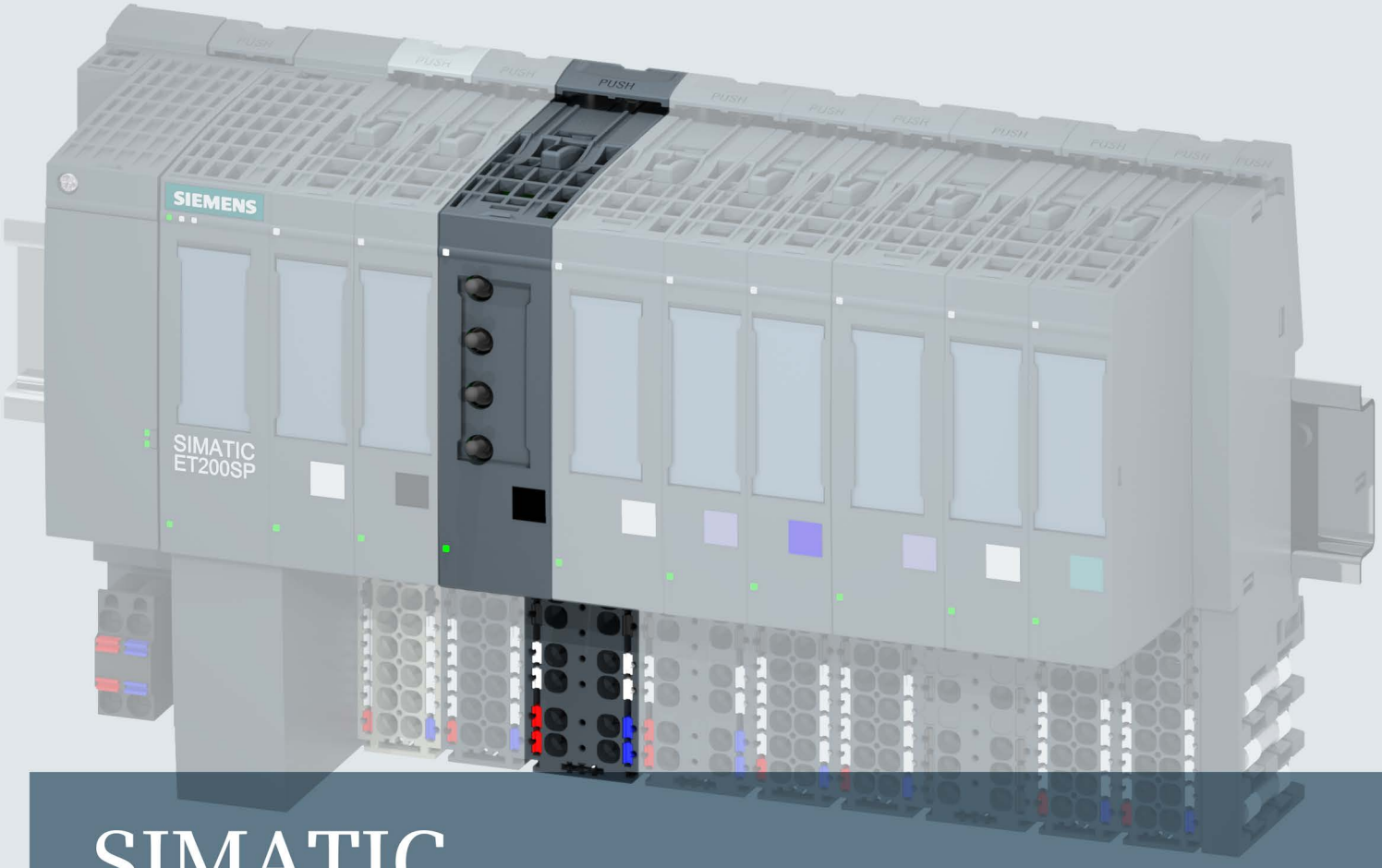

SIMATIC

ET 200SP

Digital output module RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Digital output module
RQ 4x120VDC-230VAC/5A NO MA ST
(6ES7132-6MD00-0BB1)

Manual

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Technical specifications 6

Parameter data record A

12/2015

A5E36107692-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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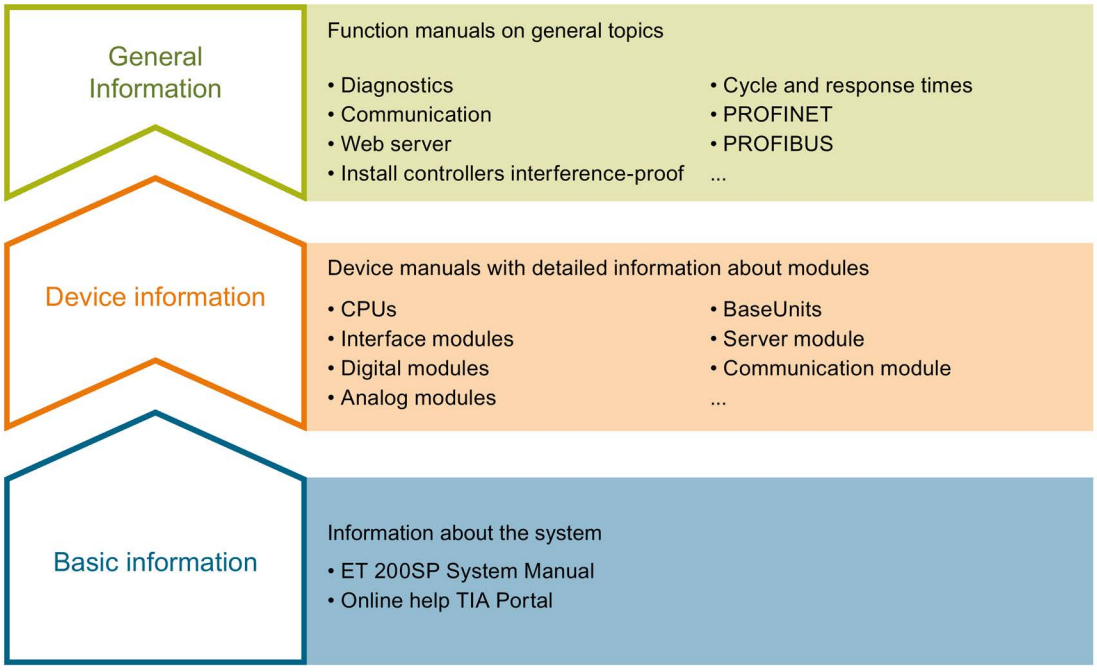
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

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"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

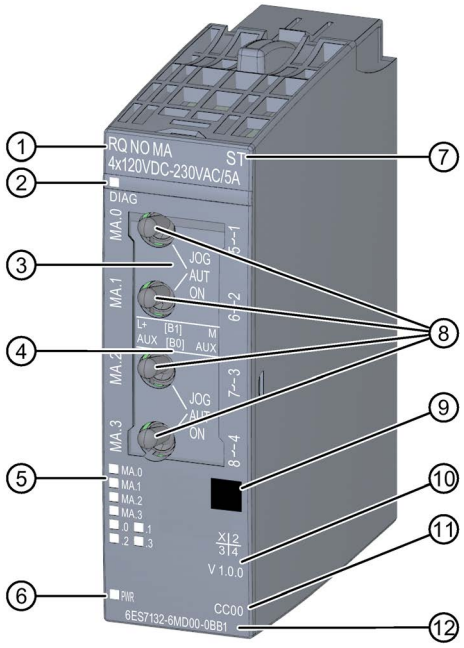
2

2.1 Properties

Article number

6ES7132-6MD00-0BB1

View of the module



① Module type and name
② LED for diagnostics
③ JOG (switch position up: jog)
AUT (switch position "middle": Automatic mode
ON (switch position down: Manual mode (MANUAL ON))
④ Wiring diagram
⑤ LEDs for channel status and manual mode
⑥ LED for supply voltage
⑦ Function class
⑧ Toggle/jog switch for manually controlling the relay
⑨ Color coding module type
⑩ Function and firmware version
⑪ Color code for selecting the color identification labels
⑫ Article number

Image 2-1 View of the module RQ 4×120VDC-230VAC/5A NO MA ST

Properties

The module has the following technical properties:

- Digital output module with 4 floating relay outputs
- Supply voltage L+
- Output current 5 A (per output)
- Normally open contact (NO: normally open)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- 4 toggle/jog switches (jog, automatic or manual mode (MANUAL ON)) for controlling the relay
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Note

When load voltage is present, the relays of the RQ 4x120VDC-230VAC/5A NO MA ST can also be activated via a manual switch even when they are in a non-configured state.

When an output is set to manual control, the relay remains active during a firmware update.

Accessories

The following accessories must be ordered separately:

- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the RQ 4x120VDC-230VAC/5A NO MA ST module with the terminal assignments for a 2-wire and 3-wire connection.

You can find information on wiring the BaseUnit in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Note

You can use and combine the different wiring options for all channels.

Note

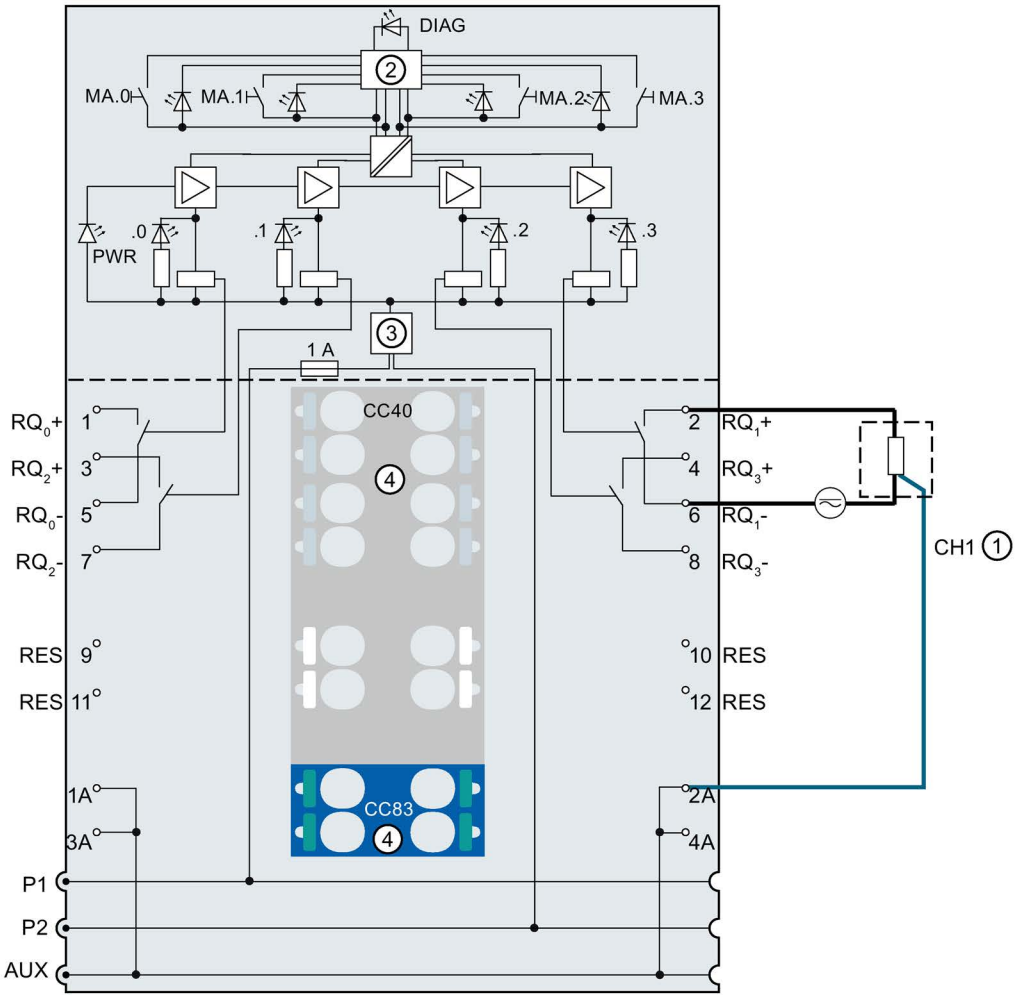
The relay contacts of the module can only switch identical voltage potential. The AUX terminals can only be used with an associated identical voltage or PE.

Note

The switch position of the toggle/jog switch is stored in the process image input (PII) and can be read there.

Wiring: 3-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO MA ST on the BaseUnit BU type B0.

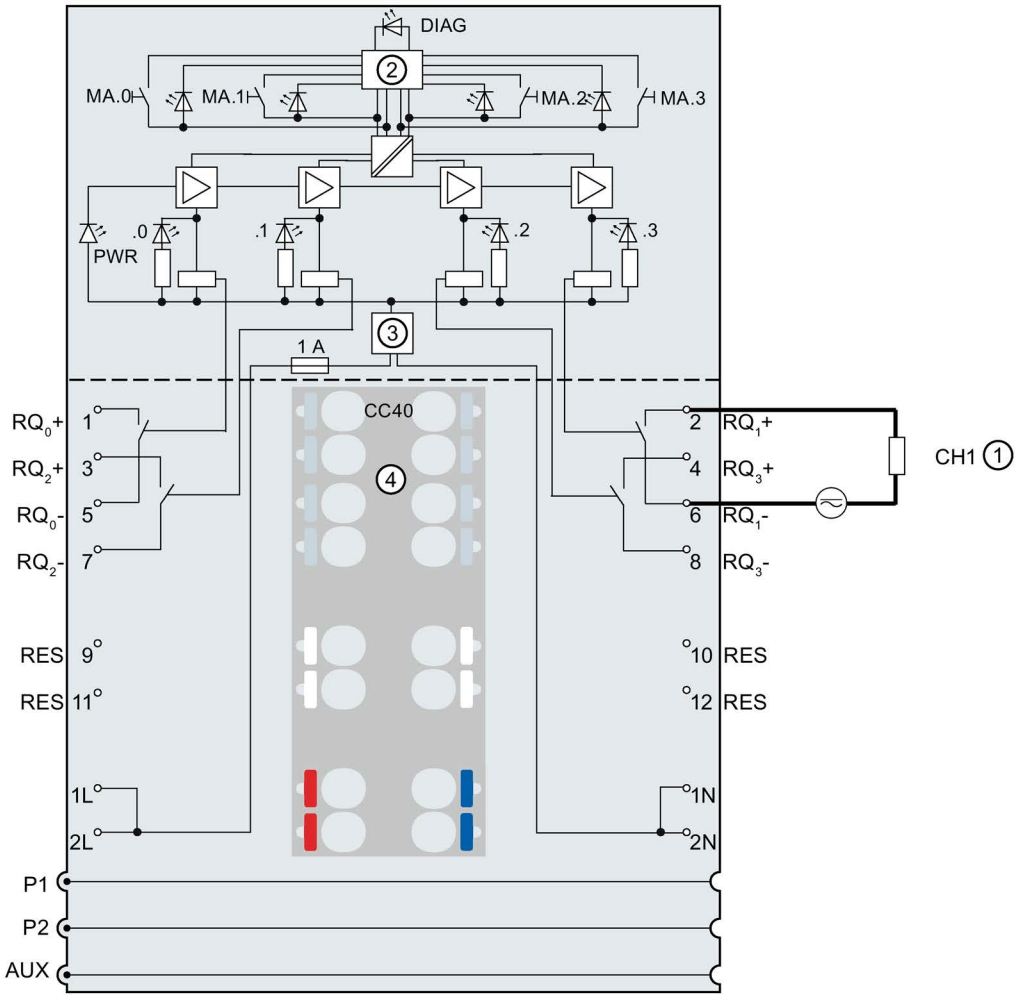


①	3-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	1A to 4A	AUX terminals (freely usable up to 230 V AC)
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
④	Color-coded label with color codes CC40 and CC83 (optional)	MA .0 .. .3	LED MANUAL ON and automatic
RQ_n+, RQ_n-	Channel n	.0, .1, .2, .3	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)	PWR	Power LED (green)

Image 3-1 Wiring and block diagram for 3-wire connection of actuators

Wiring: 2-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO MA ST on the BaseUnit BU type B1.



①	2-wire connection	1N, 2N	Neutral conductor supply voltage
②	Backplane bus interface	DIAG	Diagnostics LED (green, red)
③	Polarity reversal protection	MA .0 .. .3	LED MANUAL ON and automatic
④	Color-coded label with color code CC40 (optional)	.0, .1, .2, .3	Channel status LED (green)
RQ_n+, RQ_n-	Channel n	PWR	Power LED (green)
RES	Reserve, must remain unused for future function extensions	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)
1L, 2L	Supply voltage 24 V DC		

Image 3-2 Wiring and block diagram for 2-wire connection of actuators

Toggle/jog switch for controlling the relay

You can switch the relay using the toggle/jog switch to jog, MANUAL ON (manual mode) or automatic mode for each channel. In manual mode, the state set by the output data is ignored.

The 4 toggle/jog switches are located on the front of the electronic module.

- JOG (switch position "up": job mode): Short-term manual operation (MANUAL ON), while jogged.
- AUT (switch position "middle" or "not activated": Automatic mode): Each channel is activated via the user program (normal operation).
- ON (switch position "down": Manual mode (MANUAL ON) permanently): Each channel is switched on ("1" signal) independent of the activation of the user program (and substitute values).

Parameters/address space

4

4.1 Parameters

Parameters for RQ 4x120VDC-230VAC/5A NO MA ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 28).

The following parameter settings are possible:

Table 4- 1 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Enable • Disable	Disable	Yes	Module	Module
Channel activated	• Enable • Disable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

4.2 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

The load or supply voltage is fed module by module. The voltage buses P1, P2 and AUX are looped through the module from the left to the right neighboring module without tap.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of RQ 4×120VDC-230VAC/5A NO MA ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 4- 2 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	RQ 4×120VDC-230VAC/5A NO MA ST	X	X	X
1 x 4-channel with value status	RQ 4×120VDC-230VAC/5A NO MA ST, QI	X	X	-

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the RQ 4×120VDC-230VAC/5A NO MA ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

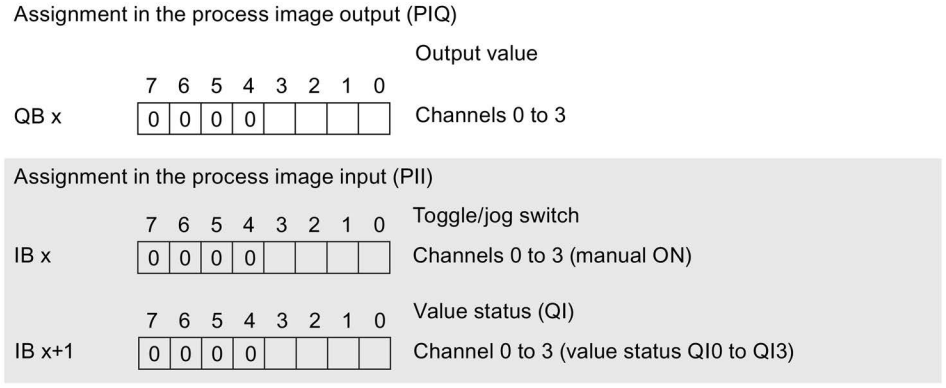


Image 4-1 Address space of RQ 4×120VDC-230VAC/5A NO MA ST with value status

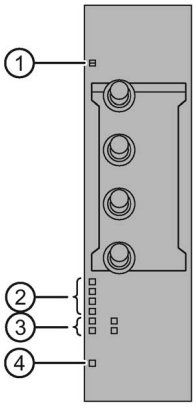
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the RQ 4x120VDC-230VAC/5A NO MA ST.



① DIAG (green/red)
② MA .0 .. .3 (yellow)
③ Channel status (green)
④ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 21).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module not ready for operation (no parameters assigned)
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

LED MA 1..4

Table 5- 2 Status display of the LED MA .0 .. .3 (manual mode)

Channel status LED	Meaning
Off	Automatic
On	Manual ON (toggle/jog switch) = Manual mode Output enabled at specific channel

Channel status LED

Table 5- 3 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated and process signal = 1

PWR LED

Table 5- 4 Status display of the PWR LED

PWR LED	Meaning
□ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The digital output module RQ 4×120VDC-230VAC/5A NO MA ST supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the RQ 4×120VDC-230VAC/5A NO MA ST

	6ES7132-6MD00-0BB1
General information	
Product type designation	ET 200SP, RQ 4x120VDC-230VAC/5A NO MA ST
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type B0, B1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	100 mA; no load
Power loss	
Power loss, typ.	1.5 W

	6ES7132-6MD00-0BB1
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Inputs	1 byte; with QI
Outputs	1 byte
Digital outputs	
Number of outputs	4
Short-circuit protection	No
Switching frequency	
With resistive load, max.	2 Hz
With inductive load, max.	0.5 Hz
With lamp load, max.	2 Hz
Total current of the outputs	
Current per channel, max.	5 A
Current per module, max.	20 A
Total current of the outputs (per module)	
Horizontal installation	
• Up to 50 °C, max.	20 A
• Up to 60 °C, max.	16 A
Vertical installation	
• Up to 40 °C, max.	20 A
• Up to 50 °C, max.	16 A
Relay outputs	
Number of relay outputs	4
Rated input voltage of relay coil L+ (DC)	24 V
Current consumption of relays (coil current of all relays), max.	40 mA
External fuse for relay outputs	Yes, with 6 A
Number of switching cycles, max.	7000000; see additional description in the manual
Switching capacity of the contacts	
• With inductive load, max.	2 A; see additional description in the manual
• With resistive load, max.	5 A; see additional description in the manual
• Thermal continuous current, max.	5 A
• Switched current, min.	100 mA; 5 V DC
• Rated switching voltage (DC)	24 V DC to 120 V DC
• Rated switching voltage (AC)	24 V AC to 230 V AC
Cable length	
Shielded, max.	1000 m
Unshielded, max.	200 m

	6ES7132-6MD00-0BB1
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	No
Short-circuit	No
Group error	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	Yes
Permitted potential difference	
Between channels and backplane bus/supply voltage	240 V AC
Insulation	
Insulation tested with	2 500 V DC (type test)
Tested with	
Between channels and backplane bus/supply voltage	2500 V DC
Between backplane bus and supply voltage	707 V DC (type test)
Dimensions	
Width	20 mm
Weights	
Weight, approx.	45 g

Note

External fuse for relay outputs

The outputs have to be protected by an external fuse.

When installed in a danger area according to the National Electric Code (NEC), the fuse must only be removed with the correct tool when the module is not in an explosion-proof zone.

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

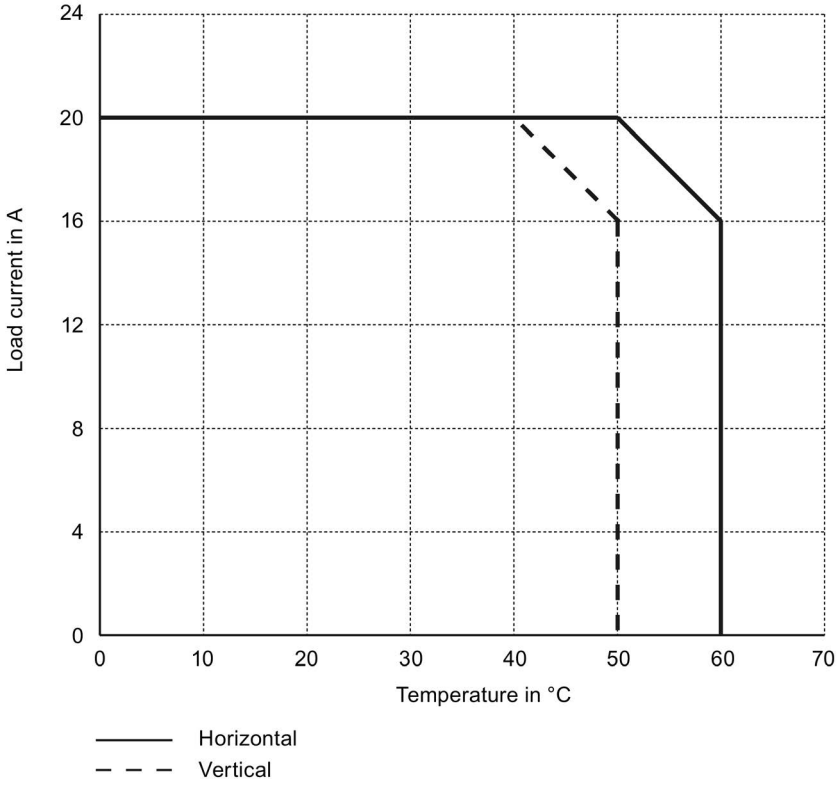


Image 6-1 Load current for mounting position

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

6.2 Switching cycles

Switching capacity and lifetime of the contacts

With an external protective circuit, the contacts will last longer than specified in the table. This table shows the switching capacity and lifetime of the relay contacts:

Table 6- 1 Switching capacity and lifetime of the relay contacts

Resistive load	Voltage	Current	Switching cycles (typical)
For resistive load	24 V DC	5.0 A	0.1 million
		4.0 A	0.2 million
		2.0 A	0.5 million
		1.0 A	1.6 million
		0.5 A	4 million
		0.1 A	7 million
	60 VDC	0.5 A	1.6 million
	120 VDC	0.2 A	1.6 million
	48 VAC	2.0 A	1.6 million
	60 VAC	2.0 A	1.2 million
	120 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
	230 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	24 V DC	2.0 A	0.1 million
		1.0 A	0.2 million
		0.5 A	0.5 million
	60 VDC	0.5 A	0.2 million
	120 VDC	0.2 A	0.5 million
	48 VAC	1.0 A	0.7 million
	60 VAC	1.0 A	0.5 million
	120 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million
		0.1 A	2 million

Resistive load	Voltage	Current	Switching cycles (typical)
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	230 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million

Note

Tests of mechanical environmental conditions

Shock tested according to IEC 60068-2-27. Shock intensity: 100 m/s^2 peak value, 11 ms duration

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

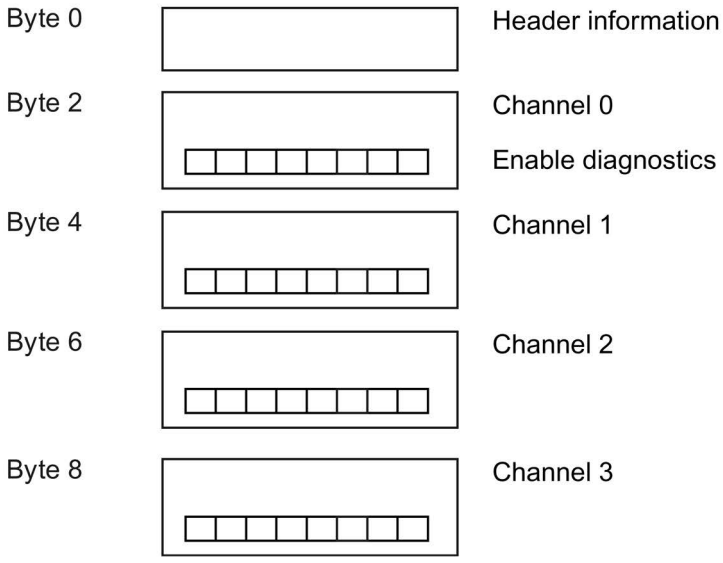


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

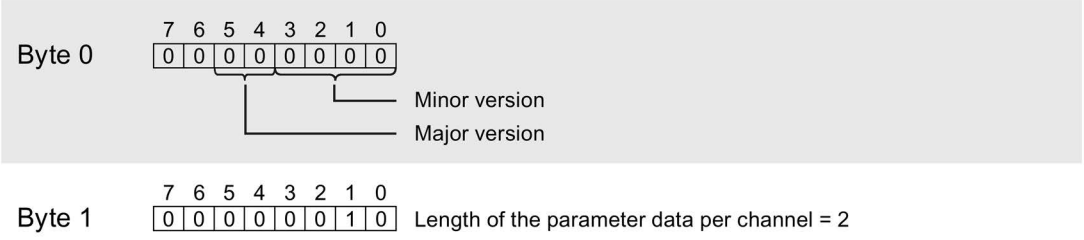
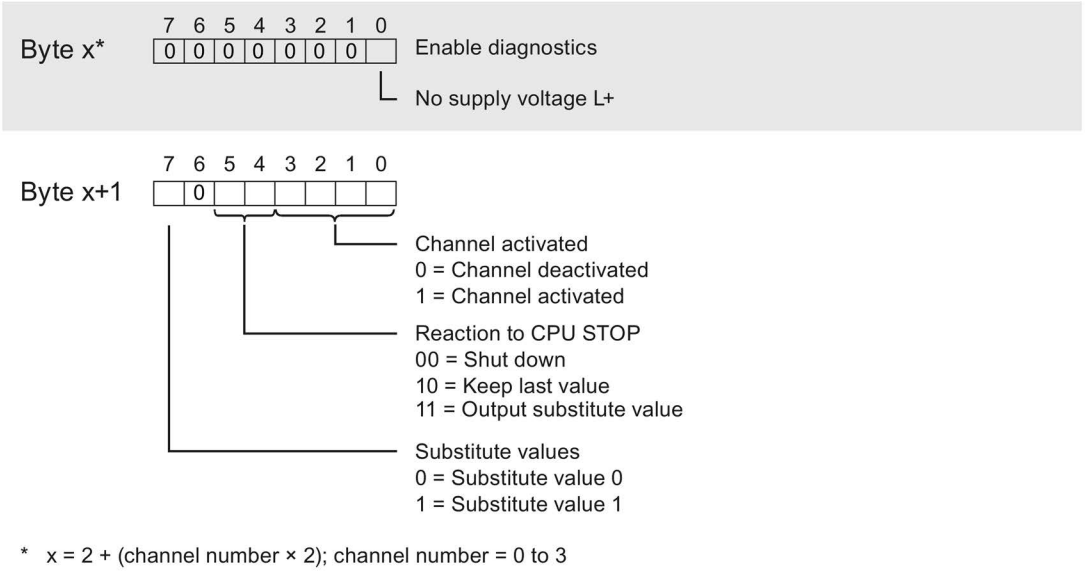


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 2); channel number = 0 to 3

Image A-3 Structure byte x to x+1 for the channels 0 to 3

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

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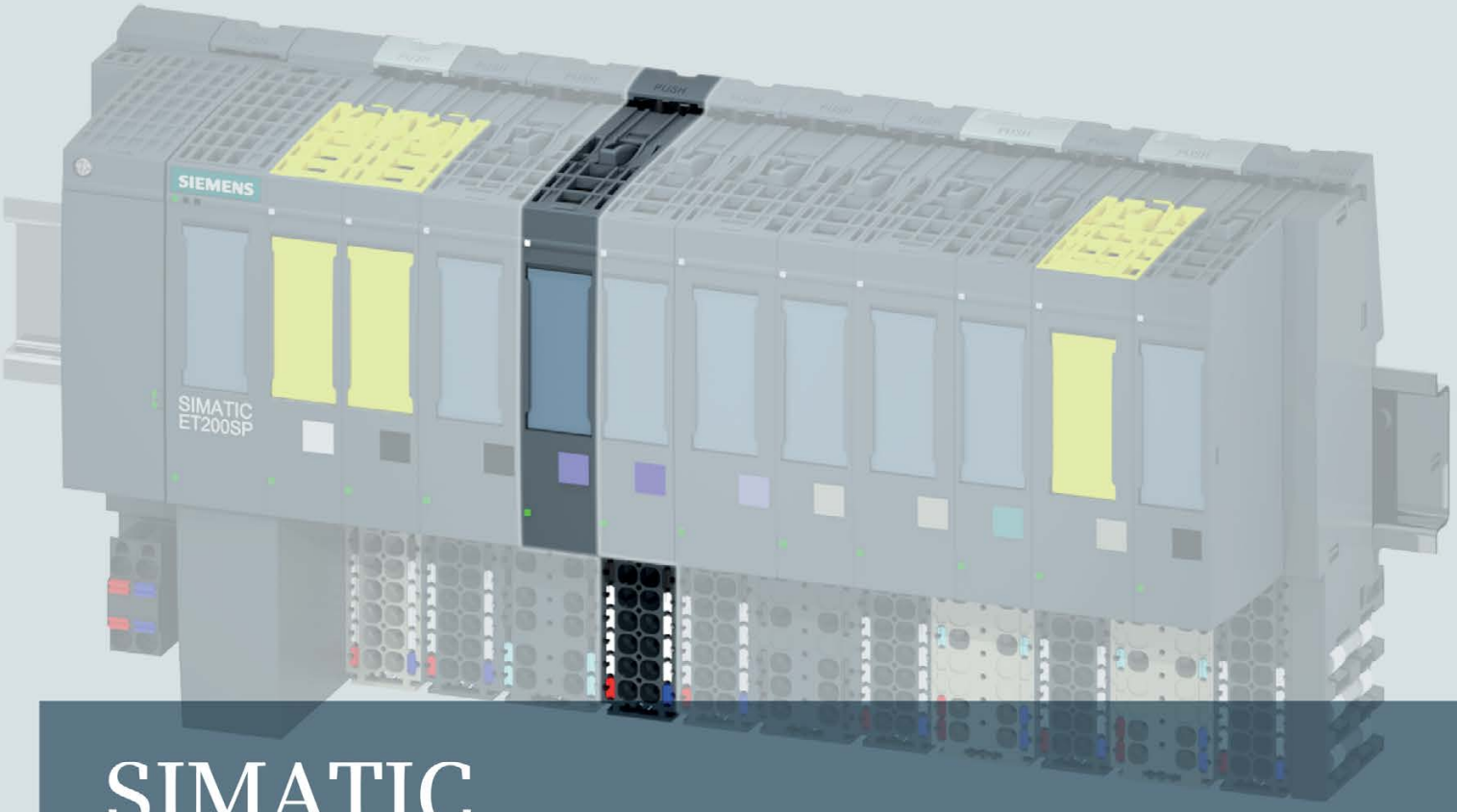

SIMATIC

ET 200SP

Analog input module AI 8xU BA (6ES7134-6FF00-0AA1)

Manual

Edition 03/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 8xU BA (6ES7134-6FF00-0AA1)

Manual

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Parameter data record A

Representation of analog values B

03/2015

A5E34941660-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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A5E34941660-AA
℗ 03/2015 Subject to change

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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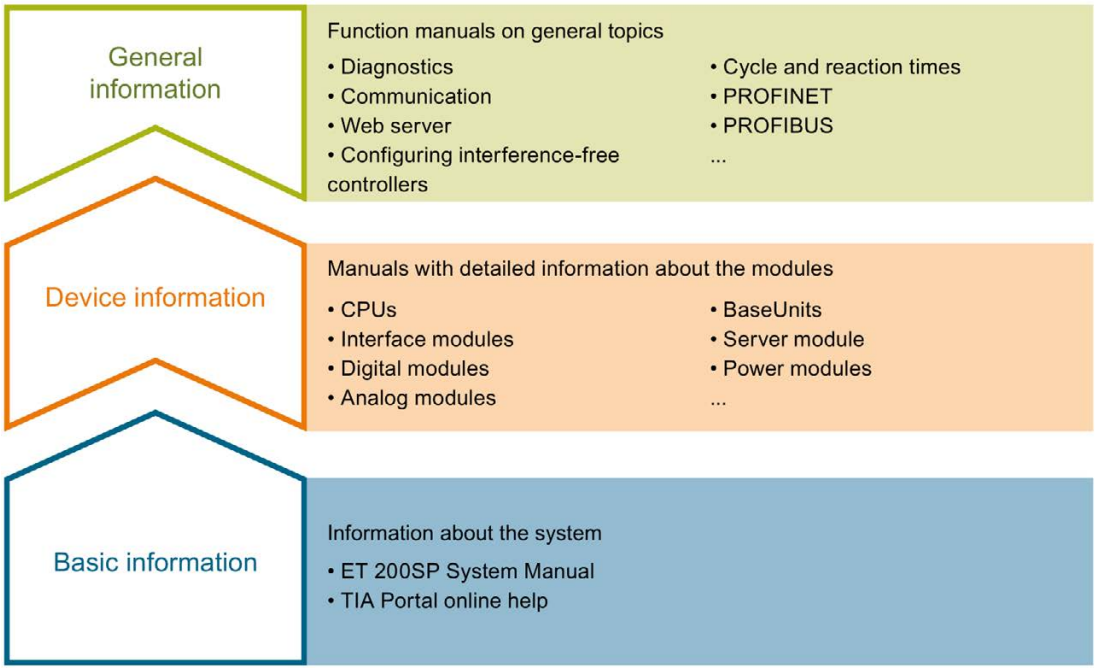
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (http://support.industry.siemens.com/cs/ww/en/ps/ae).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

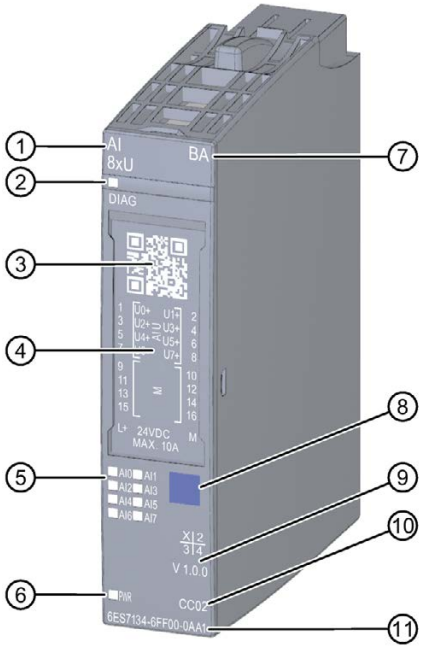
2

2.1 Properties

Article number

6ES7134-6FF00-0AA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-1 View of the AI 8×U BA module

Properties

The module has the following technical properties:

- Analog input module with 8 inputs (single-ended)
- Input ranges for voltage measurement:
  - ±10 V, resolution 16 bits including sign
  - 0 to 10 V, resolution 15 bits
- Cycle time of the module (all channels) 10 ms
- Configurable diagnostics (per module)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 8xU BA module with the terminal assignments for a 2-wire connection.

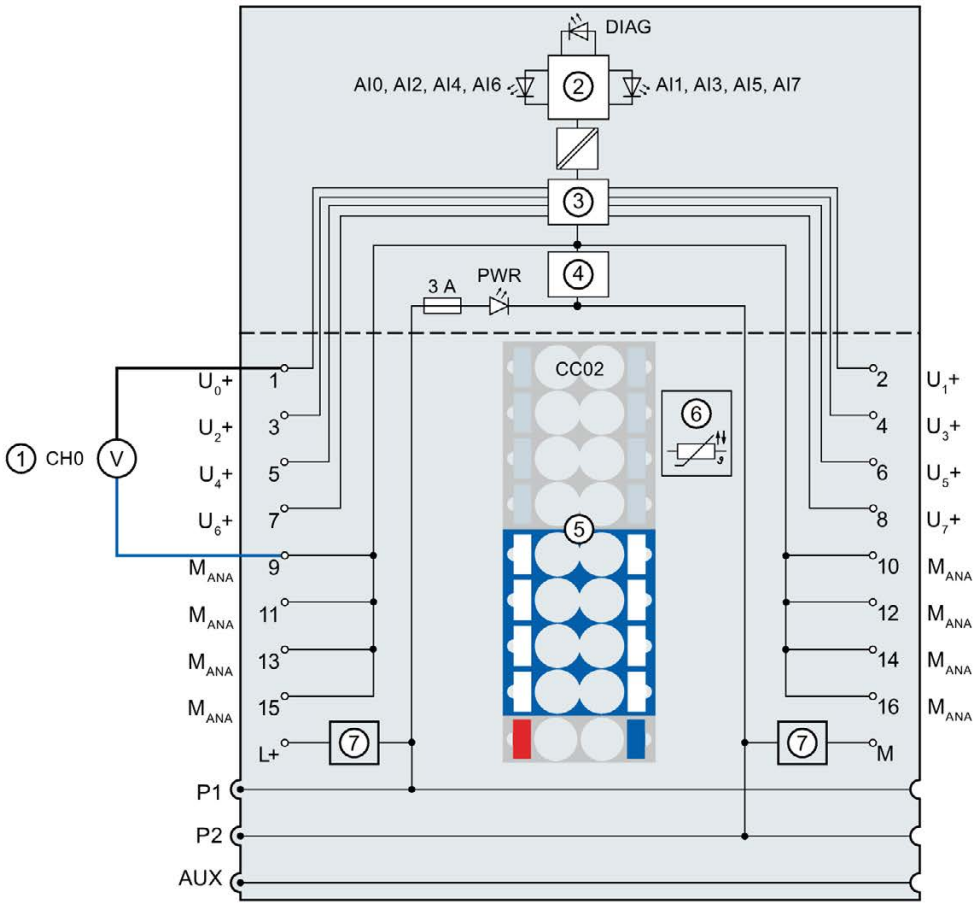
You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connection: Voltage measurement 2-wire connection

The following figure shows the block diagram and an example for the terminal assignment of the analog input module AI 8xU BA on the BaseUnit BU type A0/A1.



①	2-wire connection for voltage measurement	U_n+	Voltage input positive, channel n
②	Backplane bus interface	M_{ANA}	Ground of the analog inputs
③	Analog-to-digital converter (ADC)	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Current limitation	M	Ground
⑤	Color identification label CCxx (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	AI0 to AI7	Channel status LED (green)
		PWR	Power LED (green)

Figure 3-1 Wiring and block diagram for voltage measurement 2-wire connection

Parameters/address space

4

4.1 Measuring types and ranges

The analog input module AI 8xU BA has the following measuring ranges:

Table 4- 1 Measuring ranges

Measurement type	Measuring range	Resolution
Voltage	0 to 10 V	15 bits
	±10 V	16 bits including sign

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 29).

4.2 Parameters

AI 8xU BA parameters

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records, see section Parameter assignment and structure of the parameter data record (Page 25)).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Module	
Type/range of measurement	• Deactivated • Voltage +/- 10 V • Voltage 0 to 10 V	Voltage (+/- 10 V)	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Interference frequency suppression	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • 4800 Hz (0.625 ms) • 60 Hz (18.75 ms) [3] • 50 Hz (22.5 ms) [2] [3] • 16.6 Hz (67.5 ms) [3]	50 Hz (60 ms)	Yes	Channel	Module
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP: The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign this parameter using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 8 bytes.

[2] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

[3] By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

Note

Unused channels

Disable unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value $7FFF_H$.

4.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Type/range of measurement

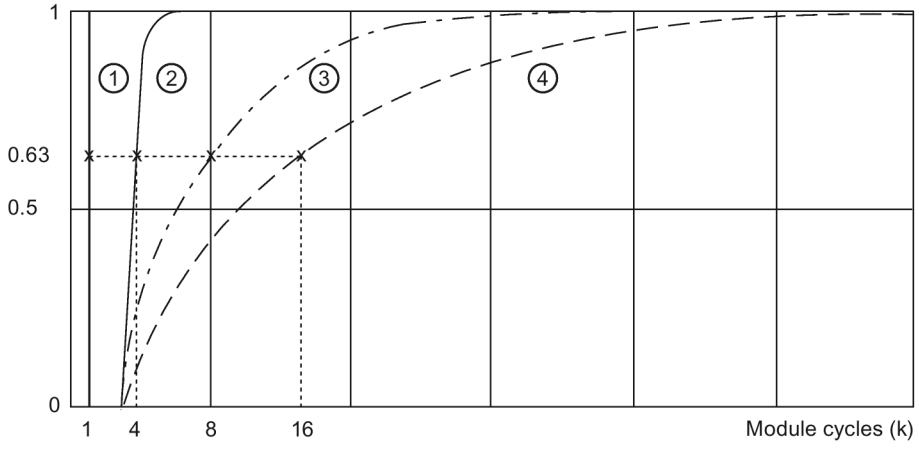
See the section Measurement types and measuring ranges (Page 12).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 4-1 Smoothing for AI 8xU BA

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the alternating voltage network may negatively affect the measured value, in particular when measuring in the low voltage range. With this parameter, the user specifies the line frequency that is predominant in the plant.

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

4.4 Address space

Address space

The figure below shows the assignment of the address space for AI 8×U BA.

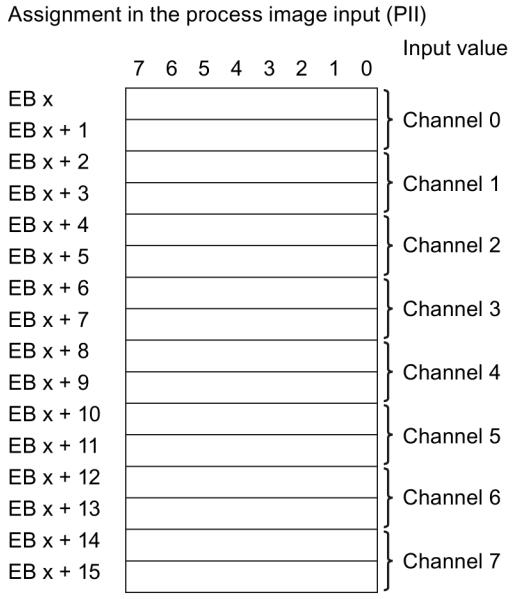


Figure 4-2 Address space of AI 8×U BA

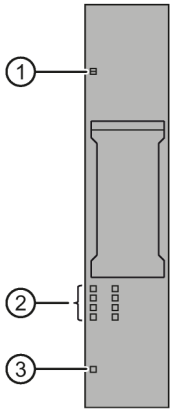
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays of the AI 8xU BA.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED displays

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 20).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated
On	Channel activated

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The analog input module AI 8×U BA supports diagnostics interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Channel temporarily unavailable
- Low limit violated
- High limit violated
- Error
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
High limit violated	7_H	Value is above overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 8×U BA

	6ES7134-6FF00-0AA1
Product type designation	ET 200SP, 8xU Basic
General information	
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC02
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable measuring range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Operating mode	
Oversampling	No
MSI	No
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	25 mA
Power loss	
Power loss, typ.	0.7 W

	6ES7134-6FF00-0AA1
Address area	
Address space per module	
Address space per module, max.	16 bytes
Analog inputs	
Number of analog inputs	8; single-ended
Maximum permitted input voltage for voltage input (destruction limit)	30 V
Cycle time (all channels), min.	1 ms; per channel
Input ranges (rated values), voltages	
0 to +10 V	Yes; 15 bits
Input resistance (0 to 10 V)	100 kΩ
-10 V to +10 V	Yes; 16 bits including sign
Input resistance (-10 V to +10 V)	100 kΩ
Cable length	
Shielded, max.	200 m
Formation of analog values for the inputs	
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Integration time configurable	Yes
Interference voltage suppression for interference frequency f1 in Hz	16.67 / 50 / 60 / 4 800 (16.67 / 50 / 60)
Conversion time (per channel)	ms; 180 / 60 / 50 / 0.625 (67.5 / 22.5 / 18.75)
Measured value smoothing	
Number of steps	4; none; 4/8/16 times
Configurable	Yes
Encoders	
Connection of the signal transmitters	
For voltage measurement	Yes
For current measurement as 4-wire transducer	No
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	± 0.01%
Temperature error (in relation to input range), (+/-)	± 0.005%
Crosstalk between inputs, min.	50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	± 0.05%
Operational limit in the entire temperature range	
Voltage in relation to input range, (+/-)	± 0.5%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	± 0.3%
Interference voltage suppression for f = n x (f1 +/- 1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	70 dB; with conversion time 67.5 / 22.5 / 18.75 ms: 40 dB

	6ES7134-6FF00-0AA1
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic interrupt	Yes
Limit interrupt	No
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	No
Group error	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes, green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green / red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	75 V DC/60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics		
		No supply voltage L+	Overflow	Underflow
Deactivated		*	*	*
Voltage	±10 V	x	x	x
	0 to 10 V	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics	
		No supply voltage L+	Overflow/underflow
Deactivated		*	*
Voltage	±10 V	x	x
	0 to 10 V	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 contains the diagnostics for the entire module.

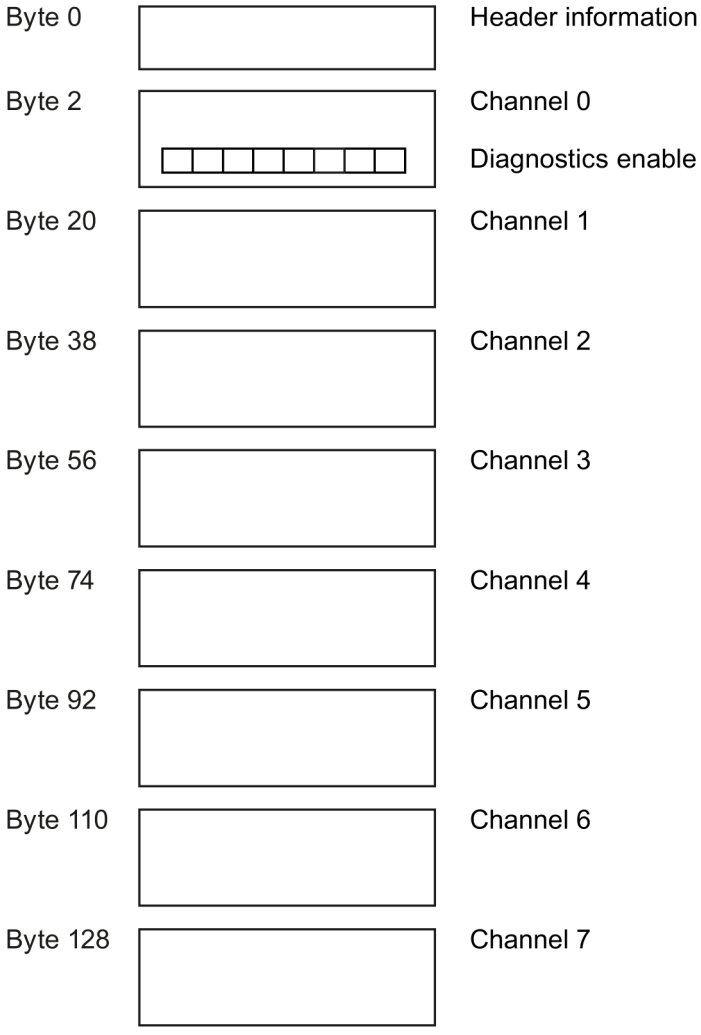


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

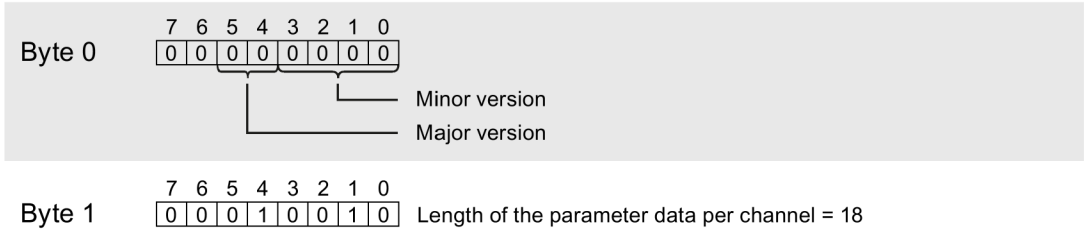
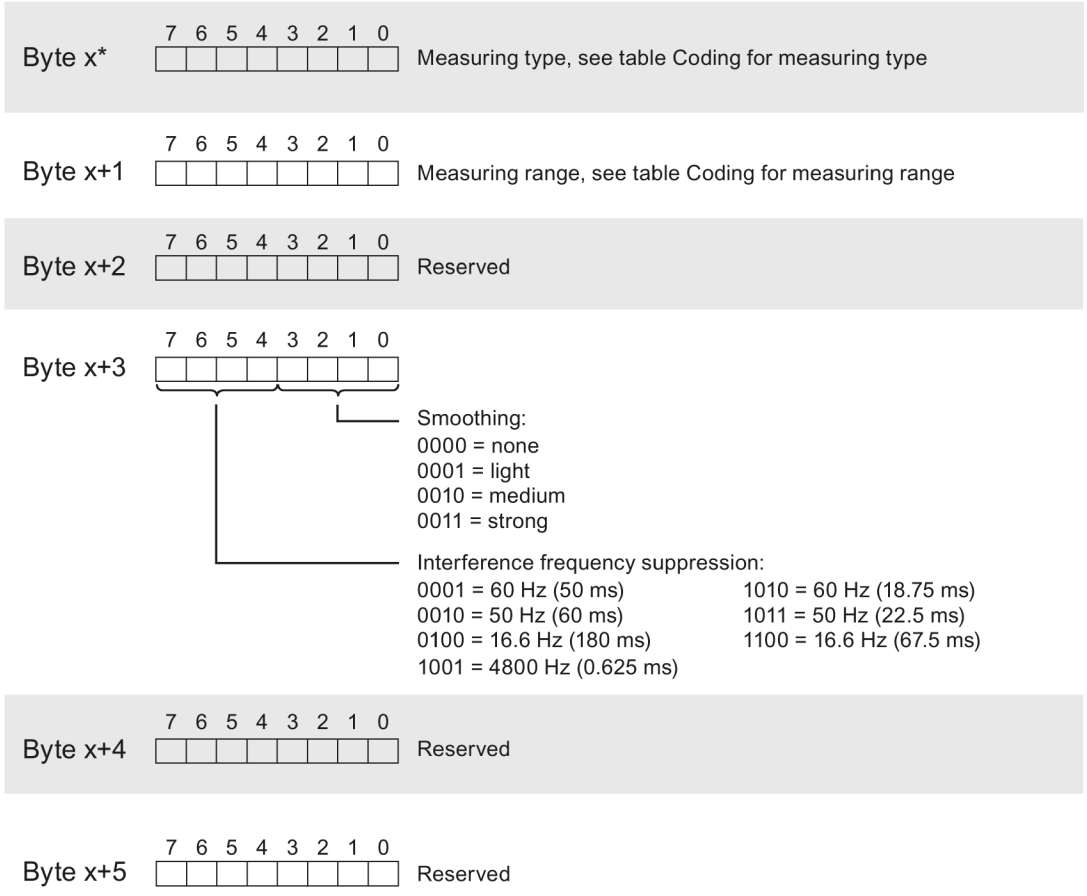


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".



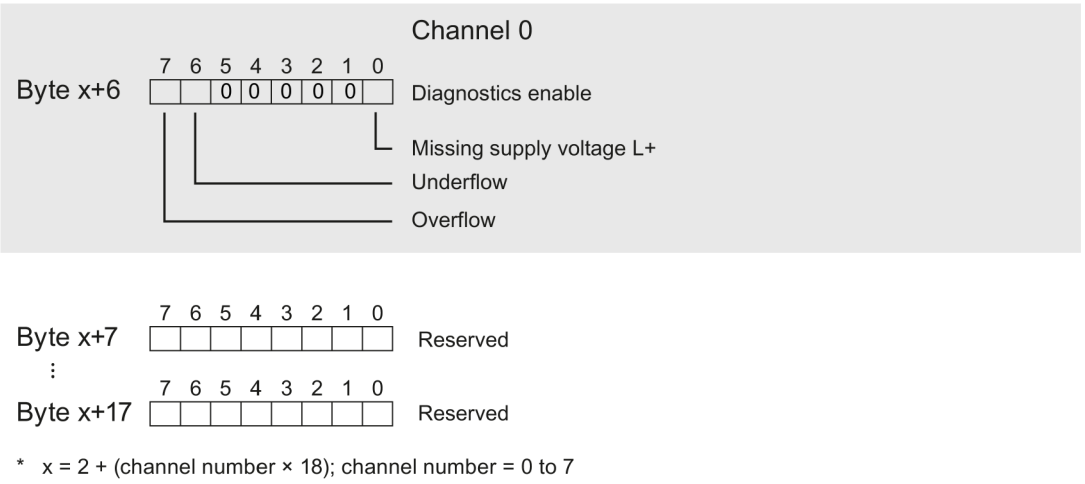


Figure A-3 Structure of byte x to x+17 for channels 0 to 7

Codes for measurement types

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table A- 1 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table A- 2 Codes for measuring ranges

Measuring range	Code
±10 V	0000 1001
0 to 10 V	0000 1011

Representation of analog values

B

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. val-ue	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table B- 4 Voltage measuring range ±10 V

Values		Voltage measuring range	Range
Dec.	Hex.	±10 V	
32767	7FFF	>11.759 V	Overflow
32511	7EFF	11.759 V	Overrange
27649	6C01		
27648	6C00	10 V	Nominal range
20736	5100	7.5 V	
1	1	361.7 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-7.5 V	
-27648	9400	-10 V	
-27649	93FF		Underrange
-32512	8100	-11.759 V	
-32768	8000	<-11.759 V	Underflow

Table B- 5 Voltage measuring range 0 to 10 V

Values		Voltage measuring range	Range
Dec.	Hex.	0 to 10 V	
32767	7FFF	>11.759 V	Overflow
32511	7EFF	11.759 V	Overrange
27649	6C01		
27648	6C00	10 V	Nominal range
20736	5100	7.5 V	
1	1	0 V + 361.7 µV	
0	0	0 V	
-1	FFFF		Underrange
-4864	ED00	-1.759 V	
-32768	8000	< -1.759 V	Underflow

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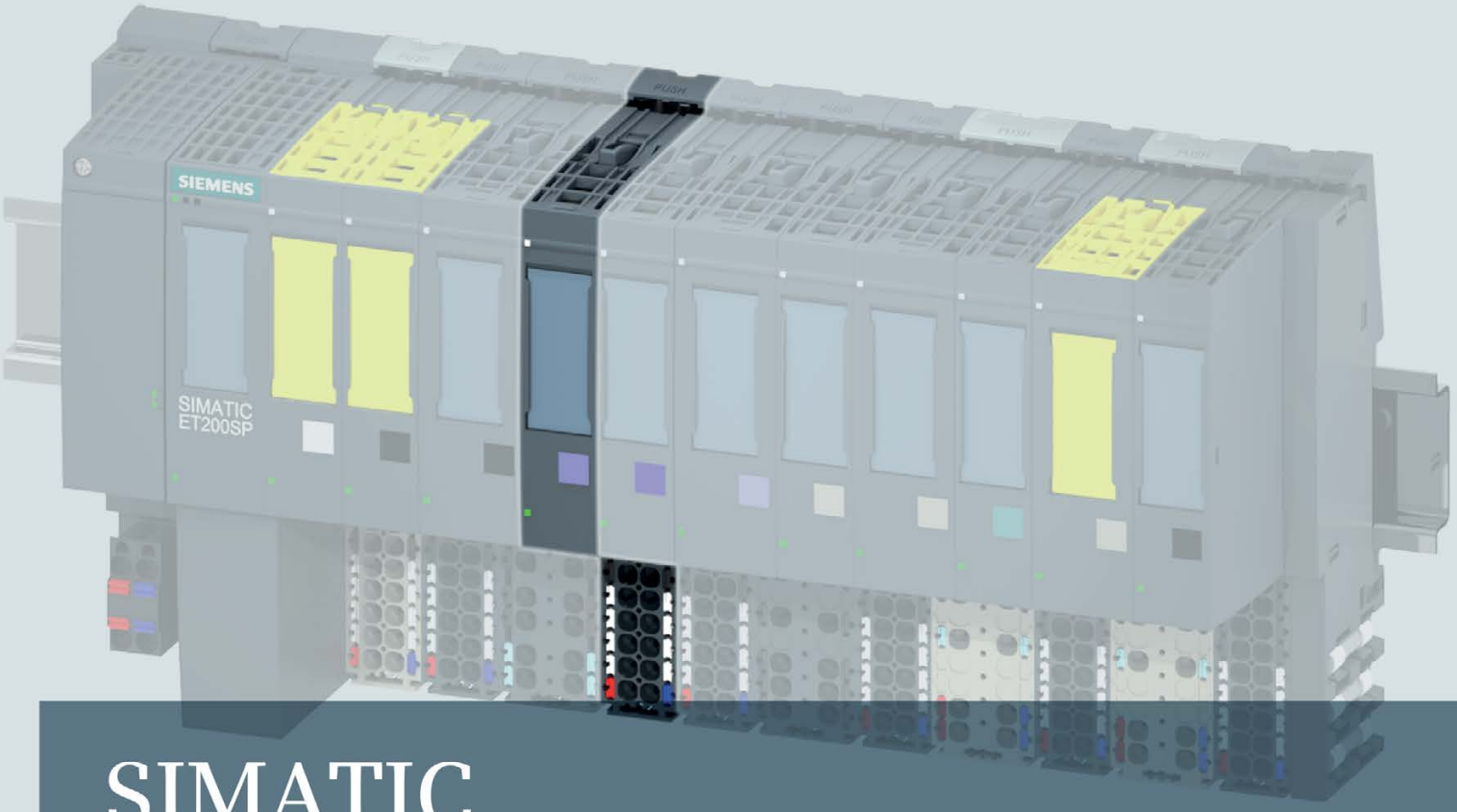

SIMATIC

ET 200SP

Analog input module AI 8xI 2-/4-wire BA (6ES7134-6GF00-0AA1)

Manual

Edition 03/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Analog input module
AI 8xI 2-/4-wire BA
(6ES7134-6GF00-0AA1)

Manual

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Interrupts/diagnostics alarms 5

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Parameter data record A

Representation of analog values B

03/2015
A5E34941201-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 03/2015 Subject to change

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Preface

Purpose of the documentation

This manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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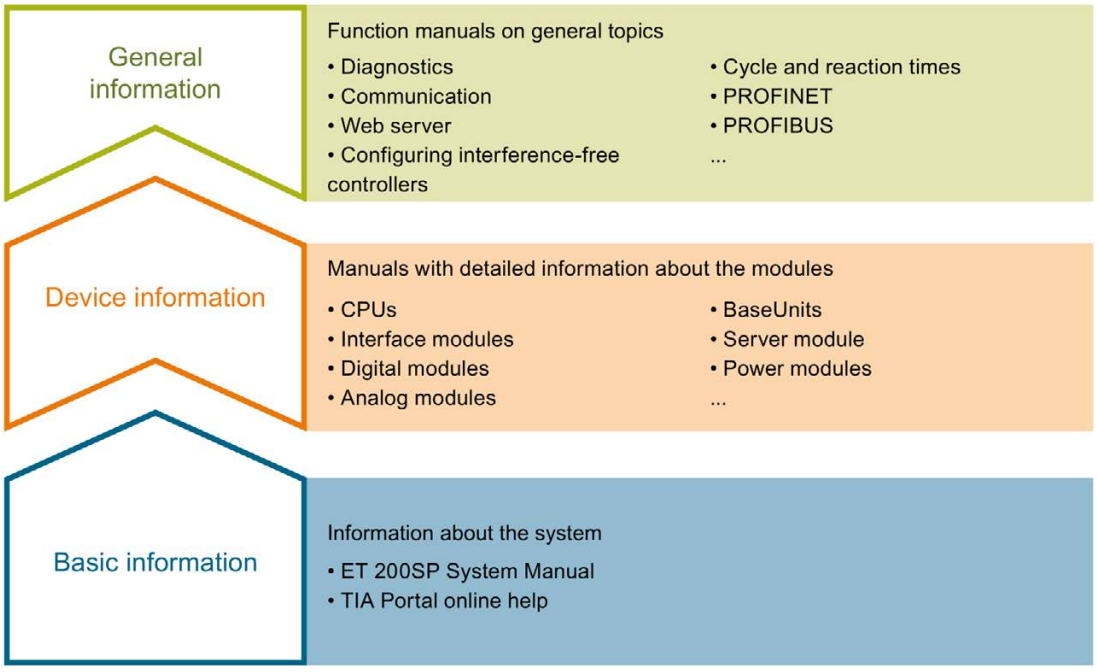
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

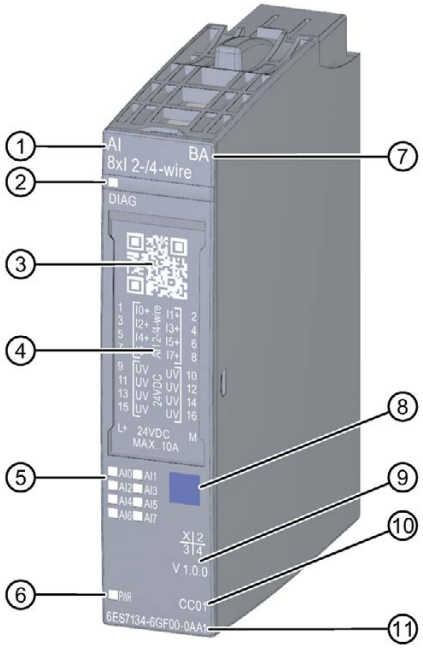
2

2.1 Properties

Article number

6ES7134-6GF00-0AA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-1 View of the AI 8×I 2-/4-wire BA module

Properties

The module has the following technical properties:

- Analog input module with 8 inputs (single-ended)
- For 2-wire and 4-wire transducers
- Input ranges for current measurement:
  - 4 to 20 mA, resolution 15 bits
  - 0 to 20 mA, resolution 15 bits
  - ±20 mA, resolution 16 bits including sign
- Cycle time of the module (all channels) 10 ms
- Configurable diagnostics (per module)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 8xI 2-/4-wire BA module with the terminal assignments for 2-wire and 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

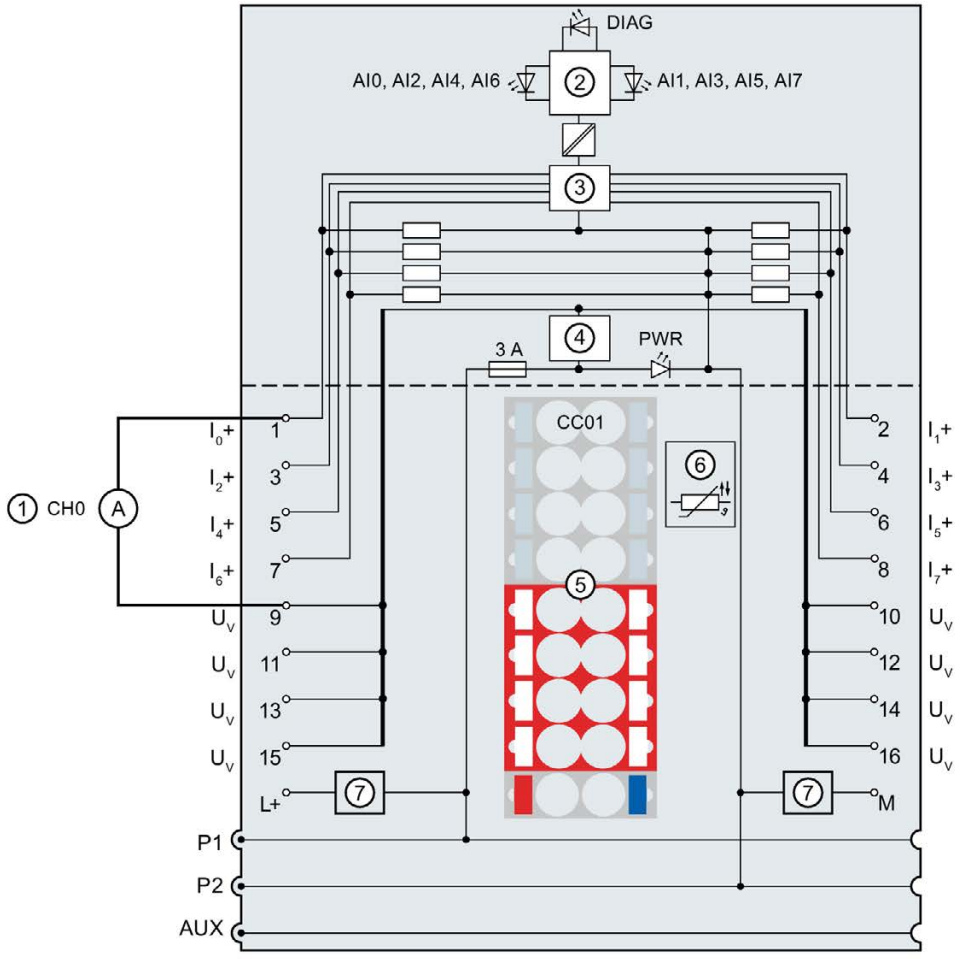
You may use and combine the different wiring options for all channels.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connection: Current measurement 2-wire connection

The following figure shows the block diagram and an example for the terminal assignment of the analog input module AI 8xI 2-/4-wire BA on the BaseUnit BU type A0/A1.

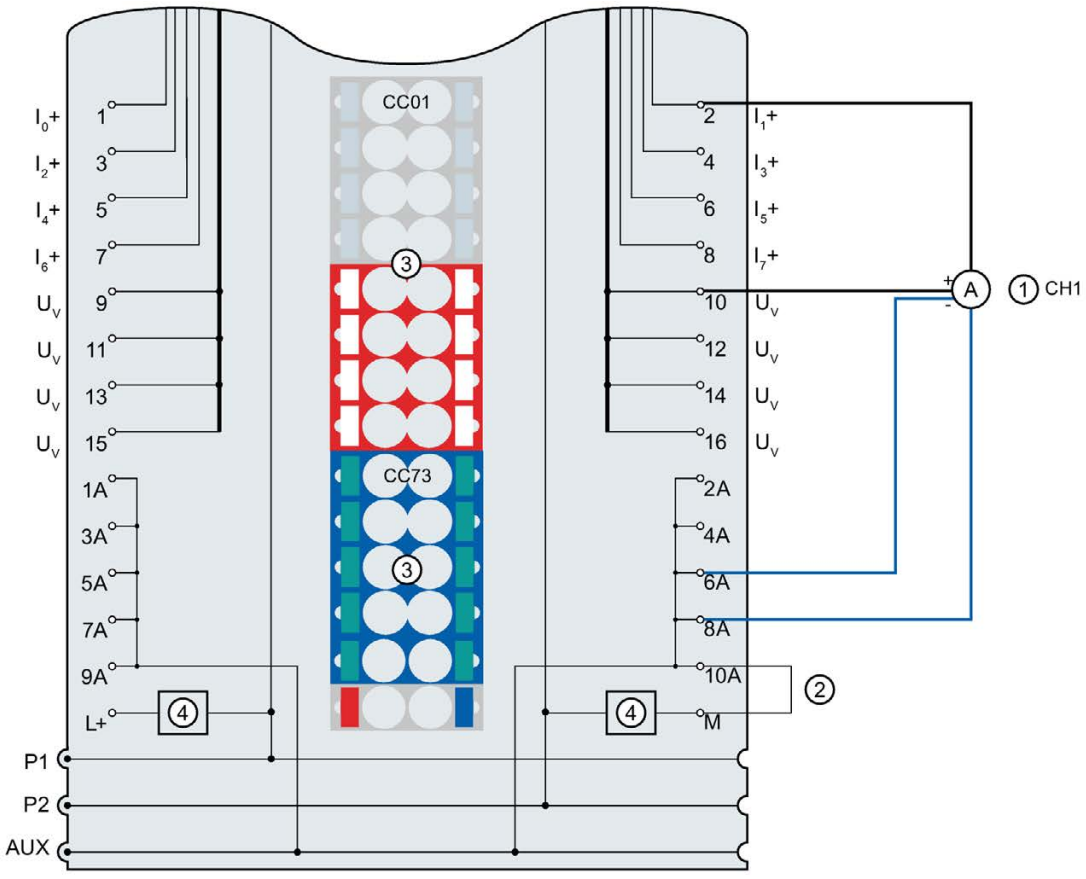


①	2-wire connection for current measurement	I_n+	Input signal, channel n
②	Backplane bus interface	U_V	Infeed voltage
③	Analog-to-digital converter (ADC)	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Current limitation	M	Ground
⑤	Color identification label CCxx (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	AI0 to AI7	Channel status LED (green)
		PWR	Power LED (green)

Figure 3-1 Wiring and block diagram for voltage measurement 2-wire connection

Connection: Current measurement 4-wire connection

The following figure shows the block diagram and an example for the terminal assignment of the analog input module AI 8xI 2-/4-wire BA on the BaseUnit BU type A0 with AUX terminals.



①	4-wire connection for current measurement
②	Connection AUX terminals to ground
③	Color identification labels CCxx (optional)
④	Filter connection supply voltage (only when light-colored BaseUnit is present)
I_n+	Input signal, channel n
U_V	Infeed voltage
L+	24 V DC (infeed only with light-colored BaseUnit)
M	Ground
1 A to 10 A	AUX terminals
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Figure 3-2 Wiring and block diagram for voltage measurement 4-wire connection

Parameters/address space

4

4.1 Measuring types and ranges

The analog input module AI 8xI 2-/4-wire BA has the following measuring ranges:

Table 4- 1 Measuring ranges

Measurement type	Measuring range	Resolution
Current (2-wire or 4-wire connection)	0 to 20 mA	15 bits
	4 to 20 mA	15 bits
Current (4-wire connection)	± 20 mA	16 bits including sign

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 32).

4.2 Parameters

AI 8xI 2-/4-wire BA parameters

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 28).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Module	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Module	Module
Type/range of measurement	• Deactivated • Current (4-wire connection) 0 to 20 mA • Current (4-wire connection) 4 to 20 mA • Current (4-wire connection) +/-20 mA • Current (2-wire connection) 0 to 20 mA • Current (2-wire connection) 4 to 20 mA	Current (4-wire connection) 4 to 20 mA	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Interference frequency suppression	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • 4800 Hz (0.625 ms) • 60 Hz (18.75 ms) [3] • 50 Hz (22.5 ms) [2 3] • 16.6 Hz (67.5 ms) [3]	50 Hz (60 ms)	Yes	Channel	Module
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP: The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. If required, you can still assign this parameter using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 8 bytes.

[2] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

[3] By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

Note

Unused channels

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value $7FFF_H$.

4.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the Diagnostics: Wire break is output.

Measurement type/measuring ranges

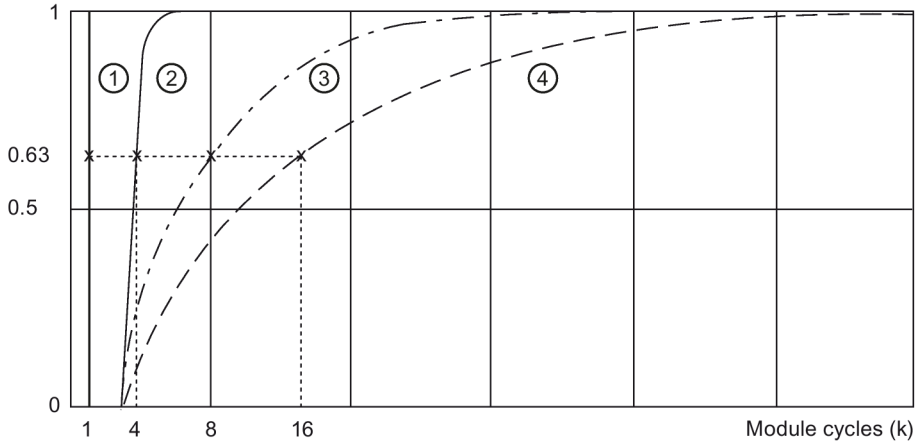
See the section Measurement types and measuring ranges (Page 13).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 4-1 Smoothing with AI 8xI 2-/4-wire BA

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the alternating voltage network may negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

4.4 Address space

Address space

The figure below shows the assignment of the address space for AI 8×I 2-/4-wire BA.

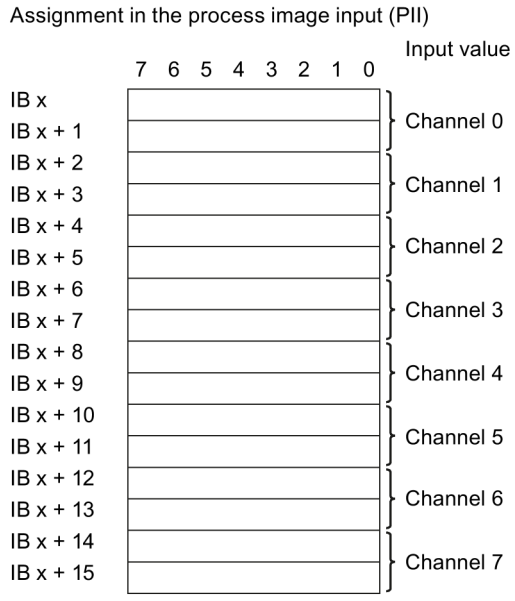


Figure 4-2 Address space of AI 8×I 2-/4-wire BA

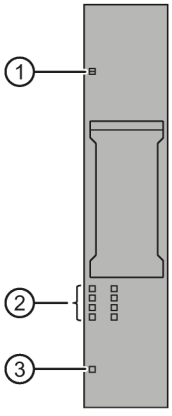
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays of the AI 8xU/I 2-/4-wire BA.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED displays

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 22).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated
On	Channel activated

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The analog input module AI 8×I 2-/4-wire BA supports diagnostics interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit (2-wire and 4-wire connection, current)
- Wire break (current 4 to 20 mA)
- Low limit violated
- High limit violated
- Error
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit *	1_H	Encoder supply to ground	Correct interplay between module and encoder
Wire break	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate channel • Connect the encoder contacts
High limit violated	7_H	Value is above overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update • Restart the firmware update

* Short-circuit of the encoder supply to ground has an effect on all channels.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 8×I 2-/4-wire BA

	6ES7134-6GF00-0AA1
Product type designation	ET 200SP, AI 8xI 2-/4-wire Basic
General information	
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC01
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable measuring range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Operating mode	
Oversampling	No
MSI	No
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	25 mA; without encoder supply

	6ES7134-6GF00-0AA1
Encoder supply	
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	0.7 A; total current of all encoders/channels
Power loss	
Power loss, typ.	0.7 W; without encoder supply voltage
Address area	
Address space per module	
Address space per module, max.	16 bytes
Analog inputs	
Number of analog inputs	8; single-ended
Maximum permitted input current for current input (destruction limit)	50 mA
Cycle time (all channels), min.	1 ms; per channel
Input ranges (rated values), currents	
0 to 20 mA	Yes
Input resistance (0 to 20 mA)	100 Ω; 15 bits
-20 mA to +20 mA	Yes
Input resistance (-20 mA to +20 mA)	100 Ω; 16 bits including sign
4 mA to 20 mA	Yes
Input resistance (4 mA to 20 mA)	100 Ω; 15 bits
Cable length	
Shielded, max.	200 m
Formation of analog values for the inputs	
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Integration time configurable	Yes
Interference voltage suppression for interference frequency f1 in Hz	16.67 / 50 / 60 / 4 800 (16.67 / 50 / 60)
Conversion time (per channel)	ms; 180 / 60 / 50 / 0.625 (67.5 / 22.5 / 18.75)
Measured value smoothing	
Number of steps	4; none; 4/8/16 times
Configurable	Yes
Encoders	
Connection of the signal transmitters	
For voltage measurement	No
For current measurement as 2-wire transducer	Yes
• Load of 2-wire transducer, max.	650 Ω
For current measurement as 4-wire transducer	Yes

	6ES7134-6GF00-0AA1
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	± 0.01%
Temperature error (in relation to input range), (+/-)	0.005%/K
Crosstalk between inputs, min.	50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	± 0.05%
Operational limit in the entire temperature range	
Current in relation to input range, (+/-)	± 0.5%
Basic error limit (operational limit at 25 °C)	
Current in relation to input range, (+/-)	± 0.3%
Interference voltage suppression for f = n x (f1 +/- 1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	70 dB; with conversion time 67.5 / 22.5 / 18.75 ms: 40 dB
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic interrupt	Yes
Limit interrupt	No
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; for 4 to 20 mA
Short-circuit	Yes; encoder supply to ground; module-based
Group error	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green / red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No

	6ES7134-6GF00-0AA1
Permitted potential difference	
Between different circuits	75 V DC/60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range with PROFINET.

Measurement type	Measuring range	Diagnostics				
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow	Wire break
Deactivated		*	*	*	*	*
Current (4-wire connection)	0 to 20 mA	x	x	x	x	-
	4 to 20 mA	x	x	x	x	x
	±20 mA	x	x	x	x	-
Current (2-wire connection)	0 to 20 mA	x	x	x	-	-
	4 to 20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range with PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to ground	Over-flow/underflow	Wire break
Deactivated		*	*	*	*
Current (4-wire connection)	0 to 20 mA	x	x	x	-
	4 to 20 mA	x	x	x	x
	±20 mA	x	x	x	-
Current (2-wire connection)	0 to 20 mA	x	x	x	-
	4 to 20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 contains the diagnostics for the entire module.

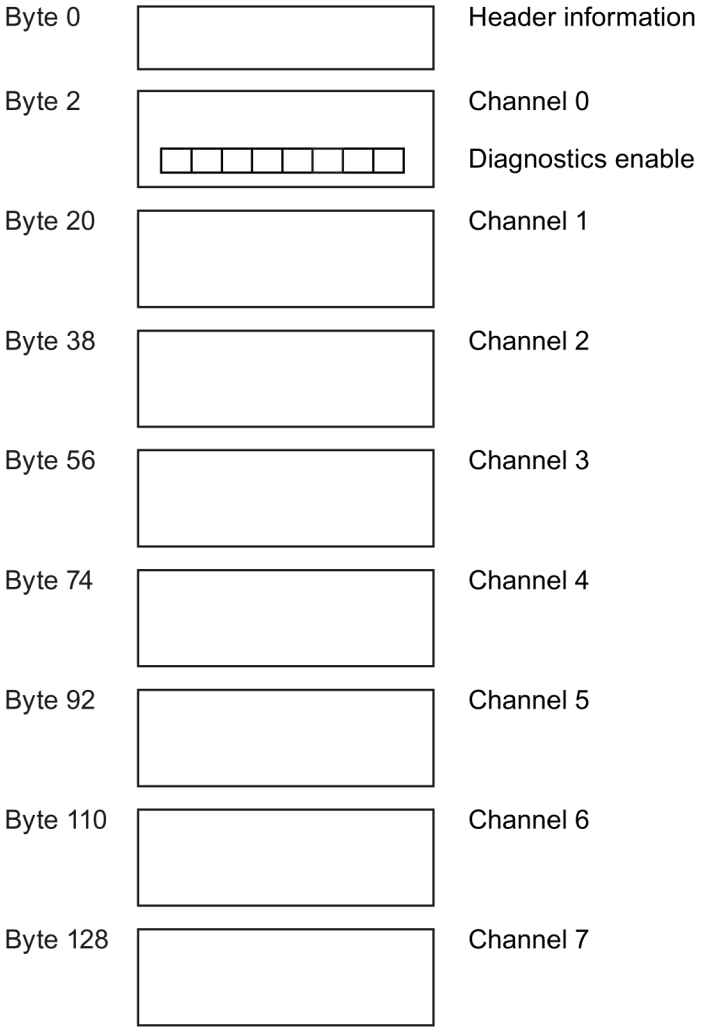


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

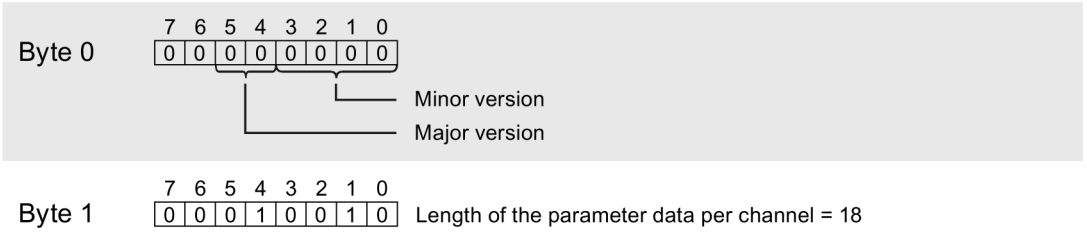
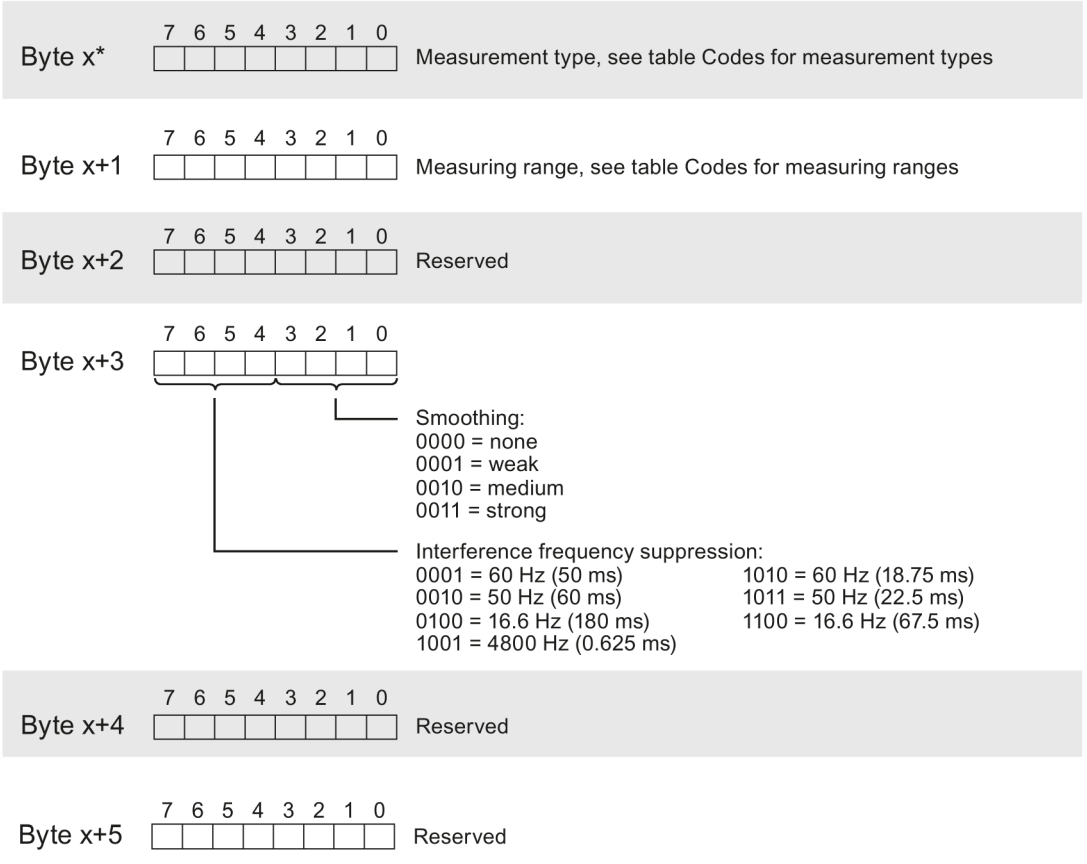


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".



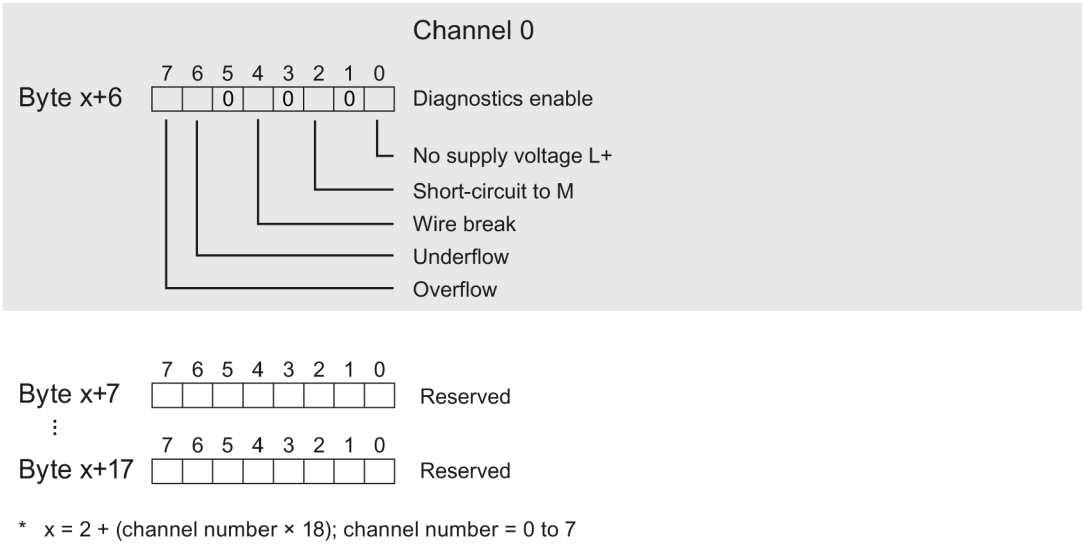


Figure A-3 Structure of byte x to x+17 for channels 0 to 7

Codes for measurement types

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table A- 1 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Current, 4-wire connection	0000 0010
Current, 2-wire connection	0000 0011

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table A- 2 Codes for measuring ranges

Measuring range	Code
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011
±20 mA	0000 0100

Representation of analog values

B

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table B- 4 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	Hex.	±20 mA	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table B- 5 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	Hex.	0 to 20 mA *	4 to 20 mA	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measurement type "2-wire connection", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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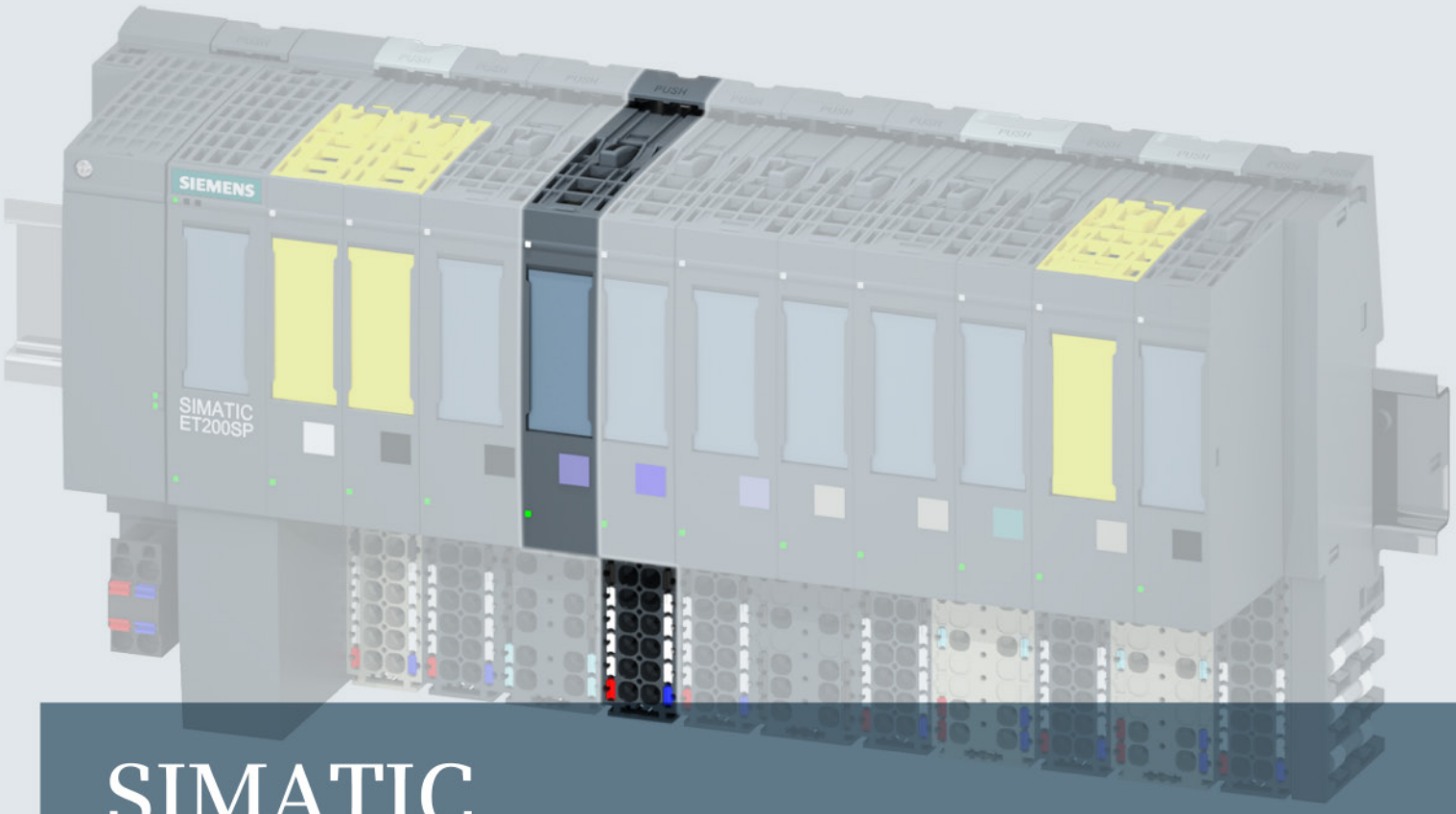

SIMATIC

ET 200SP

Analog input module AI 4xU/I 2-wire ST (6ES7134-6HD00-0BA1)

Manual

Edition 07/2014

Answers for industry.

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SIMATIC

ET 200SP
Analog Input Module
AI 4xU/I 2-wire ST
(6ES7134-6HD00-0BA1)

Manual

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Representation of analog values B

07/2014

A5E03572832-AC

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 07/2014 Subject to change

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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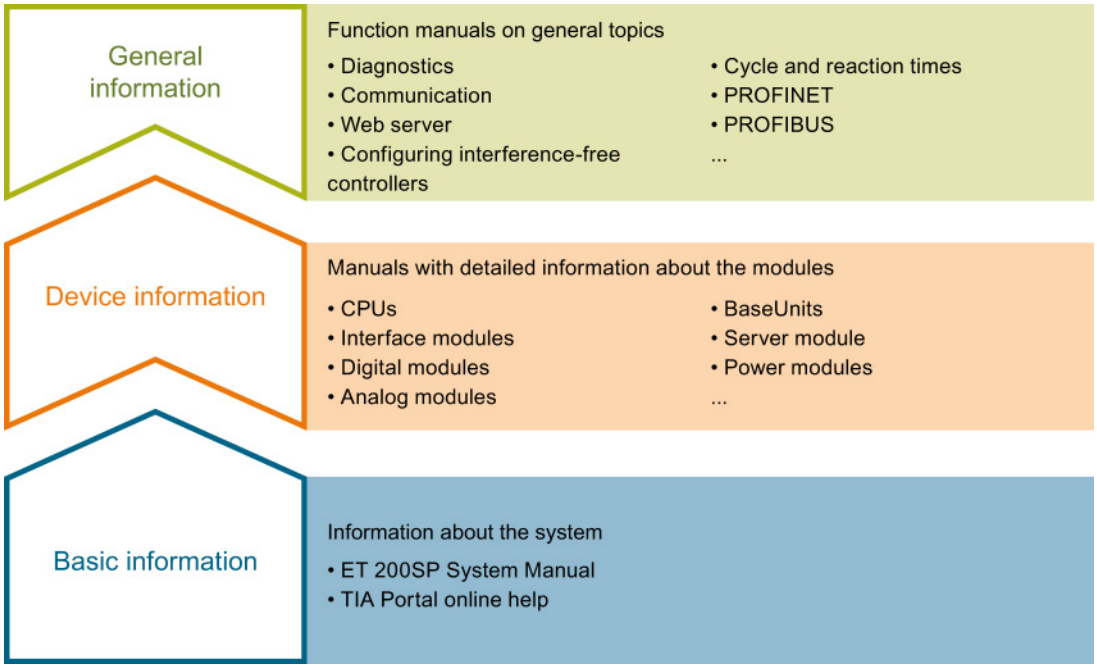
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC distributed I/O system. ET 200SP. The STEP 7 online help supports you in the configuration and programming.

Device information

Manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics, technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

Product overview

2

2.1 Properties

Article number

6ES7134-6HD00-0BA1

View of the module

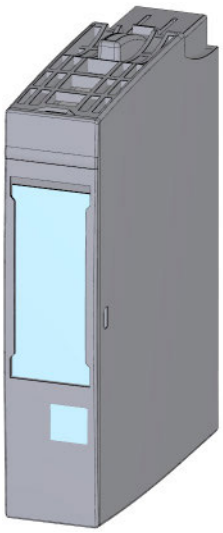


Figure 2-1 View of the module AI 4×U/I 2-wire ST

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Measuring type voltage and current for 2-wire transducer (can be set for each channel)
- Input ranges for voltage measurement:
  - ±10 V, resolution 16 bits including sign
  - ±5 V, resolution 16 bits including sign
  - 1 to 5 V, resolution 15 bits
  - 0 to 10 V, resolution 15 bits
- Input ranges for current measurement:
  - 4 to 20 mA, resolution 15 bits
  - 0 to 20 mA, resolution 15 bits
- Electrically isolated from the supply voltage L+ (only for voltage measuring type)
- Permitted common mode voltage: 10 V_{ss}
- Configurable diagnostics per module

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

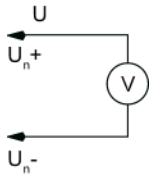
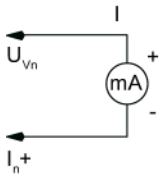
Wiring up

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment

Terminal assignment for AI 4×U/I 2-wire ST (6ES7134-6HD00-0BA1)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Explanation**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	U_0+	**2**	U_1+	Voltage input (terminals 1 to 8) • U_n+: Input signal "+", channel n • U_n-: Input signal "-", channel n	A0 A1	 CC03 6ES7193-6CP03-2MA0
3	U_2+	**4**	U_3+			
5	U_0-	**6**	U_1-			
7	U_2-	**8**	U_3-			
9	U_{V0}	**10**	U_{V1}	Current input (terminals 9 to 16) • U_{Vn}: Supply voltage channel n • I_n+: Current input "+", channel n		
11	U_{V2}	**12**	U_{V3}			
13	I_0+	**14**	I_1+			
15	I_2+	**16**	I_3+			
L+	24 VDC	**M**	M			
Voltage input  				Current input  		

[1] Usable BaseUnit types, can be identified by the last two digits of the article number.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Also keep this in mind during the configuration.

See also

You will find additional information on the BaseUnit types in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Schematic circuit diagram

Schematic circuit diagram

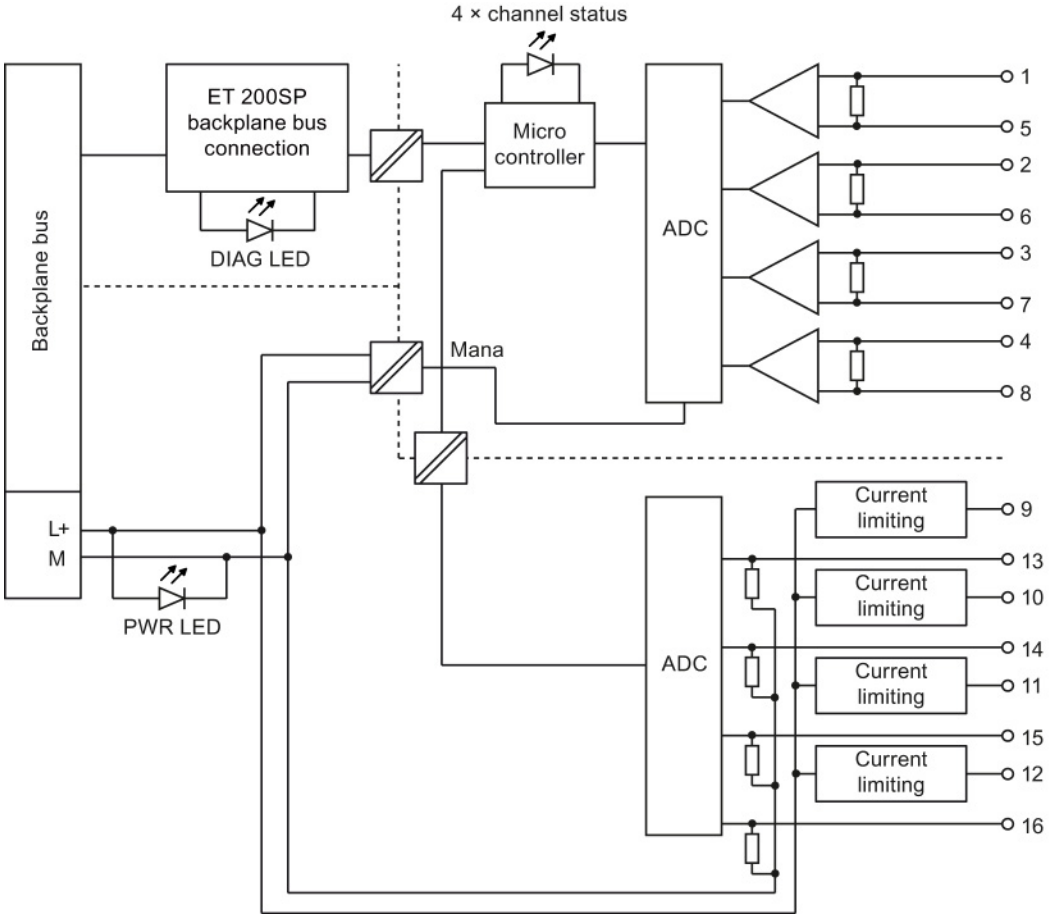


Figure 3-1 Schematic circuit diagram for AI 4×U/I 2-wire ST

Parameters/address space

4

4.1 Measuring types and ranges

The analog input module AI 4×U/I 2-wire ST has the following measuring ranges:

Table 4- 1 Measuring ranges

Measuring type	Measuring range	Resolution
Voltage	±10 V	16 bits including sign
	±5 V	16 bits including sign
	1 to 5 V	15 bits
	0 to 10 V	15 bits
Current (2-wire transducer)	4 to 20 mA	15 bits
	0 to 20 mA	15 bits

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 32).

4.2 Parameters

Parameters of the AI 4xU/I 2-wire ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 28).

The following parameter settings are possible:

Table 4- 2 Settable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Overflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Underflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Wire break	• Disable • Enable	Disable	yes	Module	Module
Measuring type/range	• deactivated • Voltage +/- 5 V • Voltage +/- 10 V • Voltage 1..5 V • Voltage 0..10 V • Current (2-wire transducer) 0..20 mA • Current (2-wire transducer) 4..20 mA	Current (2-wire transducer) 4..20 mA	yes	Channel	Channel

Parameter	Value range	Default	Configur-ation in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Smoothing	• none • weak • medium • strong	none	yes	Channel	Channel
Interference frequency suppression	• 60 Hz • 50 Hz[1] • 16.6 Hz	50 Hz	yes	Channel	Module
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	no	Module	Module

[1] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

Note

Unused channels

Disable unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always returns the value $7FFF_H$.

4.3 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply. Short-circuit is also detected in the range 1 to 5 V, when both input signals are short-circuited.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, however, the short-circuit diagnostics suppresses the underflow diagnostics. Short-circuit is output as the diagnostics event.

Diagnostics overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics info is output.

Type/range of measurement

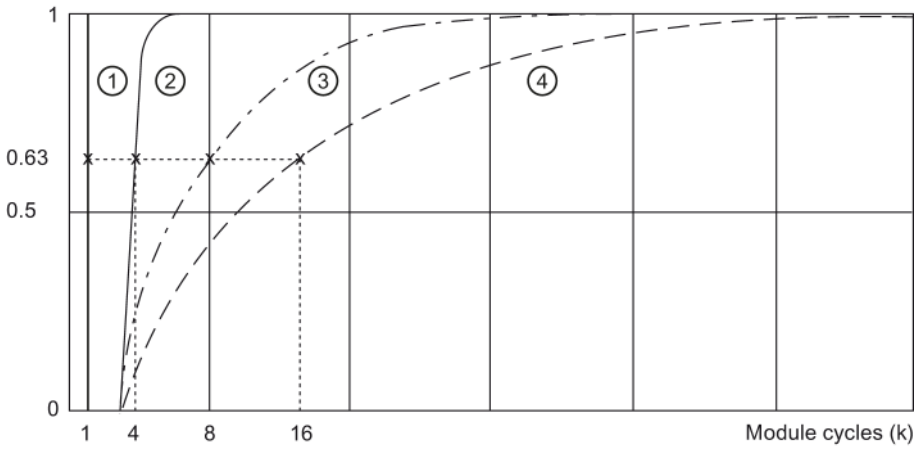
Refer to the section Measuring types and ranges (Page 13).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 4-1 Smoothing with AI 4xU/I 2-wire ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the supply frequency that is predominant in the plant.

Potential group

Specifies that a BaseUnit with voltage supply feed-in is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 4×U/I 2-wire ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

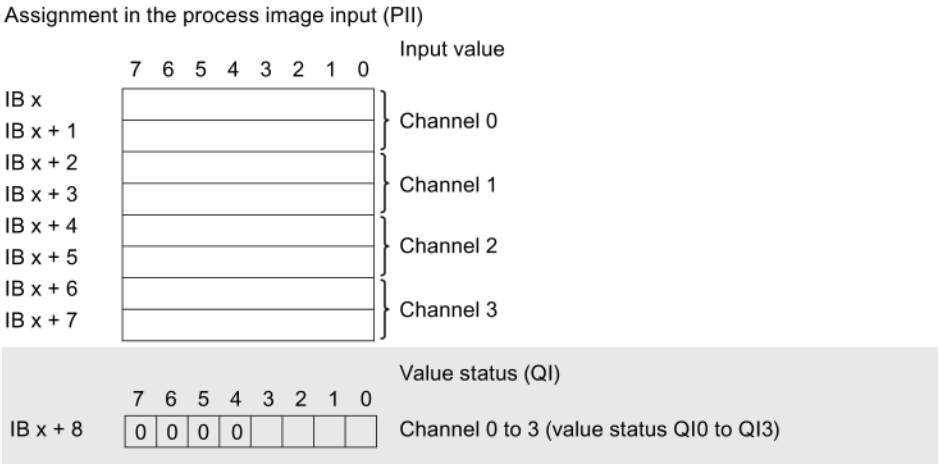


Figure 4-2 Address space of the AI 4×U/I 2-wire ST with value status

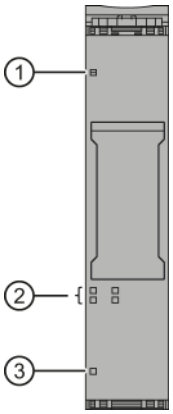
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the AI 4xU/I 2-wire ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 22).

DIAG LED

Table 5- 1 DIAG LED fault/error display

DIAG LED	Meaning
off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
on	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
off	Channel disabled
on	Channel enabled

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
off	No supply voltage L+
on	Supply voltage L+ present

5.2 Interrupts

The analog input module AI 4×U/I 2-wire ST supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit (current, voltage 1..5 V)
- Wire break (current 4..20 mA)
- Low limit violated
- High limit violated
- Error
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware being updated. The module does not perform any measurements during this time.	–
Short-circuit (current)*	1_H	Sensor supply to ground	Correct the module/encoder tuning
		Input to sensor supply	
Short-circuit (1 to 5 V)	1_H	Short-circuit of input signal	Correct the module/encoder tuning
		Open input	Connect input
Line break (current)	6_H	Impedance of encoder circuit too high.	Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the sensor contacts
High limit violated	7_H	Value is above the overrange.	Correct the module/encoder tuning
Low limit violated	8_H	Value is below the underrange.	Correct the module/encoder tuning
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostics can also be reported for unaffected channels and/or the measured value can be affected temporarily.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 4×U/I 2-wire ST

	6ES7134-6HD00-0BA1
Product type designation	AI 4xU/I 2-wire ST
General information	
Firmware version	V1.1
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC03
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V11 SP2 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Input current	
Current consumption, max.	37 mA; without encoder supply

	6ES7134-6HD00-0BA1
Encoder supply	
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s
Power loss	
Power loss, typ.	0.85 W; without encoder supply voltage
Address area	
Address space per module	
Address space per module, max.	8 bytes; + 1 byte for QI information
Analog inputs	
Number of analog inputs	4
Maximum permitted input voltage for voltage input (destruction limit)	30 V
Maximum permitted input current for current input (destruction limit)	50 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on the parameter assignment of the enabled channels)
A/D resolution at analog input	16 bits
Analog inputs, configurable	Yes
Configurable input variable	Yes
Input ranges	
Voltage	Yes
Current	Yes
Thermocouple	No
Resistance thermometer	No
Resistance	No
Input ranges (rated values), voltages	
0 to +10 V	Yes; 15 bits
Input resistance (0 to 10 V)	120 kΩ
1 to 5 V	Yes; 15 bits
Input resistance (1 to 5 V)	120 kΩ
-10 V to +10 V	Yes; 16 bits including sign
Input resistance (-10 V to +10 V)	120 kΩ
-5 V to +5 V	Yes; 16 bits including sign
Input resistance (-5 V to +5 V)	120 kΩ
Input ranges (rated values), currents	
0 to 20 mA	Yes; 15 bits
Input resistance (0 to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage
4 to 20 mA	Yes; 15 bits
Input resistance (4 to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage
Cable length	
Cable length shielded, max.	1000 m; 200 m for voltage measurement

	6ES7134-6HD00-0BA1
Analog value formation	
Measuring principle	Integrating (sigma-delta)
Integration and conversion time / resolution per channel	
Resolution with overrange (bits including sign), max.	16 bits
Integration time configurable	Yes
Interference suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
Conversion time (per channel)	180 / 60 / 50 ms
Measured value smoothing	
Configurable	Yes
Setting: None	Yes
Setting: Weak	Yes
Setting: Medium	Yes
Setting: Strong	Yes
Encoders	
Connection of the signal transmitters	
for voltage measurement	Yes
for current measurement as 2-wire transducer	Yes
• Load of the 2-wire transducer, max.	650 Ω
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	± 0.01 %
Temperature error (in relation to input range), (+/-)	± 0.005 %
Crosstalk between inputs, min.	50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	± 0.05 %
Operational limit in the entire temperature range	
Voltage in relation to input range, (+/-)	± 0.5 %
Current in relation to input range, (+/-)	± 0.5 %
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	± 0.3 %
Current in relation to input range, (+/-)	± 0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
Series-mode interference (peak of the interference < nominal value of the input range), min.	70 dB
Common mode voltage, max.	10 V
Common mode interference, min.	90 dB

	6ES7134-6HD00-0BA1
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Monitoring of supply voltage	Yes
Wire break	Yes; for 4 to 20 mA
Short-circuit	Yes; for 1 to 5 V or for 2-wire operation: Short-circuit of the encoder supply to ground or short-circuit of an input to the encoder supply
Group error	Yes
Overflow/underflow	Yes
Diagnostics display LED	
Monitoring of the supply voltage (PWR LED)	Yes; green LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes, per channel group between the group of the 2-wire current inputs and the group of the voltage inputs
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes; only for voltage inputs
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic isolation)
Between the inputs (UCM)	10 VDC
Insulation	
Insulation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFINET.

Measuring type	Measuring range	Diagnostics				
		No supply voltage L+	Short-circuit to M	Overflow	Underflow	Wire break
deactivated		*	*	*	*	*
Voltage	±5 V	x	-	x	x	-
	±10 V	x	-	x	x	-
	1..5 V	x	x	x	x	-
	0..10 V	x	-	x	x	-
Current (2-wire transducer)	0..20 mA	x	x	x	x	-
	4..20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFIBUS.

Measuring type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to M	Overflow/ Underflow	Wire break
deactivated		*	*	*	*
Voltage	±5 V	x	-	x	-
	±10 V	x	-	x	-
	1..5 V	x	x	x	-
	0..10 V	x	-	x	-
Current (2-wire transducer)	0..20 mA	x	x	x	-
	4..20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 contains the diagnostics for the entire module.

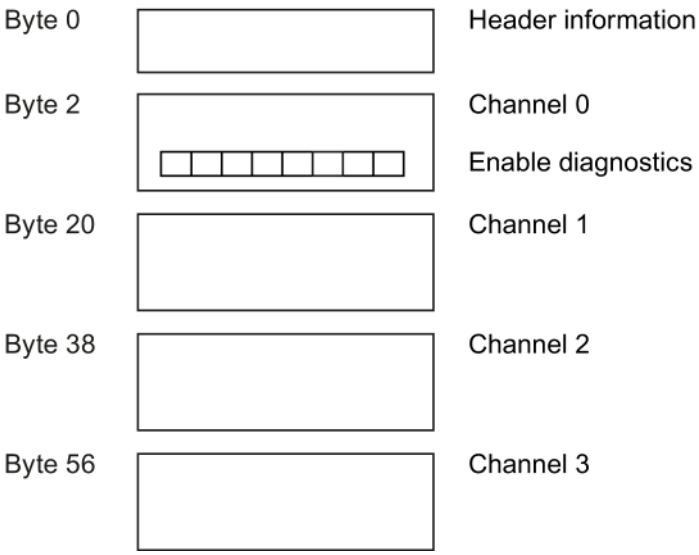


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

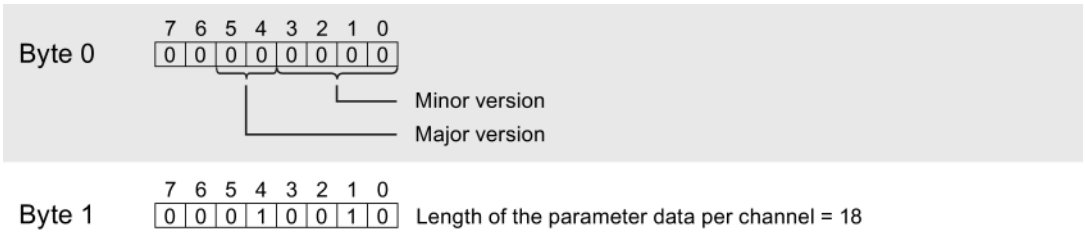


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

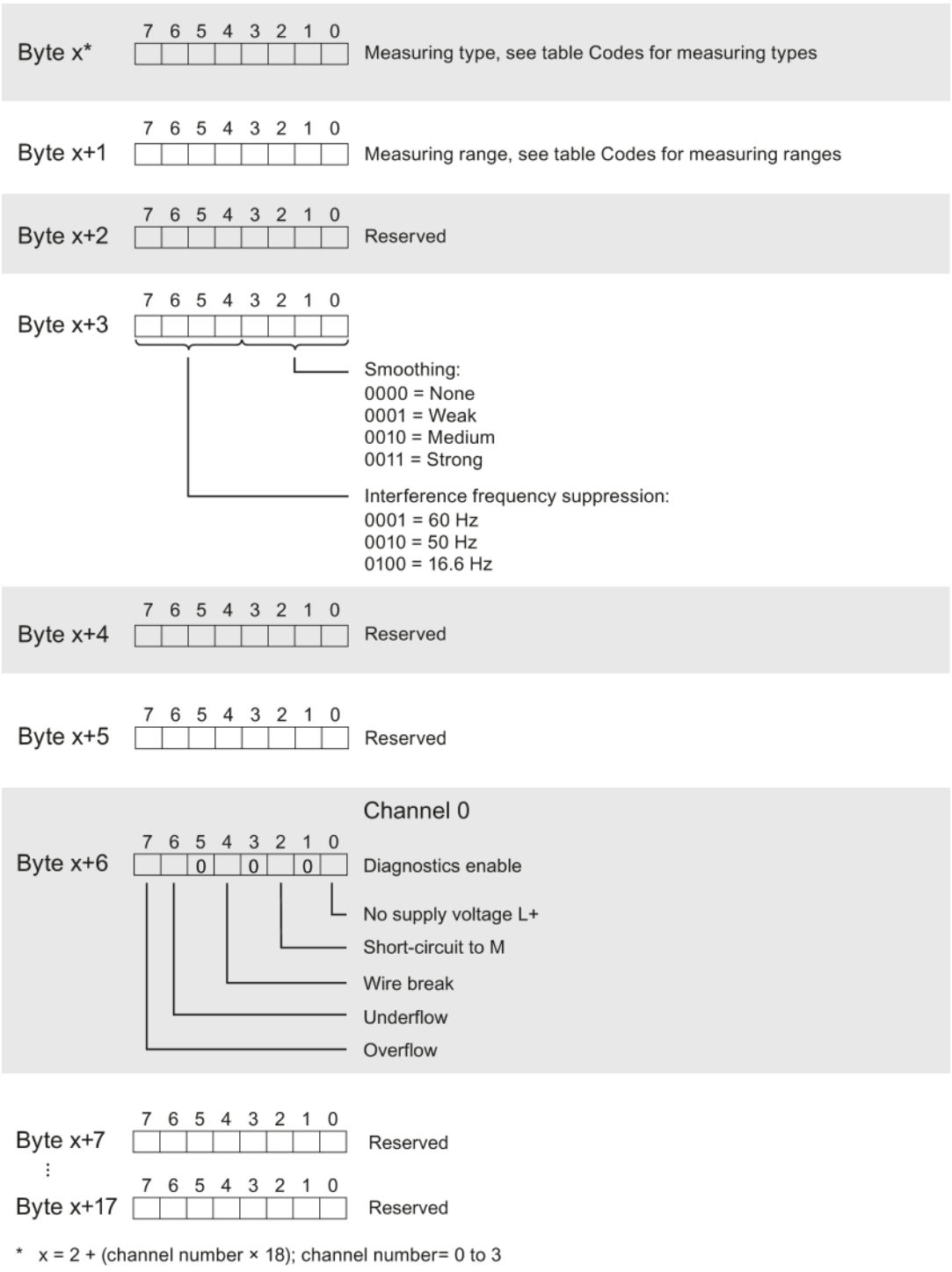


Figure A-3 Structure of byte x to x+17 for channels 0 to 3

Codes for the measuring type

The following table contains the codes for the measuring types of the analog input module. You must enter these codes at byte x (see previous figure).

Table A- 1 Codes for the measuring type

Measuring type	Coding
Deactivated	0000 0000
Voltage	0000 0001
Current, 2-wire transducer	0000 0011

Codes for the measuring range

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table A- 2 Codes for the measuring range

Measuring type	Coding
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current	
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011

Representation of analog values

B

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its assigned parameters.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Note

The digitalized temperature values are the result of a conversion in the analog module. The following resolution therefore does not apply to temperature values.

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table B- 4 Voltage measuring range ±10 V and ±5 V

Values		Voltage measuring range		Range
Dec.	Hex.	±10 V	±5 V	
32767	7FFF	>11.759 V	>5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	<-11.759 V	<-5.879 V	Underflow

Table B- 5 Voltage measuring range 1 to 5 V and 0 to 10 V

Values		Voltage measuring range		Range
Dec.	Hex.	1 to 5 V	0 to 10 V	
32767	7FFF	>5.704 V	>11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	0 V + 361.7 µV	
0	0	1 V	0 V	
-1	FFFF		Negative values are not possible	Underrange
-4864	ED00	0.296 V		
-32768	8000	<0.296 V		Underflow

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table B- 6 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	Hex.	0 to 20 mA *	4 to 20 mA	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measuring type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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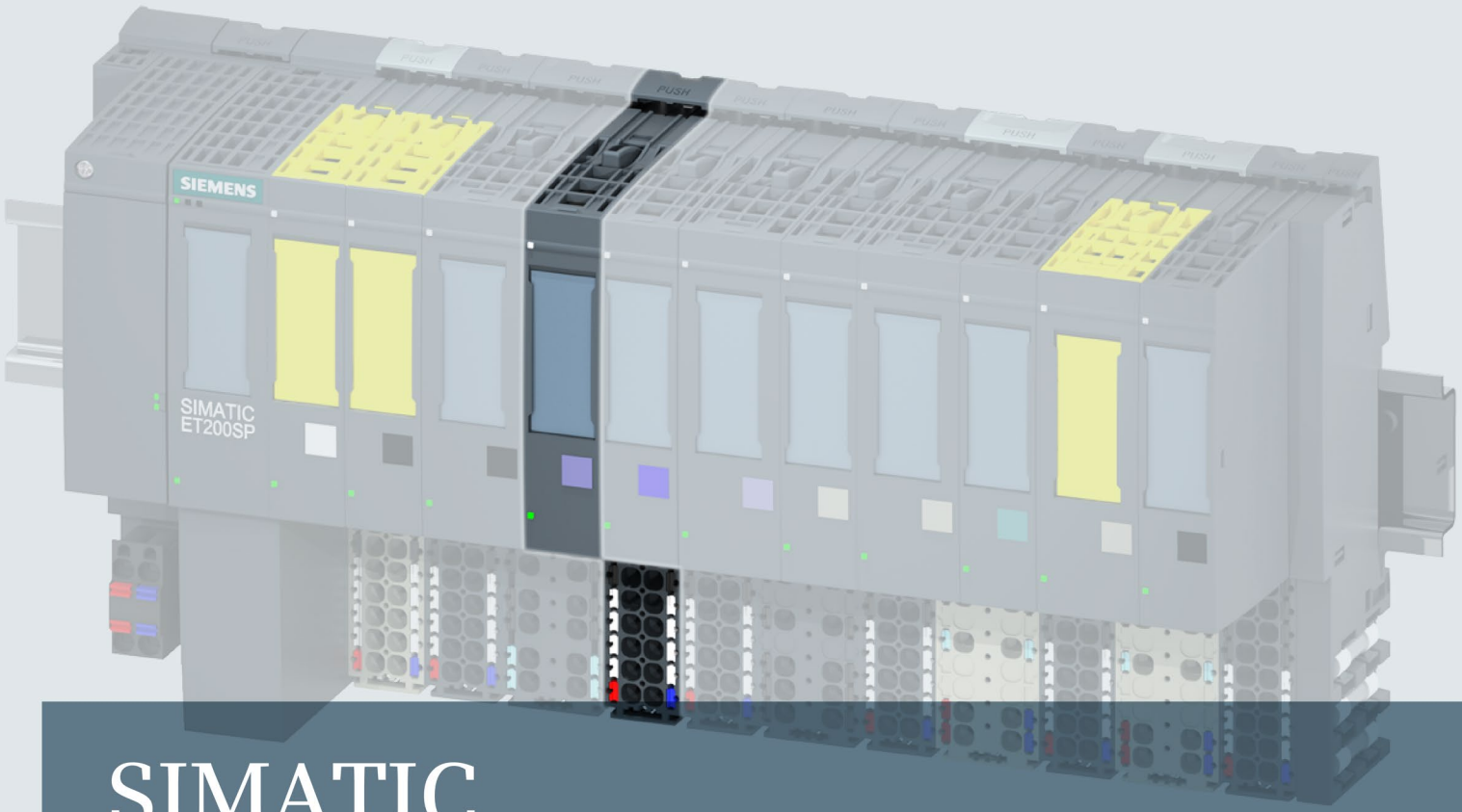

SIMATIC

ET 200SP

Analog input module AI 2xU ST (6ES7134-6FB00-0BA1)

Manual

Edition 12/2015

Answers for industry.

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SIMATIC

ET 200SP
Analog input module AI 2xU ST (6ES7134-6FB00-0BA1)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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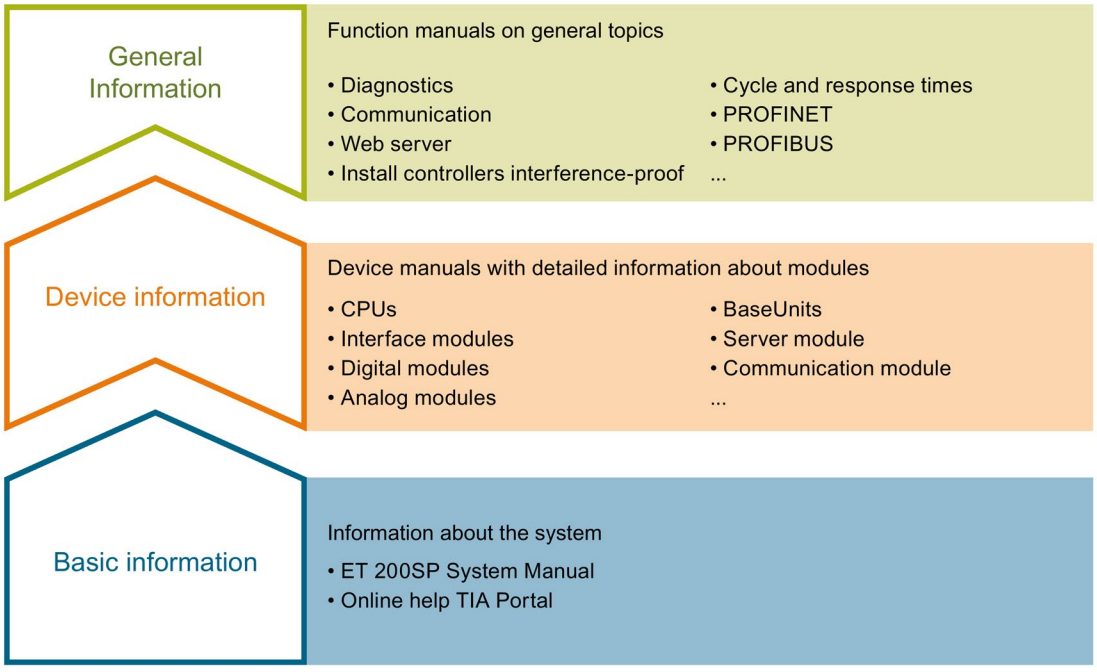
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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In doing so you can select:

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- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

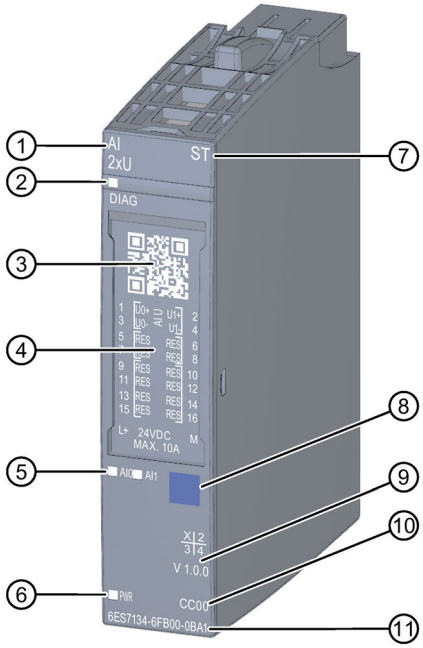
2

2.1 Properties

Article number

6ES7134-6FB00-0BA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module AI 2×U ST

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Voltage measurement type (can be set per channel)
- Input ranges for voltage measurement:
  - ±5 V, resolution 16 bits including sign
  - ±10 V, resolution 16 bits including sign
  - 1 to 5 V, resolution 15 bits
  - 0 to 10 V, resolution 15 bits
- Electrically isolated from supply voltage L+
- Permitted common mode voltage: 10 V_{ss}
- Configurable diagnostics (per module)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 2xU ST module with the terminal assignments.

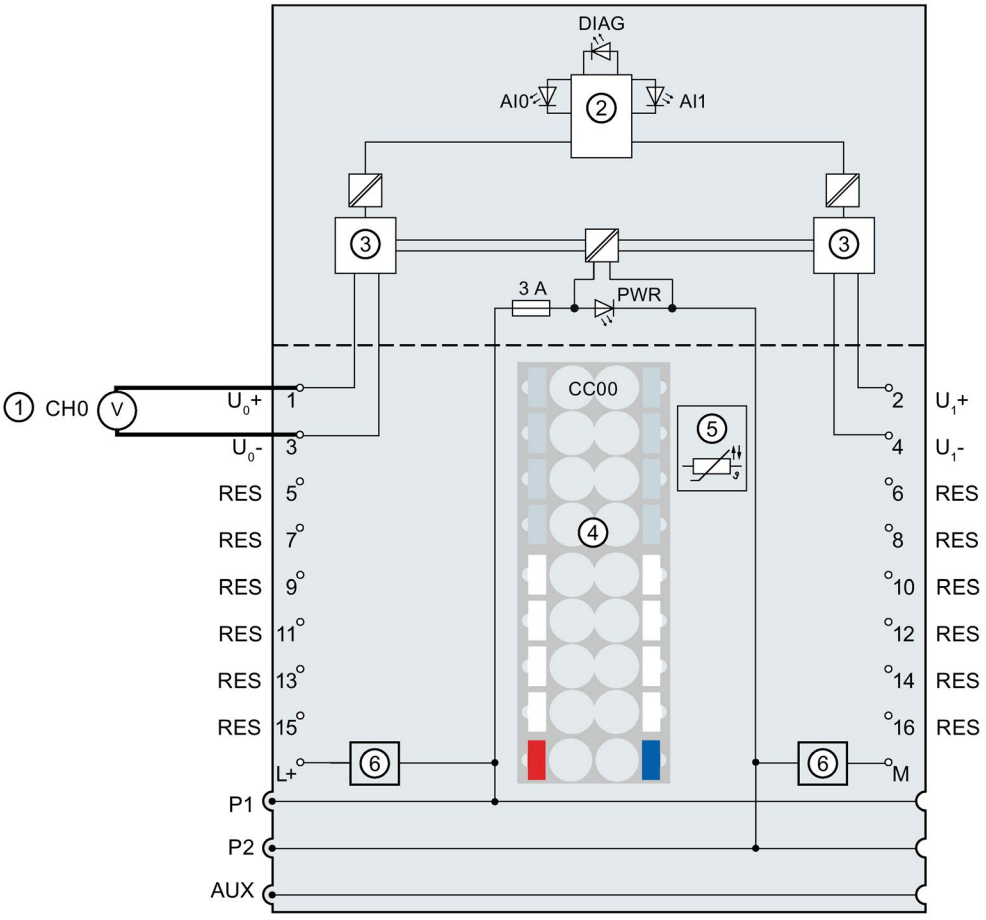
You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: Voltage measurement 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xU ST on the BaseUnit BU type A0/A1.



①	2-wire connection for voltage measurement	U_n+	Voltage input positive, channel n
②	Backplane bus interface	U_n-	Voltage input negative, channel n
③	Analog-to-digital converter (ADC)	RES	Reserve, must remain unused for future function extensions
④	Color-coded label with color code CC00 (optional)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Temperature recording for BU type A1 only (function cannot be used for this module)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)	DIAG	Diagnostics LED (green, red)
		AI0, AI1	Channel status LED (green)
		PWR	Power LED (green)

Image 3-1 Wiring and block diagram for voltage measurement 2-wire connection

Parameters/address space

4

4.1 Measuring types and ranges

The analog input module AI 2×U ST has the following measuring ranges:

Table 4- 1 Measuring ranges

Measurement type	Measuring range	Resolution
Voltage	± 5 V	16 bits incl. sign
	± 10 V	16 bits incl. sign
	1 to 5 V	15 bits
	0 to 10 V	15 bits

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 32).

4.2 Parameters

Parameters of the AI 2xU ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 28).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow [1]	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow [1]	• Disable • Enable	Disable	Yes	Module	
Measurement type/measuring range	• Deactivated • Voltage +/- 5 V • Voltage +/- 10 V • Voltage 0..10 V • Voltage 1..5 V	Voltage +/- 10 V	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel

Parameter	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Interference frequency suppression	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • None	50 Hz (60 ms)	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

[2] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

Note

Unused channels

Disable the unused channels in the parameter assignment.

A deactivated channel always returns the value $7FFF_H$.

4.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Diagnostics are enabled when both input signals are short-circuited in the range 1 to 5 V.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, however, the short-circuit diagnostics suppresses the underflow diagnostics. Short-circuit is output as the diagnostics event.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Measurement type/measuring range

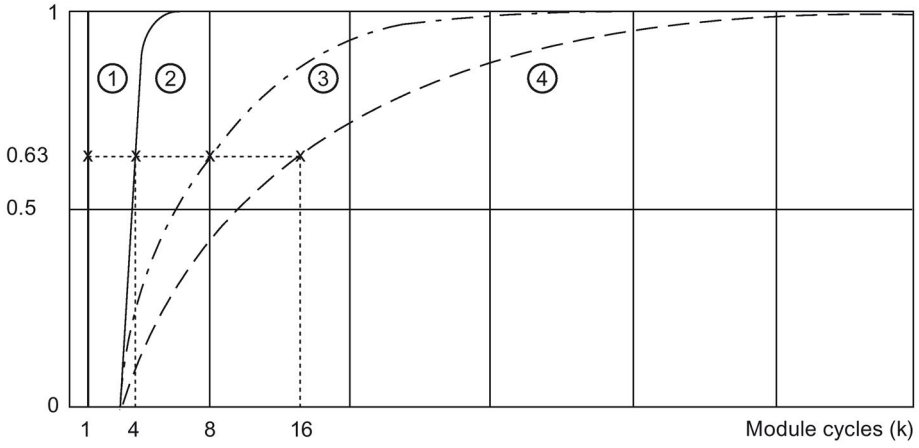
Refer to the section Measuring types and ranges (Page 13).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Image 4-1 Smoothing for AI 2xU ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 and 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 2×U ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

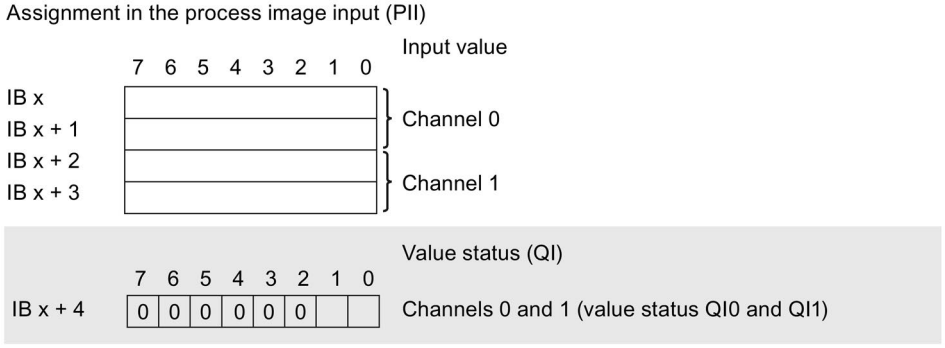


Image 4-2 Address space of the AI 2×U ST with value status

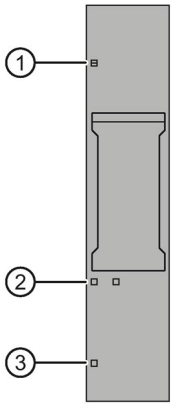
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the AI 2xU ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 22).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel disabled
On	Channel activated

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The AI 2×U ST analog input module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (voltage 1 V to 5 V)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (1 to 5 V)	1_H	Short-circuit of input signal	Correct interplay between module and encoder
		Open input	Connect input
High limit violated	7_H	Value is above the overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below the underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read process values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 2×U ST

	6ES7134-6FB00-0BA1
General information	
Product type designation	ET 200SP, AI 2xU Standard
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable measuring range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
Oversampling	No
MSI	No
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Calibration in RUN possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	37 mA
Encoder supply	
24 V encoder supply	
24 V	No
Additional 24 V encoder supply	
24 V	No

	6ES7134-6FB00-0BA1
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
Address space per module, max.	4 bytes; + 1 byte for QI information
Analog inputs	
Number of analog inputs	2
Maximum permissible input voltage for voltage input (destruction limit)	30 V
Cycle time (all channels), min.	500 µs
Input ranges (rated values), voltages	
0 to +10 V	Yes; 15 bits
Input resistance (0 to 10 V)	180 kΩ
1 V to 5 V	Yes; 15 bits
Input resistance (1 V to 5 V)	180 kΩ
-10 V to +10 V	Yes; 16 bits incl. sign
Input resistance (-10 V to +10 V)	180 kΩ
-5 V to +5 V	Yes; 16 bits incl. sign
Input resistance (-5 V to +5 V)	180 kΩ
Cable length	
Shielded, max.	200 m
Formation of analog values for the inputs	
Measuring principle	Sigma Delta
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Integration time configurable	Yes
Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz / off
Conversion time (per channel)	50 ms @ 60 Hz, 60 ms @ 50 Hz, 180 ms @ 16.6 Hz, 250 µs without filter
Measured value smoothing	
Number of levels	4
Configurable	Yes
Setting: None	Yes; 1 x cycle time
Setting: Weak	Yes; 4 x cycle time
Setting: Medium	Yes; 8 x cycle time
Setting: Strong	Yes; 16 x cycle time

	6ES7134-6FB00-0BA1
Encoders	
Connection of the signal transmitters	
For voltage measurement	Yes
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	0.01%
Temperature error (in relation to input range), (+/-)	0.005%/K
Crosstalk between inputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	0.05%
Operational limit in the entire temperature range	
Voltage in relation to input range, (+/-)	0.5%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	0.3%
Interference voltage suppression for f = n x (f1 +/-1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	70 dB
Common mode voltage, max.	10 V
Common mode interference, min.	90 dB
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Limit interrupt	No
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	No
Short-circuit	Yes; with 1 to 5 V
Group error	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED

	6ES7134-6FB00-0BA1
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Between the inputs (UCM)	10 Vss
Isolation	
Isolation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow
Deactivated		*	*	*	*
Voltage	±5 V	x	-	x	x
	±10 V	x	-	x	x
	1 V to 5 V	x	x	x	x
	0 V to 10 V	x	-	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow
Deactivated		*	*	*	*
Voltage	±5 V	x	-	x	x
	±10 V	x	-	x	x
	1 V to 5 V	x	x	x	x
	0 V to 10 V	x	-	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

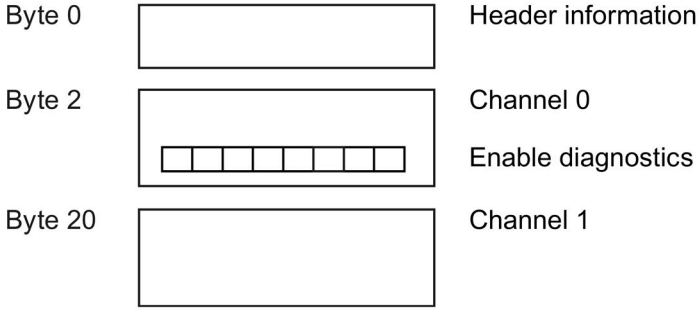


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

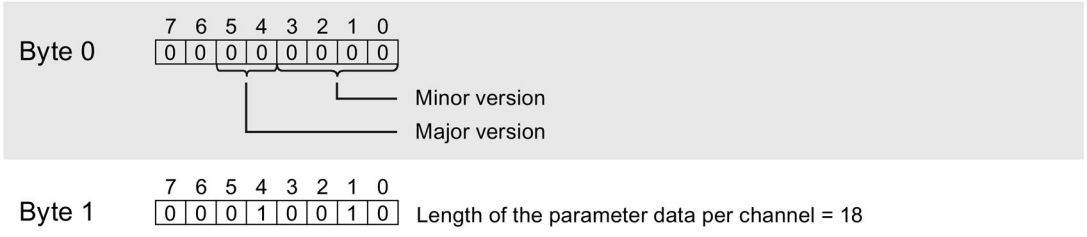
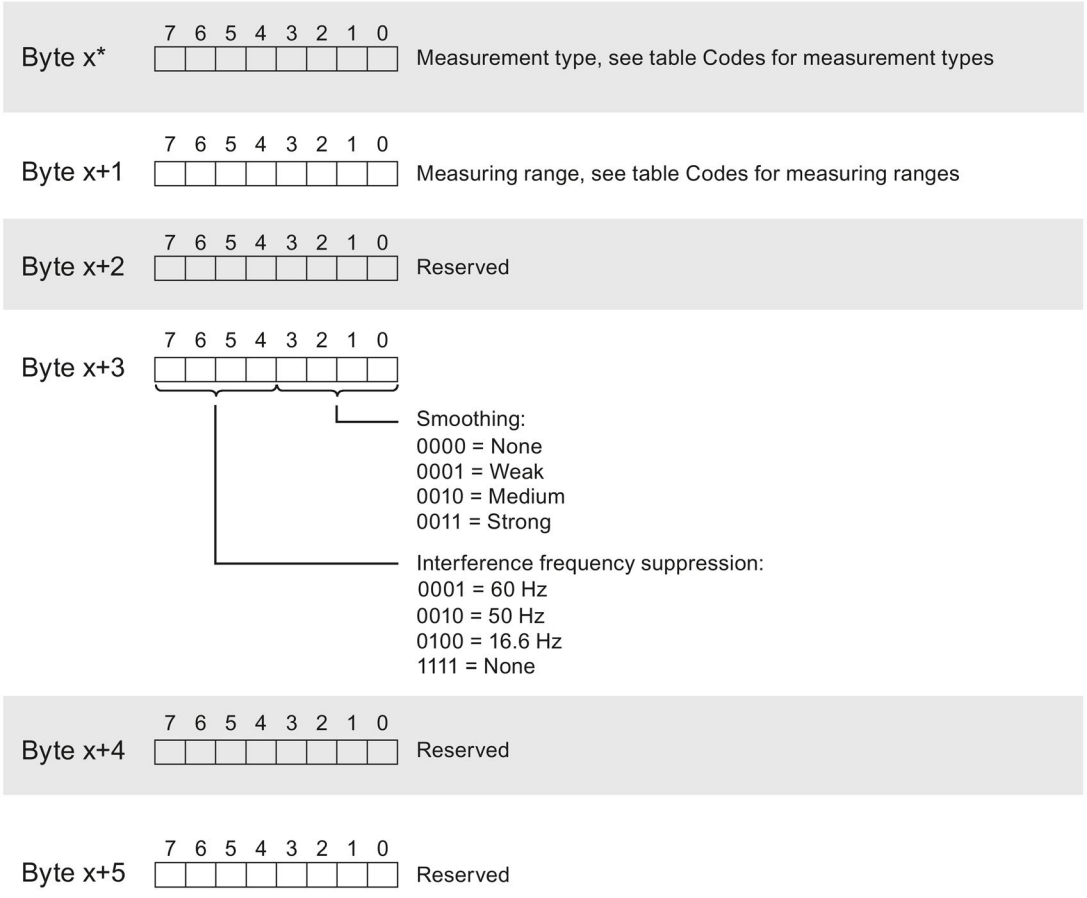


Image A-2 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".



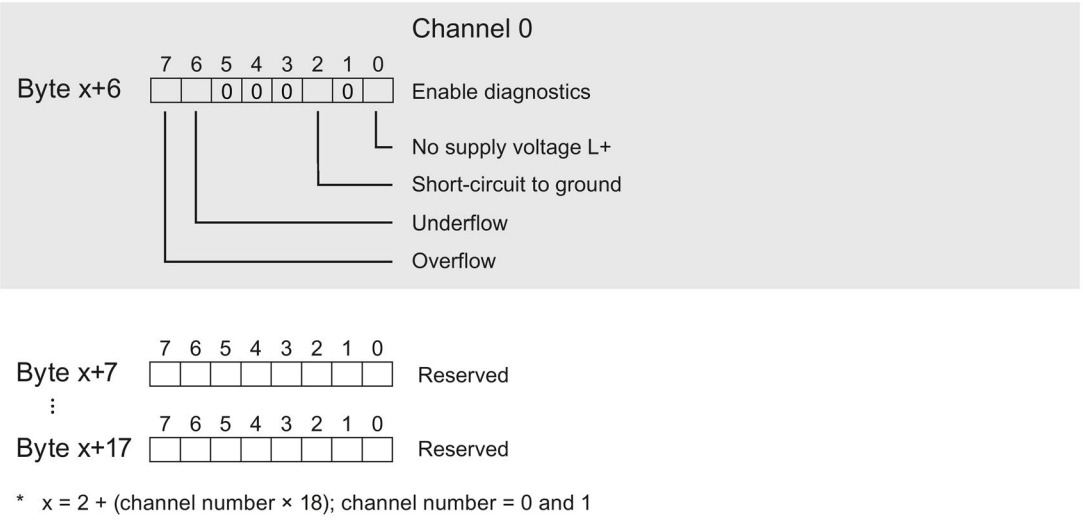


Image A-3 Structure of bytes x to x+17 for channels 0 and 1

Codes for measurement types

The following table contains the codes for the measuring types of the analog input module. You must enter these codes at byte x (see previous figure).

Table A- 1 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table A- 2 Codes for measuring ranges

Measurement type	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011

Error transmitting the data record

The module always checks all values of the transmitted data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values

This appendix shows the analog values for all measuring ranges that you can use with the analog input module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its assigned parameters.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.3 Representation of analog values in voltage measuring ranges

Voltage measuring range ±10 V to ±5 V

Table B- 4 Voltage measuring range ±10 V to ±5 V

System		Voltage measuring range		Range
dec	hex	±10 V	±5 V	
32767	7FFF	>11.759 V	>5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	<-11.759 V	<-5.879 V	Underflow

Voltage measuring ranges 1 V to 5 V and 0 V to 10 V

Table B- 5 Voltage measuring ranges 1 V to 5 V and 0 V to 10 V

System		Voltage measuring range		Range
dec	hex	1 V to 5 V	0 V to 10 V	
32767	7FFF	>5.704 V	>11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	0 V + 361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	<0.296 V	<-1.759 V	Underflow

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SIMATIC

ET 200SP

Analog input module AI 2xI 2-/4-wire ST (6ES7134-6GB00-0BA1)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 2xI 2/4-wire ST (6ES7134-6GB00-0BA1)

Manual

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Representation of analog values B

12/2015

A5E36104399-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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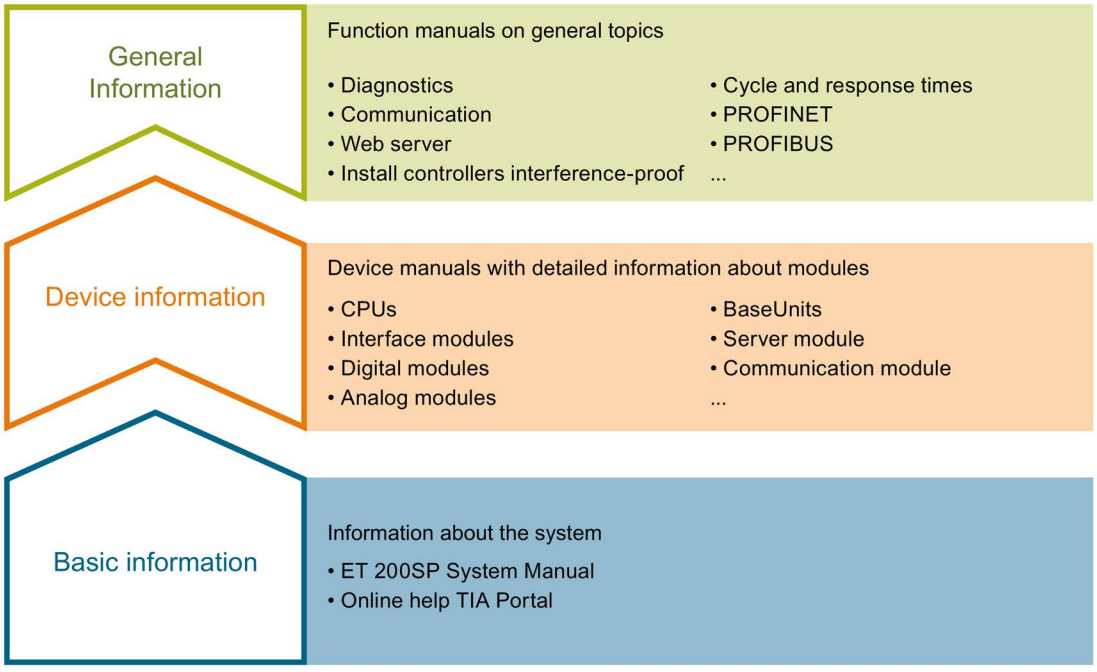
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

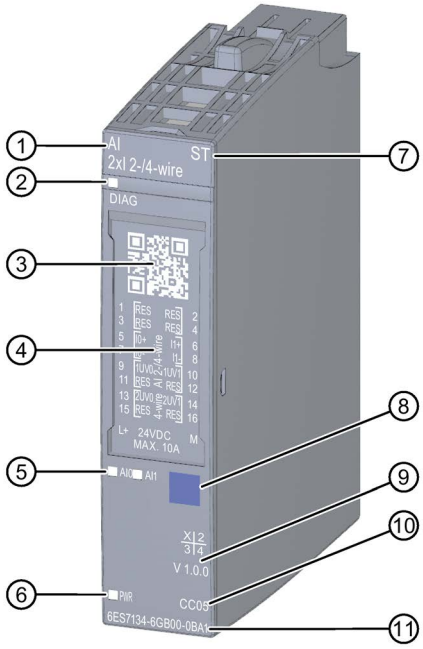
2

2.1 Properties

Article number

6ES7134-6GB00-0BA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module AI 2×I 2-/4-wire ST

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Measuring type current for 2- and 4-wire transducers
- Input ranges for current measurement:
  - 0 mA to 20 mA, resolution 15 bits
  - 4 to 20 mA, resolution 15 bits
  - ± 20 mA, resolution 16 bit incl. sign
- Electrically isolated from supply voltage L+
- Permitted common mode voltage: 10 V_{pp}/3.5 V_{rms}
- Configurable diagnostics (per module)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 2xI 2-/4-wire ST module with the various terminal assignments for a 2- und 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

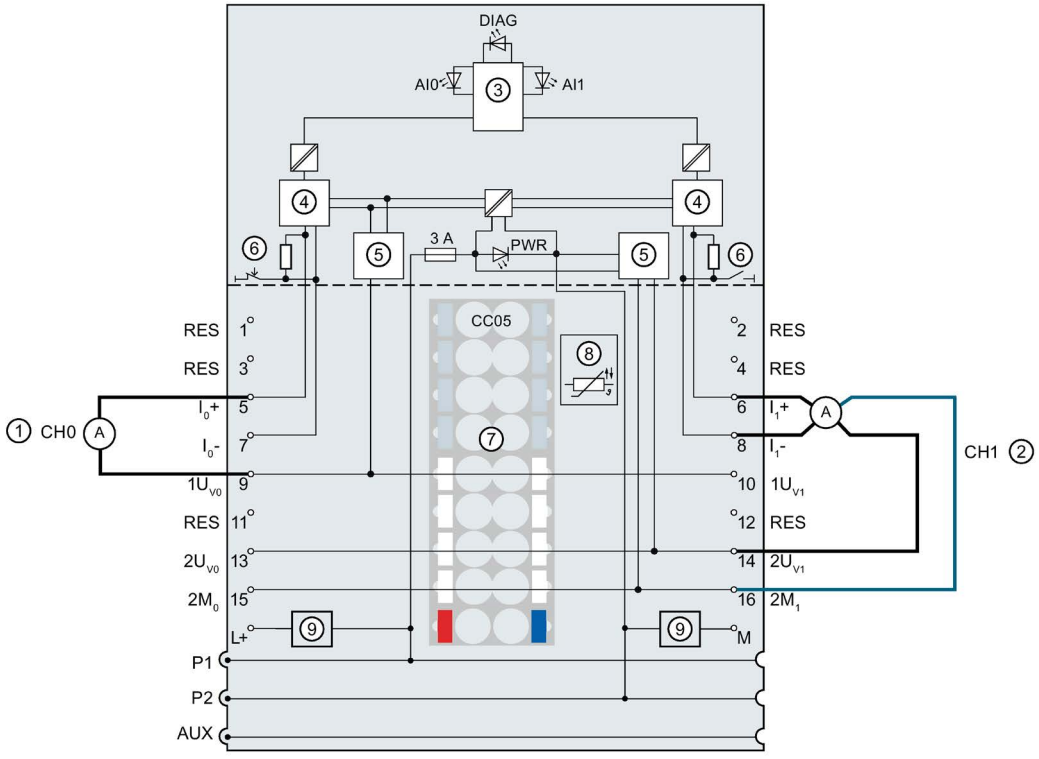
You can use and combine the different wiring options for all channels.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: Current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xI 2-/4-wire ST on the BaseUnit BU type A0/A1.



①	2-wire connection for current measurement (2-wire transducer)	$1U_n$	Supply voltage (2-wire transducer), channel n
②	4-wire connection for current measurement (4-wire transducer)	$2U_n$	Supply voltage (4-wire transducer), channel n
③	Backplane bus interface	RES	Reserve, must remain unused for future function extensions
④	Analog-to-digital converter (ADC)	$2M_n$	Reference potential (4-wire transducer)
⑤	Current limitation	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Switchover 2-wire / 4-wire	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Color-coded label with color code CC05 (optional)		
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	AI0, AI1	Channel status LED (green)
I_n+	Current input positive, channel n	PWR	Power LED (green)
I_n-	Current input negative, channel n		

Image 3-1 Wiring and block diagram for current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

Parameters/address space

4

4.1 Measurement types and measuring ranges

The analog input module AI 2×I 2-/4-wire ST has the following measuring ranges:

Table 4- 1 Measuring ranges

Measurement type	Measuring range	Resolution
Current (2-wire transducer)	0 to 20 mA	15 bits
	4 mA to 20 mA	15 bits
Current (4-wire transducer)	0 mA to 20 mA	15 bit
	4 mA to 20 mA	15 bits
	± 20 mA	16 bits incl. sign

You can find the tables of measuring ranges and overflow, overrange, etc. in the section Representation of analog values in the current measuring ranges (Page 35) and the "Analog value processing" function manual.

4.2 Parameters

Parameters of AI 2×I 2-/4-wire ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 29).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow [1]	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Underflow [1]	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Measurement type/measuring range	• Deactivated • Current (4-wire transducer) 0 to 20 mA • Current (4-wire transducer) 4 to 20 mA • Current (4-wire transducer) +/- 20 mA • Current (2-wire transducer) 0 to 20 mA • Current (2-wire transducer) 4 to 20 mA	Current (4-wire transducer) 4 to 20 mA	Yes	Channel	Channel

Parameter	Range of values	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • None	• 50 Hz (60 ms)	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

[2] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

Note

Unused channels

"Deactivate" the unused channels in the parameter assignment.

A deactivated channel always returns the value $7FFF_H$.

4.3 Description of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics alarm for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the short-circuit diagnostics is output.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or has too little current for the measurement in the range of 4 mA to 20 mA.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics is output.

Measurement type/measuring range

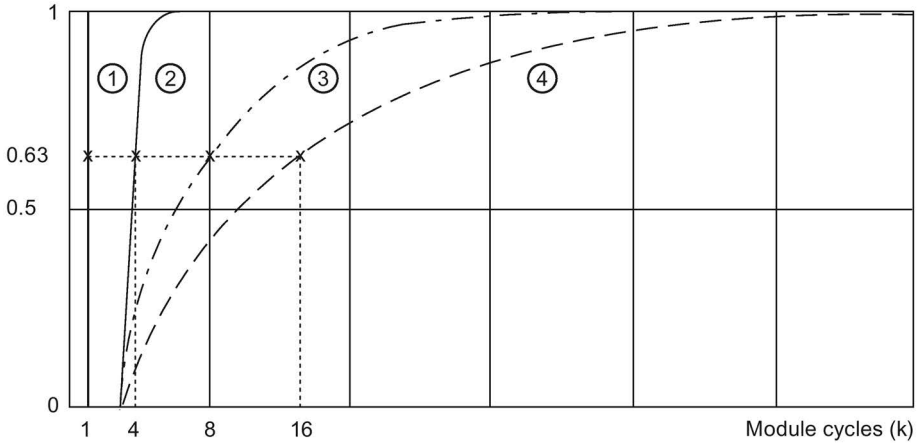
See the section Measurement types and measuring ranges (Page 13).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.



① No smoothing
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Image 4-1 Smoothing for AI 2×I 2-/4-wire ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no errors on the module.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 2xI 2-/4-wire ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

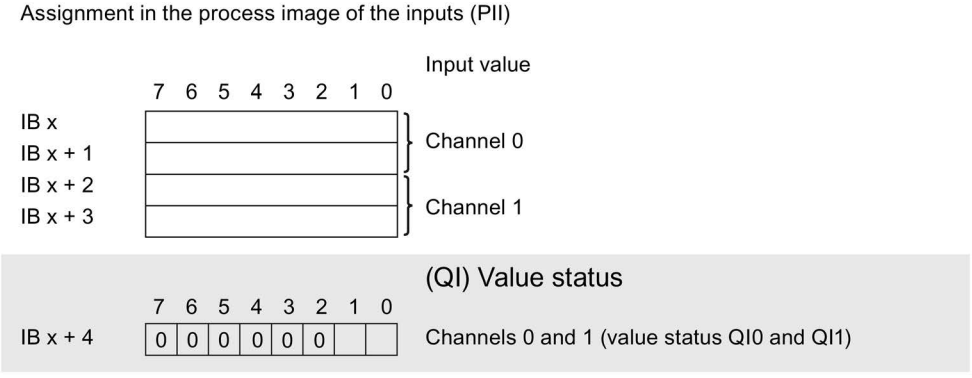


Image 4-2 Address space of the AI 2xI 2-/4-wire ST with value status

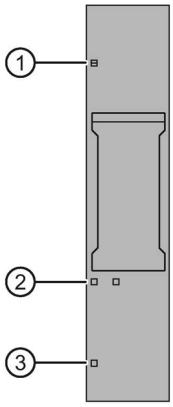
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED display of the AI 2×I 2-/4-wire ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED displays

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 23).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status	Meaning
Off	Channel disabled
On	Channel activated

PWR LED

Table 5- 3 Status display of the PWR LED

PWR	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The AI 2×I 2-/4-wire ST analog input module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (encoder supply)
- Wire break (current 4 to 20 mA)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (encoder supply) [1]	1_H	Encoder supply to ground	Correct interplay between module and encoder
		Input after encoder supply	
Wire break (current 4 to 20 mA)	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate channel • Connect the encoder contacts
High limit violated	7_H	Value is above the overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below the underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies for the entire module).	Replace the module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment (wire break diagnostics set only with the permitted measuring ranges).
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update. • Restart the firmware update.

[1] Since the module has no encoder supply for separate channels, a short-circuit in a channel has a permanent effect on the other channel.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 2×I 2-/4-wire ST

	6ES7134-6GB00-0BA1
General information	
Product type designation	ET 200SP, AI 2xI 2/4-wire ST
Firmware version	V1.0
• FW update possible	Yes
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC05
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable measuring range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Operating mode	
Oversampling	No
MSI	No
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Calibration in RUN possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	45 mA; without encoder supply
Encoder supply	
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	50 mA; total current for both channels

	6ES7134-6GB00-0BA1
Additional 24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	200 mA; total current for both channels
Power loss	
Power loss, typ.	1.1 W
Address area	
Address space per module	
Address space per module, max.	4 bytes; + 1 byte for QI information
Analog inputs	
Number of analog inputs	2
Permissible input current for current input (destruction limit), max.	50 mA
Cycle time (all channels), min.	500 µs
Input ranges (rated values), currents	
0 mA to 20 mA	Yes; 15 bits
Input resistance (0 to 20 mA)	130 Ω; 90 Ohm with 2 wires
-20 mA to +20 mA	Yes; 16 bits incl. sign
Input resistance (-20 mA to +20 mA)	130 Ω; 90 Ohm with 2 wires
4 mA to 20 mA	Yes; 15 bits
Input resistance (4 mA to 20 mA)	90 Ω; 130 Ohm for 4 wire
Cable length	
Shielded, max.	1000 m
Formation of analog values for the inputs	
Measuring principle	Sigma Delta
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Integration time configurable	Yes
Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz / off
Conversion time (per channel)	50 ms @ 60 Hz, 60 ms @ 50 Hz, 180 ms @ 16.6 Hz, 250 µs without filter
Measured value smoothing	
Number of levels	4
Configurable	Yes
Setting: None	Yes; 1 x cycle time
Setting: Weak	Yes; 4 x cycle time
Setting: Medium	Yes; 8 x cycle time
Setting: Strong	Yes; 16 x cycle time

	6ES7134-6GB00-0BA1
Encoders	
Connection of the signal transmitters	
For current measurement as 2-wire transducer	Yes
• Load of 2-wire transducer, max.	650 Ω
For current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	0.01%
Temperature error (in relation to input range), (+/-)	0.005%/K
Crosstalk between inputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	0.05%
Operational limit in the entire temperature range	
Current in relation to input range, (+/-)	0.5%
Basic error limit (operational limit at 25 °C)	
Current in relation to input range, (+/-)	0.3%
Interference voltage suppression for f = n x (f1 +/- 1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	70 dB
Common mode voltage, max.	10 V
Common mode interference, min.	90 dB
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Limit interrupt	No
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	Yes; for 4 to 20 mA
Short-circuit	Yes; short-circuit of the encoder supply
Group error	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED

	6ES7134-6GB00-0BA1
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Between the inputs (UCM)	10 Vss
Isolation	
Isolation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	32 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics				
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow	Wire break
Deactivated		*	*	*	*	*
Current (4-wire transducer)	0 mA to 20 mA	x	x	x	x	-
	4 mA to 20 mA	x	x	x	x	x
	±20 mA	x	x	x	x	-
Current (2-wire transducer)	0 mA to 20 mA	x	x	x	-	-
	4 mA to 20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to ground	Overflow/underflow	Wire break
Deactivated		*	*	*	*
Current (4-wire transducer)	0 mA to 20 mA	x	x	x	-
	4 mA to 20 mA	x	x	x	x
	+/- 20 mA	x	x	x	-
Current (2-wire transducer)	0 mA to 20 mA	x	x	x	-
	4 mA to 20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for entire module

Note

Channel 0 includes the diagnostics enable for the entire module.

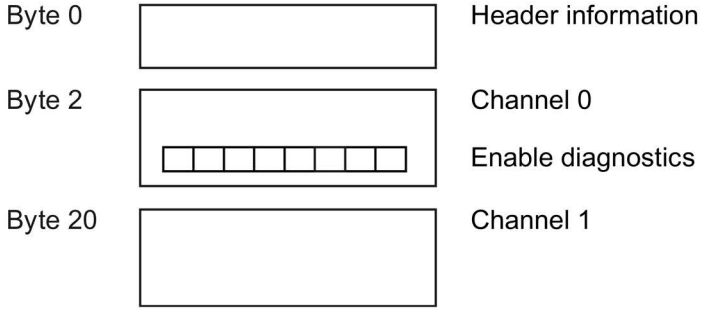


Image A-1 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

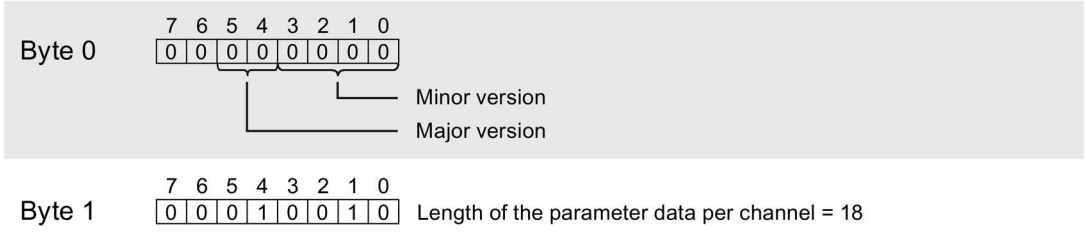
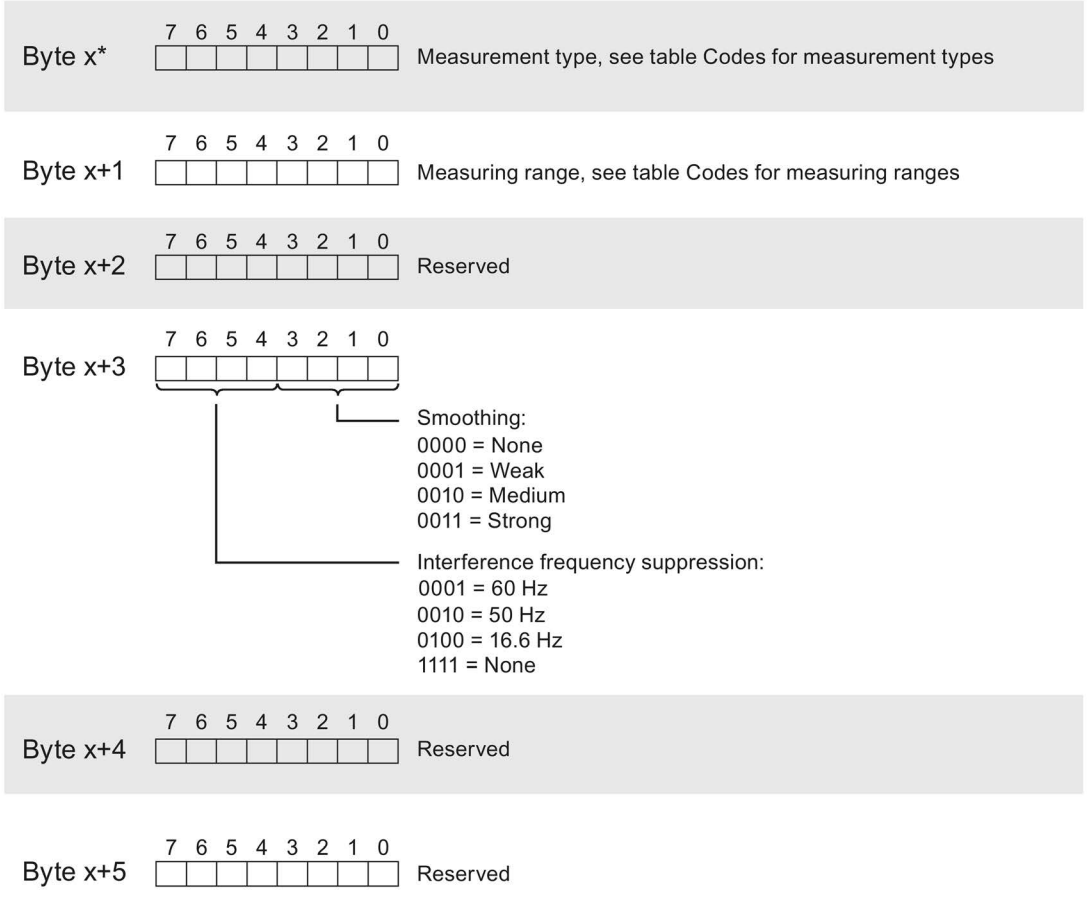


Image A-2 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".



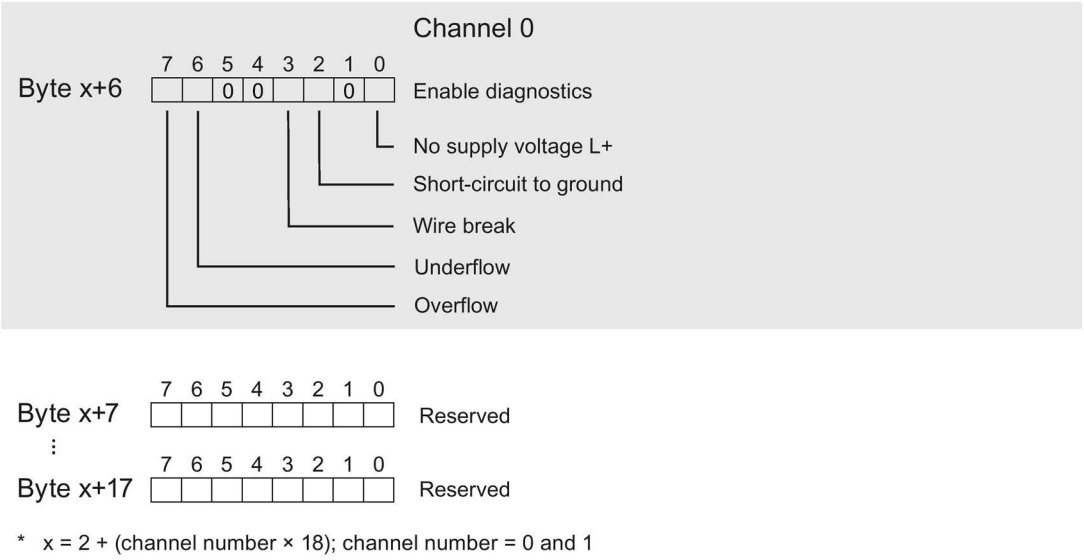


Image A-3 Structure of bytes x to x+17 for channels 0 and 1

Codes for measurement types

The following table contains the codes for the measuring types of the analog input module. You must enter these codes in byte x (see channel parameter block figure).

Table A- 1 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes in byte x+1 (see channel parameter block figure).

Table A- 2 Codes for measuring ranges

Measuring range	Coding
Current	
0 mA to 20 mA	0000 0010
4 mA to 20 mA	0000 0011
±20 mA	0000 0100

Error transmitting the data record

The module always checks all values of the transmitted data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values for analog inputs

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table B- 4 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	Hex.	±20 mA	
32767	7FFF	> 23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table B- 5 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	Hex.	0 to 20 mA*	4 to 20 mA	
32767	7FFF	> 23.52 mA	> 22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	< -3.52 mA	< 1.185 mA	Underflow

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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SIMATIC

ET 200SP

Analog input module AI 2xU/I 2-/4-wire HS (6ES7134-6HB00-0DA1)

Manual

Edition 09/2016

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SIMATIC

ET 200SP
Analog input module
AI 2xU/I 2-/4-wire HS
(6ES7134-6HB00-0DA1)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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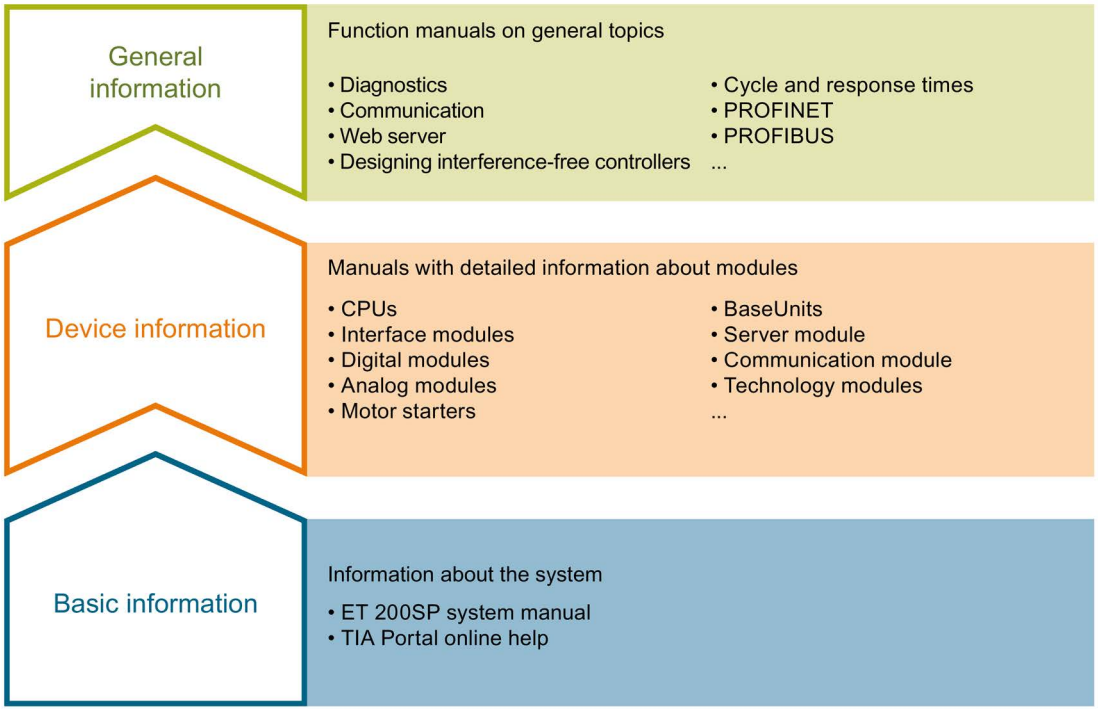
Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

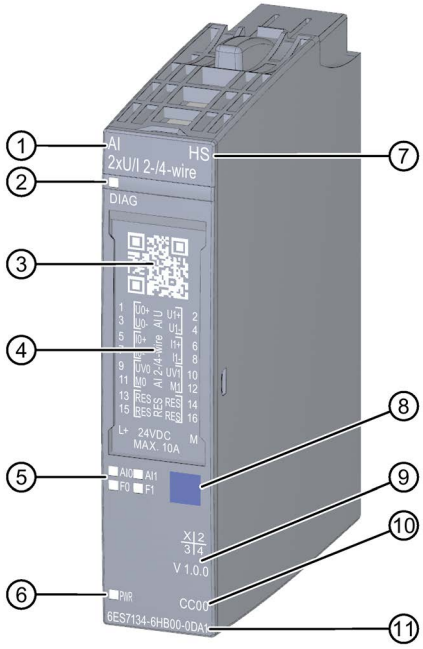
2

2.1 Properties

Article number

6ES7134-6HB00-0DA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-1 View of the AI 2×U/I 2-/4-wire HS module

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Measurement types voltage and current for 2-/4-wire transducers
- Input ranges for voltage measurement:
  - ±10 V, resolution 16 bit including sign
  - ±5 V, resolution 15 bit incl. sign
  - 1 to 5 V, resolution 13 bit
  - 0 to 10 V, resolution 15 bit
- Input ranges for current measurement:
  - ±20 mA, resolution 16 bit incl. sign
  - 4 to 20 mA, resolution 14 bit
  - 0 to 20 mA, resolution 15 bit
- Electrically isolated between the channels
- Electrically isolated from supply voltage L+
- Permitted common mode voltage: 100 V_{pp}/35 V_{rms}
- Configurable diagnostics (per channel)
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Basic version	1	V1.0.0
Isochronous mode with send clock up to 250 µs	2	V1.1.0
Value status	2	V1.1.0
Oversampling channel 0	2	V1.1.0
Oversampling channel 0 and 1	2	V2.0.0
Isochronous mode with send clock up to 125 µs	2	V2.0.1

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Connecting

3

3.1 Wiring and block diagram

This section contains the block diagram of the AI 2xU/I 2-/4-wire HS module with the various terminal assignments for a 2-wire and 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

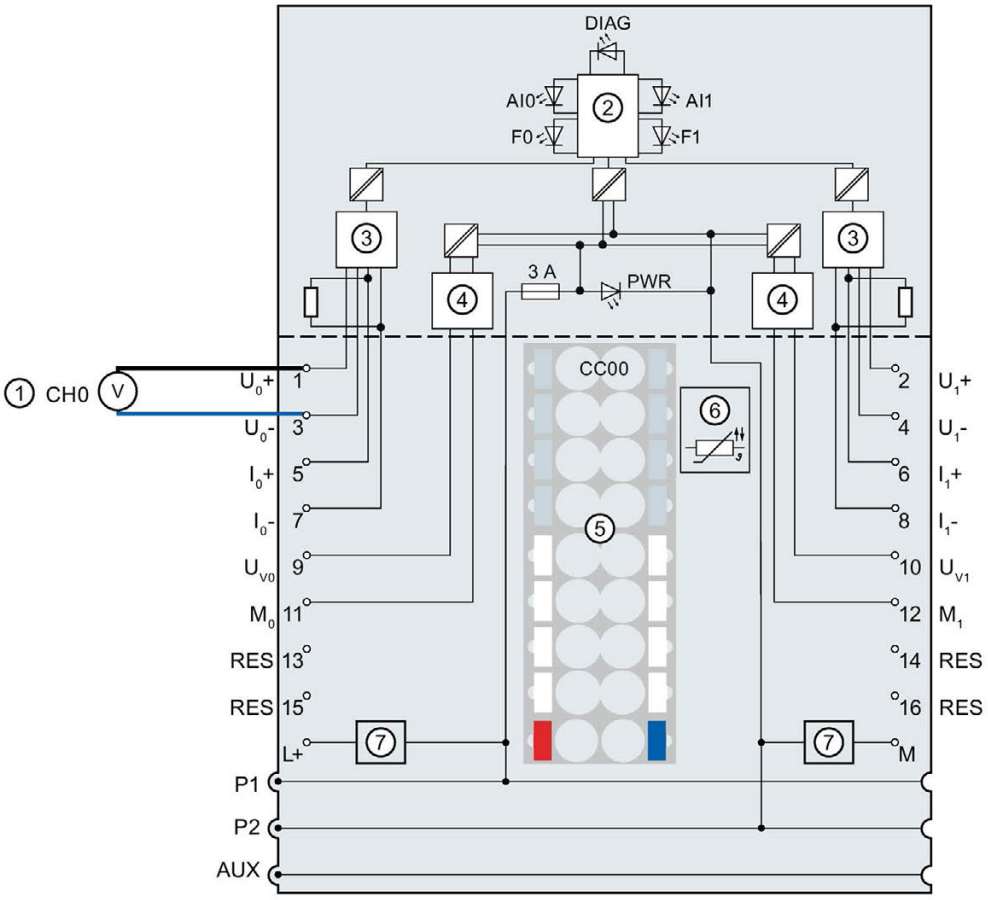
You may use and combine the different wiring options for all channels.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connection: Voltage measurement 2-wire connection

The following figure shows the block diagram and an example for the terminal assignment of the analog input module AI 2xU/I 2-/4-wire HS on the BaseUnit BU type A0/A1.

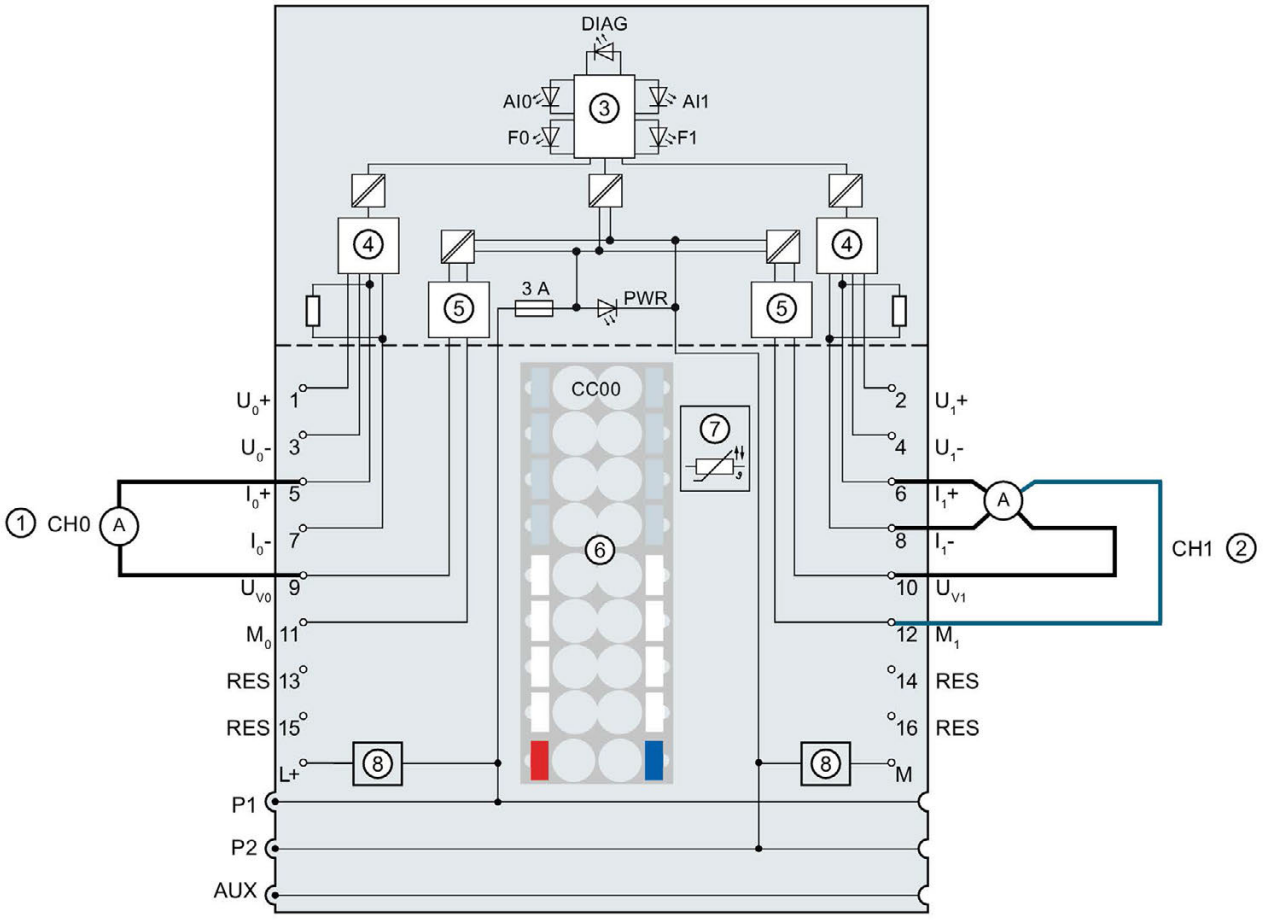


①	2-wire connection for voltage measurement	U_{Vn}	Supply voltage, channel n
②	Backplane bus interface	RES	Reserve, must remain unused for future function extensions
③	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
④	Current limitation	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color identification label CCxx (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	AI0, AI1	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1	Channel fault LED (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)
I_n+	Current input positive, channel n		
I_n-	Current input negative, channel n		

Figure 3-1 Wiring and block diagram for voltage measurement 2-wire connection

Connection: Current measurement 2-wire and 4-wire connection

The following figure shows the block diagram and an example for the terminal assignment of the analog input module AI 2xU/I 2-/4-wire HS on the BaseUnit BU type A0/A1.



①	2-wire connection for current measurement	U_n+	Voltage input positive, channel n
②	4-wire connection for current measurement	U_n-	Voltage input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	RES	Reserve, must remain unused for future function extensions
⑤	Current limitation	M_n	Reference ground to U_{Vn}, channel n
⑥	Color identification label CCxx (optional)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)	DIAG	Diagnostics LED (green, red)
I_n+	Current input positive, channel n	AI0, AI1	Channel status LED (green)
I_n-	Current input negative, channel n	F0, F1	Channel fault LED (red)
		PWR	Power LED (green)

Figure 3-2 Wiring and block diagram for current measurement 2-wire and 4-wire connection

Parameters/address space

4

4.1 Measurement types and measuring ranges

The analog input module AI 2×U/I 2/4-wire HSF has the following measuring ranges:

Table 4- 1 Measuring ranges

Measurement type	Measuring range	Resolution
Voltage	±10 V	16 bit incl. sign
	±5 V	15 bit incl. sign
	0 to 10 V	15 bit
	1 to 5 V	13 bit
Current (2-/4-wire transducers)	±20 mA [1]	16 bit incl. sign
	0 to 20 mA	15 bit
	4 to 20 mA	14 bit

You can find the tables of measuring ranges and overflow, overrange, etc. in the section Representation of analog values (Page 47) and the "Analog Value Processing" function manual.

[1] Measuring range "+/-20 mA" is only possible with the measurement type "Current (4-wire transducer)".

4.2 Parameters

Parameters of the AI 2xU/I 2/4-wire HS

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of parameter data record (Page 41).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Sampling rate	1 value/cycle	1 value/cycle	No	Module	Module
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Type/range of measurement	• Deactivated • Voltage 1 to 5 V • Voltage +/- 5 V • Voltage +/- 10 V • Voltage 0 to 10 V • Current (4-wire transducer) 0 to 20 mA • Current (4-wire transducer) +/- 20 mA • Current (4-wire transducer) 4 to 20 mA • Current (2-wire transducer) 0 to 20 mA • Current (2-wire transducer) 4 to 20 mA	Current (4-wire transducer) 4 to 20 mA	Yes	Channel	Channel
Smoothing	• None • 2 times • 4 times • 8 times • 16 times • 32 times • 64 times	None	Yes	Channel	Channel
Hardware interrupt high limit 1	• Disable • Enable	Disable	Yes	Channel	- [1]
Hardware interrupt low limit 1	• Disable • Enable	Disable	Yes	Channel	
Hardware interrupt high limit 2	• Disable • Enable	Disable	Yes	Channel	
Hardware interrupt low limit 2	• Disable • Enable	Disable	Yes	Channel	

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
High limit 1	• Value	27648	Yes	Channel	Channel [1]
Low limit 1	• Value	0	Yes	Channel	
High limit 2	• Value	27648	Yes	Channel	
Low limit 2	• Value	0	Yes	Channel	
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 4 bytes.

Note

Unused channels

"Deactivate" the unused channels in the parameter assignment.

A deactivated channel always returns the value $7FFF_H$.

4.3 Description of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics alarm for missing or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply. A short-circuit is also detected in the range of 1 to 5 V if the input signal is short-circuited or the input is not connected.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the short-circuit diagnostics is output.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or has too little current for the measurement in the range of 4 mA to 20 mA.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics is output.

Measurement type/measuring range

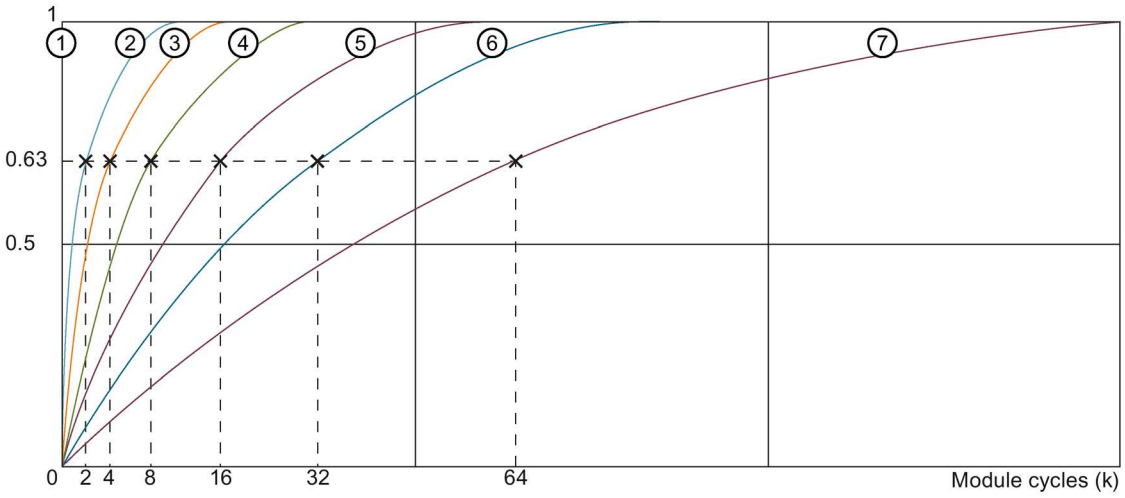
See the section Measurement types and measuring ranges (Page 18).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 7 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.



① No smoothing
② 2x smoothing
③ 4x smoothing
④ 8x smoothing
⑤ 16x smoothing
⑥ 32x smoothing
⑦ 64x smoothing

Figure 4-1 Smoothing with AI 2×U/I 2-/4-wire HS

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

4.4 Oversampling

Function

Oversampling is the acquisition of data in constant bus cycle segments (sub-cycles). The configured number n of sub-cycles corresponds to one PROFINET bus cycle.

Oversampling is useful whenever you require acquisition of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With oversampling, a PROFINET bus cycle is divided into constant bus sub-cycles:

- One measured value is acquired in each sub-cycle.
- The minimum PROFINET bus cycle is 250 µs. Only a subset of functions is available for shorter sub-cycles.
- The shortest possible sub-cycle is 50 µs.
- You can configure oversampling:
  - For channel 0 (1-channel operation)
  - For channel 0/1 (2-channel operation)
- The number of sub-cycles can be set as follows:
  - From 2 to 16 for one channel
  - From 2 to 8 for two channels

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameter:

- Sampling rate

Note

Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

Overview of the operating modes

Function	Normal operation	Oversampling in normal operation		Oversampling in high-speed	
		1-channel operation	2-channel operation	1-channel operation	2-channel operation
Isochronous mode	Yes, optional	Yes, required		Yes, required	
• Shortest send clock	125 µs	500 µs		250 µs	
Oversampling	No	Yes		Yes	
• Number of oversampling levels (sampling rate)	-	2 to 16	2 to 8	2 to 16	2 to 8
• Shortest sub-cycle (= shortest sampling time)	-	250 µs		50 µs	
Hardware interrupt	x	-		-	
Smoothing	x	x		-	
±10 V	x	x		x	
0 to 10 V	x	x		-	
±5 V	x	x		-	
1 to 5 V	x	x		-	
±20 mA	x	x		x	
0 to 20 mA	x	x		-	
4 to 20 mA	x	x		-	
Overflow/underflow	x	x		x[1)]	
Wire break 4 to 20 mA	x	x		-	
Short-circuit (1 to 5 V)	x	x		-	
Short-circuit encoder supply with current measuring ranges	x	x		x	
Load voltage diagnostics	x	x		x	
Value status (QI)	x	-		-	
Address space	4 bytes	32 bytes		32 bytes	

1 For product version 1, the result must be present for at least one fieldbus cycle + 250 µs for a reliable detection of the diagnostics (overflow/underflow) as of firmware version 1.x.

Sampling interval

The duration of a subcycle is the sampling interval. The cycle time T (send clock) for isochronous mode is specified in the configuration software. This time, divided by the configured sampling rate n_{Sample}, yields the sampling interval t_{Sample} of the module.

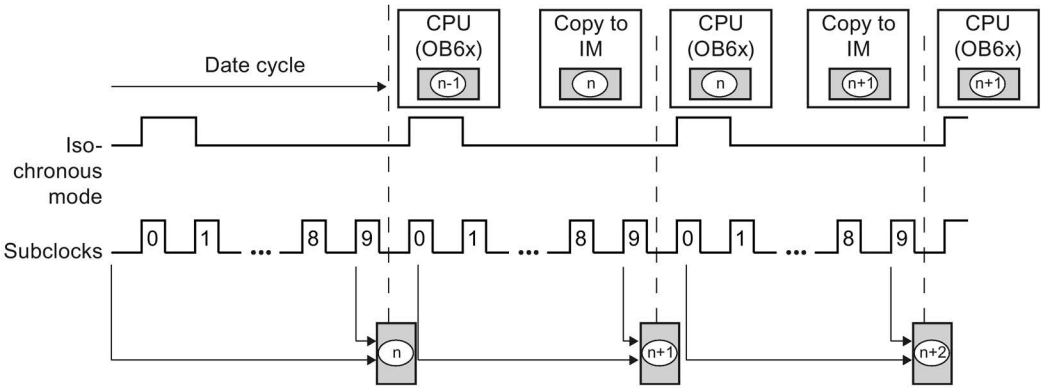
Example calculation:

$$t_{Sample} = \frac{T}{n_{Sample}} = \frac{1\ ms}{16} = 62{,}5\ \mu s$$

Figure 4-2 Example of calculating the sampling interval

Chronological sequence

The figure shows the chronological sequence for oversampling. The acquired measured vales of a data cycle with oversampling are only copied to the interface module in the subsequent bus cycle and are then available to the processing CPU one bus cycle later.



① n = measured values from bus cycle n

Figure 4-3 Oversampling

4.5 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit =1: No fault is present on the channel.

Bit =0: The wiring, the value created on the channel, or similar is incorrect.

Address space

The following figure shows the assignment of the address space for the AI 2xU/I 2-/4-wire HS with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

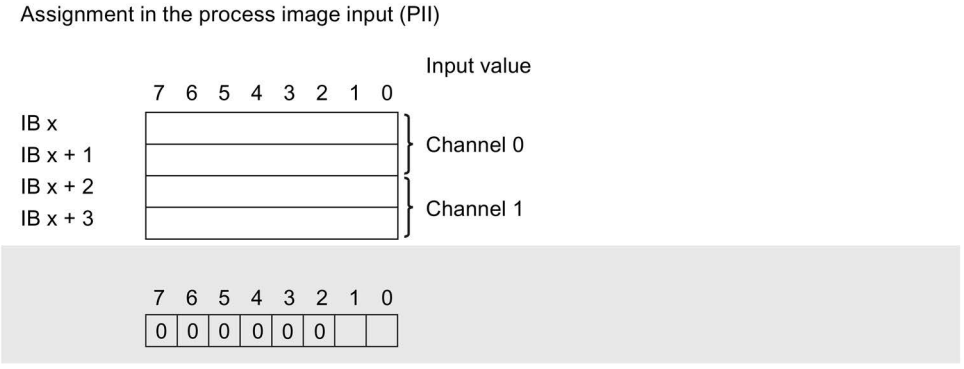


Figure 4-4 Address space of the AI 2xU/I 2-/4-wire HS with value status

Address space of the AI 2×U/I 2-/4-wire HS for oversampling with one channel

The following figure shows the assignment of the address space for oversampling with one channel. Writing always starts from IB x. If fewer than 16 sub-cycles are set, the addresses that are then unused are filled with $7FFF_H$.

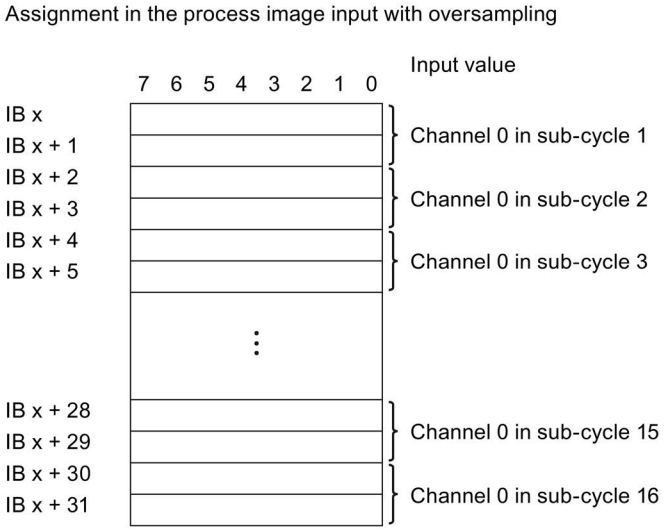


Figure 4-5 Address space of AI 2xU/I 2-/4-wire HS for oversampling with one channel

Address space of the AI 2×U/I 2-/4-wire HS for oversampling with two channels

The following figure shows the assignment of the address space for oversampling with two channels. Writing always starts from IB x. Only a maximum of 8 sub-cycles are possible. If fewer than 8 sub-cycles are set, the addresses that are then unused are filled with $7FFF_H$.

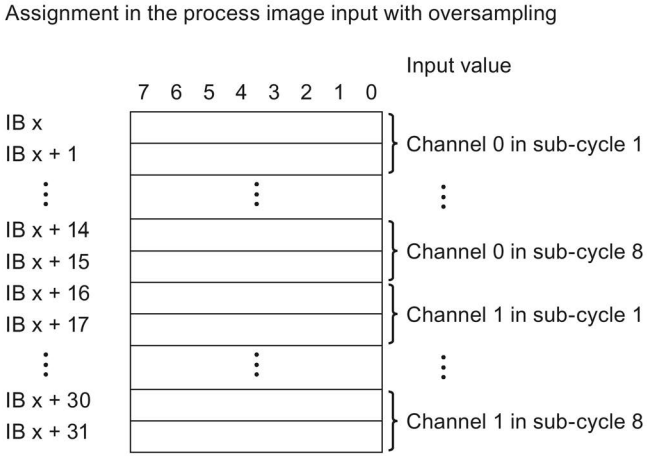


Figure 4-6 Address space of AI 2xU/I 2-/4-wire HS for oversampling with two channels

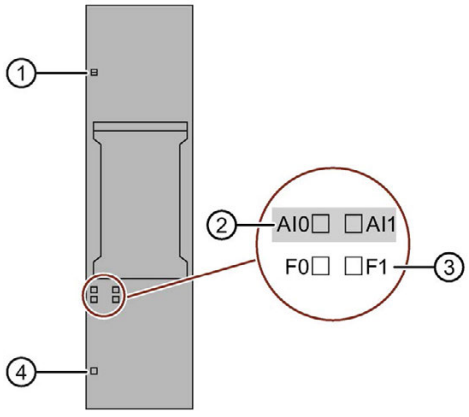
Interrupts/diagnostics interrupts

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays of the AI 2×U/I 2-/4-wire HS.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 5-1 LED displays

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 34).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status/channel fault LED

Table 5- 2 Status/error display of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Channel deactivated or no load voltage L+
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

PWR LED

Table 5- 3 Status display of the PWR LED

PWR	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The analog input module AI 2×U/I 2-/4-wire HS supports hardware and diagnostic interrupts.

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Low limit 1 violated
- High limit 1 violated
- Low limit 2 violated
- High limit 2 violated

If an interrupt occurs, a corresponding interrupt OB is called in the CPU of the IO controller.

S7-1500

Detailed information on the event is available in the STEP 7 online help.

The block interface is shown here with optimized block access, which is set in the TIA Portal by default.

Name	Data type	Comment
LADDR	HW_IO	Hardware identifier of the module triggering the interrupt
USI	WORD	USI (High/Low)
IChannel	USInt	Channel that triggered the hardware interrupt
EventType	Byte	Error event

S7-300/400 or a different CPU

You can obtain detailed information on the event in the hardware interrupt organization block with the instruction "RALARM" (read additional interrupt info) and in the STEP 7 online help.

The channel of the module that triggered the hardware interrupt is entered in the start information of OB4x in the OB4x_POINT_ADDR tag. The following figure shows the assignment to the bits of double word 8 in local data.

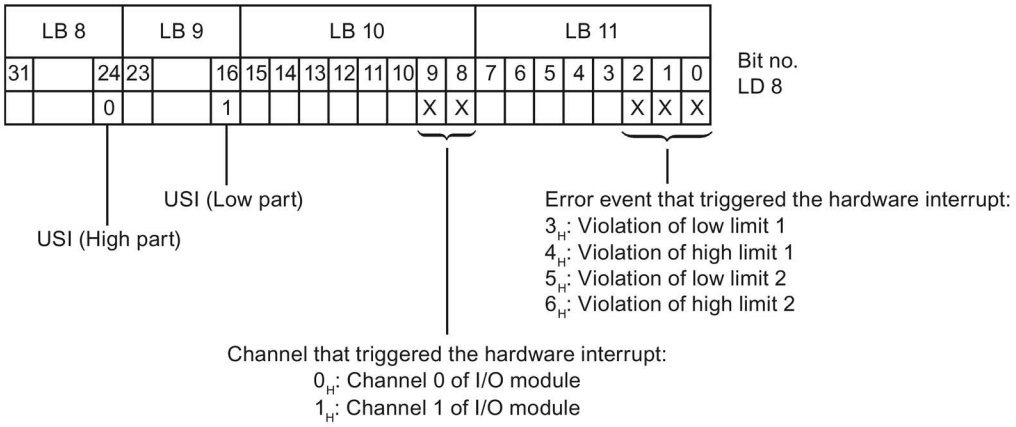


Figure 5-2 OB4x_POINT_ADDR tag

Structure of the additional interrupt information

Table 5- 4 Structure of USI = W#16#0001

Data block name		Content	Comment	Bytes
USI		W#16#0001	User Structure Identifier: Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#01	Channel 0 and 1 of the I/O module	1
The error event that triggered the hardware interrupt follows.				
	Error event	B#16#03	Low limit 1 violated	1
		B#16#04	High limit 1 violated	
		B#16#05	Low limit 2 violated	
		B#16#06	High limit 2 violated	

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- Short-circuit (current and voltage 1 to 5 V)
- Line break (current)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- No load voltage
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (current)	1_H	Encoder supply to ground	Correct interplay between module and encoder
		Input after encoder supply	
Short-circuit (1 to 5 V)	1_H	Short circuit of input signal	Correct interplay between module and encoder
		Open input	Connect input
Wire break (current)	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect the encoder contacts
High limit violated	7_H	Value is above overrange.	Correct the output value
Low limit violated	8_H	Value is below underrange.	Correct the output value
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies for the entire module).	Replace the module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment (wire break diagnostics set only with the permitted measuring ranges).
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 2×U/I 2-/4-wire HS

	6ES7134-6HB00-0DA1
General information	
Firmware version	V2.0.1
• FW update possible	Yes
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable measuring range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
Oversampling	Yes; 2 channels per module
MSI	No
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption (rated value)	39 mA; without encoder supply
Encoder supply	
24 V encoder supply	
24 V	Yes, with current measurement
Short-circuit protection	Yes
Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s

	6ES7134-6HB00-0DA1
Power loss	
Power loss, typ.	0.95 W; without encoder supply
Address area	
Address space per module	
Address space per module, max.	4 byte; + 1 byte for QI information (32 bytes in oversampling mode)
Analog inputs	
Number of analog inputs	2; Differential inputs
Maximum permitted input voltage for voltage input (destruction limit)	30 V
Maximum permitted input current for current input (destruction limit)	50 mA
Cycle time (all channels), min.	125 µs
Analog input with oversampling	Yes
• Values per cycle, max.	16
• Resolution, min.	50 µs
Input ranges (rated values), voltages	
0 to +10 V	Yes; 15 bit
Input resistance (0 to 10 V)	75 kΩ
1 V to 5 V	Yes; 13 bit
Input resistance (1 V to 5 V)	75 kΩ
-10 V to +10 V	Yes; 16 bit incl. sign
Input resistance (-10 V to +10 V)	75 kΩ
-5 V to +5 V	Yes; 15 bit incl. sign
Input resistance (-5 V to +5 V)	75 kΩ
Input ranges (rated values), currents	
0 to 20 mA	Yes; 15 bit
Input resistance (0 to 20 mA)	130 Ω
-20 mA to +20 mA	Yes; 16 bit incl. sign
Input resistance (-20 mA to +20 mA)	130 Ω
4 mA to 20 mA	Yes; 14 bit
Input resistance (4 mA to 20 mA)	130 Ω
Cable length	
Shielded, max.	1000 m; 200 m for voltage measurement
Formation of analog values for the inputs	
Measuring principle	Instantaneous value encryption (successive approximation)
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Interference voltage suppression for interference frequency f1 in Hz	No
Conversion time (per channel)	10 µs

	6ES7134-6HB00-0DA1
Smoothing of the measured values	
Number of levels	7; none; 2/4/8/16/32/64 times
Configurable	Yes
Encoders	
Connection of the signal transmitters	
For voltage measurement	Yes
For current measurement as 2-wire transducer	Yes
• Load of 2-wire transducer, max.	650 Ω
For current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	0.03%
Temperature error (in relation to input range), (+/-)	0.01%/K
Crosstalk between inputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	0.1%
Operational limit in the entire temperature range	
Voltage in relation to input range, (+/-)	0.3%
Current in relation to input range, (+/-)	0.3%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	0.2%
Current in relation to input range, (+/-)	0.2%
Interference voltage suppression for f = n x (f1 +/- 1%), f1 = interference frequency	
Common mode voltage, max.	35 V
Common mode interference, min.	90 dB
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Filtering and processing time (TCI), min.	80 µs
Bus cycle time (TDP), min.	125 µs
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Wire break	Yes; channel-based, only for 4 to 20 mA
Short-circuit	Yes; channel-based, for 1 to 5 V, and for current measuring ranges for short circuit in encoder supply
Overflow/underflow	Yes

	6ES7134-6HB00-0DA1
Diagnostics display LED	
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between the inputs (UCM)	75 V DC / 60 V AC
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	32 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics					Hardware interrupts
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow	Wire break	
Deactivated		*	*	*	*	*	*
Voltage	1 to 5 V	x	x	x	x	-	x
	±5 V	x	-	x	x	-	x
	±10 V	x	-	x	x	-	x
	0 to 10 V	x	-	x	x	-	x
Current (4-wire transducer)	0 to 20 mA	x	x	x	x	-	x
	±20 mA	x	x	x	x	-	x
	4 to 20 mA	x	x	x	x	x	x
Current (2-wire transducer)	0 to 20 mA	x	x	x	-	-	x
	4 to 20 mA	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics				Hardware interrupts
		No supply voltage L+	Short-circuit to ground	Overflow/underflow	Wire break	
Deactivated		*	*	*	*	*
Voltage	1 to 5 V	x	x	x	-	-
	+/- 5 V	x	-	x	-	-
	+/- 10 V	x	-	x	-	-
	0 to 10 V	x	-	x	-	-
Current (4-wire transducer)	0 to 20 mA	x	x	x	-	-
	+/- 20 mA	x	x	x	-	-
	4 to 20 mA	x	x	x	x	-
Current (2-wire transducer)	0 to 20 mA	x	x	x	-	-
	4 to 20 mA	x	x	x	x	-

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels).

Note

Following a firmware update, you need to re-configure the I/O module before you can use the new functions.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

Note

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment results in a brief exit from clocked measuring mode and renewed synchronization with the fieldbus cycle. The slowest channel provides the "internal" measuring cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

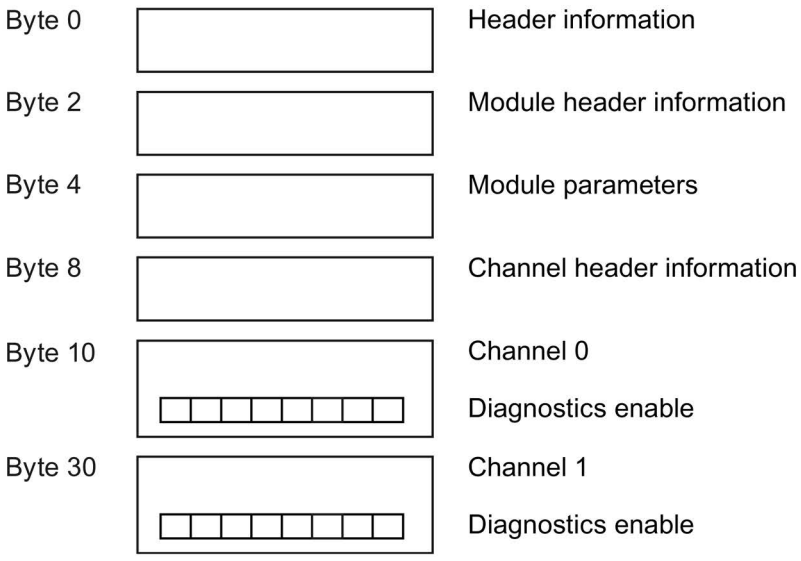


Figure A-1 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

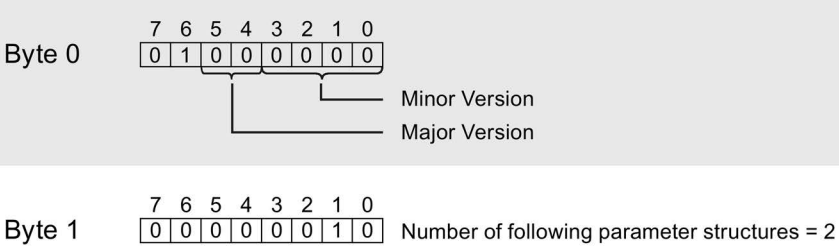


Figure A-2 Header information

Module header information

The figure below shows the structure of the module header information.

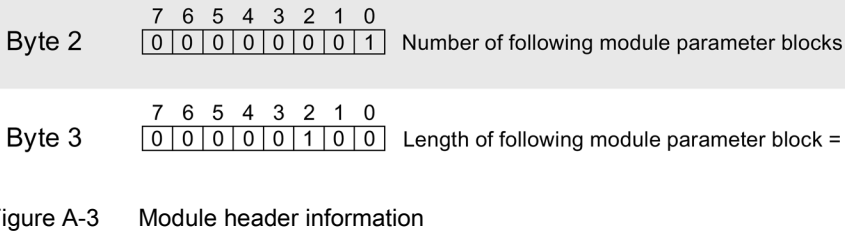


Figure A-3 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Enable a parameter by setting the corresponding bit to "1".

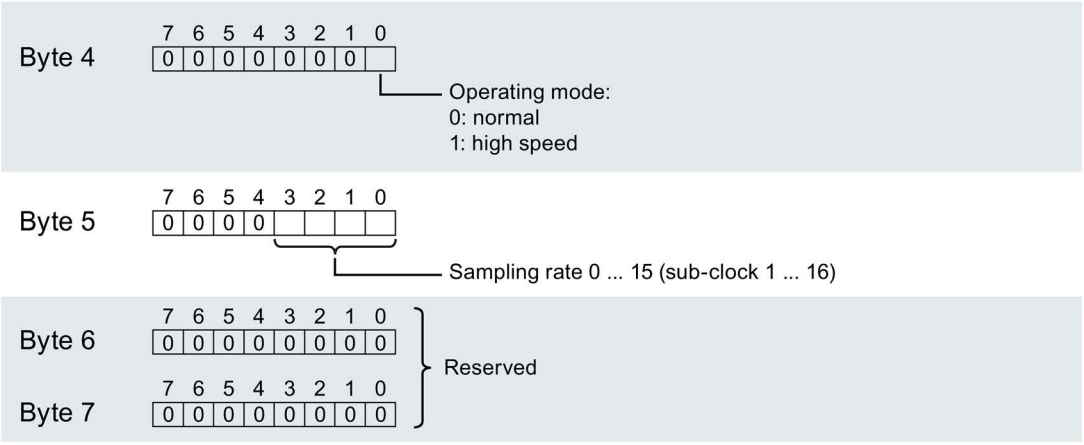


Figure A-4 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

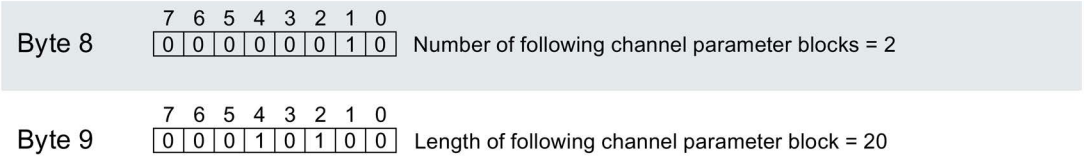
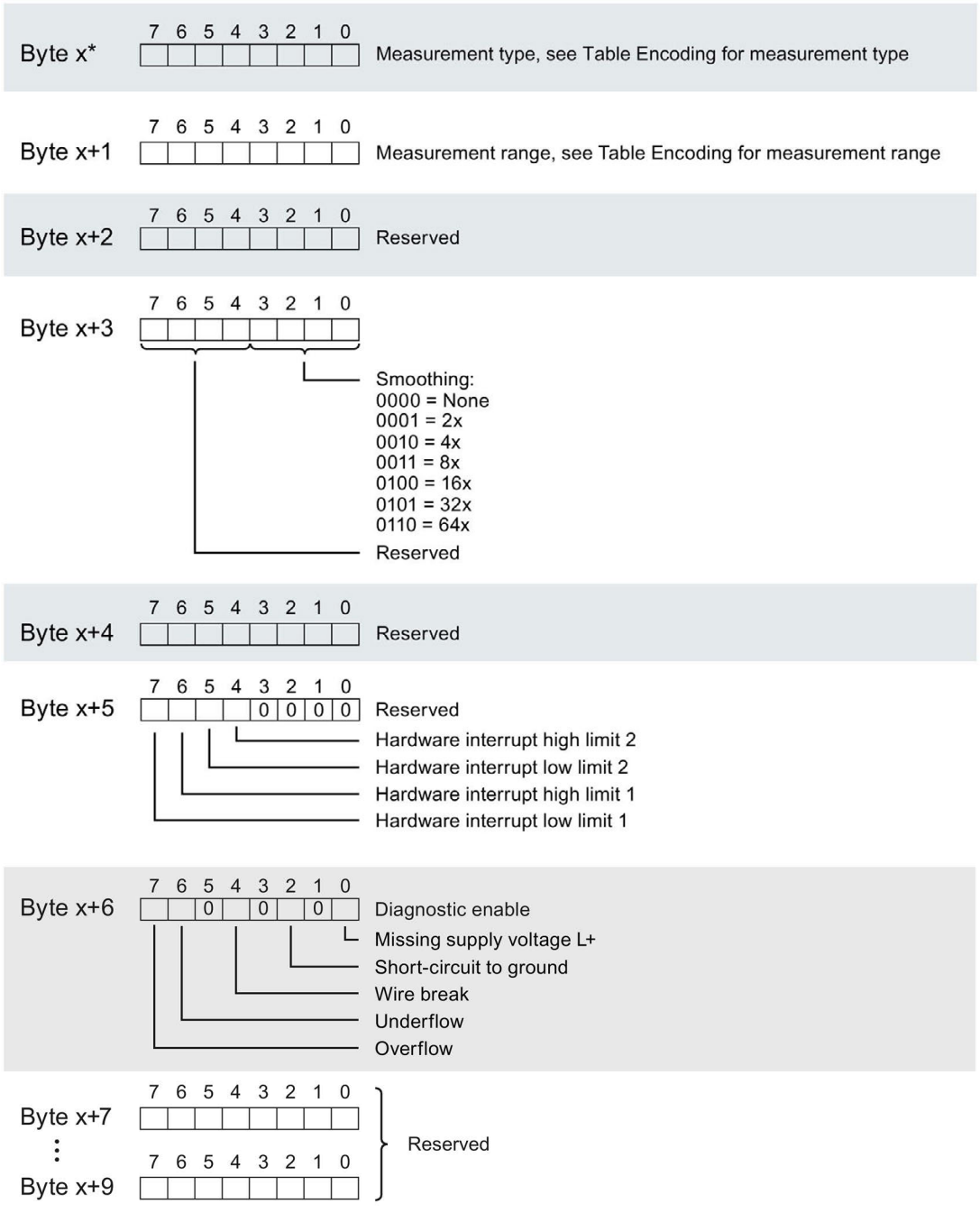


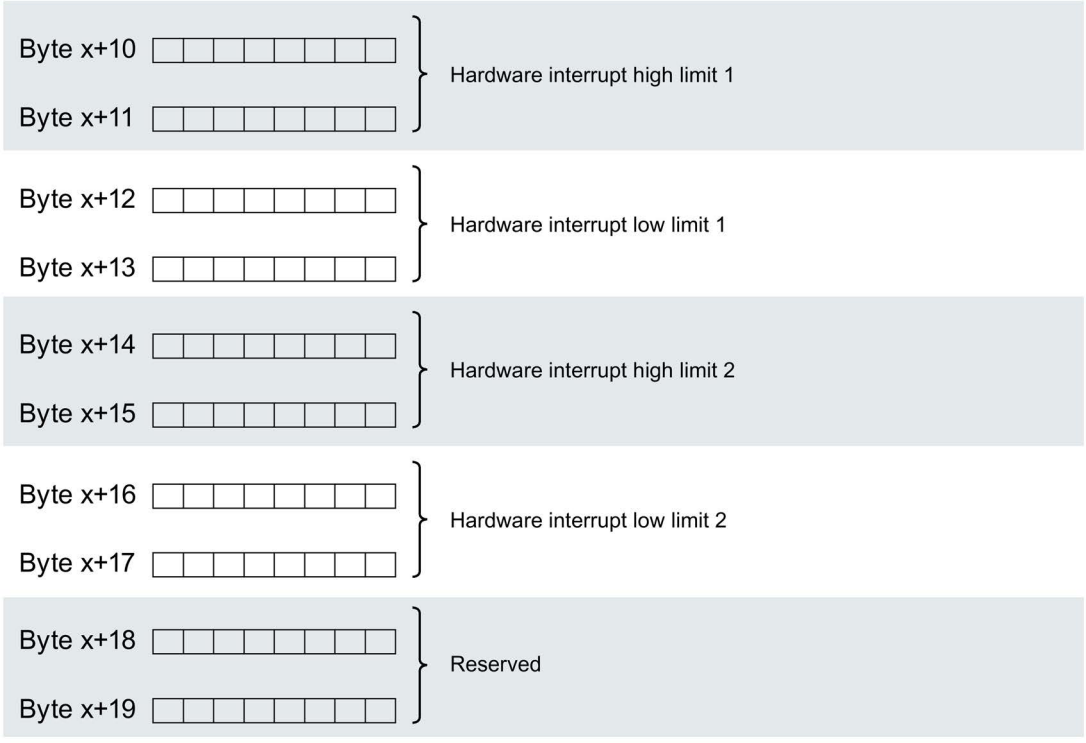
Figure A-5 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".





* x = 10 + (channel number × 20); channel number = 0 to 1

Figure A-6 Structure of byte x to x+19 for channels 0 and 1

Codes for measurement types

The following table contains the codes for the measurement types of the analog input module. You must enter these codes in byte x (see channel parameter block figure).

Table A- 1 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes in byte x+1 (see channel parameter block figure).

Table A- 2 Codes for measuring ranges

Measuring range	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current	
±20 mA	0000 0100
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011

Representation of analog values

B

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table B- 4 Voltage measuring range ±10 V and ±5 V

Values		Voltage measuring range		Range
Dec.	Hex.	±10 V	±5 V	
32767	7FFF	> 11.759 V	> 5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	< -11.759 V	< -5.879 V	Underflow

Table B- 5 Voltage measuring range 1 V to 5 V and 0 V to 10 V

Values		Voltage measuring range		Range
Dec.	Hex.	1 to 5 V	0 to 10 V	
32767	7FFF	> 5.704 V	> 11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	< 0.296 V	< -1.759 V	Underflow

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table B- 6 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	Hex.	±20 mA	
32767	7FFF	> 23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table B- 7 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	Hex.	0 to 20 mA*	4 to 20 mA	
32767	7FFF	> 23.52 mA**	> 22.81 mA**	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	< -3.52 mA	< 1.185 mA	Underflow

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

** For measurement type "2-wire transducer", the behavior described here is supported for overflow up to max. 35 mA.

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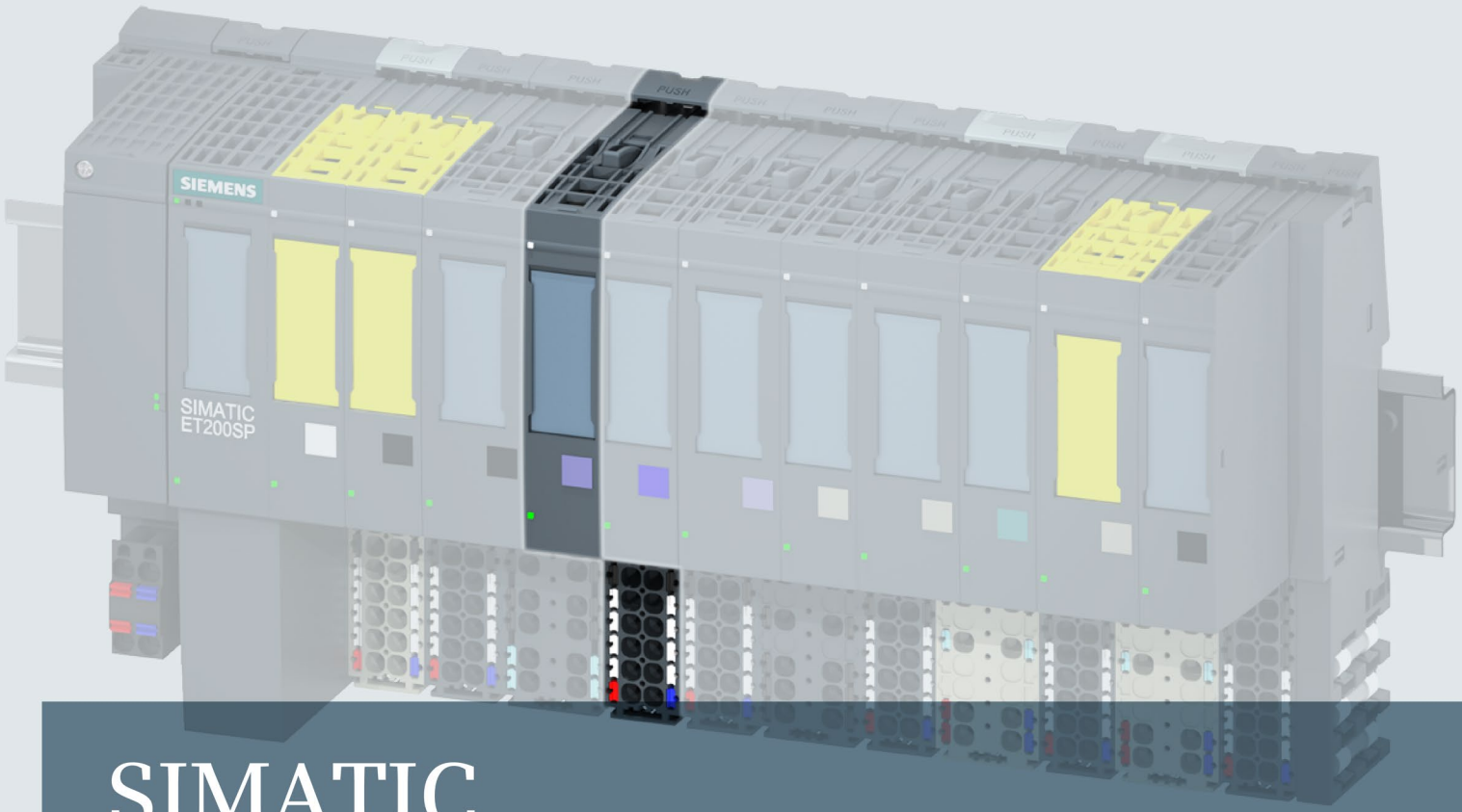

SIMATIC

ET 200SP

Analog input module AI 2xU/I 2-/4-wire HF (6ES7134-6HB00-0CA1)

Manual

Edition 12/2015

Answers for industry.

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SIMATIC

ET 200SP
Analog input module
AI 2xU/I 2-/4-wire HF
(6ES7134-6HB00-0CA1)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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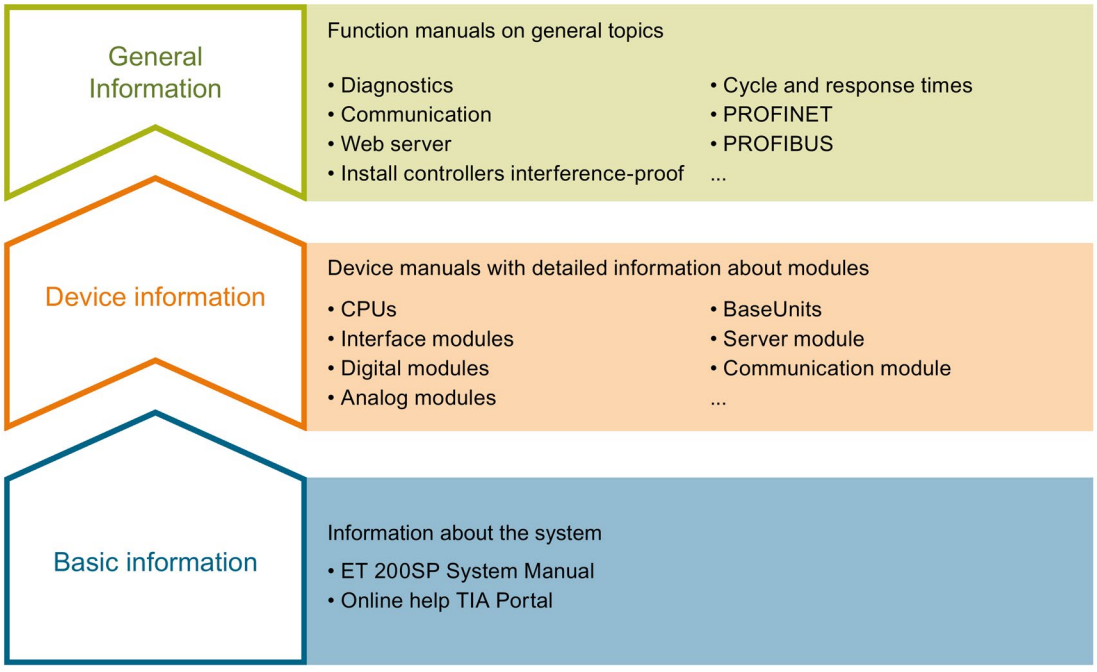
Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

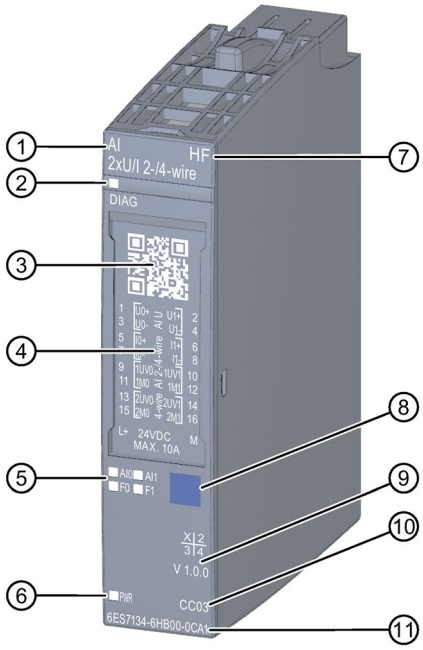
2

2.1 Properties

Article number

6ES7134-6HB00-0CA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module AI 2×U/I 2-/4-wire HF

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Resolution: Up to 16 bits including sign
- Single channel electrical isolation
- Voltage measurement type can be set per channel
- Current measuring type can be set per channel (for 2-wire or 4-wire transducer)
- Configurable diagnostics (per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Calibration in runtime
- Isochronous mode (PROFINET IO only)
- Value status (PROFINET IO only)

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Measuring range adjustment	1	V2.0.0
Scaling of measured values	1	V2.0.0
Module-internal shared input (MSI)	1	V2.0.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file [1].

[1] Version required for STEP 7: V5.5 SP4 HF7

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 2xU/I 2-/4-wire HF module with the various terminal assignments for a 2- und 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

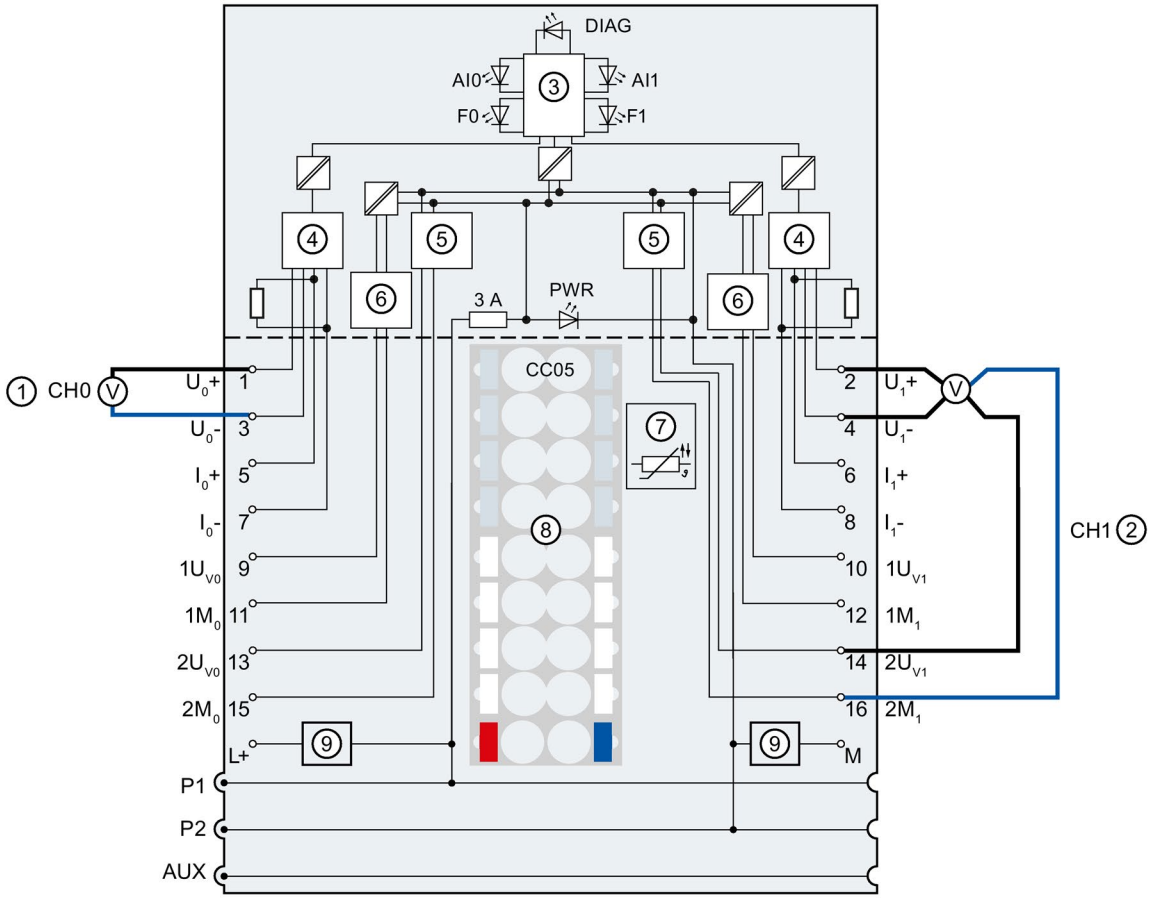
You can use and combine the different wiring options for all channels.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: Voltage measurement 2-wire and 4-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xU/I 2-/4-wire HF on the BaseUnit BU type A0/A1.

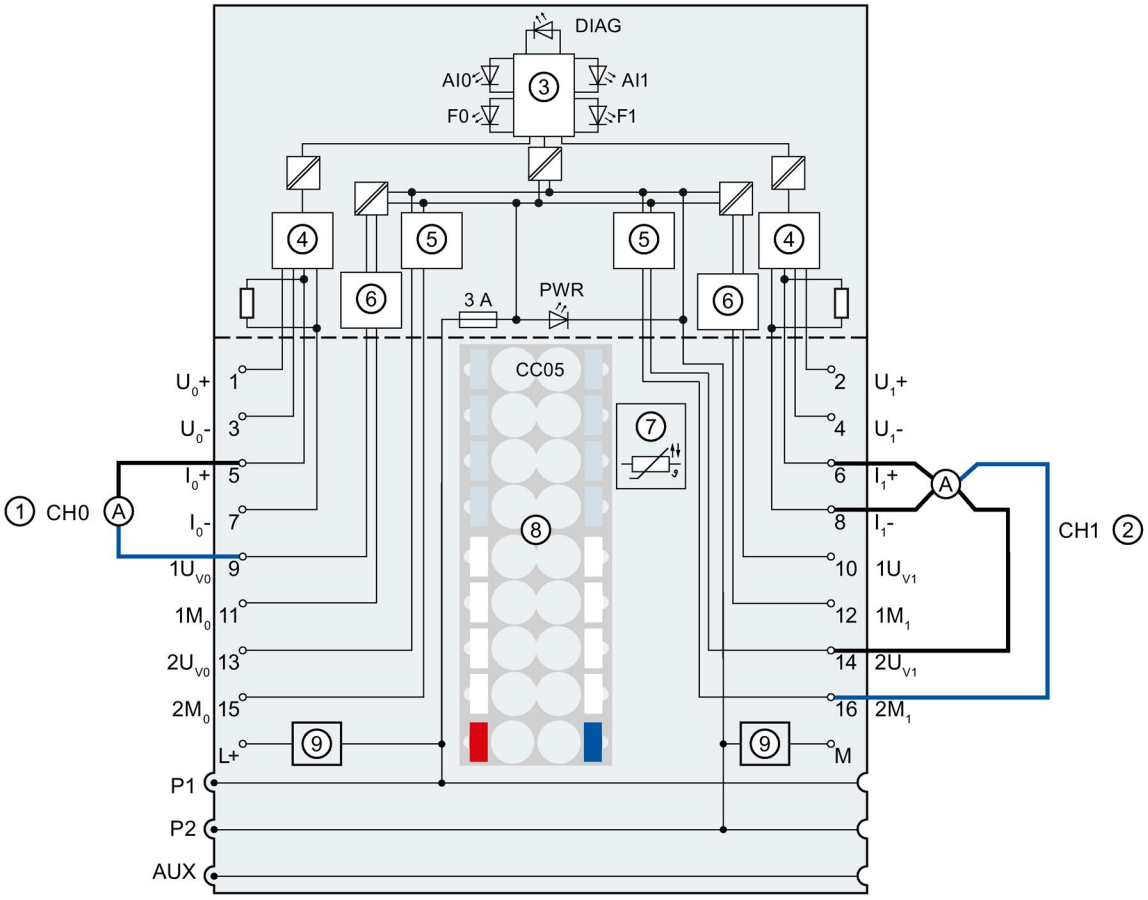


①	2-wire connection for voltage measurement	I_n+	Current input positive, channel n
②	4-wire connection for voltage measurement	I_n-	Current input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
⑤	Current limitation (4-wire)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Current limitation (2-wire)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Color-coded label with color code CC05 (optional)	AI0, AI1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
U_n+	Voltage input positive, channel n	PWR	Power LED (green)
Un-	Voltage input negative, channel n		

Image 3-1 Wiring and block diagram for voltage measurement 2-wire and 4-wire connection

Wiring: Current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xU/I 2-/4-wire HF on the BaseUnit BU type A0/A1.



①	2-wire connection for current measurement (2-wire transducer)	U_n+	Voltage input positive, channel n
②	4-wire connection for current measurement (4-wire transducer)	U_n-	Voltage input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
⑤	Current limitation (4-wire)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Current limitation (2-wire)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Color-coded label with color code CC05 (optional)	AI0, AI1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
I_n+	Current input positive, channel n	PWR	Power LED (green)
I_n-	Current input negative, channel n		

Image 3-2 Wiring and block diagram for current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table shows the measurement types and the respective measuring range.

Table 4- 1 Measurement types and measuring ranges

Measurement type	Measuring range	Resolution
Voltage	± 5 V	16 bits incl. sign
	± 10 V	16 bits incl. sign
	1 to 5 V	15 bits
	0 to 10 V	15 bits
Current	0 to 20 mA (2-wire and 4-wire transducer)	15 bits
	4 to 20 mA (2-wire and 4-wire transducer)	15 bits
	± 20 mA (only with 4-wire transducer)	16 bit including sign

You can find the tables of measuring ranges and overflow, overrange, etc. in the appendix Representation of analog values (Page 52) and the "Analog value processing" function manual.

Measuring range adjustment

See Measuring range adjustment (Page 21).

Scaling of measured values

See Scaling of measured values (Page 24).

4.2 Parameters

Parameters of the AI 2xU/I 2-/4-wire HF

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of parameter data record (Page 42).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Measurement type/measuring range	• Deactivated • Voltage – ±5 V – ±10 V – 1 V to 5 V – 0 V to 10 V • Current (4-wire transducer) – 0 to 20 mA – 4 to 20 mA – ±20 mA • Current (2-wire transducer) – 0 to 20 mA – 4 to 20 mA	Current (4-wire transducer) 4..20 mA	Yes	Channel	Channel
Smoothing	• None • 2 times • 4 times • 8 times • 16 times • 32 times	None	Yes	Channel	Channel
Interference frequency suppression [2]	• 16.6 Hz (67.5 ms) • 50 Hz (22.5 ms) • 60 Hz (18.75 ms) • 300 Hz (10 ms) • 600 Hz (5 ms) • 1.2 kHz (2.5 ms) • 2.4 kHz (1.25 ms) • 4.8 kHz (0.625 ms)	50 Hz (22.5 ms)	Yes	Channel	Channel
Measuring range adjustment [1]	• Disable • Enable	Disable	Yes	Channel	-
Measuring range adjustment high limit [1]	Value within the nominal range of the measuring range in mV or µA	0	Yes	Channel	-
Measuring range adjustment low limit [1]	Value within the nominal range of the measuring range in mV or µA	0	Yes	Channel	-
Scaled high nominal range limit [3]	REAL	20.0	Yes	Channel	-
Scaled low nominal range limit [3]	REAL	4.0	Yes	Channel	-

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt high limit 1 [1]	• Disable • Enable	Disable	Yes	Channel	-
Hardware interrupt low limit 1 [1]	• Disable • Enable	Disable	Yes	Channel	-
Hardware interrupt high limit 2 [1]	• Disable • Enable	Disable	Yes	Channel	-
Hardware interrupt low limit 2 [1]	• Disable • Enable	Disable	Yes	Channel	-
Hardware interrupt high limit 1 [1]	• Value (INT) • Value (REAL) [3]	• 27648 • 0.0 [3]	Yes	Channel	-
Hardware interrupt low limit 1 [1]	• Value (INT) • Value (REAL) [3]	• 0 • 0.0 [3]	Yes	Channel	-
Hardware interrupt high limit 2 [1]	• Value (INT) • Value (REAL) [3]	• 27648 • 0.0 [3]	Yes	Channel	-
Hardware interrupt low limit 2 [1]	• Value (INT) • Value (REAL) [3]	• 0 • 0.0 [3]	Yes	Channel	-
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

2 In normal operation, different interference frequency suppression settings can be configured for both channels. These cause different integration times for the analog-to-digital conversion. The module-internal time for updating the user data is now based on the longer integration time for both channels.
In isochronous mode, both channels must be configured with the same interference frequency suppression of 4.8 kHz.

3 Only for configuration SCALE.

Note

Unused channels

Deactivate the unused inputs in the parameter assignment.

A deactivated input always returns the value $7FFF_H$ or $7F800000_H$ with measured value scaling.

Property of the module in isochronous mode

The permitted interference frequency suppression of both channels for isochronous mode of the modules is 4.8 kHz (0.625 ms).

Note that no instantaneous value for the time Ti is returned in isochronous mode. The analog module AI 2xU/I 2-/4-wire HF returns a mean value for the range of 0.625 ms starting at Ti.

4.3 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs. A short-circuit is also detected in the range of 1 to 5 V if the input signal is short-circuited or the input is not connected.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the short-circuit diagnostics is output.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enable the diagnostics if the module has no current flow or has too little current for the measurement in the range of 4 to 20 mA.

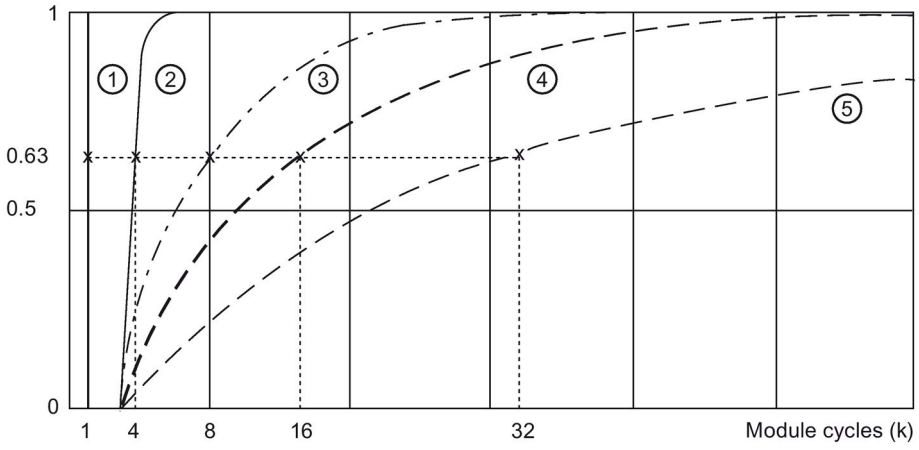
The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics is output.

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 5 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)
⑤ Very strong (k = 32)

Image 4-1 Smoothing AI 2×U/I 2-/4-wire HF

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Measuring range adjustment

The measuring range adjustment is a limited section of a measuring range supported by the analog input module. It is available for current and voltage measurements.

A limited measuring range in S7 format is shown, which is defined by the high and low limits of the measuring range adjustment.

Scaling of measured values

With measured value scaling, the user data of an analog input module is displayed as REAL (32-bit floating point) instead of S7 format.

The representation of the measuring range is defined by the scaled high and low limits of nominal range limit (as REAL).

The measured value scaling can be combined with the measuring range adjustment. In this case, the measuring range is adjusted first and then the representation of the measuring range is scaled.

BaseUnit with incoming supply voltage

Specifies that a light-colored BaseUnit with incoming supply voltage is located on this slot (see ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.4 Measuring range adjustment

Introduction

The measuring range adjustment is available for current and voltage measuring ranges.

The measuring range adjustment (base measuring range) is valid for the following ranges:

- Nominal range
- Underrange (of the measuring range adjustment)
- Overrange (of the measuring range adjustment)

Note

Live zero measuring ranges are not supported.

Function

The measuring range adjustment is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable part of the measuring range in S7 format.

- The function is enabled with the "Measuring range adjustment" parameter
- The "Measuring range adjustment high limit" parameter sets the high limit of the measuring range in mV or µA.
- The "Measuring range adjustment low limit" parameter sets the low limit of the measuring range in mV or µA.

Note

The "Measuring range adjustment" function can be used in combination with the "Measured value scaling" function. See also Scaling of measured values (Page 24).

Note

When the "Measuring range adjustment high limit" and "Measuring range adjustment low limit" parameters are too close together, resolution may be lost, which means it may no longer be possible to show every value.

Rules

- The limits of the measuring range adjustment must be selected within the nominal range of the base measuring range. They are specified in integers.
- The measuring range adjustment is resolved depending on the base measuring range from 0_H to $6C00_H$ or 9400_H to $6C00_H$.
- Underranges/overranges apply in accordance with the S7 format and the base measuring range.
  Special consideration: Negative values are not possible for "Current (2-wire transducer) 0..20 mA". With a measuring range adjustment, an underrange is offered when possible and cut off at 0 mA. If the underrange limit ($ED00_H$) is > 0 mA, QI = 0 and the analog value 8000_H are output when it is violated.

Example

The following values result, for example:

Table 4- 3 Example of measuring range adjustment

Measuring range adjustment	Measuring range resolution	
	Bipolar	Unipolar
Base measuring range	±10 V	0 V to 10 V
Adjusted measuring range	+2 V to +5 V	+2 V to +5 V
Measuring range adjustment high limit	5000 mV (S7: +27648)	5000 mV (S7: +27648)
Measuring range adjustment low limit	2000 mV (S7: -27648)	2000 mV (S7: 0)

The following example illustrates the effect of a measuring range adjustment:

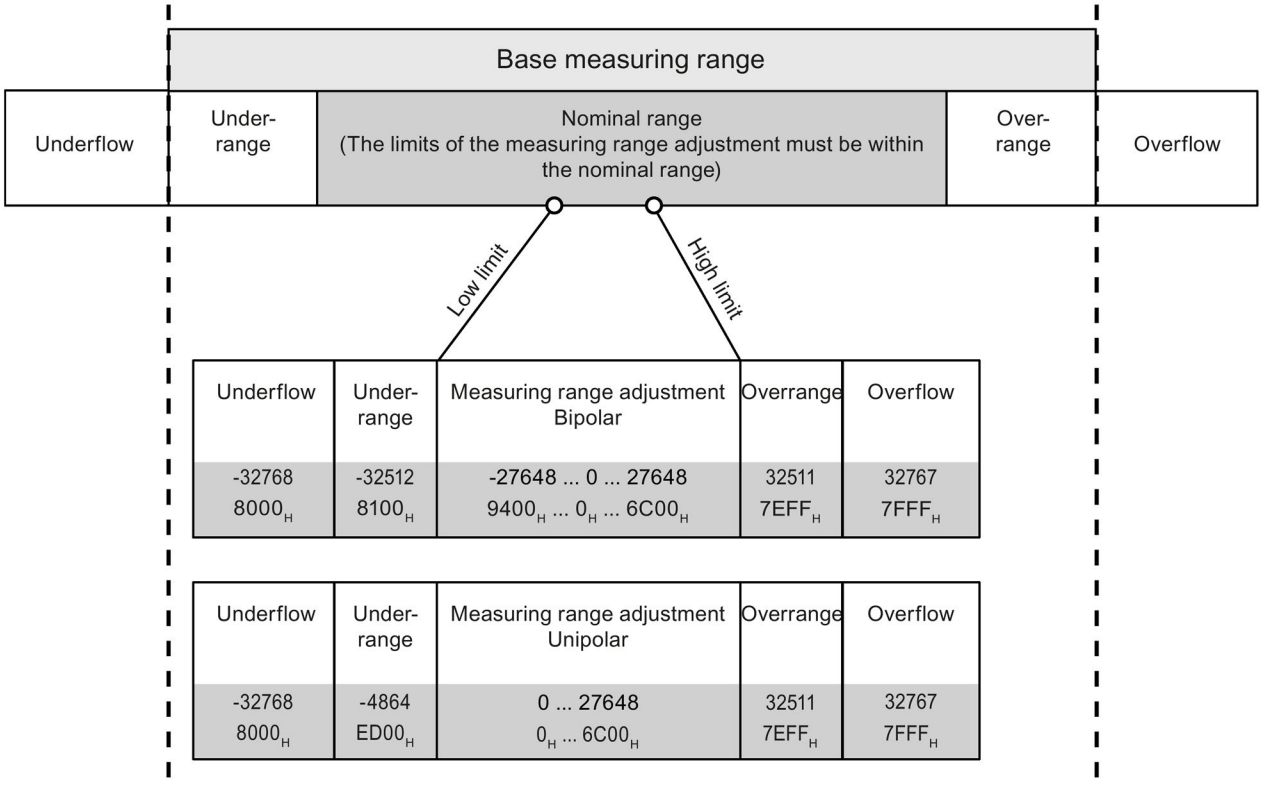


Image 4-2 Example of a measuring range adjustment

Configuration

The following figure shows an example of a configuration:

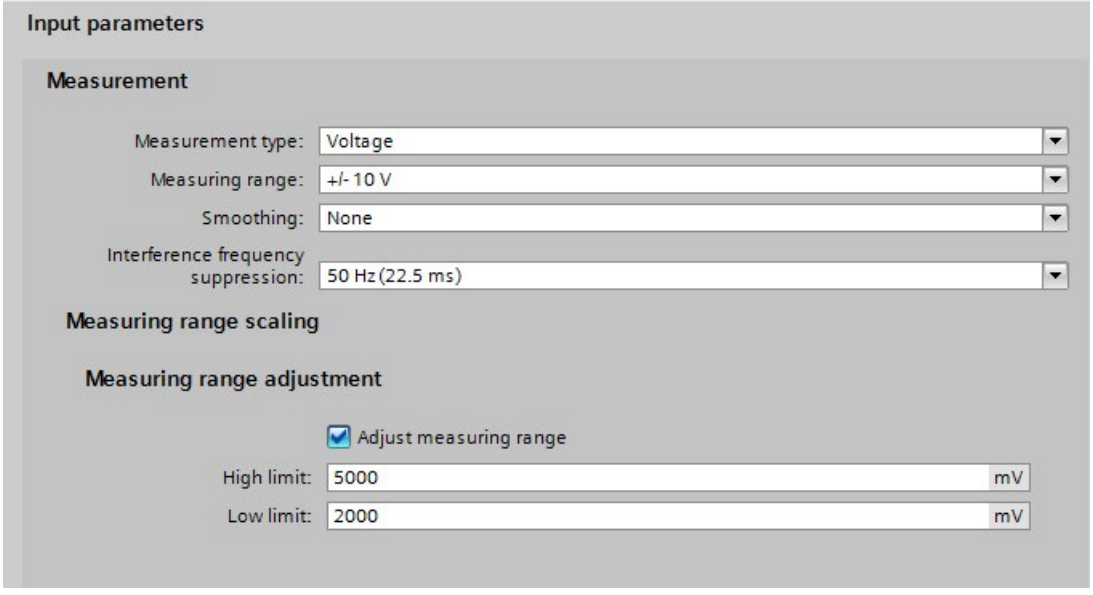


Image 4-3 Example of a configuration

In the configuration example, a measuring range adjustment of 2000 mV to 5000 mV is displayed.

4.5 Scaling of measured values

Introduction

The measured value scaling can be combined with the measuring range adjustment. In this case, the measuring range is adjusted first and then the representation of the measuring range is scaled.

Function

With measured value scaling, the user data of an AI 2xU/I 2-/4-wire HF module is displayed as REAL (32-bit floating point) instead of S7 format.

The representation of the measuring range is defined by the following parameters:

- The "Scaled high nominal range limit" parameter sets the desired display value (in REAL) for the high nominal range limit of the measuring range.
- The "Scaled low nominal range limit" parameter sets the desired display value (in REAL) for the low nominal range limit of the measuring range.

Note

With measured value scaling, the substitute value is minus infinity for underflow (FF800000H) and plus infinity for overflow (7F800000H).

Note

Effects of inversion

It is possible to set the "Scaled high nominal range limit" parameter lower than the "Scaled low nominal range limit" parameter, whereby the representation of the measuring range will be inverted compared to the terminal value (V, mA).

Overflow/underflow and hardware interrupts are always based on representation in REAL. A terminal value of > 11.76 V triggered an underflow for an inverted measured value scaling. Hardware interrupts react similarly.

Note

When the Parameter "Scaled high nominal range limit" and "Scaled low nominal range limit" parameters are too close together, resolution may be lost, which means it may no longer be possible to show every value.

Example

The following values result, for example:

Table 4- 4 Example of measured value scaling

	Low nominal range limit	High nominal range limit
Base measuring range	-10 V	+10 V
S7 format	-27648	+27648
Scaling of measured values	1.00	7.00

As shown in the table, -10 V corresponds to 1.00 and +10 V corresponds to 7.00.

Combination with measuring range adjustment

If the measuring range adjustment is enabled in addition to measured value scaling, first the measuring range is scaled and then the representation of the measuring range. The table below shows an example of the combination of measured value scaling and measuring range adjustment.

Table 4- 5 Example for a combination of measured value scaling and measuring range adjustment

	Low nominal range limit	High nominal range limit
Measuring range adjustment	-4000 mV	8000 mV
S7 format	-27648	+27648
Scaling of measured values	1.00	7.00

As shown in the table, -4 V corresponds to 1.00 and +8 V corresponds to 7.00.

Configuration

The following figures show examples of a configuration in STEP 7:

Configuration of measured value scaling

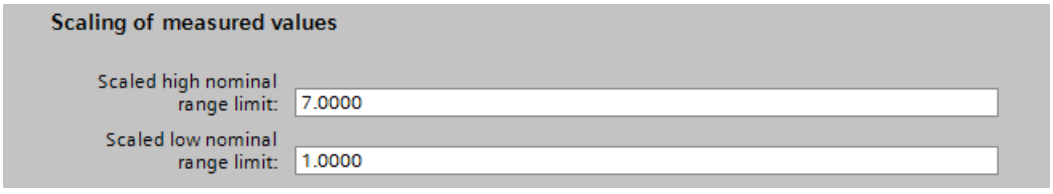


Image 4-4 Configuration of measured value scaling

Configuration with measuring range adjustment and measured value scaling

In the configuration example, a measuring range adjustment of -4000 mV to 8000 mV is displayed and additionally converted to a scaled high and low nominal range limit of 1.00 to 7.00.

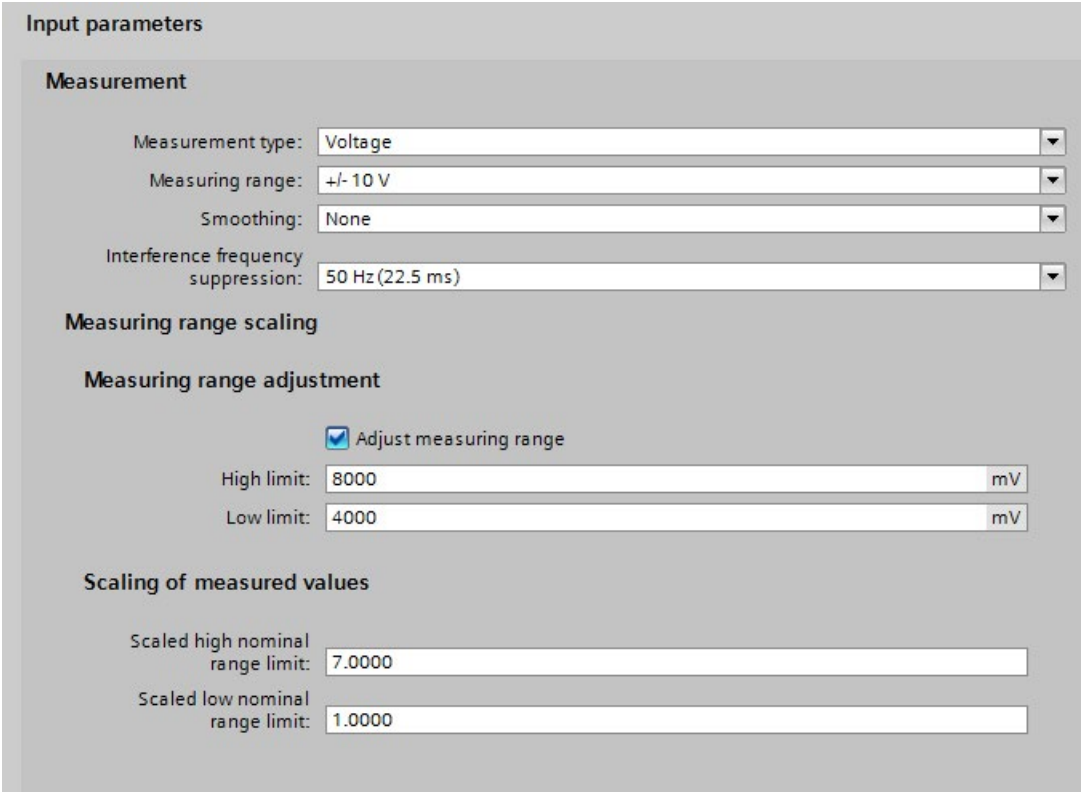


Image 4-5 Configuration with measuring range adjustment and measured value scaling

4.6 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of AI 2xU/I 2-/4-wire HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 4- 6 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 2-channel without value status	AI 2xU/I 2-, 4-wire HF V1.0	X	X	X
1 x 2-channel with value status	AI 2xU/I 2-, 4-wire HF V1.0, QI	X	X	---
1 x 2-channel without value status	AI 2xU/I 2-, 4-wire HF V2.0	---	X	X
1 x 2-channel with value status	AI 2xU/I 2-, 4-wire HF V2.0, QI	---	X	---
1 x 2-channel with value status for module-internal Shared Input with up to 4 submodules	AI 2xU/I 2-, 4-wire HF V2.0, MSI	---	X	---
1 x 2-channel with value status and measured value scaling	AI 2xU/I 2-, 4-wire HF V2.0, SCALE	---	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AI 2xU/I 2-, 4-wire HF, QI,
- AI 2xU/I 2-, 4-wire HF, MSI
- AI 2xU/I 2-, 4-wire HF, SCALE

An additional bit is assigned to each channel for the value status. The value status bit indicates whether the read in analog value is valid. (0 = value is incorrect).

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 1 and 0 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: The wiring, the value created on the channel, etc. is incorrect.

Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF, QI

The following figure shows the assignment of the address space for the AI 2xU/I 2-/4-wire HF, QI with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

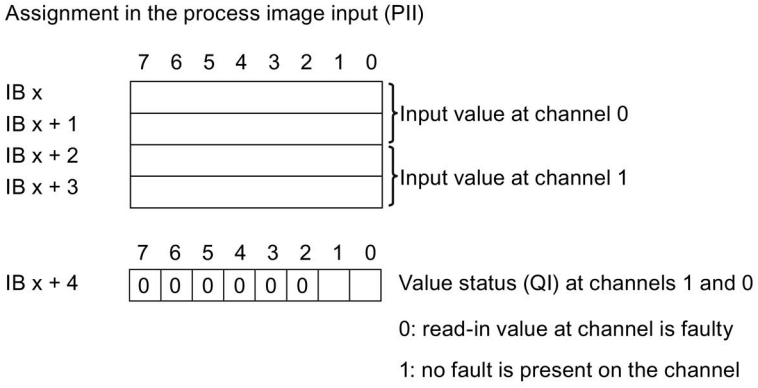


Image 4-6 Address space of the analog input module AI 2xU/I 2-/4-wire HF, QI with value status

Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF MSI

For the configuration as a 1 x 2-channel module (module-internal shared input, MSI), channels 0 and 1 of module are copied to up to four submodules. Channels 0 and 1 are then available with identical input values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the 1st submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2.

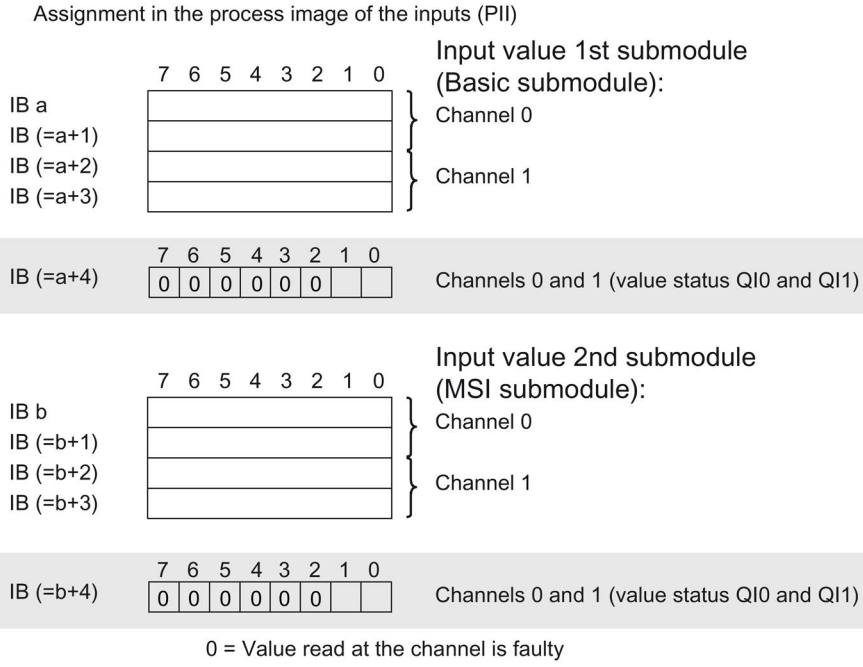


Image 4-7 Address space for configuration as 1x 2-channel AI 2×U/I 2-/4-wire HF MSI with value status

The figure below shows the assignment of the address space with submodules 3 and 4.

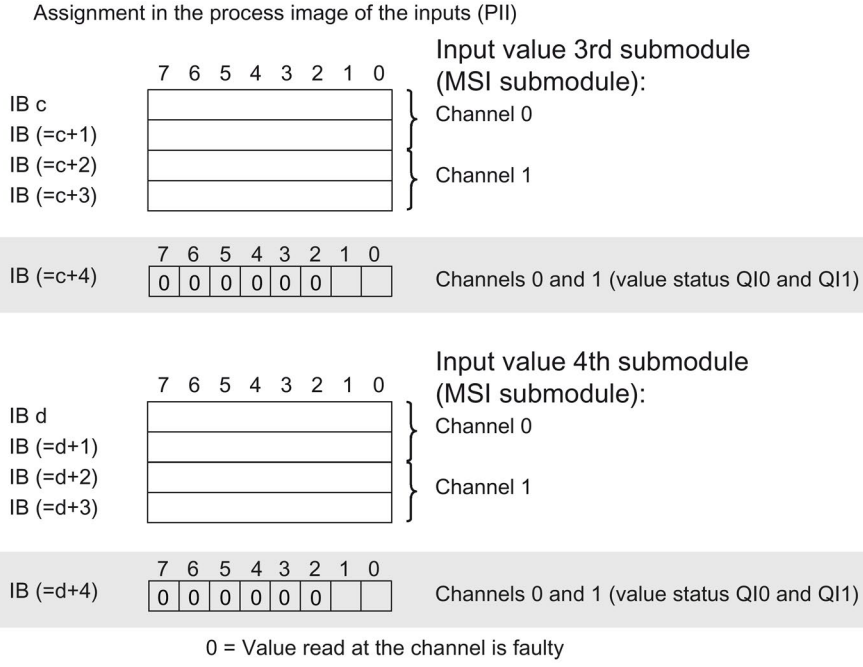


Image 4-8 Address space for configuration as 1x 2-channel AI 2×U/I 2-/4-wire HF MSI with value status

Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF SCALE

The following figure shows the assignment of the address space for the AI 2xU/I 2-/4-wire HF, SCALE with value status (Quality Information (QI)). The value status cannot be deselected for this configuration.

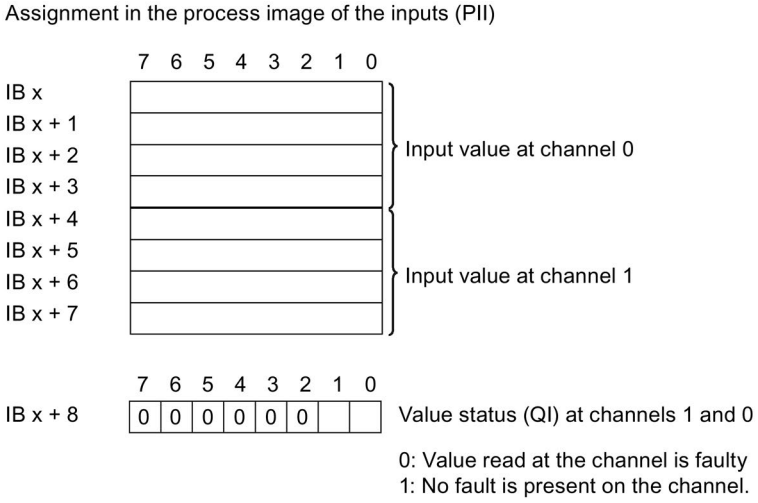


Image 4-9 Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF, SCALE with value status

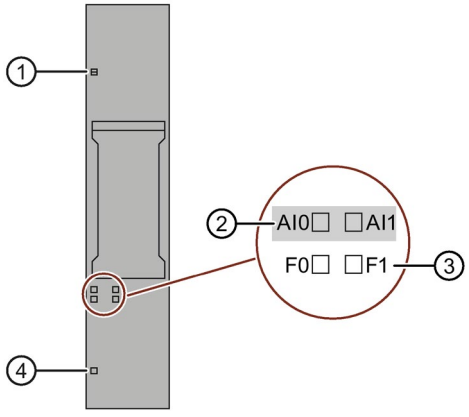
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED display of the AI 2xU/I 2-/4-wire HF.



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Image 5-1 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 35).

Table 5- 1 Error display DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Table 5- 2 Status and error display LED channel status / channel error

LEDs		Meaning
Channel status	Channel error	
Off	Off	Channel deactivated or load voltage missing
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

Table 5- 3 PWR LED status display

PWR LED	Meaning
Off	Load voltage missing
On	Load voltage present

5.2 Interrupts

The analog input module AI 2×U/I 2-/4-wire HF supports hardware and diagnostic interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (current: sensor supply; voltage: 1 to 5 V, encoder supply)
- Wire break (current: 4 to 20 mA)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Hardware interrupt lost
- Supply voltage missing
- Channel temporarily unavailable

Hardware interrupts

The module generates a hardware interrupt at the following events:

- Violation of low limit 1
- Violation of high limit 1
- Violation of low limit 2
- Violation of high limit 2

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Detailed information on the event is available in the STEP 7 online help.

The block interface is represented here with optimized block access, which is set in the TIA Portal by default.

Name	Data type	Comment
LADDR	HW_IO	Hardware identifier of the module triggering the interrupt
USI	WORD	USI (High/Low)
IChannel	USInt	Channel that triggered the hardware interrupt
EventType	Byte	Error event

S7-300/400 or a different CPU

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

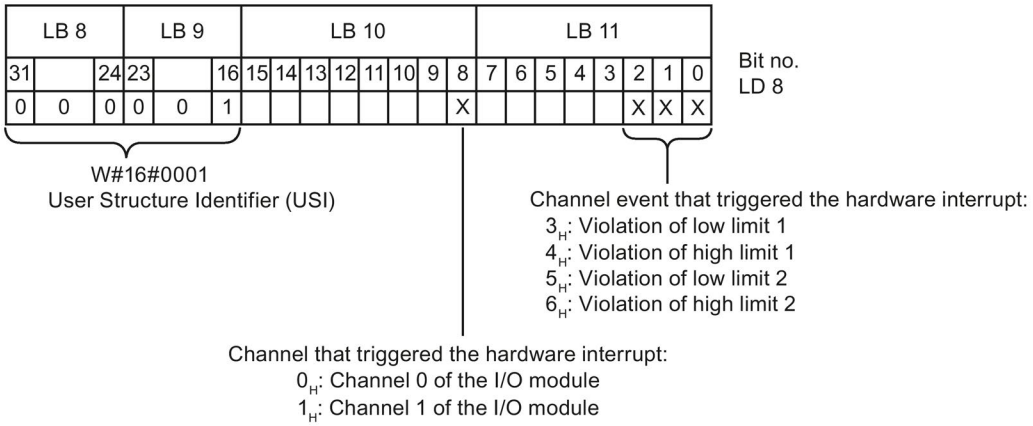


Image 5-2 OB start information

Structure of the additional interrupt information

Table 5- 4 Structure of the additional interrupt information

Data block name		Content	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information for hardware interrupts of the I/O module	2
Channel that triggered the hardware interrupt.				
	Channel	B#16#00 to B#16#01	Channel 0 and 1 of the I/O module	1
Event that triggered the hardware interrupt.				
	Error event	B#16#03	Violation of low limit 1	1
		B#16#04	Violation of high limit 1	
		B#16#05	Violation of low limit 2	
		B#16#06	Violation of high limit 2	

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (encoder supply)	1_H	Short-circuit encoder supply to ground	Correct interplay between module and encoder
Short-circuit (1 to 5 V)	1_H	Short-circuit of input signal	Correct interplay between module and encoder
		Open input	Connect input
Wire break (current 4 to 20 mA)	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the encoder contacts
High limit violated	7_H	Value is above the overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below the underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies for the entire module).	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel: Incorrect parameter assignment.	• Correct the parameter assignment (wire break diagnostics set only with the permitted measuring ranges).
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Hardware interrupt lost	16_H	Error is reported when a hardware interrupt (high/low limit) could not be reported.	• Limits might be assigned twice. • If necessary, reduce the bus cycle. • If necessary, use higher SFU.
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read process values in this state.	• Wait for firmware update • Restart the firmware update
		Switch to user calibration	

Technical specifications

6

Technical specifications of the AI 2×U/I 2-/4-wire HF

	6ES7134-6HB00-0CA1
General information	
Product type designation	ET 200SP, AI 2xU/I 2/4-wire High Feature, PU 1
Firmware version	V2.0
• FW update possible	Yes
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC03
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable measuring range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13
STEP 7 can be configured/integrated as of version	V5.5 / -
PCS 7 can be configured/integrated as of version	V8.1 SP1
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
Oversampling	No
MSI	Yes
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Calibration in RUN possible	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption (rated value)	39 mA; without sensor supply

	6ES7134-6HB00-0CA1
Encoder supply	
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s (two-wire)
Additional 24 V encoder supply	
Short-circuit protection	Yes; channel-based
Output current, max.	100 mA; max. 150 mA per channel for a duration < 10 s (four-wire)
Power loss	
Power loss, typ.	0.95 W; without sensor supply
Address area	
Address space per module	
Address space per module, max.	4 bytes; + 1 byte for QI information
Analog inputs	
Number of analog inputs	2; Differential inputs
Maximum permissible input voltage for voltage input (destruction limit)	30 V
Permissible input current for current input (destruction limit), max.	50 mA
Input ranges (rated values), voltages	
0 to +10 V	Yes; 15 bits
Input resistance (0 to 10 V)	75 kΩ
1 V to 5 V	Yes; 15 bits
Input resistance (1 V to 5 V)	75 kΩ
-10 V to +10 V	Yes; 16 bits incl. sign
Input resistance (-10 V to +10 V)	75 kΩ
-5 V to +5 V	Yes; 16 bits incl. sign
Input resistance (-5 V to +5 V)	75 kΩ
Input ranges (rated values), currents	
0 mA to 20 mA	Yes; 15 bits
Input resistance (0 to 20 mA)	130 Ω
-20 mA to +20 mA	Yes; 16 bits incl. sign
Input resistance (-20 mA to +20 mA)	130 Ω
4 mA to 20 mA	Yes; 15 bits
Input resistance (4 mA to 20 mA)	130 Ω
Cable length	
Shielded, max.	1000 m; 200 m for voltage measurement

	6ES7134-6HB00-0CA1
Formation of analog values for the inputs	
Measuring principle	Sigma Delta
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bits
Integration time configurable	Yes
Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 / 300 / 600 / 1 200 / 2 400 / 4 800
Basic execution time of the module (all channels enabled)	1 ms
Measured value smoothing	
Number of levels	6; none; 2/4/8/16/32 times
Configurable	Yes
Encoders	
Connection of the signal transmitters	
For voltage measurement	Yes
For current measurement as 2-wire transducer	Yes
• Load of 2-wire transducer, max.	650 Ω
For current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	0.01%
Temperature error (in relation to input range), (+/-)	0.003%/K
Crosstalk between inputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	0.01%
Operational limit in the entire temperature range	
Voltage in relation to input range, (+/-)	0.1%
Current in relation to input range, (+/-)	0.1%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	± 0.05%; 0.1% with SFU 4.8 kHz
Current in relation to input range, (+/-)	± 0.05%; 0.1% with SFU 4.8 kHz
Interference voltage suppression for f = n x (f1 +/- 1%), f1 = interference frequency	
Common mode voltage, max.	35 V
Common mode interference, min.	90 dB
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Filtering and processing time (TCI), min.	800 µs
Bus cycle time (TDP), min.	1 ms
Jitter, max.	5 µs

	6ES7134-6HB00-0CA1
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	Yes, measuring range 4 to 20 mA only
Short-circuit	Yes; for 1 to 5 V, and for current measuring ranges for short-circuit in sensor supply
Group error	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Between the inputs (UCM)	75 V DC/60 V AC
Isolation	
Isolation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	32 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics					Hardware interrupts
		Underflow	Overflow	Wire break	Short-circuit to ground	Missing supply voltage L+	
Deactivated	*	*	*	*	*	*	*
Voltage	±5 V	x	x	–	x [1]	x	x
	±10 V	x	x	–	x [1]	x	x
	1 V to 5 V	x	x	–	x	x	x
	0 V to 10 V	x	x	–	x [1]	x	x
Current (4-wire transducer)	0 mA to 20 mA	x	x	–	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x
	±20 mA	x	x	-	x	x	x
Current (2-wire transducer)	0 mA to 20 mA	x [1 2]	x	–	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 only possible as of firmware V2.0

2 The diagnostics Underflow can always be enabled for "Current (2-wire transducer) 0..20 mA", but it is only reported when a complete underflow range is created by the measuring range adjustment.

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Table A- 1 Dependencies of the measurement type and measuring range PB

Measurement type	Measuring range	Diagnostics						Hardware interrupts
		Underflow	Overflow	Wire break	Load voltage L+	Short-circuit to ground	Smoothing / interference frequency suppression	
Deactivated	*	*	*	*	*	*	*	*
Voltage	±5 V	x	x	–	x	x [1]	x	–
	±10 V	x	x	–	x	x [1]	x	–
	1 V to 5 V	x	x	–	x	x	x	–
	0 V to 10 V	x	x	–	x	x [1]	x	–
Current (4-wire transducer)	0 mA to 20 mA	x	x	–	x	x	x	–
	4 mA to 20 mA	x	x	x	x	x	x	–
	±20 mA	x	x	-	x	x	x	–
Current (2-wire transducer)	0 mA to 20 mA	–	x	–	x	x	x	–
	4 mA to 20 mA	x	x	x	x	x	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

[1] only possible as of firmware V2.0

A.2 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the measuring range of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Note

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment results in a brief exit from clocked measuring mode and renewed synchronization with the fieldbus cycle. The slowest channel provides the "internal" measuring cycle.

Note

Changing parameter settings in runtime can cause the process values to freeze for the duration of the parameter assignment for the module.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

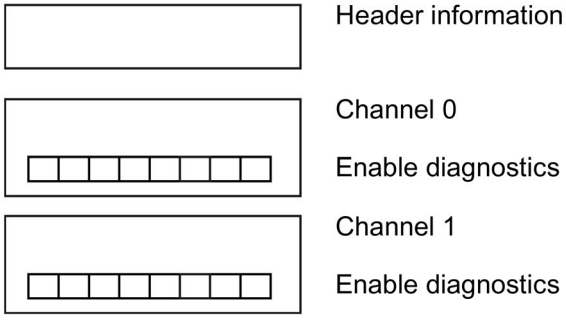


Image A-1 Structure of data record 128

Header information (V1.0)

The figure below shows the structure of the header information (V1.0).

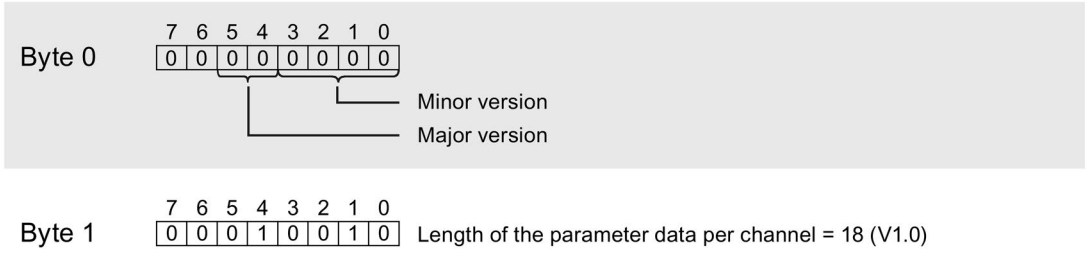


Image A-2 Header information (V1.0)

Header information (V2.0)

The figure below shows the structure of the header information (V2.0).

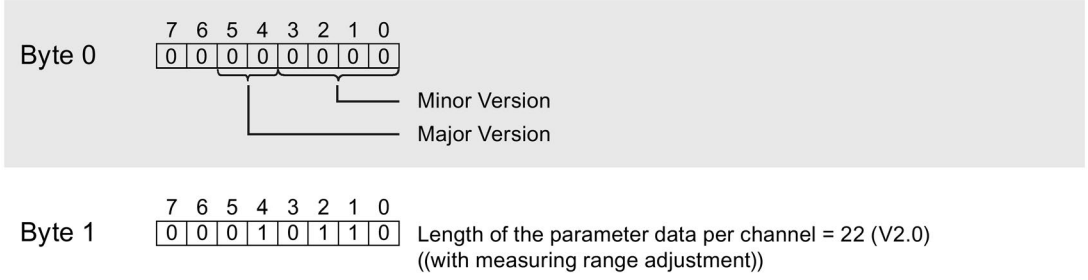


Image A-3 Header information (V2.0)

Header information (V2.0 SCALE)

The figure below shows the structure of the header information.

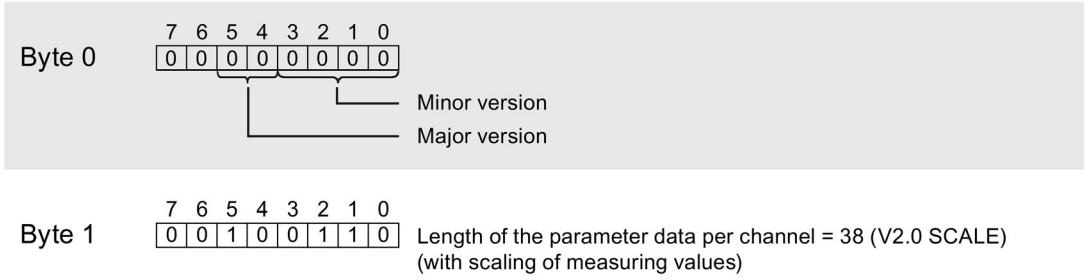


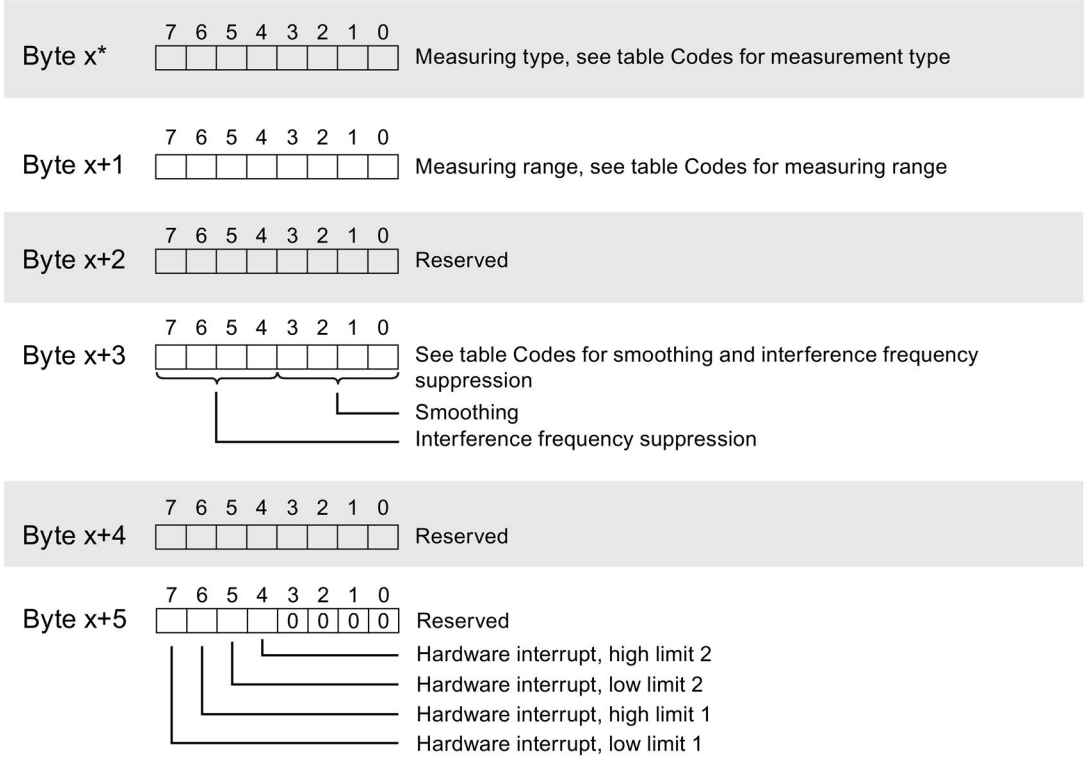
Image A-4 Header information (V2.0 SCALE)

Parameter (V1.0)

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 18); channel number is 0 or 1



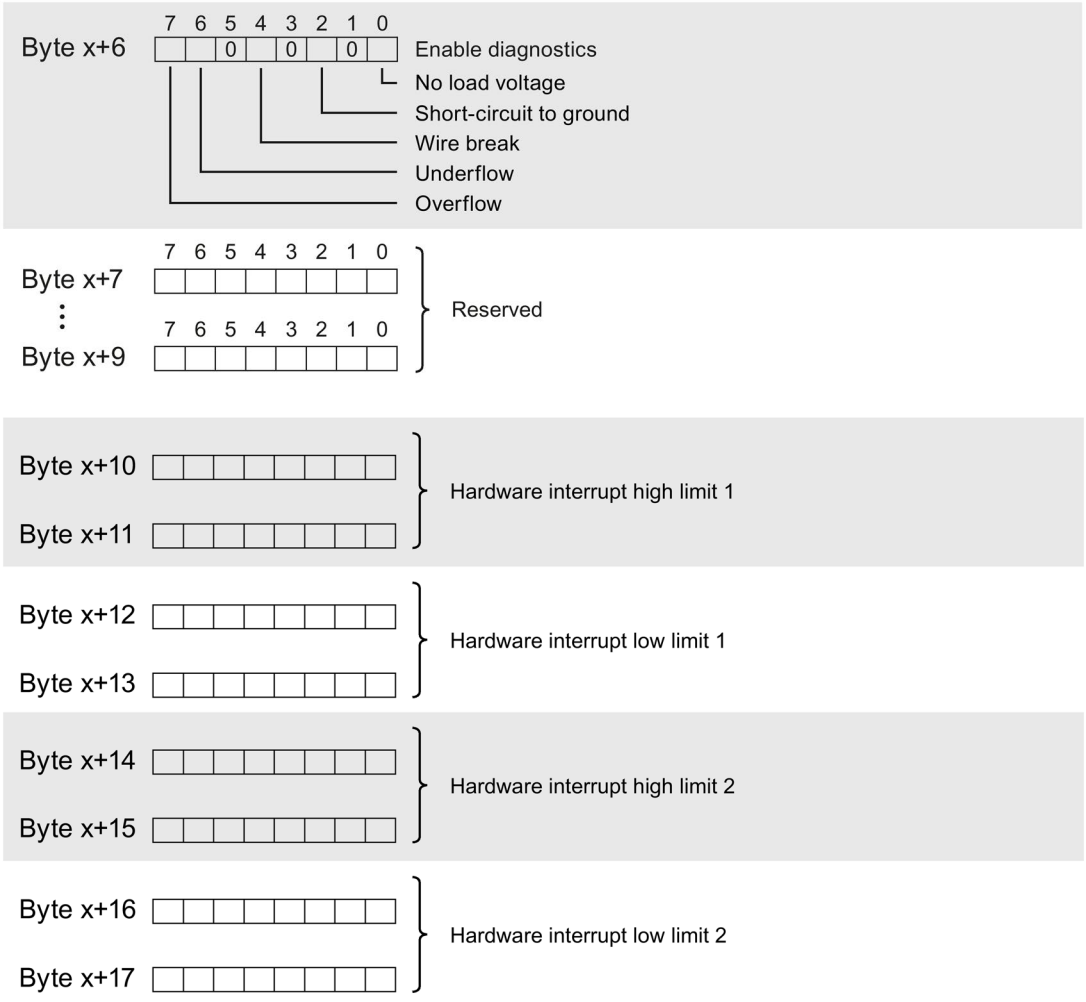


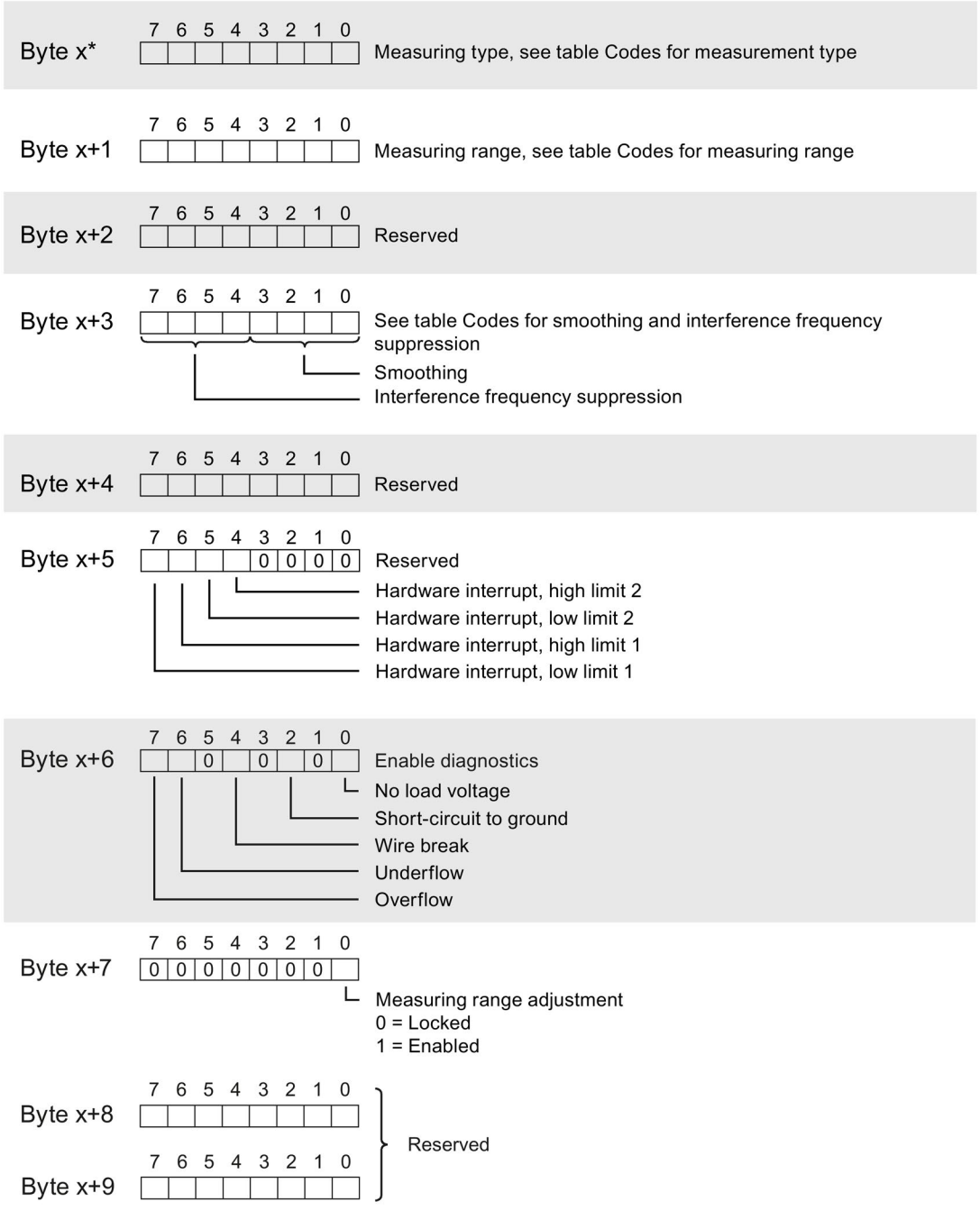
Image A-5 Structure of byte x to x+17 for channel 0 and 1

Parameter (V2.0)

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 22); channel number is 0 or 1



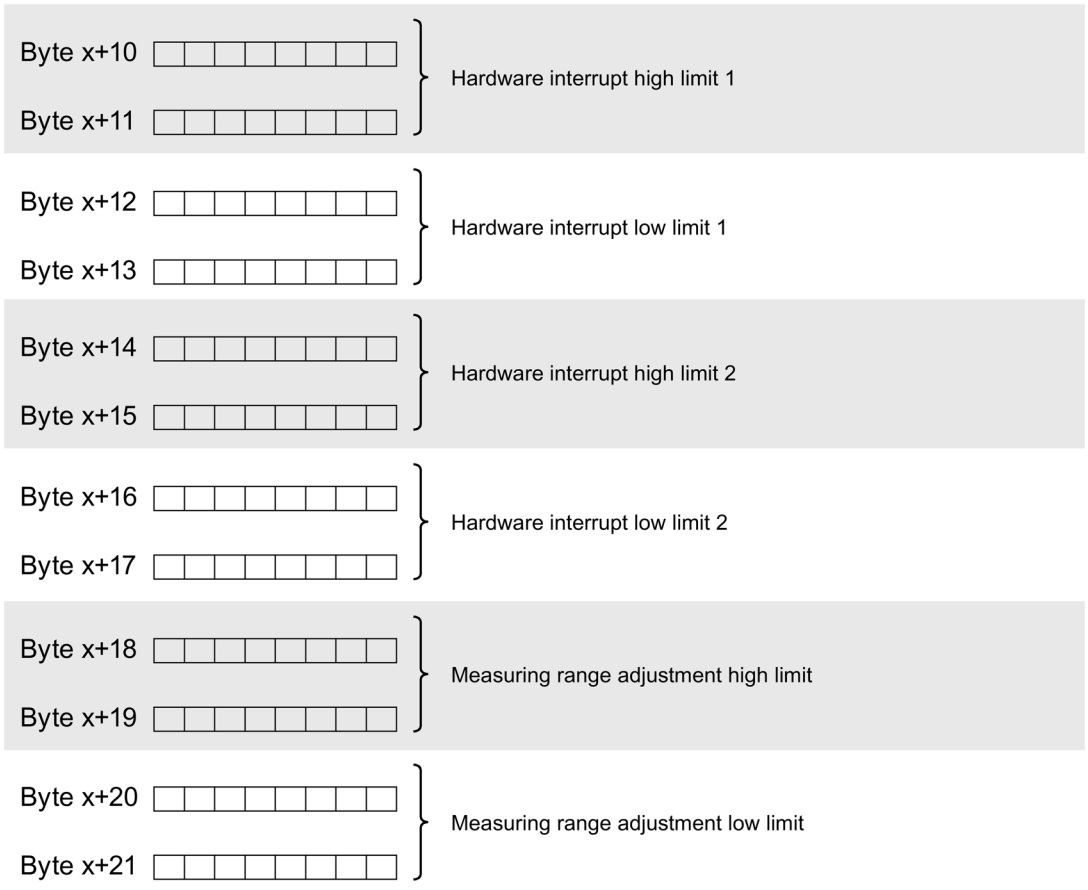


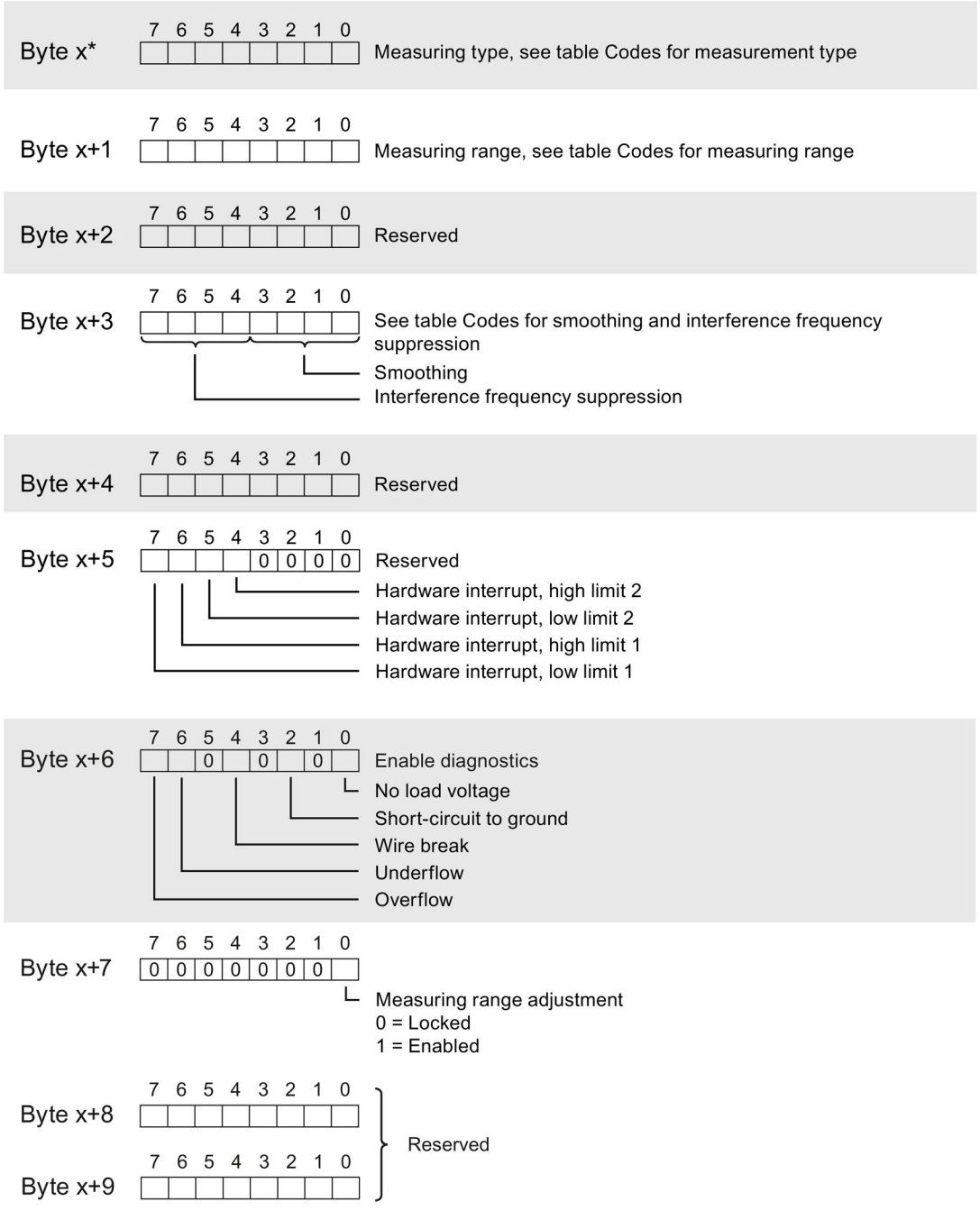
Image A-6 Structure of bytes x to x+21 for channels 0 and 1

Parameter (V2.0 SCALE)

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 38); channel number is 0 or 1



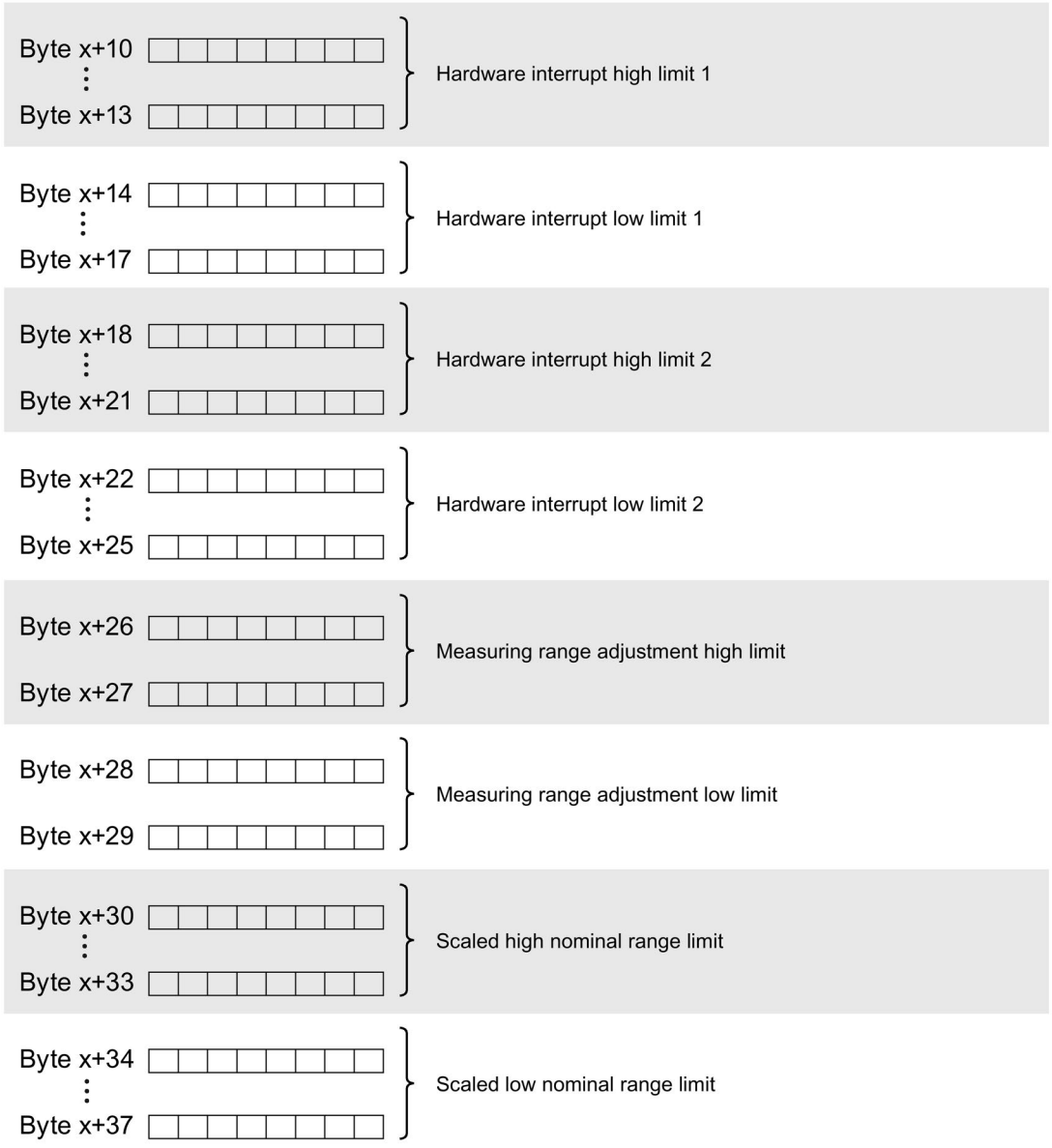


Image A-7 Structure of bytes x to x+37 for channels 0 and 1

Codes for measurement types

The following table contains all the measurement types of the analog input module with its codes. You must enter these codes at byte x (see previous figure).

Table A- 2 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for measuring ranges

The following table contains all codes for the measuring ranges of the analog input module. You must enter these codes at byte x+1 (see previous figure).

Table A- 3 Codes for measuring ranges

Measuring range	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current	
0 mA to 20 mA	0000 0010
4 mA to 20 mA	0000 0011
±20 mA	0000 0100

Codes for smoothing and interference frequency suppression

The following table contains all coding for smoothing and interference frequency suppression. You must enter these codes at byte x (see previous figure).

Table A- 4 Codes for smoothing

Smoothing	Code
None	0000
2 times	0100
4 times	0001
8 times	0101
16 times	0010
32 times	0011

Table A- 5 Codes for interference frequency suppression

Interference frequency suppression	Code
16.6 Hz (67.5 ms)	0100
50 Hz (22.5 ms)	0010
60 Hz (18.75 ms)	0001
300 Hz (10 ms)	0101
600 Hz (5 ms)	0110
1.2 kHz (2.5 ms)	0111
2.4 kHz (1.25 ms)	1000
4.8 kHz (0.625 ms)	1001

Error transmitting the data record

The module always checks all values of the transmitted data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

This section shows the analog values for all measuring ranges supported by the analog input module AI 2xU/I 2-/4wire HF.

Measured value resolution

The digitized analog value is the same for input and output values at the same nominal range. The analog values are represented as a fixed point number in the two's complement.

The resolutions 15 and 16 bits including sign are displayed. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table B- 1 Resolution of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

The tables below set out the digitized representation of the input ranges by bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	> 117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	< -117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	> 117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	< -17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table B- 4 Voltage measuring range ±10 V and ±5 V

Values		Voltage measuring range		Range
Dec.	Hex.	±10 V	±5 V	
32767	7FFF	> 11.759 V	> 5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	< -11.759 V	< -5.879 V	Underflow

Table B- 5 Voltage measuring range 1 V to 5 V and 0 V to 10 V

Values		Voltage measuring range		Range
Dec.	Hex.	1 to 5 V	0 to 10 V	
32767	7FFF	> 5.704 V	> 11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	< 0.296 V	< -1.759 V	Underflow

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table B- 6 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	Hex.	±20 mA	
32767	7FFF	> 23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table B- 7 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	Hex.	0 to 20 mA*	4 to 20 mA	
32767	7FFF	> 23.52 mA	> 22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	< -3.52 mA	< 1.185 mA	Underflow

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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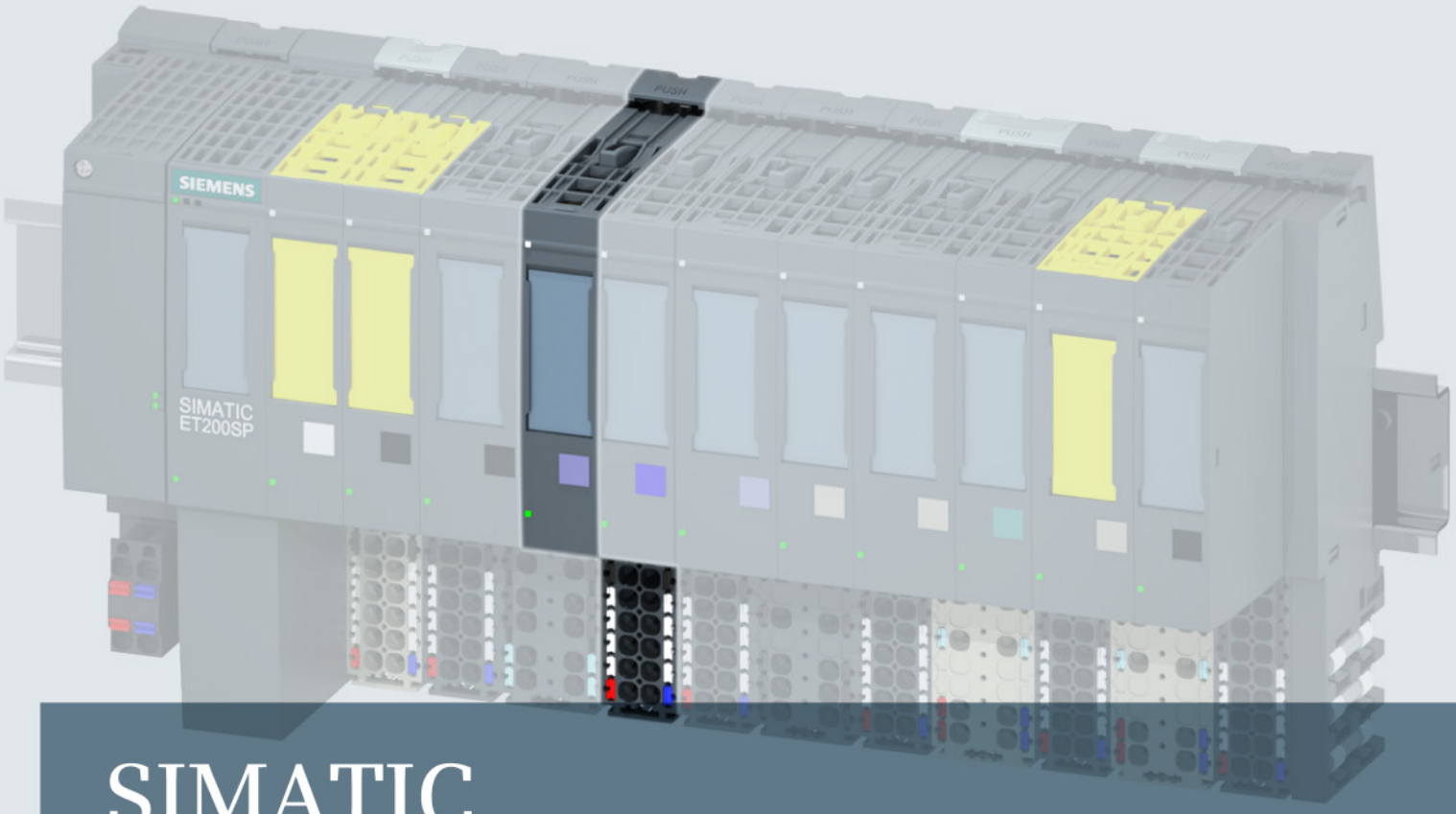

SIMATIC

ET 200SP

Analog input module AI 4xI 2-/4-wire ST (6ES7134-6GD00-0BA1)

Manual

Edition 07/2014

Answers for industry.

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ET 200SP
Analog Input Module
AI 4xI 2-/4-wire ST
(6ES7134-6GD00-0BA1)

Manual

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07/2014

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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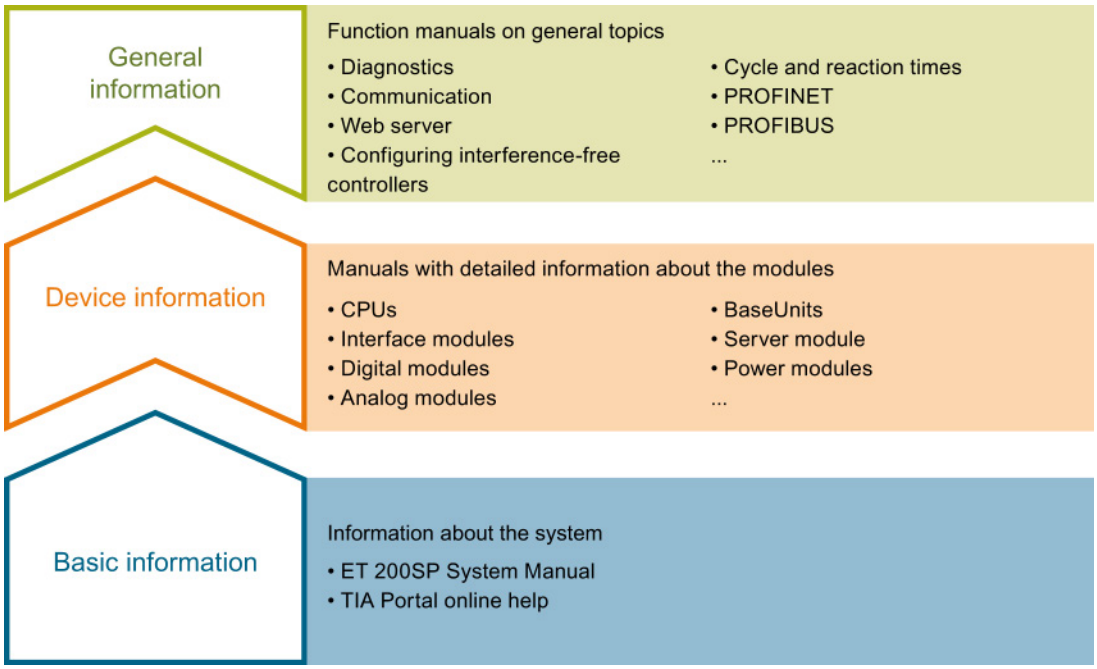
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC distributed I/O system. ET 200SP. The STEP 7 online help supports you in the configuration and programming.

Device information

Manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics, technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

Product overview

2

2.1 Properties

Article number

6ES7134-6GD00-0BA1

View of the module

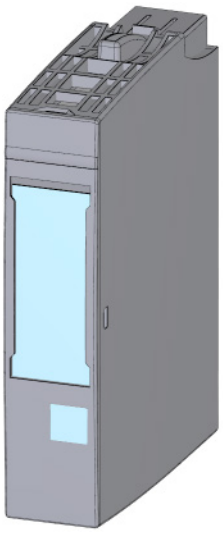


Figure 2-1 View of the module AI 4×I 2-/4-wire ST

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Measuring type current for 2-/4-wire transducers
- Input ranges
  - 4 to 20 mA, resolution 15 bits
  - 0 to 20 mA, resolution 15 bits
  - ±20 mA, resolution 16 bits including sign

- Electrically isolated from the supply voltage L+ (only for input type 4-wire transducer)
- Permitted common mode voltage: 10 V_{SS}
- Configurable diagnostics per module

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

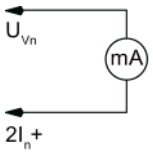
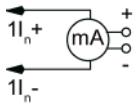
Wiring up

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment

<table>
<tr><th colspan="7">Terminal assignment for AI 4×I 2-/4-wire ST (6ES7134-6GD00-0BA1)</th></tr>
<tr><th>Terminal</th><th>Assignment</th><th>Terminal</th><th>Assignment</th><th>Explanation</th><th>BaseUnit[1]</th><th>Color identification label (terminals 1 to 16)</th></tr>
<tr><td>1</td><td>1I_0+</td><td>2</td><td>1I_1+</td><td rowspan="4">4-wire connection (terminal 1 to 8):
• 1I_n+: Input signal "+", channel n
• 1I_n-: Input signal "-", channel n</td><td rowspan="9">A0
A1</td><td rowspan="9">
CC03
6ES7193-6CP03-2MA0</td></tr>
<tr><td>3</td><td>1I_2+</td><td>4</td><td>1I_3+</td></tr>
<tr><td>5</td><td>1I_0-</td><td>6</td><td>1I_1-</td></tr>
<tr><td>7</td><td>1I_2-</td><td>8</td><td>1I_3-</td></tr>
<tr><td>9</td><td>U_{V0}</td><td>10</td><td>U_{V1}</td><td rowspan="4">2-wire connection (terminal 9 to 16):
• U_{Vn}: Supply voltage channel n
• 2I_n+: Input signal "+", channel n</td></tr>
<tr><td>11</td><td>U_{V2}</td><td>12</td><td>U_{V3}</td></tr>
<tr><td>13</td><td>2I_0+</td><td>14</td><td>2I_1+</td></tr>
<tr><td>15</td><td>2I_2+</td><td>16</td><td>2I_3+</td></tr>
<tr><td>L+</td><td>24 VDC</td><td>M</td><td>M</td></tr>
<tr><td colspan="3">2-wire connection
  </td><td colspan="4">4-wire connection
  </td></tr>
</table>

[1] Usable BaseUnit types, can be identified by the last two digits of the article number.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Also keep this in mind during the configuration.

See also

You will find additional information on the BaseUnit types in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Schematic circuit diagram

Schematic circuit diagram

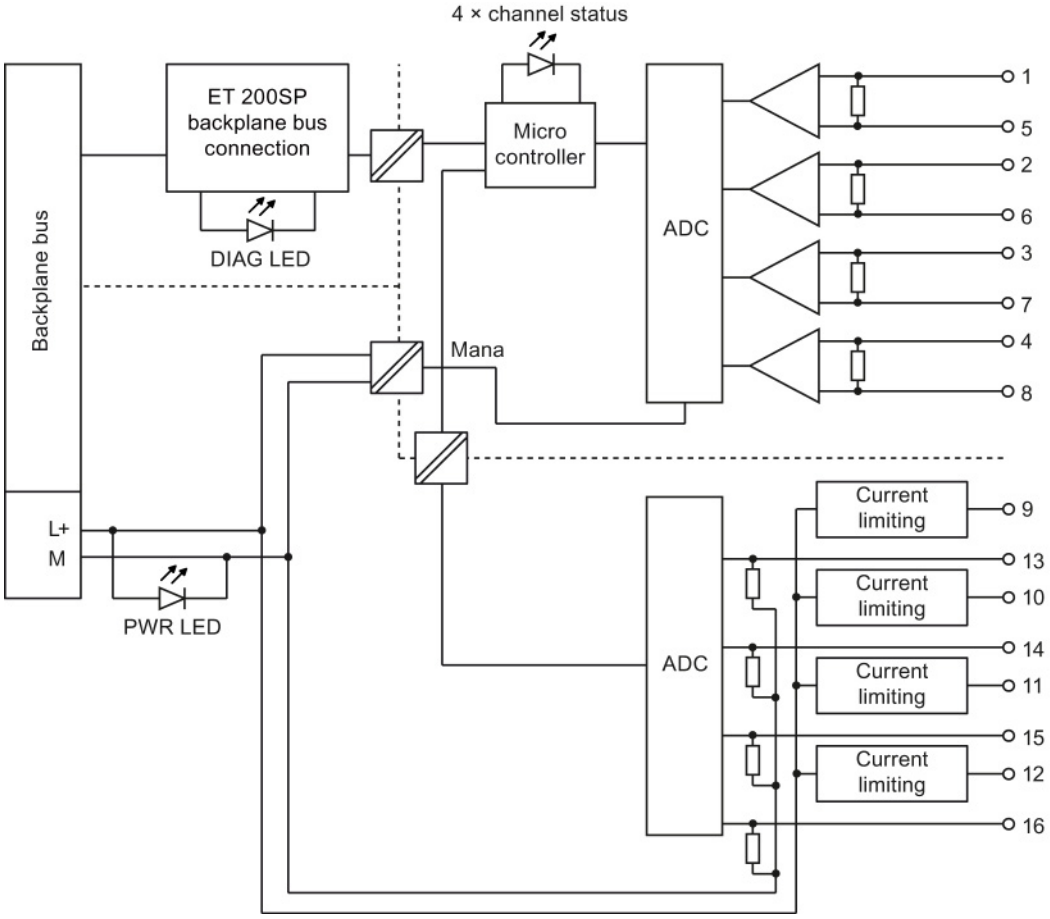


Figure 3-1 Schematic circuit diagram for AI 4×I 2-/4-wire ST

Parameters/address space

4

4.1 Measuring types and ranges

The analog input module AI 4xI 2-/4-wire ST has the following measuring ranges:

Table 4- 1 Measuring ranges

Measuring type	Measuring range	Resolution
Current (2-wire transducer)	0 to 20 mA	15 bits
	4 to 20 mA	15 bits
Current (4-wire transducer)	0 to 20 mA	15 bits
	4 to 20 mA	15 bits
	± 20 mA	16 bits including sign

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 31).

4.2 Parameters

Parameters of the AI 4xI 2-/4-wire ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 27).

The following parameter settings are possible:

Table 4- 2 Settable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Overflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Underflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Wire break	• Disable • Enable	Disable	yes	Module	Module
Measuring type/range	• deactivated • Current (4-wire transducer) 0..20 mA • Current (4-wire transducer) 4..20 mA • Current (4-wire transducer) +/-20 mA • Current (2-wire transducer) 0..20 mA • Current (2-wire transducer) 4..20 mA	Current (4-wire transducer) 4..20 mA	yes	Channel	Channel

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Smoothing	• none • weak • medium • strong	none	yes	Channel	Channel
Interference frequency suppression	• 60 Hz • 50 Hz[1] • 16.6 Hz	50 Hz	yes	Channel	Module
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	no	Module	Module

[1] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

Note

Unused channels

"Disable" unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always returns the value $7FFF_H$.

4.3 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply.

Diagnostics overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics info is output.

Type/range of measurement

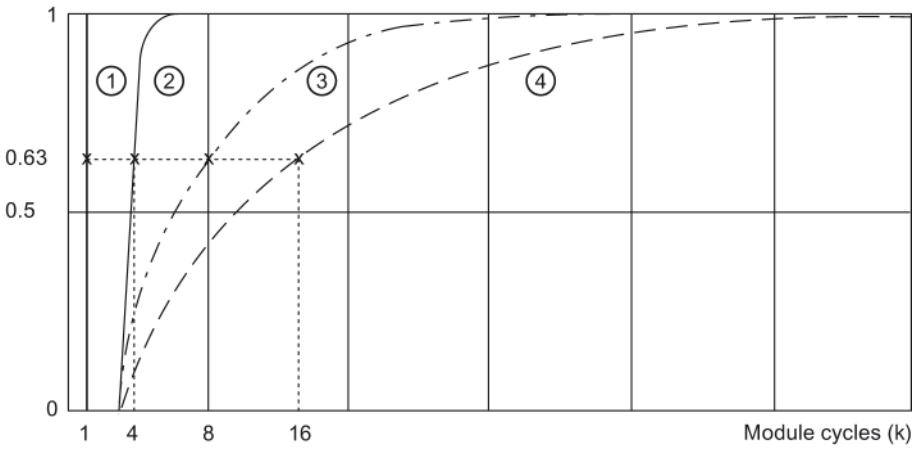
See the section Measuring types and measuring ranges (Page 12).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 4-1 Smoothing with AI 4xI 2-/4-wire ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the supply frequency that is predominant in the plant.

Potential group

Specifies that a BaseUnit with voltage supply feed-in is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no faults/errors on the module.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 4×I 2-/4-wire ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

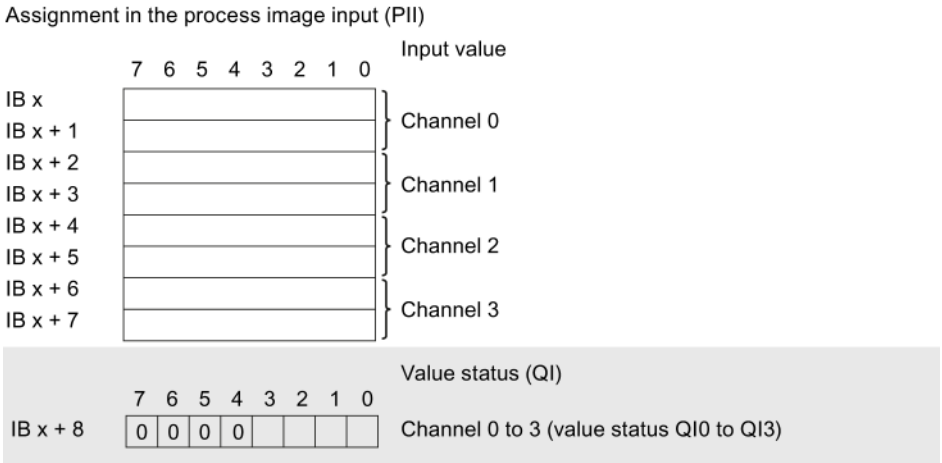


Figure 4-2 Address space of the AI 4×I 2-/4-wire ST with value status

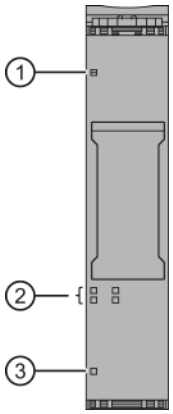
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the AI 4xI 2-/4-wire ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 21).

DIAG LED

Table 5- 1 DIAG LED fault/error display

DIAG LED	Meaning
off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
on	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
off	Channel disabled
on	Channel enabled

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
off	No supply voltage L+
on	Supply voltage L+ present

5.2 Interrupts

The analog input module AI 4xI 2-/4-wire ST supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit (current, 2-wire transducer)
- Wire break (current 4..20 mA)
- Low limit violated
- High limit violated
- Error
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware being updated. The module does not perform any measurements during this time.	–
Short-circuit (2-wire transducer, current)*	1_H	Sensor supply to ground	Correct the module/encoder tuning
		Input to sensor supply	
Line break (current)	6_H	Impedance of encoder circuit too high.	Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the sensor contacts
High limit violated	7_H	Value is above the overrange.	Correct the module/encoder tuning
Low limit violated	8_H	Value is below the underrange.	Correct the module/encoder tuning
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostics can also be reported for unaffected channels and/or the measured value can be affected temporarily.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 4×I 2-/4-wire ST

	6ES7134-6GD00-0BA1
Product type designation	AI 4xI 2-/4-wire ST
General information	
Firmware version	V1.1
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC03
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V11 SP2 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Input current	
Current consumption, max.	37 mA; without encoder supply
Encoder supply	
24 V encoder supply	
24 V	Yes
Short-circuit protection	Yes
Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s

	6ES7134-6GD00-0BA1
Power loss	
Power loss, typ.	0.85 W; without encoder supply voltage
Address area	
Address space per module	
Address space per module, max.	8 bytes; + 1 byte for QI information
Analog inputs	
Number of analog inputs	4
Maximum permitted input current for current input (destruction limit)	50 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on the parameter assignment of the enabled channels)
A/D resolution at analog input	16 bits
Analog inputs, configurable	Yes
Configurable input variable	Yes
Input ranges	
Voltage	No
Current	Yes
Thermocouple	No
Resistance thermometer	No
Resistance	No
Input ranges (rated values), currents	
0 to 20 mA	Yes
Input resistance (0 to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage in 2-wire operation
-20 to +20 mA	Yes
Input resistance (-20 to +20 mA)	100 Ω
4 to 20 mA	Yes
Input resistance (4 to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage in 2-wire operation
Cable length	
Cable length shielded, max.	1000 m
Analog value formation	
Measuring principle	Integrating (sigma-delta)
Integration and conversion time / resolution per channel	
Resolution with overrange (bits including sign), max.	16 bits
Integration time configurable	Yes
Interference suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
Conversion time (per channel)	180 / 60 / 50 ms

	6ES7134-6GD00-0BA1
Measured value smoothing	
Configurable	Yes
Setting: None	Yes
Setting: Weak	Yes
Setting: Medium	Yes
Setting: Strong	Yes
Encoders	
Connection of the signal transmitters	
for current measurement as 2-wire transducer	Yes
• Load of the 2-wire transducer, max.	650 Ω
for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	± 0.01 %
Temperature error (in relation to input range), (+/-)	± 0.005 %
Crosstalk between inputs, min.	50 dB; applies to up to +/-5 V overvoltage in other channels
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	± 0.05 %
Operational limit in the entire temperature range	
Current in relation to input range, (+/-)	± 0.5 %
Basic error limit (operational limit at 25 °C)	
Current in relation to input range, (+/-)	± 0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
Series-mode interference (peak of the interference < nominal value of the input range), min.	70 dB
Common mode voltage, max.	10 V
Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; for 4 to 20 mA
Short-circuit	Yes; 2-wire operation: Short-circuit of the encoder supply to ground or short-circuit of an input to the encoder supply
Group error	Yes
Overflow/underflow	Yes
Diagnostics display LED	
Monitoring of the supply voltage (PWR LED)	Yes; green LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red LED

	6ES7134-6GD00-0BA1
Electrical isolation	
Electrical isolation of channels	
Between the channels	Yes; per channel group between the group of the 2-wire current inputs and the group of the 4-wire current inputs
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes; only for 4-wire transducer
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic isolation)
Between the inputs (UCM)	10 VDC
Insulation	
Insulation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFINET.

Measuring type	Measuring range	Diagnostics				
		No supply voltage L+	Short-circuit to M	Overflow	Underflow	Wire break
deactivated		*	*	*	*	*
Current (4-wire connection)	0..20 mA	x	-	x	x	-
	4..20 mA	x	-	x	x	x
	±20 mA	x	-	x	x	-
Current (2-wire connection)	0..20 mA	x	x	x	x	-
	4..20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFIBUS.

Measuring type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to M	Overflow/ Underflow	Wire break
deactivated		*	*	*	*
Current (4-wire connection)	0..20 mA	x	-	x	-
	4..20 mA	x	-	x	x
	±20 mA	x	-	x	-
Current (2-wire connection)	0..20 mA	x	x	x	-
	4..20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 contains the diagnostics for the entire module.

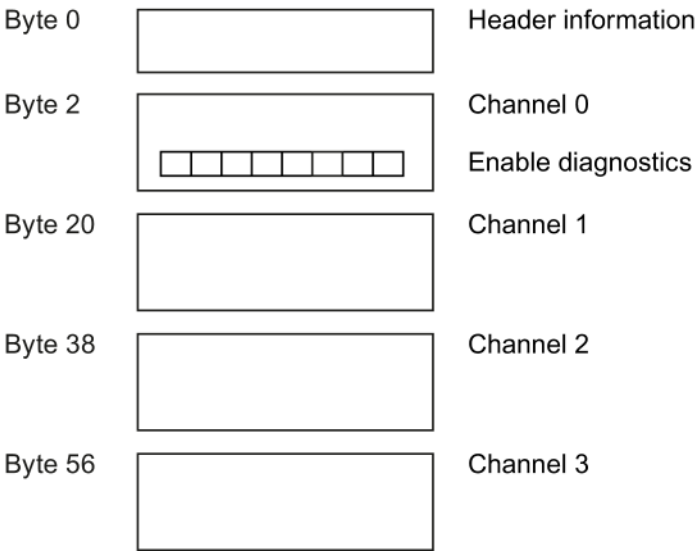


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

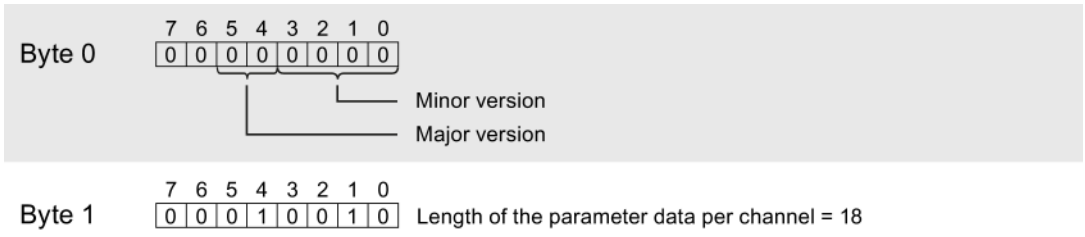
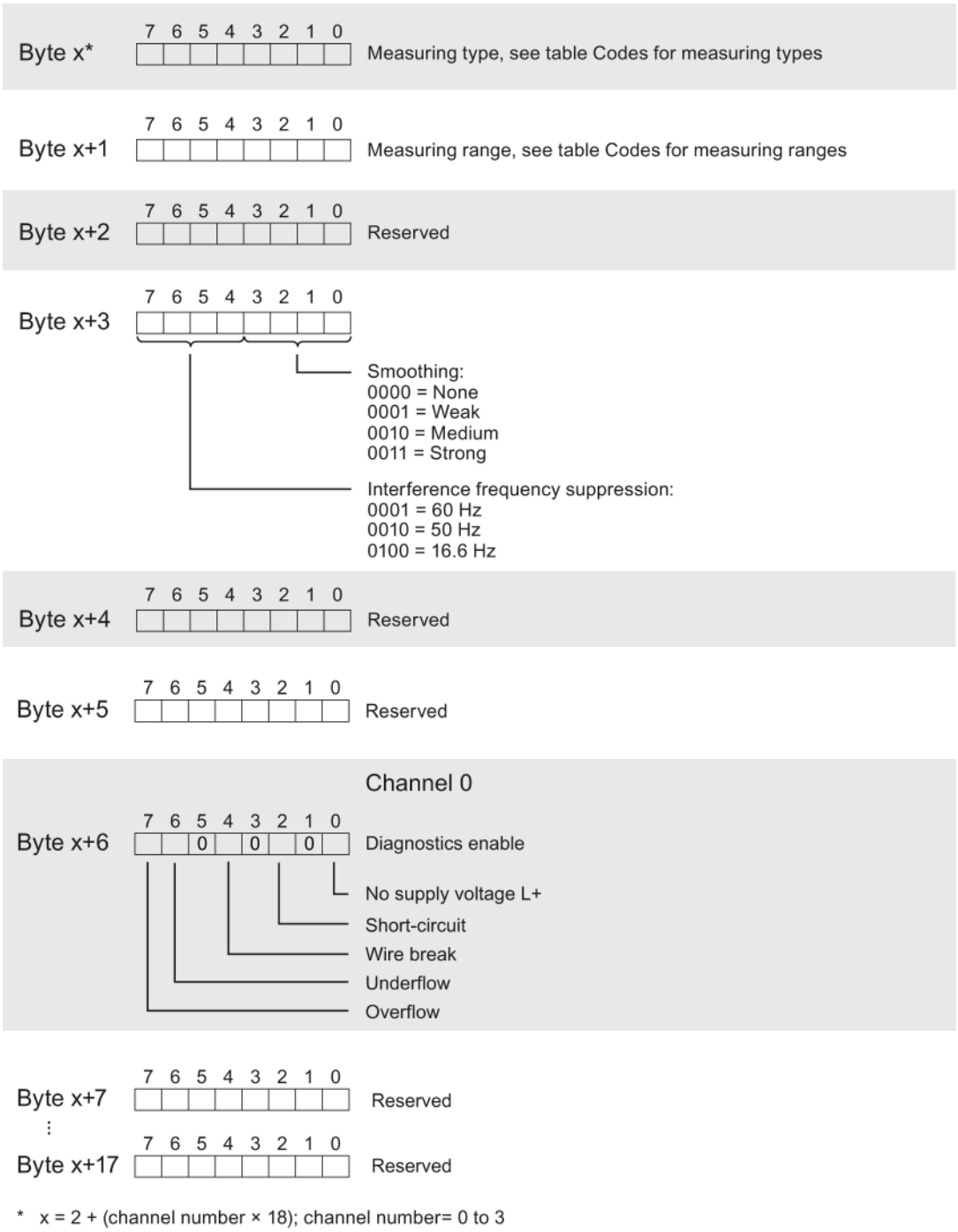


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 18); channel number= 0 to 3

Figure A-3 Structure of byte x to x+17 for channels 0 to 3

Codes for the measuring type

The following table contains the codes for the measuring types of the analog input module. You must enter these codes at byte x (see previous figure).

Table A- 1 Codes for the measuring type

Measuring type	Coding
Deactivated	0000 0000
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for the measuring range

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table A- 2 Codes for the measuring range

Measuring range	Coding
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011
±20 mA	0000 0100

Representation of analog values

B

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its assigned parameters.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Note

The digitalized temperature values are the result of a conversion in the analog module. The following resolution therefore does not apply to temperature values.

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table B- 4 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	Hex.	±20 mA	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table B- 5 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	Hex.	0 to 20 mA *	4 to 20 mA	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measuring type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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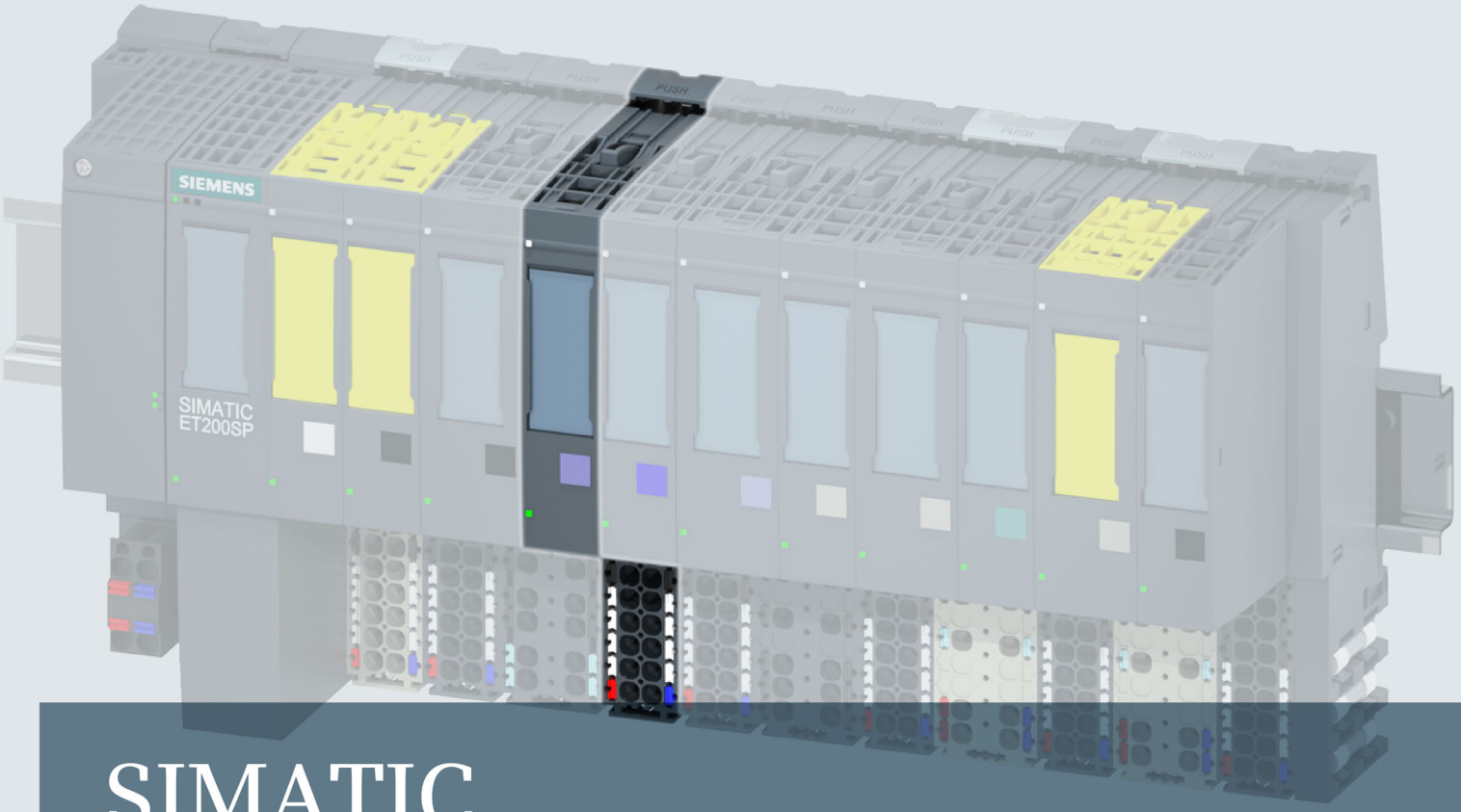

SIMATIC

ET 200SP

Analog input module AI 4xI 2-wire 4...20mA HART (6ES7134-6TD00-0CA1)

Manual

Edition 11/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Analog Input Module
AI 4xI 2-wire 4…20mA HART

Manual

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Legal information

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indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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Preface

Validity of the documentation

This manual describes the analog input module AI 4xI 2-wire 4…20mA HART, article number 6ES7134-6TD00-0CA1.

It supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics relating to your automation system.

The complete documentation for the ET 200SP system consists of the system manual, function manuals, and manuals for the individual devices.

The STEP 7 information system (online help) also supports you in configuring and programming your automation system.

Overview of documentation for analog input module AI 4xI 2-wire 4…20mA HART

The following table lists further documentation that you will need when using analog input module AI 4xI 2-wire 4…20mA HART.

Table 1- 1 Documentation

Topic	Documentation	Most important contents
System description	System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning
Analog value processing	Function Manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, assembly system) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostic evaluation
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications

SIMATIC manuals

The latest manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Article number

6ES7134-6TD00-0CA1

View of the module

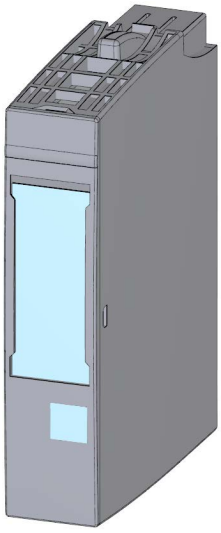


Figure 2-1 View of the AI 4xI 2-wire 4…20mA HART module

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Measurement type current for 2-wire HART transducer
- Input range 4 mA to 20 mA
- Resolution 16 bits including sign
- Configurable diagnostics per channel

The module supports the following functions:

- HART communication (Rev. 5 to Rev. 7)
- Firmware update
- I&M identification data
- Configuration in RUN
- Value status (PROFINET IO only)
- Up to four HART variables directly in the input address space

You can configure the module with STEP 7 in the TIA Portal as well as with HW Config and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Terminal assignment

The AI 4xI 2-wire 4…20mA HART analog module can be used with all A0 or A1-type BaseUnits.

You connect the transducers to the BaseUnit of the analog module. The infeed of the supply voltage at the light BaseUnit of the associated potential group supplies the module and the transducers connected to the encoder supply voltages.

A new potential group always begins with a light BaseUnit.

BaseUnit

The BaseUnit is not included in the product package of the module and must be ordered separately.

An overview of the BaseUnits that you can use with the analog module can be found in Product information for documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864)

Information regarding selection of the suitable BaseUnit can be found in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and in the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521).

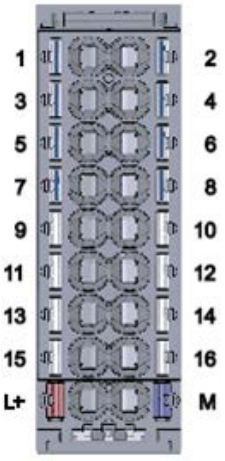
Information regarding wiring of the BaseUnit, creating the cable shield, etc., can be found in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) in the section "Connecting".

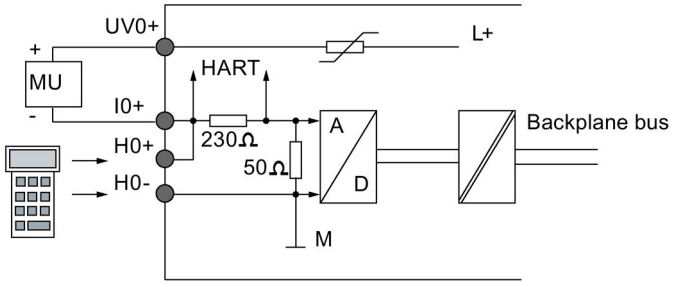
Note

The first BaseUnit of a station must be a light BaseUnit. Also keep this in mind during the configuration.

General terminal assignment

Table 3- 1 Terminal assignment of the AI 4xI 2-wire 4…20mA HART (6ES7134-6TD00-0CA1)

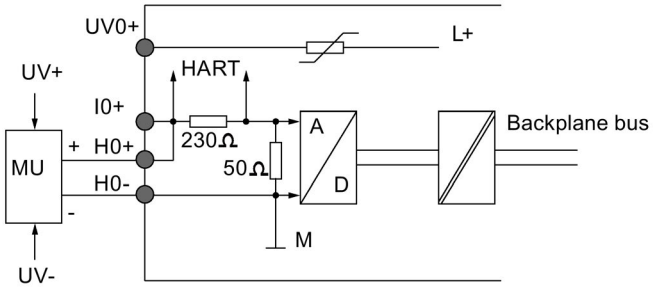
<table>
<tr><th colspan="7">Terminal assignment for AI 4xI 2-wire 4…20mA HART (6ES7134-6TD00-0CA1)</th></tr>
<tr><th>Terminal</th><th>Assign-ment</th><th>Terminal</th><th>Assign-ment</th><th>Explanation</th><th>BaseUnit</th><th>Color identification label (terminals 1 to 16)</th></tr>
<tr><td>1</td><td>H_0+</td><td>2</td><td>H_1+</td><td rowspan="2">HART test connections (terminals 1 to 8):
• Hn+: HART signal "+", channel n
• Hn-: HART signal "-", channel n</td><td rowspan="9">A0
A1</td><td rowspan="9"> 

Recommended color identification label: CC03
6ES7193-6CP03-2MA0</td></tr>
<tr><td>3</td><td>H_2+</td><td>4</td><td>H_3+</td></tr>
<tr><td>5</td><td>H_0-</td><td>6</td><td>H_1-</td><td rowspan="2">2-wire connection (terminals 9 to 16):
• U_{Vn}: Supply voltage channel n
• I_n+: Input signal "+", channel n</td></tr>
<tr><td>7</td><td>H_2-</td><td>8</td><td>H_3-</td></tr>
<tr><td>9</td><td>U_{V0}</td><td>10</td><td>U_{V1}</td><td rowspan="4"></td></tr>
<tr><td>11</td><td>U_{V2}</td><td>12</td><td>U_{V3}</td></tr>
<tr><td>13</td><td>I_0+</td><td>14</td><td>I_1+</td></tr>
<tr><td>15</td><td>I_2+</td><td>16</td><td>I_3+</td></tr>
<tr><td>L+</td><td>24 VDC</td><td>M</td><td>M</td><td></td><td></td><td></td></tr>
<tr><td colspan="7">2-wire connection using the example of channel 0
 

The HART test terminals Hn+ / Hn- are used for optional measuring of the HART signal, e.g., with an external hand-held device.</td></tr>
</table>

Terminal assignment for AI 4xI 2-wire 4…20mA HART (6ES7134-6TD00-0CA1)

4-wire connection using the example of channel 0



A non-isolated 4-wire connection is possible by connecting the transducer to the HART test terminals Hn+ and Hn-.

3.2 Schematic circuit diagram

Block diagram

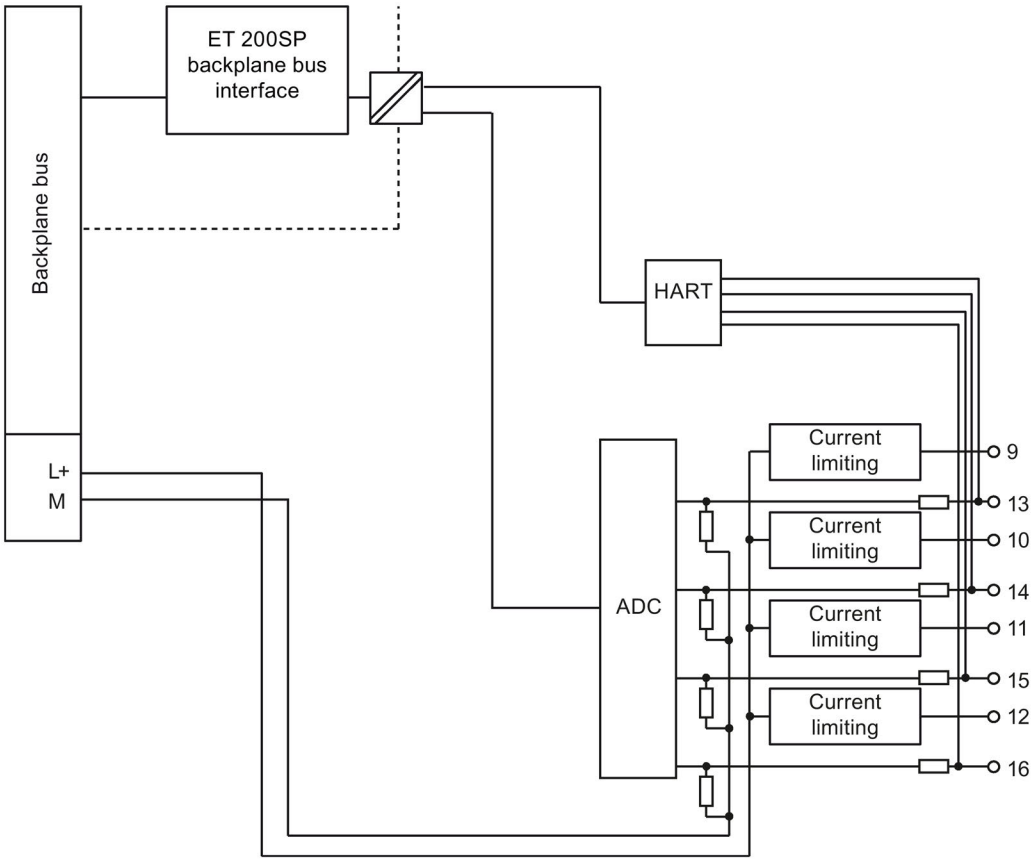


Figure 3-1 Block diagram for AI 4xI 2-wire 4…20mA HART

Supply voltage L+/M

You connect the supply voltage (24 V DC) to terminals L+ and M. An internal circuit-breaker protects the analog module from reverse polarity. The analog module monitors whether the supply voltage is connected.

HART function

4

Definition

"HART" stands for "Highway Addressable Remote Transducer".

The HART functionality also enables you to use the AI 4xI 2-wire 4…20mA HART analog module to exchange data with the connected field devices. The HART protocol is generally accepted as a standard protocol for communication with intelligent field devices: HART is a registered trademark of the HART Communication Foundation (HCF), which owns all the rights to the HART protocol. You can find detailed information about HART in the HART specification.

Advantages of HART

Using the AI 4xI 2-wire 4…20mA HART analog module offers the following advantages:

- Connection compatibility with standard analog modules: Current loop 4 - 20 mA
- Additional digital communication using the HART protocol
- Numerous field devices with HART functions are in use
- The option to use HART is integrated in the S7 system by means of the AI 4xI 2-wire 4…20mA HART analog module.

Use in the system

The AI 4xI 2-wire 4…20mA HART analog module is used in the distributed I/O connected to PROFIBUS DP or PROFINET IO.

You can connect a field device to any channel: The AI 4xI 2-wire 4…20mA HART analog module operates as a HART master, monodrop; the field devices operate as HART devices.

Typical applications

The following applications are typical:

- Commissioning of field devices (centralized parameter assignment)
- Online modification of field device parameters
- Information, maintenance and diagnostic displays for the field devices
- Integration of configuration tools for field devices via the HART interface

4.1 How HART works

Introduction

The HART protocol describes the physical form of the transfer: transfer procedures, message structure, data formats and commands.

HART signal

The figure below shows the analog signal with the modulated HART signal (FSK method), which consists of sine waves of 1200 Hz and 2200 Hz and has a mean value of 0. It can be filtered out using an input filter so that the original analog signal is available again.

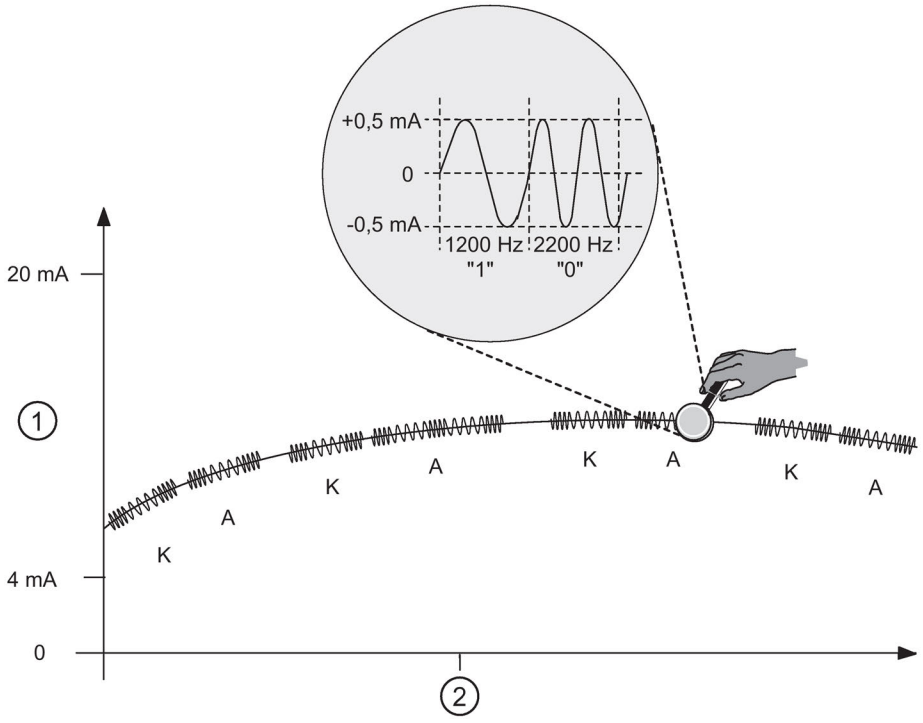


Figure 4-1 The HART signal

①	Analog signal
②	Time (seconds)
K	Command
A	Response

HART communication

The AI 4xI 2-wire 4…20mA HART analog module processes the HART communication in multiplex mode, i.e., consecutively channel-by-channel. As a result, HART commands of the individual channels influence the speed of the HART processing of the other channels.

When HART mode is enabled, the analog module autonomously sends HART commands to the connected field devices. This takes place alternatingly on a channel-specific basis with any pending external HART commands that arrive via the command interface of the module, see section 4.3 "HART command interface".

HART commands

The assignable properties of the HART field devices (HART parameters) can be set with HART commands and read by means of HART replies. The HART commands and their parameters are divided into three groups with the following properties:

- Universal
- Common practice
- Device-specific

Universal commands must be supported by all manufacturers of HART field devices and common practice commands should be supported. There are also device-specific commands that apply only to the particular field device.

Examples of HART commands

The following two tables show examples of HART commands:

Table 4- 1 Examples of universal commands

Command	Function
0	Read manufacturer and device type - only with this command 0 can field devices be addressed by means of a short frame address
11	Read manufacturer and device type
1	Read primary variable and unit
2	Read current output and percent of range, digitally as floating-point number (IEEE 754)
3	Read up to four pre-defined dynamic variables (primary variables, secondary variables, etc.)
13, 18	Read or write tag, descriptor and date (data included in transmission)

Table 4- 2 Examples of common practice commands

Command	Function
36	Set upper range value
37	Set lower range value
41	Perform self-test
43	Set the primary variable to zero
109	Switch burst mode on or off

Structure of the HART protocol

Each HART frame sent from the analog module to the connected field device (request frame) and each HART frame from the field device (response frame) has the following basic structure.

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK

PREAMBLE: Bytes (0xFF) for synchronizing.
5 to 20 bytes depending on parameter assignment

STRT: Start character (start delimiter)

ADDR: Address of the field device (1 byte; short address or 5 bytes; long address)

COM: HART command number

BCNT: Byte count, number of bytes to follow without checksum

STATUS: HART device status (1st and 2nd status bytes). Only present for a response frame. For structure of HART device status, see below.

DATA: Transferred user data / parameters, quantity depending on command (0…230 bytes)

CHK: Checksum

With the exception of the preamble bytes, this structure is contained in the communication data of the HART command interface. See section HART request and response data records (Page 64).

HART replies always contain data. Status information (HART device status; 1st and 2nd status bytes) is always sent together with a HART response. You should evaluate these to make sure the response is correct.

Structure of HART device status (1st and 2nd status bytes)

Table 4- 3 1st status byte

When Bit 7 = 1: "Communication error"	
Bit 6 = 1	Parity error
Bit 5 = 1	Overflow
Bit 4 = 1	Framing error
Bit 3 = 1	Checksum error
Bit 2 = 0	Reserved
Bit 1 = 1	Overflow in the receive buffer
Bit 0 = 0	Reserved
When Bit 7 = 0: "Specific according to the response frame"	

Table 4- 4 2nd status byte

Bit 7 = 1	Device fault
Bit 6 = 1	Configuration changed
Bit 5 = 1	Startup (cold start)
Bit 4 = 1	Additional status information available
Bit 3 = 1	Fixed analog output current setting
Bit 2 = 1	Analog output current saturated
Bit 1 = 1	Secondary variable outside the limits
Bit 0 = 1	Primary variable outside the range

HART-Fast-Mode

The AI 4xI 2-wire 4…20mA HART analog module supports the processing of HART commands as a SHC sequence ("Successive HART Command").
That is, if the analog module detects a HART command with SHC bit set for a channel, the complete HART command processing on the HART analog module is reserved for this channel for approximately 2 s. For all other channels of the analog module, no HART frame processing occurs during this time, see section HART communication interface (Page 26)

Note

- During the time a HART channel of the AI 4xI 2-wire 4…20mA HART analog module is processing an SHC sequence, and thus the complete HART processing of the module is reserved for this channel, the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
- HART commands for other channels are not processed and are acknowledged correspondingly.

Burst mode

The AI 4xI 2-wire 4…20mA HART analog module does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

4.2 Use of HART

System environment for the use of HART

To use an intelligent field device with HART functionality, you require the following system environment:

- Current loop 4 - 20 mA

  Connection of the transducers to the AI 4xI 2-wire 4…20mA HART analog module

- HART configuration tool "Client":
  You can assign the HART parameters using an external hand-held operating device (HART Handheld) or a HART configuration tool (PDM). Both assume the function of a "client":

  The configuration tool goes through the AI 4xI 2-wire 4…20mA HART analog module whereas the HART Handheld is connected directly in parallel with the field device. See terminal assignment "HART test connections (terminals 1 to 8)" in the section 3.1 "Terminal assignment".

  PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*.

- HART system connection:
  The AI 4xI 2-wire 4…20mA HART analog module assumes the function of a "master" by forwarding the commands received from the HART configuration tool or as programmed commands from an S7 user program, for example, to the intelligent field device and sending back the replies. Data records that are transferred via the ET 200SP I/O bus serve as the interface of the AI 4xI 2-wire 4…20mA HART analog module. The data records must be created and interpreted by the client. .

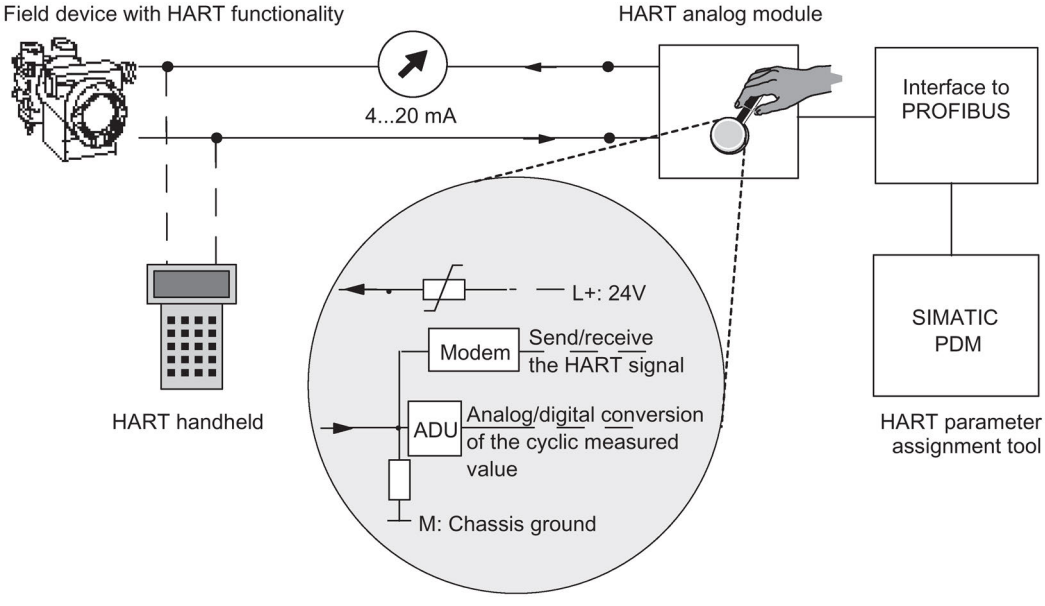


Figure 4-2 System environment for the use of HART

Error management

The two HART status bytes (HART device status) that are transferred with each response of the field device contain error information about the HART communication, HART command, and device status.
This is evaluated by the AI 4xI 2-wire 4…20mA HART analog module and made available in the system via S7 diagnostic messages.

Configuration/commissioning

You configure the AI 4xI 2-wire 4…20mA HART analog module in the SIMATIC system with STEP 7 or the TIA Portal. You assign parameters for the individual channels with respect to the actual analog value acquisition and the use of HART variables in the input address space of the module.
You can configure one field device per channel. By means of this configured field device, the configuration / parameter assignment of the connected field device is then carried out using PDM or the EDD for the ET 200SP.

It is also possible to configure the AI 4xI 2-wire 4…20mA HART analog module using a GSD file for PROFIBUS DP and PROFINET IO. However, in this case, direct configuration / parameter assignment of the connected field devices is not possible.

Parameter reassignment of the field devices

The HART analog module generally accepts parameter reassignments for field devices. Access rights can only be allocated in the configuration tool.

For parameter reassignment of the field devices connected to the HART analog module, proceed as follows:

1. You start the parameter reassignment of a field device using a HART command that you enter using the SIMATIC PDM configuration tool or as a programmed command in the STEP 7 user program.
2. After you have reassigned the parameters of a HART field device, the corresponding bit is set in the device status of the connected field device (in the 2nd status byte).
3. Because of the parameter reassignment of the field device, the HART analog module triggers a diagnostic interrupt "Configuration changed", provided this diagnostic interrupts is enabled. See section 7.3 "Diagnostic alarms". This diagnostic interrupt is to be regarded as information and not as an error and is automatically deleted again by the analog module after approximately 1 minute.

A diagnostic interrupt can also be triggered, if enabled, when parameter reassignment is carried out with the hand-held device.

See also

Terminal assignment (Page 15)

Diagnostics alarms (Page 46)

4.3 HART communication interface

Data records

The HART commands are sent as so-called external HART requests from the client (e.g., PDM or the STEP 7 user program) to the connected field device via data records. The response of the field device is made available again in the system via data records.

HART communication may only be handled by one client (e.g., PDM) per channel. If a channel is handled by several clients, the response made available by the module cannot be allocated to one client with certainty. The AI 4xI 2-wire 4…20mA HART analog module does not support client management.

Each client/channel is allocated fixed data records:

Table 4- 5 Structure of the data records

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87

The corresponding data records are transferred to the module with the "WRREC" instruction and read by the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS.

Errors during interpretation of the request data record are signaled in the corresponding response data record. The faulty request can be read back again using the request data record.

Rules

- After having written a request data record, a client must read the response data record before it may write another request data record.
- The client can evaluate the "processing status" in the response data record: If the "processing status" indicates "successful" or "error," the response data record contains current response data or error displays.
- The response data record must always be read completely because the analog module may modify the data record after the initial reading with "successful" or "error" status. If the processing status in the response data record indicates "successful" or "error", the data record contains current response data or error displays.

- The client may only write a request data record to the module again when it has read the response to the previously written request data record via the corresponding response data record. Otherwise, the response from the module is overwritten.
- The STATUS component in the response frame (HART device status in the response data) provides information on whether errors have occurred and, if so, which errors.

Each request is stored on a channel-specific basis, and the corresponding request data record is disabled. Another writing of the same request data record is thus not possible and is acknowledged with BUSY.
The disable of the request data record is reset after the termination or completion of the requested HART command.

SHC sequence

If a HART command is sent to the module with a set SHC bit, then this channel is reserved for HART commands for 2 seconds. This means that no more internal HART commands are sent to the field device with this channel.

Each time a HART command with a set SHC bit is sent, the module reserves this channel again for another 2 seconds for HART commands. If a HART command without a set SHC bit is detected for this channel, or if no further command occurs for this channel within 2 seconds after the previous HART command, then command 3 or 9 for reading the HART variables is cyclically sent to the field device for this channel.

4.4 HART variables

Introduction

Numerous HART field devices make available additional measured quantities (e.g. sensor temperature).

A maximum of four HART variables supported by the connected field device can be cyclically read per channel with activated HART functionality. The HART variables are read automatically using HART command 3 (for field devices with HART Rev. 5) or command 9 (for field devices with HART Rev. 6 or higher).

These four HART variables per channel are always stored in HART variable data record 121 and can be read at any time. See section HART variable data record (Page 61).

In addition, a maximum of 4 HART variables can be configured directly in the input address space of the AI 4xI 2-wire 4…20mA HART analog module. You assign the respective HART variables to a channel in the properties dialog for the module. The parameter assignment uses parameter data record 140, see section Parameter assignment and structure of the HART mapping parameters (Page 57). This makes it easy for you to process measured values directly from the field device as input data in the automation device.

Address assignment

Provided you map HART variables in the input address space of the module by means of the configuration tool or selection of the appropriate configuration, 20 bytes are always additionally allocated for the HART variables.

Configuration of HART variables

You can configure up to 4 HART variables for each channel

- PV (Primary Variable)
- SV (Secondary Variable)
- TV (Tertiary Variable)
- QV (Quaternary)

When HART mode is enabled, the AI 4xI 2-wire 4…20mA HART analog module autonomously and cyclically reads the variables supplied by the connected field devices and makes them available in the input address space according to the configuration.

Each HART variable consists of a 4-byte value and a quality code byte.

Quality code

The quality code describes the process status of the corresponding HART variable.

Basic structure of the quality code

Bit	7….6	5....2	1…0
	Quality 0 0: Bad 0 1: Uncertain 1 0: Good 1 1: Good	Sub-status Coded according to "PROFIBUS PA Profile for Process Control Devices"	Limits 0 0: OK 0 1: Low limit 1 0: High limit 1 1: Constant

The quality codes generated by the AI 4xI 2-wire 4…20mA HART analog module are based on the HART Revision of the utilized field device.

Field devices with HART Revision 5

A quality code is formed exclusively from the 1st and 2nd status bytes (HART device status) of the response frames (HART command 3).

Quality code	Meaning (process status)	
80_H	Value is okay	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Configuration changed • Startup (cold start) • Fixed analog output current setting
78_H	Value is uncertain	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Additional status information available • Analog output current saturated • Secondary variable outside the limits • Primary variable outside the range
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module startup
00_H	Initialization value from S7 system	

Field devices with HART Revision 7 or higher

The quality code is formed from the 1st status byte (HART device status) and the "Device variable status" (DVS) of the response frames (HART command 9).

Quality code	Meaning (process status)	
80_H	Value is okay	
89_H	"Good" with "Low limit"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above).
$8A_H$	"Good" with "High limit"	
$28_H...2B_H$	"Bad"	
$68_H...6B_H$		
$78_H...7B_H$	"Manual" or "Fixed" (manually controlled or fixed value)	
$88_H...8B_H$	"More device variable state available" (additional status information available)	
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module startup
00_H	Initialization value from S7 system	

Parameters 5

5.1 Parameters of the AI 4xI 2-wire 4…20mA HART

You specify how the AI 4xI 2-wire 4…20mA HART analog module operates using parameters.

The parameters are subdivided into:

- Channel or technology parameters (data record 128)

  With PROFIBUS DP GSD configuration, there is a reduced configuration via the startup configuration (Prm frame).

- Parameters that define the display of HART variables in the address space of the module; HART mapping parameters (data record 140)

With configuration in the user program, the parameters are transferred to the modules via data records with the "WRREC" instruction; see section Parameter assignment and structure of the channel/technology parameters (Page 54).

5.1.1 Channel/technology parameters

Parameters of the AI 4xI 2-/4-wire ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

Table 5- 1 Configurable channel/technology parameters and their default settings

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics encoder supply	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics overflow	• Disable • Enable	Disable	Yes	Channel	Module [2]

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics underflow	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics wire break	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics HART	• Disable • Enable	Disable	Yes	Channel	Module [2]
Measuring type/range	• Disabled • Current (2-wire transducer) 4..20 mA • Current (2-wire transducer) 4..20 mA HART	Current (2-wire transducer) 4..20 mA HART	Yes	Channel	Channel
Smoothing	• none • 4-fold (weak) • 16-fold (medium) • 32-fold (strong)	none	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz (integration time 16.6 ms) • 50 Hz [1] (integration time 20 ms) • 10 Hz (integration time 100 ms)	50 Hz	Yes	Channel	Module [2]
Current limit for wire break diagnostics	• 1.185 mA • 3.6 mA	1.185 mA	Yes	Channel	Cannot be changed[2]
Number of HART preamble bytes	5…20	5	Yes	Channel	Cannot be changed[2]
Number of HART repetitions	0…255	5	Yes	Channel	Cannot be changed[2]
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	No	Module	Module

[1] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

[2] Because the PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes per ET 200SP station, the options for parameter assignment are limited. In this case, the parameter assignment uses data record 245. If required, you can assign this parameter using data record 128 as described in the "GSD File PROFINET IO" column (see table above).

Note

Unused channels

"Disable" unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always supplies the analog value $7FFF_H$.

See also

Parameter assignment and structure of the channel/technology parameters (Page 54)

5.1.2 Explanation of the channel/technology parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics encoder supply

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply.

The short-circuit and underflow diagnostics can be enabled simultaneously. If both diagnostic events occur simultaneously, the short-circuit diagnostics information is output.

Diagnostics overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics wire break

Enabling of the diagnostics when the module has no current flow at the input or the current flow at the input is below the configured wire break limit.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics information is output.

Diagnostics HART

Enabling of the diagnostics of the HART frame-specific monitoring and the status information supplied by the connected field device in the HART frame (HART device status).

Current limit for wire break diagnostics

You use this to specify the current limit for detecting wire breaks. If the current falls below the configured wire break limit, the measured value is declared invalid and, if wire break diagnostics is enabled, corresponding diagnostics information is generated. When value status is configured, the analog value is marked as invalid.

With a wire break limit of 3.6 mA, the measured value becomes invalid when the current falls below 3.6 mA and is marked as valid again when it rises above 3.8 mA.

There is no hysteresis for a wire break limit of 1.185 mA.

Measuring type/range

The AI 4xI 2-wire 4…20mA HART analog input module has the following measuring ranges:

Table 5- 2 Measuring ranges

Measuring type	Measuring range	Resolution
Disabled	-	-
Current (2-wire transducer)	4 to 20 mA	15 bits + sign
Current (2-wire transducer)	4 to 20 mA HART	15 bits + sign

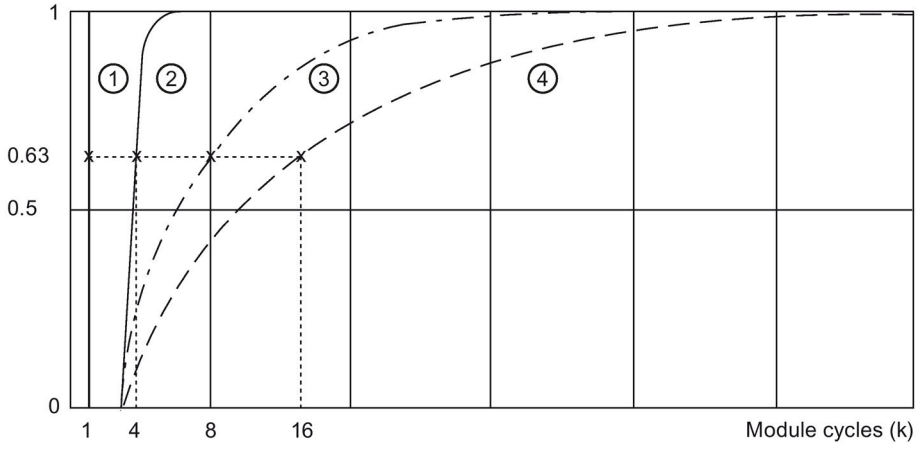
An overview of the measuring range as well as overflow, overrange, etc., can be found in the section Analog value representation (Page 71) and in Analog Value Processing function manual.

Smoothing

The individual measured values are smoothed by filtering. Smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 5-1 Smoothing of the analog value

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC supply system may interfere with the measured value, in particular in low voltage ranges. .

Number of HART preamble bytes

Specifies the number of preamble bytes that the module prefixes to each HART frame to be sent (FF_H). These bytes are used for synchronizing the frames.

Number of HART repetitions

Specifies the number of HART frame repetitions. If the analog module receives no response or receives a response with error to a HART frame sent to the field device, the frame is accordingly repeated, i.e., resent to the field device.

Because HART communication of the individual channels uses multiplex operation, faulty HART frames affect the other channels when the number of HART repetitions is high. In other words, the other channels are processed less frequently.

Potential group

Specifies that a BaseUnit with supply voltage infeed is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

See also

Parameters of the AI 4xI 2-wire 4…20mA HART (Page 31)

5.1.3 HART mapping parameters

The HART mapping parameters allow a maximum of 4 HART variables to be configured (mapped) in the address space of the module.

Each HART variable occupies 5 bytes of input data. As soon as you configure (map) at least one HART variable in the input address space, the addresses for all four variables are occupied (20 bytes).

With PROFIBUS DP GSD configuration with HART variables, the HART variables cannot be directly configured. The four secondary variables are supplied in ascending channel order in the address space of the module.
When required, this can be changed using data record 140; see section Parameter assignment and structure of the HART mapping parameters (Page 57).

Parameters

Table 5- 3 Configurable HART mapping parameters

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 0	Channel	0…3	0	Yes	0
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 1	Channel	0…3	0	Yes	1
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 2	Channel	0…3	0	Yes	2
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 3	Channel	0…3	0	Yes	3
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary

Configuring/address space

6

6.1 Configuring

You configure the AI 4xI 2-wire 4…20mA HART analog module

- In the TIA Portal V13.0.1 or higher
- With STEP 7 V5.5 + SP4 or higher (HSP0263)
- Using GSD/GSDML

The GSD files for the ET 200SP Distributed I/O System can be downloaded from the Internet:

GSDML (http://support.automation.siemens.com/WW/view/en/57138621)

GSD (http://support.automation.siemens.com/WW/view/en/ 73016883)

Configuration options

The following configurations are possible:

- Without value status and without HART variables ("AI 4xI 2-wire 4…20mA HART")
- Without value status, with HART variables ("AI 4xI 2-wire 4…20mA HART, 4 variables")
- With value status and without HART variables ("AI 4xI 2-wire 4…20mA HART, QI")
- With value status, with HART variables ("AI 4xI 2-wire 4…20mA HART, 4 variables, QI")

With GSD/GSDML configuration, you must select one of the possible configurations directly.

With STEP 7 configuration (TIA Portal or HW Config), the configuration occurs indirectly via the parameters.

Restrictions

- The module can be operated only downstream of a Standard IM or High-Feature IM.
- Value status is not available for a PROFIBUS DP station.
- Downstream of a Standard IM (V1.1), the module can be operated only in the "Without value status and without HART variables" configuration. The module downstream of a Standard IM (V1.1) is not available in the TIA Portal.

6.2 Address space

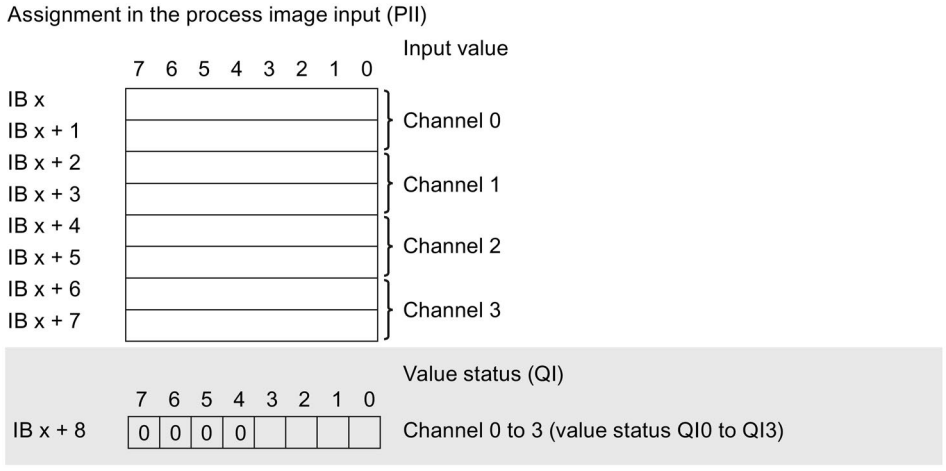
The following figure shows the allocation of the address space of the AI 4xI 2-wire 4…20mA HART module for a configuration with value status (Quality Information, QI) and with HART variables.

The addresses for the value status are only available if the value status has been enabled or the corresponding configuration has been configured from the GSDML.

The addresses for the HART variables are only available if configuration/parameter assignment of the HART variables has been carried out or the corresponding configuration has been configured from the GSD/GSDML.

If the HART variables are configured and there is no value status configuration or parameter assignment, the HART variables begin directly after the analog values, thus starting from IB x + 8.

Table 6- 1 Address space of analog input module AI 4xI 2-wire 4…20mA HART



IB x+9 …. IB x+12	Value	Configured HART variable 0
IB x+13	Quality code	
IB x+14 …. IB x+17	Value	Configured HART variable 1
IB x+18	Quality code	
IB x+19 …. IB x+22	Value	Configured HART variable 2
IB x+23	Quality code	
IB x+24 …. IB x+27	Value	Configured HART variable 3
IB x+28	Quality code	

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to the corresponding channel. The provide information about the validity of the analog value, namely irrespective of the diagnostics enables.

Bit = 1: There is no error in the analog value or the analog value acquisition of the channel.

Bit = 0: The analog value of the channel cannot be correctly acquired.
The channel is disabled; there is a fault in the wiring or module.

Evaluating HART variables

If you have configured (mapped) HART variables for the analog module, four HART variables with 5 bytes each are stored in the input address space.

Each HART variable consists of a 4-byte real value and a quality code byte. The quality code describes the validity of the value; see section HART variables (Page 28) .

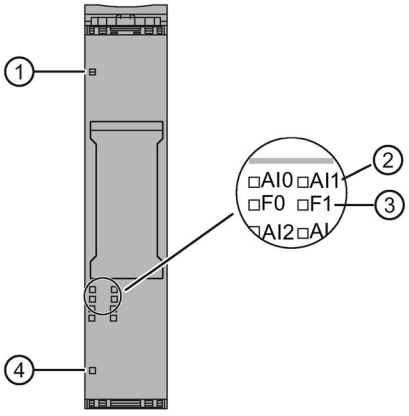
Interrupts/diagnostics alarms

7

7.1 Status and error displays

LED displays

The figure below shows the status and error displays of the AI 4xI 2-wire 4…20mA HART analog input module.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 7-1 LED displays

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostic alarms can be found in the section Diagnostics alarms (Page 46).

Table 7- 1 Status display of the channel status/channel fault LEDs

LEDs		Meaning
Channel status	Channel fault	
Off	Off	Channel disabled or module switched off
On	Off	Channel enabled and no channel diagnostics present
Off	On	Channel enabled and channel diagnostics present
On	On	Channel enabled and **only** HART channel diagnostics present

Table 7- 2 DIAG LED error display

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP is not OK or switched off
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics, at least one error is currently present

Table 7- 3 Status display of the PWR LED

PWR LED	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

7.2 Interrupts

The AI 4xI 2-wire 4…20mA HART analog input module supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt for the following events:

- Channel/component temporarily unavailable
- Short-circuit / Overload of encoder voltage
- Wire break
- Low limit violated
- High limit violated
- Error
- No supply voltage L+
- HART communication error or HART field device error

7.3 Diagnostics alarms

A diagnostic alarm is generated for each detected diagnostic event. The DIAG LED flashes on the module.

There is additionally a channel-specific display of the diagnostics through the corresponding channel fault/channel status LEDs.

The diagnostic alarms can, for example, be read from the diagnostic buffer of the CPU or be displayed in STEP 7 using the Online and Diagnostics view. You can evaluate the error codes with the user program.

Table 7- 4 Diagnostic alarms, their meaning and how to deal with them

Diagnostic alarm	Error code	Meaning	Remedy
Channel/component temporarily unavailable	$1F_H$	• Update of the firmware is being performed or has been canceled. The module does not perform any measurements during this time.	
Short-circuit Overload of encoder voltage *	$10E_H$	• Short-circuit of the encoder supply to M • Short-circuit of the input to the encoder supply • Overload of the encoder supply	• Correct the module/encoder tuning
Wire break	6_H	• Impedance of encoder circuit too high. • Wire break between the module and sensor • Channel not connected (open)	• Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section • Connect the cable • Disable diagnostics • Connect the sensor contacts
High limit violated	7_H	• The analog value is above the overrange.	• Correct the module/encoder tuning
Low limit violated	8_H	• The analog value is below the underrange.	• Correct the module/encoder tuning
Error	9_H	• Internal module error occurred.	• Replace module
No supply voltage	11_H	• No or insufficient supply voltage L+	• Check wiring of the supply voltage L+ on the BaseUnit • Check BaseUnit type

Diagnostic alarm	Error code	Meaning	Remedy
HART communication error	141_H	• HART field device is not responding • Timing error • HART field device has not understood the sent command (1st status byte)	• Check the process wiring • Correct the parameter assignment • Set output current of ≥4 mA • Increase the number of assigned repetitions
HART primary variable outside the range	142_H	• Incorrect parameters in the HART field device • HART field device is at "Primary variable outside the limits" in simulation mode • Incorrect measuring point • Primary variable assigned outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct transducer is connected
HART analog output current saturated	143_H	The output current of the HART field device is saturated: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART fixed analog output current setting	144_H	The output current of the HART field device is set to a fixed value: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART secondary variable outside the limits	149_H	• Incorrect parameters in the HART field device • HART field device is at "Non-primary variable outside the limits" in simulation mode • Incorrect measuring point • Non-primary variable assigned outside the limits	
HART additional status information available	145_H	• The identifier for "Additional status information available" of the HART field device was set in the HART device status (in the 2nd status byte).	• Read status using HART command 48 and eliminate error/cause, if necessary

Diagnostic alarm	Error code	Meaning	Remedy
HART configuration changed (reset again automatically by the module after approximately 1 minute)	146_H	• The identifier for "Parameter reassignment" of the HART field device was set in the HART device status (in the 2nd status byte).	• If you do not want a diagnostic interrupt to be triggered for parameter reassignment, the diagnostic interrupt must not be enabled.
Malfunction of the HART field device	147_H	• The field device signals a malfunction in the HART device status (in the 2nd status byte)	• Read status using HART command 48 and eliminate error/cause, if necessary • Replace the field device

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostic information can also be signaled on unaffected channels and/or the measured value can be affected temporarily.

Technical specifications

8

8.1 Technical specifications of the AI 4xI 2-wire 4…20mA HART

Technical specifications of the AI 4xI 2-wire 4…20mA HART

6ES7134-6TD00-0CA1	
Product type designation	AI 4xI 2-wire 4…20mA HART
General information	
Usable BaseUnits	BU type A0, A1
HART support	Rev. 5 to Rev. 7
Product functions	
I&M data	Yes, I&M0 to I&M3
Firmware update capability	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 + SP1
STEP 7 can be configured/integrated as of version	V5.5 + SP4 + HSP0263
PROFIBUS as of GSD version/GSD revision	GSD V3.0
PROFINET as of GSD version/GSD revision	GSDML V2.31
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Rated value (DC)	24 V / 110 mA
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Input current	
Current consumption, max.	25 mA; without encoder supply
Encoder supply	
24 V encoder supply	Yes
Short-circuit protection	Yes
Output current per channel (4 channels), max.	20 mA; max. 50 mA per channel for a duration < 10 s
Load resistance of the encoder	> 750 Ω for L+ = 24 V

6ES7134-6TD00-0CA1	
Power loss	
Power loss, typ.	0.65 W; without encoder
Address space per module	
Without value status and without HART variables	8 bytes
With value status and without HART variables	9 bytes
Without value status, with HART variables	28 bytes
With value status, with HART variables	29 bytes
Analog inputs	
Number of analog inputs	4
Maximum permitted input current for current input (destruction limit)	50 mA
Input ranges (rated values), currents	
Current 4 mA to 20 mA	Yes, 15 bits + sign
Input resistance (4 to 20 mA)	280 Ω; + approx. 0.35 V diode forward voltage
Cable length	
Cable length shielded, max.	800 m
Analog value formation	
Measuring principle	Integrating (sigma-delta)
Integration and conversion time / resolution per channel	
Resolution with overrange (bits including sign), max.	16 bits
	Yes, channel-by-channel
Interference suppression for interference frequency f1 in Hz	10 / 50 / 60, channel-by-channel
Measured value smoothing	
Configurable	Yes (none, weak, medium, strong), channel-by-channel
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	± 0.01 %
Temperature error (in relation to input range), (+/-)	± 0.005 %
Crosstalk between inputs, min.	60 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	± 0.05 %
Operational limit in the entire temperature range	
Current in relation to input range, (+/-)	± 0.5 %
Basic error limit (operational limit at 25 °C)	
Current in relation to input range, (+/-)	± 0.3 %
Influence of a HART signal modulated on the input signal in relation to input range	
Error with integration time 16.6 ms	± 0.05%
Error with integration time 20 ms	± 0.04%
Error with integration time 100 ms	± 0.02%

6ES7134-6TD00-0CA1	
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
Series-mode interference (peak of the interference < nominal value of the input range), min.	60 dB
Interrupts/diagnostic/status information	
Diagnostic interrupt	Yes
Diagnostic alarms	
Monitoring of supply voltage	Yes
Wire break	Yes; channel-by-channel
Short-circuit	Yes; channel-by-channel, short-circuit of the encoder supply to ground or short-circuit of an input to the encoder supply
Underflow/overflow	Yes; channel-by-channel
HART	Yes; channel-by-channel
Diagnostic display LED	
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes, red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Isolation, designed for basic isolation between channels and backplane bus	60 V AC / 75 V DC
Isolation	
Isolation tested with	500 V AC or 707 V DC (type test)
Operating temperature	
Horizontal mounting position, min.	0°C
Horizontal mounting position, max.	60°C
Vertical mounting position, min.	0°C
Vertical mounting position, max.	50°C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data records

9

Parameter assignment in the user program

You have the option of reassigning parameters for individual channels of the module and for the mapping of HART variables in RUN without affecting the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module.

- Channel/technology parameters using data record 128
- The HART mapping using data record 140.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Parameters

Only the values specified in each case in the following are permitted. Values that are not listed are rejected by the analog module.

Each parameter data record is checked by the analog module. If an incorrect parameter is detected, the complete data record is discarded and the parameters of the analog module remain unchanged.

9.1 Parameter assignment and structure of the channel/technology parameters

Structure of data record 128

Data record 128 has a length of 42 bytes and contains the channel/technology parameters of all four channels (10 bytes per channel).

The parameters are divided into parameters that influence the actual analog value acquisition, diagnostic enables, and basic parameters of HART communication.

You can use data records 131 to 134 to assign and change additional parameters and HART-specific settings. See section HART-specific settings (Page 62).

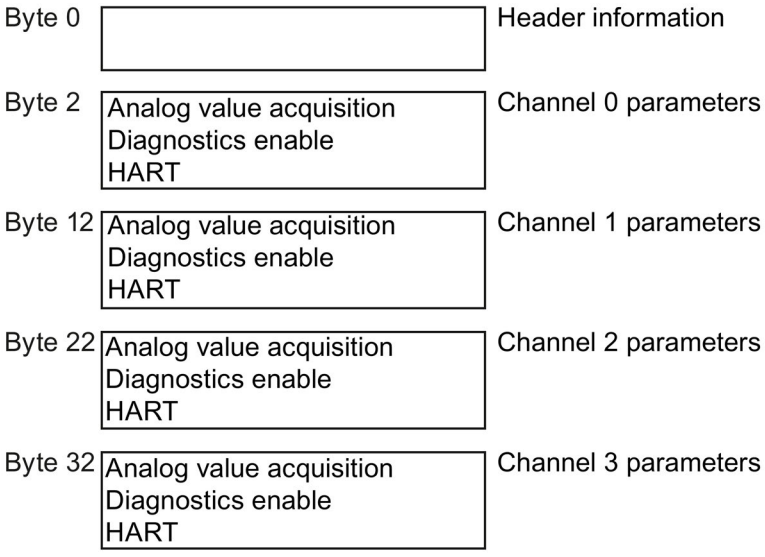


Figure 9-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

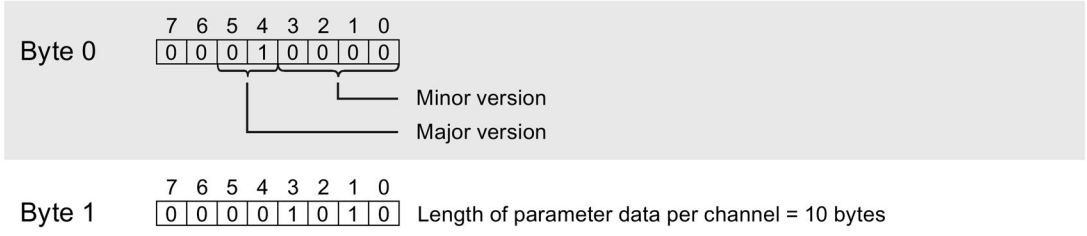
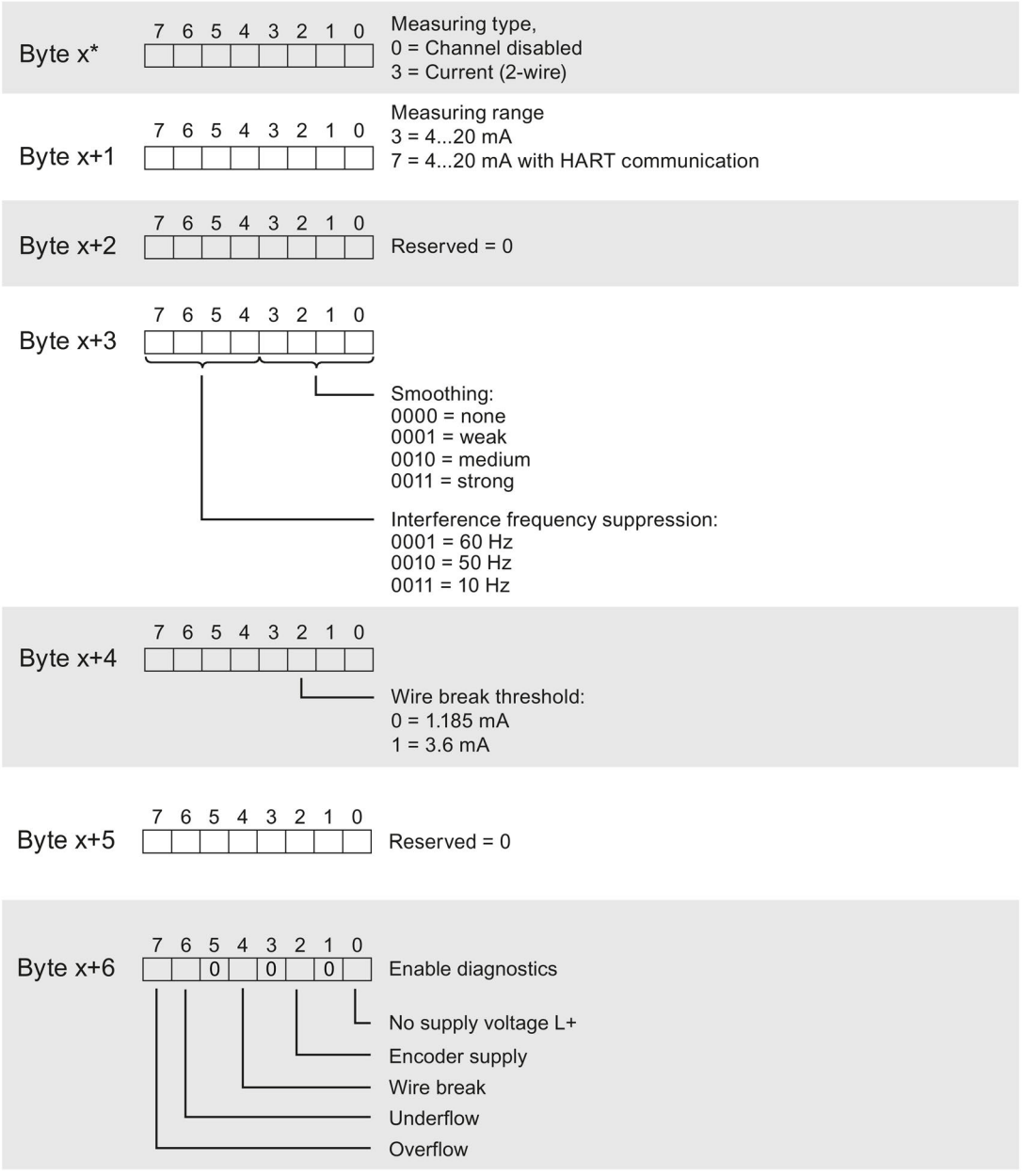


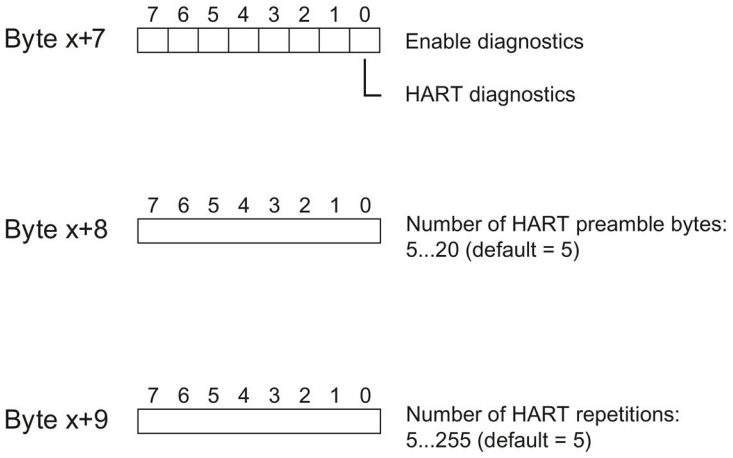
Figure 9-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

All unused bits and the bits or bytes marked with "reserved" must be set to zero.
You enable a parameter by setting the corresponding bit to "1" or the appropriate value.





* x = 2 + (channel number * 10); with channel number 0 ….3

Figure 9-3 Structure of bytes x to x+39 for channels 0 to 3

9.2 Parameter assignment and structure of the HART mapping parameters

Structure of data record 140

Data record 140 has a total length of 12 bytes.

You can use the parameters of data record 140 to configure/map up to four HART variables of the individual channels in the input address space of the module, provided the corresponding configuration is selected; see section 6.1 "Configuring".

Header information

The figure below shows the structure of the header information.

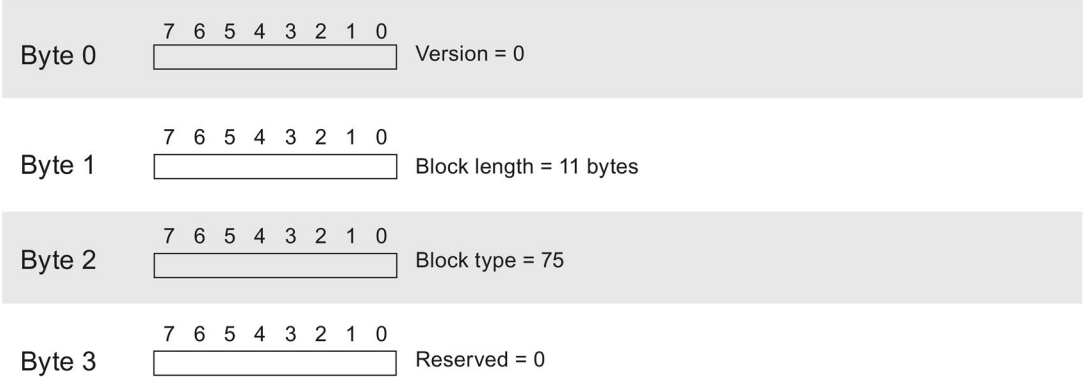
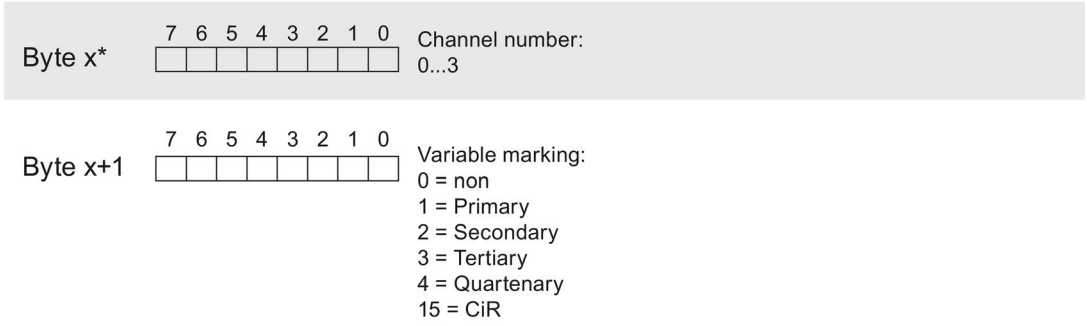


Figure 9-4 Header information

Parameters

The following figure shows the parameter assignment of the four HART variables 0...3.



* x = 4 + (HART variable * 2); with HART variable 0….3

Figure 9-5 Parameters

The variable identifiers 0 = non and 15 = CiR produce the same behavior for the AI 4xI 2-wire 4…20mA HART analog module. HART variables are not configured or mapped; that is, the corresponding memory area in the input address area remains unallocated.

HART operating data records

10

Reading/writing data in RUN

HART operating data records are transferred to the module with the "WRREC" instruction and read from the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS of the "WRREC" or "RDREC".

The following HART operating data records are available:

Data record number	Description	Length (bytes)	Writable	Readable
80	HART request Channel 0	240	Yes	Yes
81	HART response Channel 0	240	No	Yes
80	HART request Channel 1	240	Yes	Yes
81	HART response Channel 1	240	No	Yes
80	HART request Channel 2	240	Yes	Yes
81	HART response Channel 2	240	No	Yes
80	HART request Channel 3	240	Yes	Yes
81	HART response Channel 3	240	No	Yes
121	HART variables	80	No	Yes
131	HART parameters Channel 0	8	Yes	Yes
132	HART parameters Channel 1	8	Yes	Yes
133	HART parameters Channel 2	8	Yes	Yes
134	HART parameters Channel 3	8	Yes	Yes
148	HART directory	17	No	Yes
149	HART feature data	3	No	Yes

10.1 HART directory

Structure of the HART directory

Byte	Meaning	Comment
0	Profile Revision Number	= 2, 0 (Revision 2.0)
1		
2	Index of Client Management	= 255 (not relevant)
3	Number of Clients	= 1
4	Number of Channels	= 4
5	Write Read Index Offset	= 1 (The response to a request data record is made with the data record number of the request data record + 1)
6	Index of HMD Feature Parameter	= 149
7	Index of HMD Module Parameter	= 255 (not relevant)
8	Start Index of Burst Buffer Area	= 255 (not relevant)
9+n	Index of HMD Channel Parameter (Channel n)	= 131+n
9+n+4	Index of HART Client Channel Message Data	= 80+(2*n) The HART request data records cannot be configured. Data records starting from data record number 80 (80, 82, 84, 86) are used.

10.2 HART feature data

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit1 = 1: "Parameter check result is given with a read response" Bit5 = 1: "Compact format is supported"
1	Byte 1	= 0
2	Max Length Data Unit	= 240 (maximum length of the HART request data records)

10.3 HART variable data record

The AI 4xI 2-wire 4…20mA HART analog module supports a maximum of 4 HART variables per channel that are read cyclically, provided this is supported by the connected field device. These 16 HART variables are are made available in a readable manner in HART variable data record 121.

Each HART variable consists of a 4-byte real value and a quality code byte. See section 4.4.1 "Quality code".

Structure of the HART variable data record

Byte	Meaning	
Channel 0		
0…3	Value	Primary Variable (PV)
4	Quality code	
5…8	Value	Secondary Variable (SV)
9	Quality code	
10…13	Value	Tertiary (TV)
14	Quality code	
15…18	Value	Quartenary (QV)
19	Quality code	
Channel 1		
20…39	HART variables same as for Channel 0	
Channel 2		
40…59	HART variables same as for Channel 0	
Channel 3		
60…79	HART variables same as for Channel 0	

If HART is not enabled or the respective HART variable is not supplied from the connected field device, the corresponding variable = 0 and the QC = 0x37 (initialization value from the analog module).

10.4 HART-specific settings

The HART communication is available using standard parameter assignment (see section 9.1 "Parameter assignment and structure of the channel/technology parameters").

Additional HART-specific settings can be specified on a channel-specific basis using data records 131 to 134.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Each parameter reassignment of the analog module resets the HART-specific settings back to the initial values from parameter data record 128.

Where there is no supply voltage L+, the module does not assume the HART-specific settings.

Channel	Data record number
0	131
1	132
2	133
3	134

Structure of the HART-specific settings

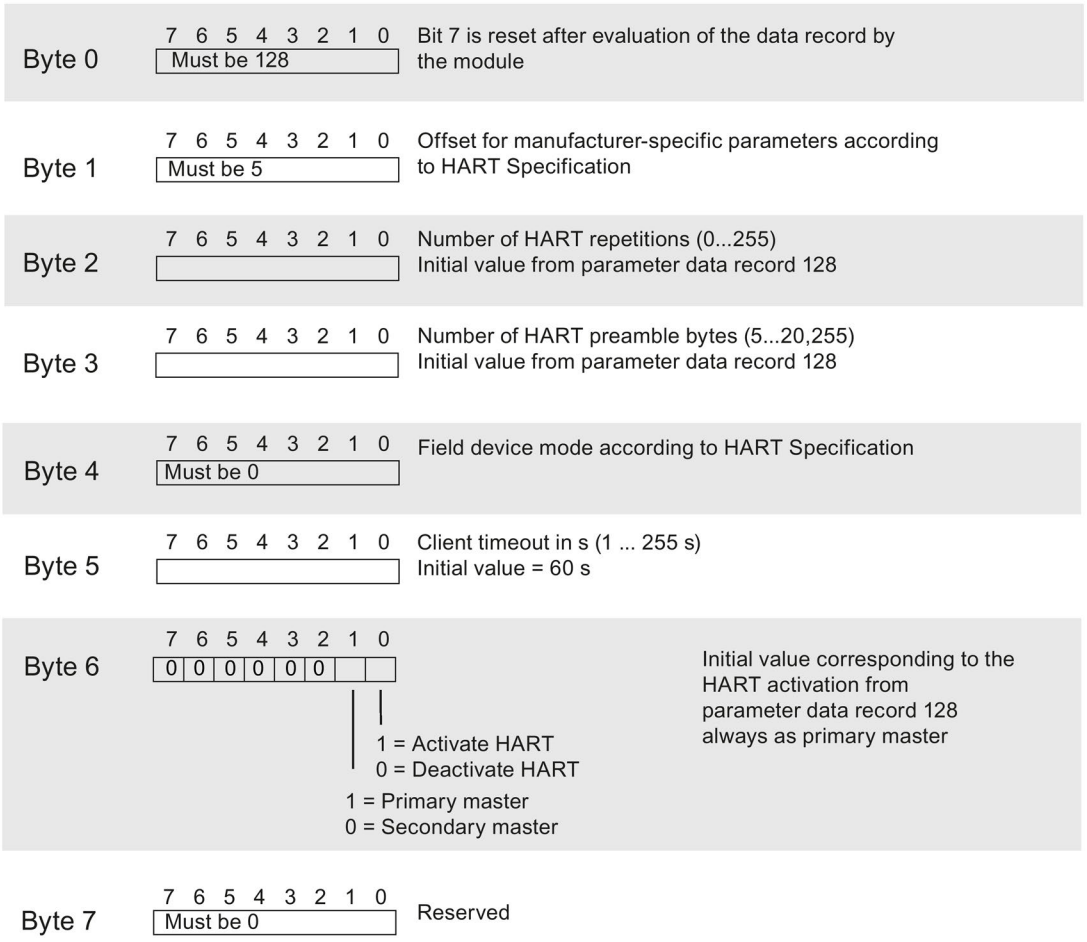


Figure 10-1 Settings

10.5 HART request and response data records

HART commands are processed on a channel-specific basis via a separate command interface with one request data record and one response data record in each case.

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87

Structure of request data records 80, 82, 84, 86

Byte	Meaning	Comment
0	Request control	
1	Number of preamble bytes	5…20
2…239	Communication data according to HART specification	

Coding "Request control":

Bit 0…1: Reserved = 0

Bit 2: 0 = Parameters are not checked

Bit 3...4: Reserved = 0

Bit 5: 0 = Transparent format *
1 = Compact format

Bit 6: 1 = Enable SHC mode **

Bit 7: 0 = HART Request

* HART commands are processed by the analog module in transparent message format and in compact message format. However, the response data from the module is always made available in transparent message format.

** Processing of a sequence of HART commands as an SHC sequence affects all other channels with HART enabled. See section 4.3 "HART command interface", SHC sequence.

Structure of response data records 81, 83, 85, 87

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2	Protocol error	
3…239	Response data according to HART specification	Only present when "Response result" = 6 = "Error, with data"

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2…239	Response data according to HART specification	Only present when "Response result" = 4 = "Successful, with data"

Coding "Response control":

Bits 0-2:	Response result (processing status) 0 = Inactive 1 = Inactive (reserved) 2 = Waiting 3 = Waiting, executing 4 = Successful, with data 5 = Successful, without data 6 = Error, with data 7 = Error, without data
Bit 3:	0 = Burst mode not active;
Bit 4:	0 = Response data come directly from the HART device
Bit 5:	0 = Response data in transparent message format
Bit 6:	0 = SHC mode not active 1 = SHC mode active
Bit 7:	0 = HART response

Coding "HART group error display"

Bit number	Meaning	Explanation
0	Additional status information available	(2nd HART status byte) You obtain additional status information, if required, with HART command 48.
1	HART communication error	The field device has detected a communication error when receiving the command. The error information can be found in the 1st HART status byte.
2	Parameter check	0: HMD parameters unchanged 1: Check HMD parameters
3	Reserved	Always 0
4…7	HART protocol error during response	0: Unspecified error 1: HMD error 2: Channel fault 3: Command error 4: Query error 5: Response error 6: Query rejected 7: Profile query rejected 8: Manufacturer-specific query rejected 9 - 15: Not used

Coding "HART protocol error during response"

HART protocol error during response	Meaning	Explanation
0	Unspecified error	Always 0
1	HMD error	0: Not specified 1: Internal communication error 2: Parameter assignment error 3: HW fault 4: Wait time expired 5: HART timer expired 6…127: Reserved 128...255: Manufacturer-specific
2	Channel fault	0: Not specified 1: Line fault 2: Short-circuit 3: Open line 4: Low current output 5: Parameter assignment error 6…127: Reserved 128…255: Manufacturer-specific

HART protocol error during response	Meaning	Explanation
3	Command error	0-127: HART protocol, Bit 7 = Always 0
4	Query error	Bit 0 = 0: Reserved Bit 1 = 1: Receive buffer overflow Bit 2 = 0: Reserved Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
5	Response error	Bit 0 = 1: GAP timeout Bit 1 = 1: Receive buffer overflow Bit 2 = 1: Timeout Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
6	Query rejected	0: Unspecified 1: Compact format not supported 2: SHC not supported 3: Impermissible command 4: No resources 5...127: Reserved 128...255: Manufacturer-specific
7	Profile query rejected	0: Not specified (not supported)
8	Manufacturer-specific query rejected	0: Not specified (not supported)

Example of HART programming (HART command interface)

For HART channel 0, the command 01 is to be sent in transparent message format to the HART field device with address "98 CF 38 84 F0".
A positive edge at input 4.0 of a digital input module leads to the writing of the HART command.

The following assumptions are made:

- The module address of the AI 4xI 2-wire 4…20mA HART analog module is 512 (200_H).
- The data record is stored in DB80: starting from address 0.0, length of 11 bytes.
- In this example, DB80 (request data record for channel 0) consists of 11 bytes.

```
STL                                 Explanation
 A I 4.0
 FP M 101.0
 = M 104.0
m2: CALL SFC 58
 REQ :=M104.0                       Write request
 IOID :=B#16#54                     Address range ID
 LADDR :=W#16#200                   Module address
 RECNUM :=B#16#50                   Data record number 80
 RECORD :=P#DB80.DBX0.0 BYTE 11     Data record with length of 11 bytes (must corre-
                                    spond to the exact length that is to be trans-
                                    ferred)
 RET_VAL :=MW93                     RET_VAL of SFC 58 (OK/error/...)
 BUSY :=M51.0                       Write operation not yet completed
 A M 51.0
 SPB m2
 BE
```

Table 10- 1 DB80: Transparent message format

Byte	Initial value (hex)	Comment (Hex)
0	00	Req_Control (00 = Transparent message format. 40 = Transparent message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	82	Start character (02 = Short Frame with command 0) (82 = Long Frame with other commands)
3	98	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	CF	
5	38	
6	84	
7	F0	
8	01	Command (CMD)
9	00	Length in bytes
10	98	Checksum (CHK) (calculated starting from byte 2 "Start character" up to the next to last byte)

A HART command can also be sent in compact message format. In this case, the data that is transferred via DB 80 is reduced to 4 bytes.

Table 10- 2 DB80: Compact message format

Byte	Initial value (hex)	Comment (Hex)
0	20	Req_Control (20 = Compact message format. 60 = Compact message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	01	Command (CMD)
3	00	Length in bytes

You can learn when the response from the field device was received by cyclically reading data record DS81 for HART channel 0. The response is always supplied in transparent message format.

Table 10- 3 FC81: Reading of the response to DB81 with SFC 59

```
STL                                 Explanation
m3: CALL SFC 59
 REQ :=1                            Read request
 IOID :=B#16#54                     Address range ID
 LADDR :=W#16#200                   Module address of the HART-AI
 RECNUM :=B#16#51                   Data record number 81
 RECORD :=P#DB81.DBX0.0 BYTE 75     Data record
 RET_VAL :=MW100                    RET_VAL of SFC 59 (OK/error/...)
 BUSY :=M49.1                       Read operation not yet completed
 A M 49.1
 SPB m3
 BE
```

The program part A M 49.1 to SPB m3 is only required if reading is to occur synchronously.

As long as "0x03" is in byte 0 of DB81, the response has not been received from the field device. As soon as bit 2 = 1 is set in byte 0, there is positive response data available from the field device that you can evaluate.
In case of a response data error, see the "HART group error display" table in byte 1 or the "HART protocol errors during response" table in byte 2 of the response of the field device.

Analog value representation

11

Table 11- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

Representation / Value range

The table below contains the decimal and hexadecimal values (codings) of the possible current measuring ranges.

Table 11- 2 Current measuring range 4 to 20 mA / 4…20 mA HART

Values		Current measuring range	Range
Dec.	Hex.	4 to 20 mA	
32767	7FFF	> 22.81 mA	Overflow
32511	7EFF	22.81 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	16 mA	
1	1	4 mA + 578.7 nA	
0	0	4 mA	
-1	FFFF		Underrange
-4864	ED00	1.185 mA	
-32768	8000	< 1.185 mA	Underflow

11.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 11- 3 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 11- 4 Unipolar input ranges

Dec. val-ue	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

11.2 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 11- 5 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table 11- 6 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 to 20 mA ***	**4 to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measuring type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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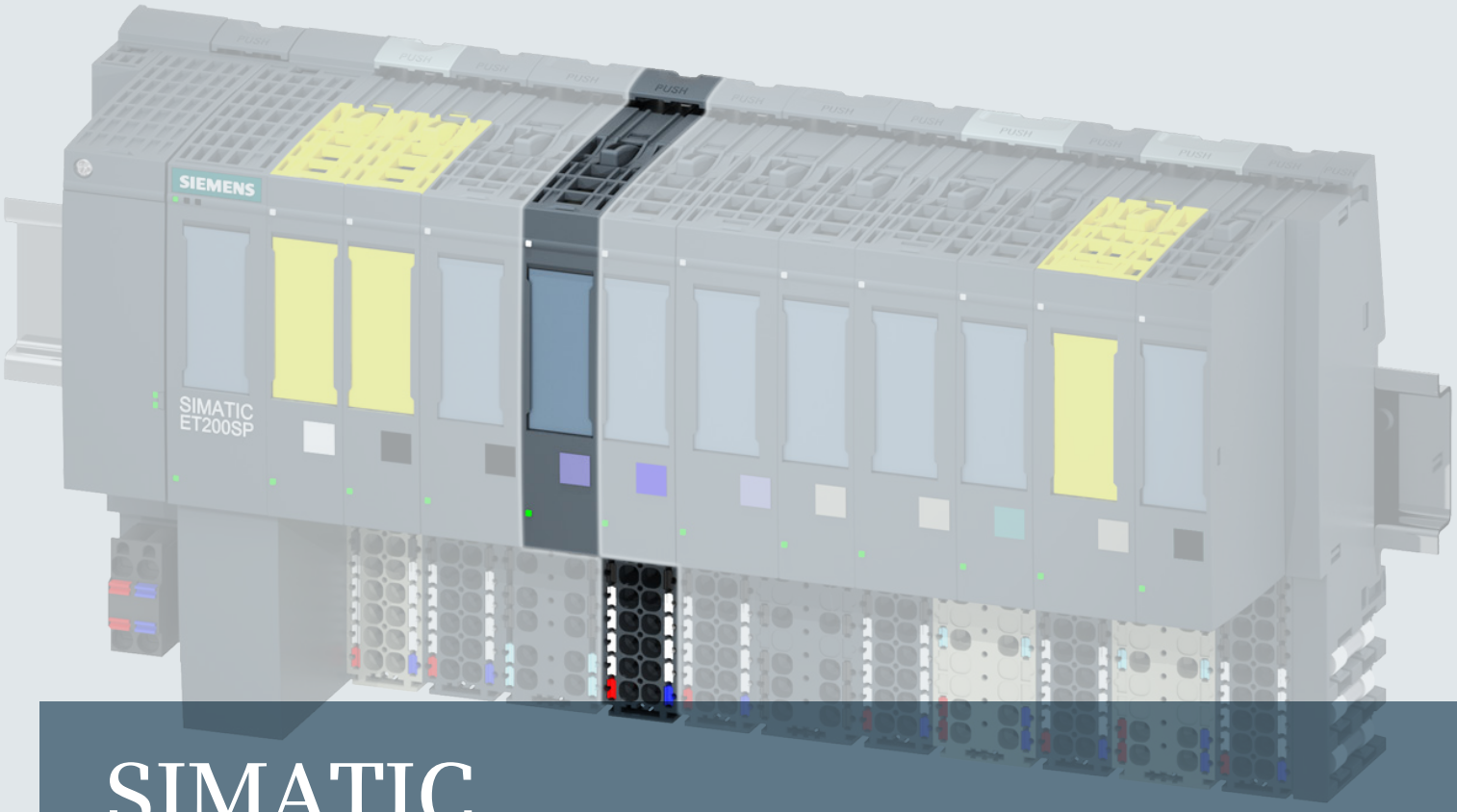

SIMATIC

ET 200SP

Analog input module AI 4xRTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0CA1)

Manual

Edition 02/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Analog input module
AI 4xRTD/TC 2-/3-/4-wire HF
(6ES7134-6JD00-0CA1)

Manual

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02/2014

A5E03573289-AD

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⚠WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Guide to documentation

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of a system manual, function manuals and product manuals.

The STEP 7 information system (online help) also supports you during the configuration and programming of your automation system.

Overview of documentation for analog input module AI 4×RTD/TC 2-/3-/4-wire HF

The following table shows additional documentation that you need when using the AI 4×RTD/TC 2-/3-/4-wire HF analog input module.

Table 1- 1 Documentation for analog input module AI 4×RTD/TC 2-/3-/4-wire HF

Topic	Documentation	Key contents
System description	ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual	• Application planning • Installation • Wiring • Commissioning
Designing interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual	• Basics • Electromagnetic compatibility • Lightning protection
Analog value processing	Function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Key contents
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Amendments and special features of the ET 200SP distributed I/O system	Product information on documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or product manuals.

SIMATIC manuals

All current manuals for SIMATIC products are available to download free of charge on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Article number

6ES7134-6JD00-0CA1

View of the module

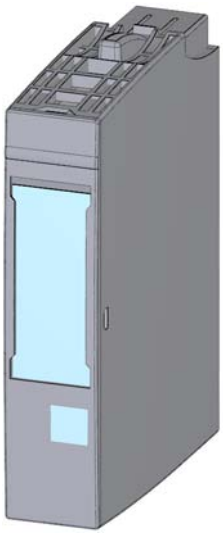


Figure 2-1 View of the module AI 4×RTD/TC 2-/3-/4-wire HF

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Resolution: Up to 16 bits including sign
- Voltage measurement type can be set per channel
- Resistor measurement type can be set per channel
- Thermal resistor (RTD) measurement type can be set per channel
- Thermocouple (TC) measurement type can be set per channel
- Configurable diagnostics for each channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)
- Automatic compensation of the line resistance with 3-wire connection

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Calibration in runtime	1	as of V2.00.00
Value status (PROFINET IO only)	1	as of V1.01.00
Scalable measuring range	1	as of V2.00.00
Selectable conductor resistance for 2-wire connection	1	as of V2.00.00
Switchable wire break check	1	as of V2.00.00

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

See also

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

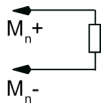
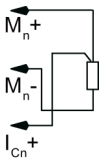
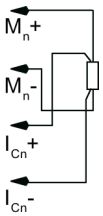
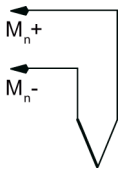
3

3.1 Pin assignment

General pin assignment

Table 3- 1 Pin assignment for AI 4xRTD/TC 2-/3-/4-wire HF

Pin assignment for AI 4×RTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0CA1)						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Notes**	**BaseUnits**[1]	**Color identification label**
1	M_0+	**2**	M_1+	• M_n+: Measuring line positive, channel n • M_n-: Measuring line negative, channel n • I_{Cn}+: Constant current line positive, channel n • I_{Cn}-: Constant current line negative, channel n	A0 A1	---
3	M_2+	**4**	M_3+			
5	M_0-	**6**	M_1-			
7	M_2-	**8**	M_3-			
9	I_{C0}+	**10**	I_{C1}+			
11	I_{C2}+	**12**	I_{C3}+			
13	I_{C0}-	**14**	I_{C1}-			
15	I_{C2}-	**16**	I_{C3}-			
L+	24 VDC	**M**	M			

RTD 2-wire connection	RTD 3-wire connection	RTD 4-wire connection	TC
			

[1] Usable BaseUnit types, can be identified by the last two digits of the article number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Keep this in mind also during the configuration.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Schematic circuit diagram

Schematic circuit diagram

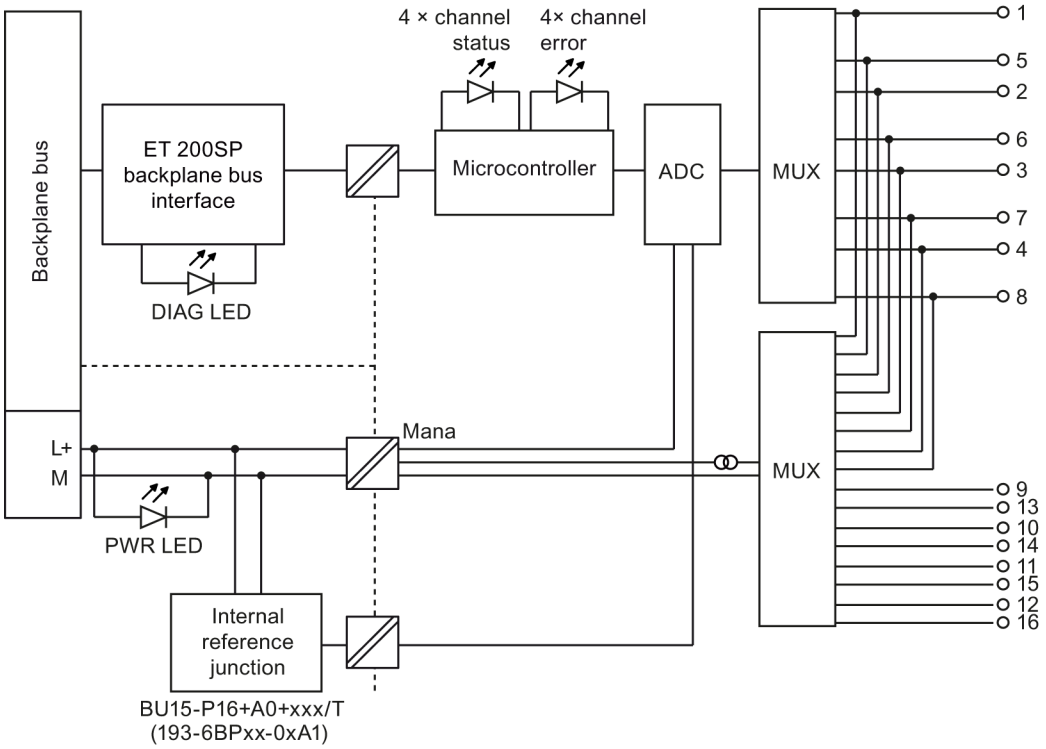


Figure 3-1 Schematic circuit diagram AI 4×RTD/TC 2-/3-/4-wire HF

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table describes the measuring range and the temperature coefficients you can configure for each measurement type:

Table 4- 1 Measurement types and measuring ranges

Measurement type	Measuring range	Temperature coefficient
Deactivated	–	–
Resistor (2-, 3-, 4-wire connection)	150 Ω / 300 Ω / 600 Ω / 3 kΩ / 6 kΩ	–
Resistor (2-wire connection)	PTC	–
Thermal resistor RTD (3-wire connection)	Climatic / Standard Cu 10	Cu 0.00427[1]
Thermal resistor RTD (2, 3, 4-wire connection)	Climatic / Standard Pt 100 Pt 200 Pt 500 Pt 1000	Pt 0.00385 / Pt 0.003916 / Pt 0.003902 / Pt 0.00392 / Pt 0.00385055
	Climatic / Standard Ni 100 Ni 120 Ni 200 Ni 500 Ni 1000	Ni 0.00618 / Ni 0.00672
	Climatic[2] / Standard[2] Ni 1000	Ni 0.005
Thermocouple (TC)	Type E, N, J, K, L, S, R, B, T, C, U, TXK (acc. to GOST)	
Voltage	±50 mV / ±80 mV / ±250 mV / ±1 V	

1 The preset temperature coefficients are valid for Europe.

2 For sensors LG-Ni 1000 from Siemens Building Ltd (Landis & Stäfa).

Special features when using Cu10 sensors

- Choose "Thermal resistor (3-wire connection)" and "Cu10" in the parameter assignment.
- Wire the Cu10 sensor into the 3-wire connection technology.
- During operation, automatic, internal compensation of the line resistance of the missing measuring line takes place.

Note

To ensure optimum line compensation with Cu10, please observe the following:

- An accurate measured value is only attained if the cable resistance of the positive constant current line to the Cu10 sensor and the cable resistance of the negative measuring line are identical in value.
- Recommendation: Keep the measuring line as short as possible.
- Different resistance values may also occur due to the connection method used.

Special features when using PTC resistors

PTCs are suitable for monitoring temperature and/or as thermal protection devices of complex drives or transformer windings.

- Choose "Thermal resistor (2-wire)" and "PTC" in the parameter assignment.
- Connect the PTC to the 2-wire connection technology.
- Use the PTC resistors, type A (PTC thermistor) in accordance with DIN/VDE 0660, part 302.
- If "Underflow" diagnostic is enabled, a "Low limit violated" diagnostic is generated for resistance values < 18 Ω, indicating a short-circuit.
- Sensor data for the PTC resistor:

Table 4- 2 Using PTC resistors

Property	Technical specifications	Comment
Switching points	**Behavior with rising temperature**	
	< 550 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	550 Ω to 1650 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	> 1650 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	Behavior with falling temperature	
	> 750 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	750 Ω to 540 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	< 540 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	Reaction to short-circuit	
	< 18 Ω	• SIMATIC S7: Bit 7 (IB x+1) = "1", Bit 0 = "0" and Bit 2 = "0"
(RRT-5) °C (RRT+5) °C (RRT+15) °C Measuring voltage/ voltage at the PTC	Max. 550 Ω min. 1330 Ω min. 4000 Ω Max. 7.5 V[1]	TNF = Rated response temperature of the sensor (according to DIN/VDE 0660)

[1] Below 23 kΩ

Assignment in the process image input (PII) with SIMATIC S7

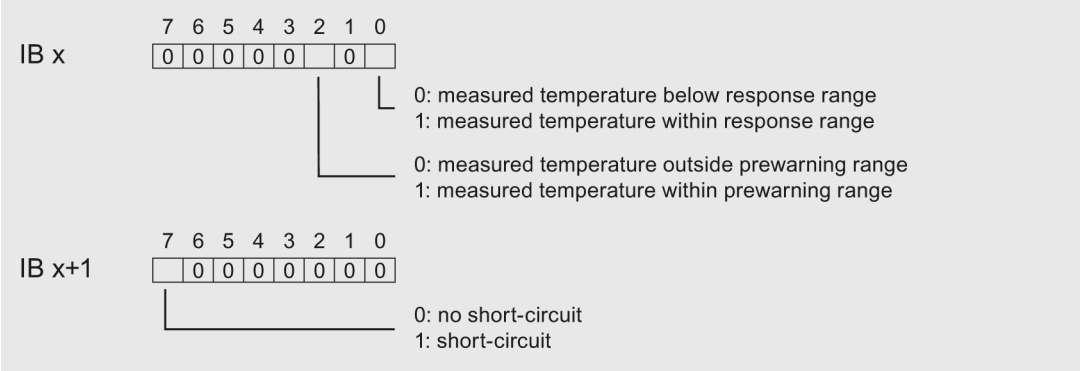


Figure 4-1 Assignment in the process image input (PII)

Notes on programming

- Bits 0+2 are relevant for evaluation in the process image input. You can monitor, for example, the temperature of a motor using bits 0+2.
- Bits 0+2 in the process image input cannot be saved. During parameter assignment, take into consideration that a motor, for example, starts up in a controlled manner (via an acknowledgment).
- Bits 0+2 can never be set at the same time; they are set one after the other.

NOTICE
No measurement is possible in the following cases: • When I/O modules are pulled out • When supply voltage to the I/O module fails • When there is a wire break or short-circuit in the measuring lines Therefore, always evaluate the diagnostics entries of the AI 4×RTD/TC 2-/3-/4-wire HF for safety reasons.

Example

The diagram shows the temperature curve and the associated switching points.

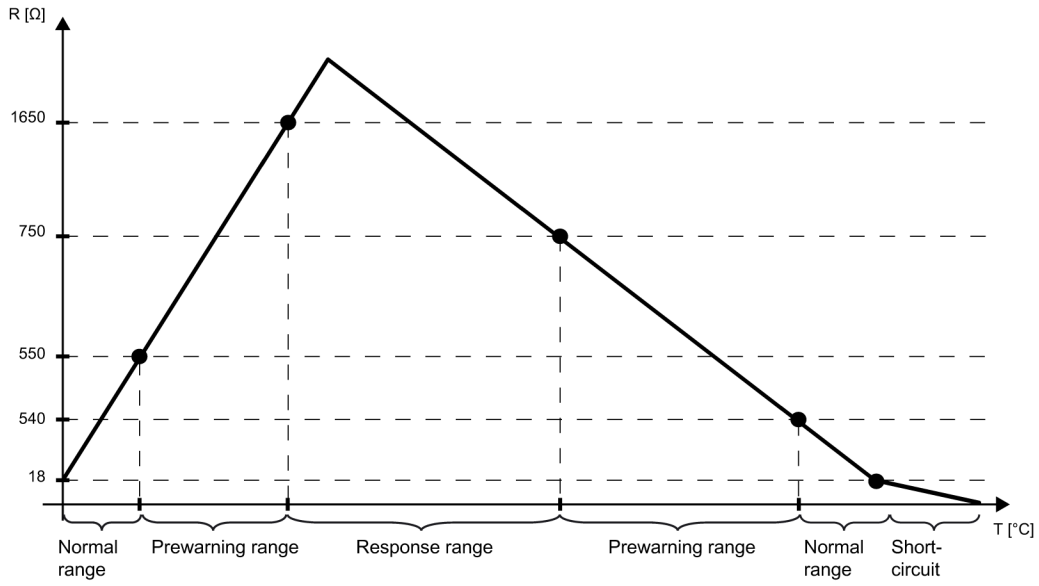


Figure 4-2 Temperature curve with prewarning range

See also

Technical specifications (Page 40)

4.2 Parameters

Parameters of the AI 4xRTD/TC 2-/3-/4-wire HF

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 52). The following parameter settings are possible:

Table 4- 3 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Reference junction	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Type/range of measurement	• Deactivated	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	• Voltage ±50 mV • Voltage ±80 mV • Voltage ±250 mV • Voltage ±1 V				
	Resistor (2-, 3-, 4-wire connection) • 150 Ω • 300 Ω • 600 Ω • 3 kΩ • 6 kΩ				
Type/range of measurement	Resistor (2-wire connection) PTC	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
Type/range of measurement	Thermal resistor (2, 3, 4-wire connection) • Pt 100 climatic range • Pt 200 climatic range • Pt 500 climatic range • Pt 1000 climatic range	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2, 3, 4-wire connection) • Pt 100 standard range • Pt 200 standard range • Pt 500 standard range • Pt 1000 standard range				

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Type/range of measurement	Thermal resistor (2, 3, 4-wire connection) • Ni 100 climatic range • Ni 120 climatic range • Ni 200 climatic range • Ni 500 climatic range • Ni 1000 climatic range	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2, 3, 4-wire connection) • Ni 100 standard range • Ni 120 standard range • Ni 200 standard range • Ni 500 standard range • Ni 1000 standard range				
Type/range of measurement	Thermal resistor (2, 3, 4-wire connection) • LG Ni 1000 climatic range	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2, 3, 4-wire connection) • LG Ni 1000 standard range				
	Thermal resistor (3-wire connection) • Cu 10 climatic range • Cu 10 standard range				
Type/range of measurement	Thermocouple • Type B (PtRh-PtRh) • Type N (NiCrSi-NiSi) • Type E (NiCr-CuNi) • Type R (PtRh-Pt) • Type S (PtRh-Pt) • Type J (Fe-CuNi) • Type L (Fe-CuNi) • Type T (Cu-CuNi) • Type K (NiCr-NiAl) • Type U (Cu-CuNi) • Type C (WRe-WRe) • Type TXK	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Temperature coefficient	• Pt 0.00385055 • Pt 0.003916 • Pt 0.003902 • Pt 0.00392 • Pt 0.00385 • Ni 0.00618 • Ni 0.00672 • LG-Ni 0.005 • Cu 0.00427	Pt 0.00385055	Yes	Channel	Channel
Temperature unit	• Degrees Celsius • Degrees Fahrenheit • Kelvin	Degrees Celsius	Yes	Channel	Module
Reference junction [4]	• No reference channel mode • Reference channel of the module • Internal reference junction • Reference channel of group 0 to 3 • Fixed reference temperature	No reference channel mode	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression [3]	• 60 Hz • 50 Hz[2] • 16.6 Hz	50 Hz	Yes	Channel	Channel
Scalable measuring range	• Disable • Enable	Disable	Yes	Channel	-
Measuring range resolution	• 2 decimal places • 3 decimal places	2 decimal places	Yes	Channel	-
Measuring range center	• Value within the nominal range of the measuring range	0	Yes	Channel	-
Conductor resistance [5]	0 to 50000 mΩ	0	Yes	Channel	-

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt high limit 1 [3]	• Disable • Enable	Disable	Yes	Channel	-
High limit 1 [3]	• Value	8500	Yes	Channel	-
Hardware interrupt low limit 1 [3]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 1 [3]	• Value	-2000	Yes	Channel	-
Hardware interrupt high limit 2 [3]	• Disable • Enable	Disable	Yes	Channel	-
High limit 2 [3]	• Value	8500	Yes	Channel	-
Hardware interrupt low limit 2 [3]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 2 [3]	• Value	-2000	Yes	Channel	-
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 24 bytes.

4 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

5 For 2-wire connection only

Note

Unused channels

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value $7FFF_H$.

4.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Reference junction

Enabling of the reference junction diagnostics if the reference temperature of the reference junction needs to be determined for the TC channel being operated.

Reference junction using the PROFINET GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module can be used as reference junction for the TC measurement, if this has the parameter setting "Thermal resistor Pt100 climatic range Degrees Celsius".

A possible parameter assignment is represented below:

Table 4- 4 RTD channel

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of a group. The distribution is performed via the interface module.

Table 4- 5 TC channel

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This must be configured as "Thermal resistor Pt 100 climatic range Degrees Celsius" and "No reference channel mode"; otherwise, Diagnostics: Reference junction is triggered.
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group.
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

Note

Shared Device and "Reference channel of group 0, 1, 2, 3"

If the transmitter and receiver for the reference junction temperature of a group are assigned to different IO controllers, then both IO controllers must be performing data exchange with the IO device to ensure error-free operation of the temperature compensation.

Reference junction using the PROFIBUS GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module can be used as reference junction for the TC measurement, if this has the parameter setting "Thermal resistor Pt100 climatic range Degrees Celsius".

The set temperature unit (e.g. Degrees Celsius) is valid for the entire module with temperature compensation "Reference channel of the module" and "Reference channel of group 0, 1, 2, 3".

Table 4- 6 **RTD channel**

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of a group. The distribution is performed via the interface module.

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "No reference channel mode". • Enable: Channel x is configured with the setting selected above.

Table 4- 7 **TC channel**

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This must be configured as "Thermal resistor Pt 100 climatic range Degrees Celsius" and "No reference channel mode"; otherwise, Diagnostics: Reference junction is triggered.
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.

Setting	Description
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group.
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "Fixed reference temperature". • Enable: Channel x is configured with the setting selected above.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics if the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or the current is insufficient for measurement at the correspondingly assigned input.

Type/range of measurement

See the section Measurement types and measuring ranges (Page 13).

Temperature coefficient

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The temperature coefficient (α value) indicates by how much the resistance of a specific material changes relatively if the temperature increases by 1 °C.

The other values facilitate a sensor-specific setting of the temperature coefficient and enhance accuracy.

Temperature unit

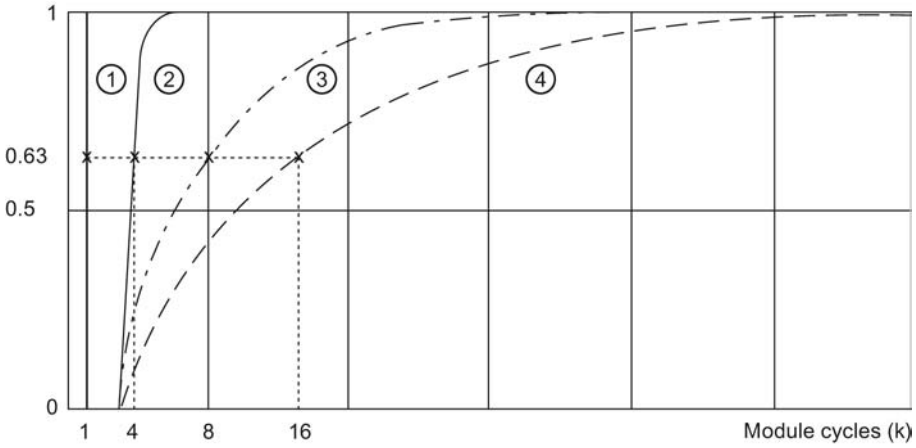
Selection between Degrees Celsius, Fahrenheit and Kelvin as the temperature unit for the selected measuring range.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This specification is valid for all signal changes at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 4-3 Smoothing for AI 4×RTD/TC 2-/3-/4-wire HF

Interference frequency suppression

Suppresses the interferences affecting analog input modules that are caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network is likely to have a negative effect on measured values particularly with measurement in the low voltage range and on thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Measuring range resolution

Parameters for the measurement type thermal resistor standard and thermocouple.

Allows you to increase the resolution to 2 or 3 decimal places for a configurable section of the measuring range. See the Scalable measuring range (Page 28) section.

Measuring range center

Determines the temperature over which the scalable measuring range is symmetrically spanned. The value must be within the nominal range of the underlying measuring range. It is specified in integers.

Maximum / Minimum

Corresponds to overflow / underflow for the scalable measuring range.

Conductor resistance

Parameters for the measurement types resistor and thermal resistor (2-wire connection).

Used to compensate for the conductor resistance without having to interfere with the sensor wiring.

If the "Conductor resistor" parameter is configured higher than a value 0 mΩ, the module then automatically uses the factory calibration data.

Hardware interrupt enable

Enabling of a hardware interrupt if the high limit 1/2 or the low limit 1/2 is violated.

Low limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

Potential group

Specifies that a BaseUnit with incoming voltage supply is located on this slot (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Scalable measuring range

Introduction

The scalable measuring range is available for the temperature measuring ranges of thermal resistors (RTD) standard and thermocouples. The measuring ranges for voltage, resistor and thermal resistor climatic are not supported.

The scalable measuring range is valid for the following ranges:

- Nominal range
- Underrange
- Overrange

Function

The scalable measuring range is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable section.

- The "Measuring range resolution" parameter determines the resolution to 2 or 3 decimal places.
- The "Measuring range center" parameter determines the temperature over which the scalable measuring range is symmetrically spanned.

Value ranges

Table 4- 8 Value ranges

Scalable measuring range	Measuring range resolution		Values hex.
	2 decimal places	3 decimal places	
Overflow	>325.11	>32.511	$7FFF_H$
High limit	325.11	32.511	$7EFF_H$
Measuring range center	0	0	0_H
Low limit	-325.12	-32.512	8100_H
Underflow	<-325.12	<-32.512	8000_H

To obtain an absolute temperature, the measuring range center in the application program (as offset) must be calculated with the value of the user data of the scalable measuring range.

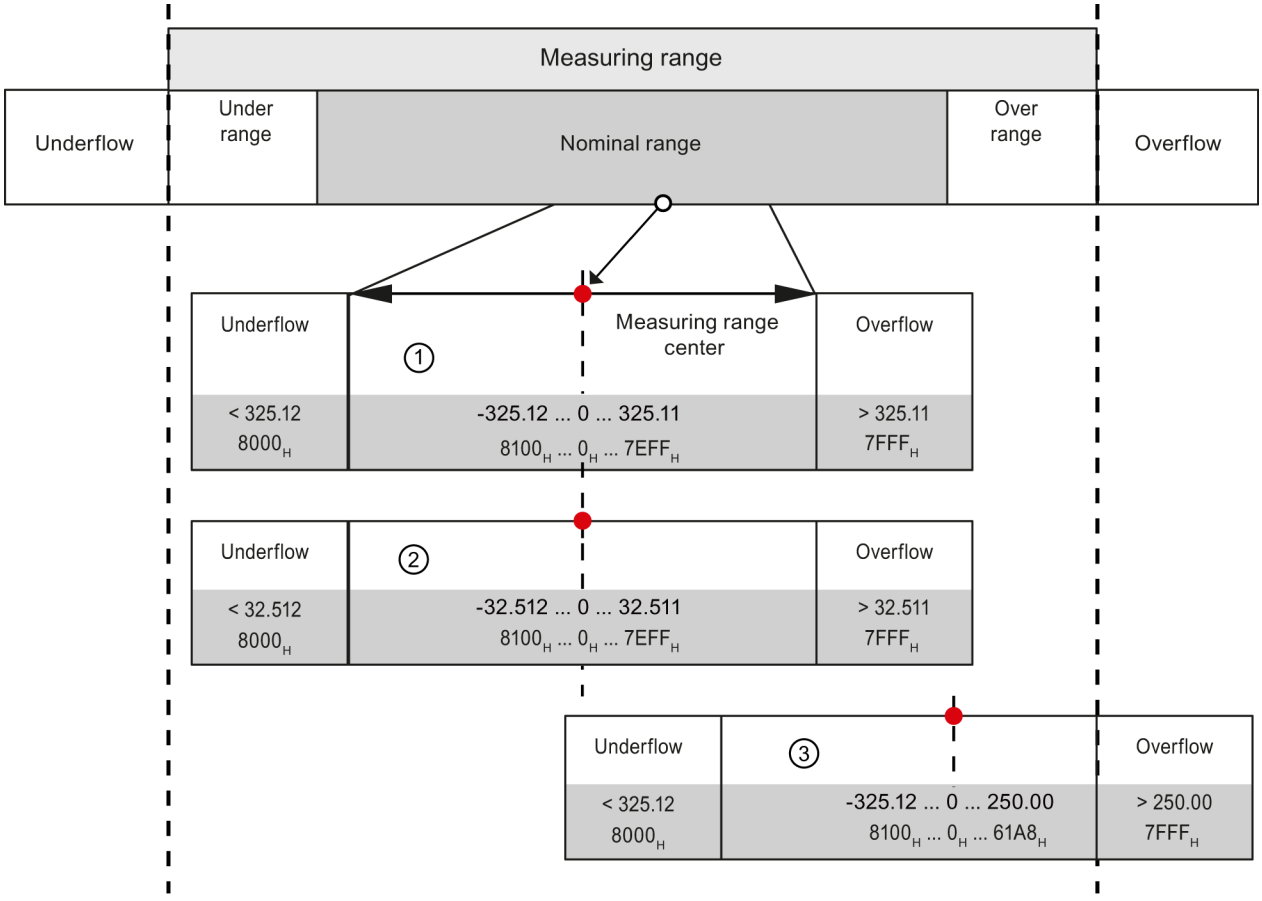
The measuring range center is always output in the user data as the value "0". The user data are correspondingly mapped to the bipolar input ranges in S7 format. Underflow / overflow is also formed in accordance with the limits of S7.

Rules

- The measuring range center must be within the nominal range of the underlying measuring range. It is specified in integers.
- The scalable measuring range is spanned symmetrically over the measuring range center. Depending on the resolution, various value ranges result (①, ②).
- The scalable measuring range is limited by underflow and overflow of the underlying measuring range:
  - It is clipped at the underflow when it falls below the limit.
  - It is clipped at the overflow when it exceeds the limit (③).

Example

The following example illustrates the effect of scalable measuring ranges:



① Scalable measuring range with 2 decimal places in hexadecimal S7 format
② Scalable measuring range with 3 decimal places in hexadecimal S7 format
③ Scalable measuring range which is cut off at the overflow of the underlying measuring range (clipping)

Figure 4-4 Examples of scalable measuring ranges

4.4.1 Configuration

Requirement

You must select a valid temperature measuring range for configuration.

Configuration

The function is activated using the "Scalable measuring range" parameter.

The following figure shows an example of a configuration in STEP 7:

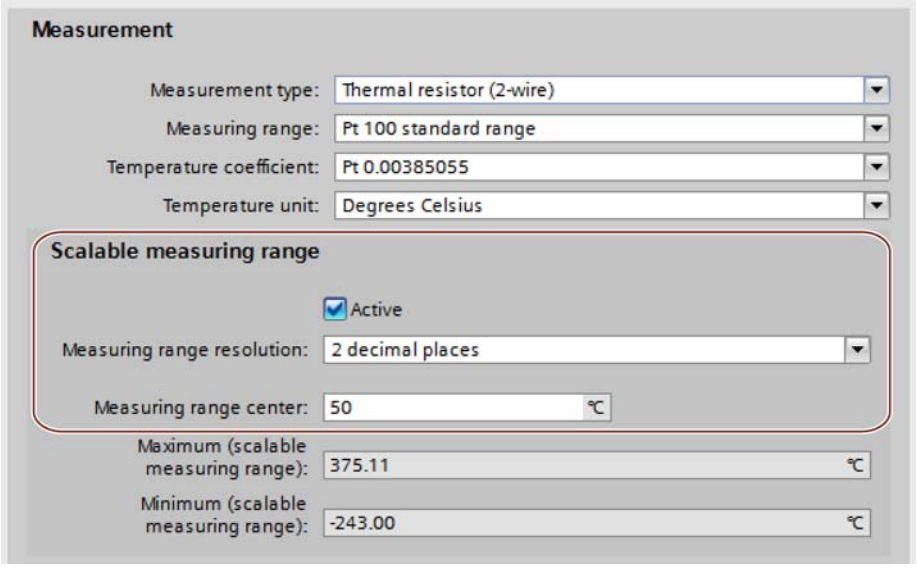


Figure 4-5 Configuration for the scalable measuring range

Reference

You will find more information on the configuration in the STEP 7 online help.

4.4.2 Evaluating data record 235

Evaluation in the user program

In the user program, you can evaluate the status and the limits of the scalable measuring range with data record 235, which may result by reaching underflow/overflow.

Structure of data record 235

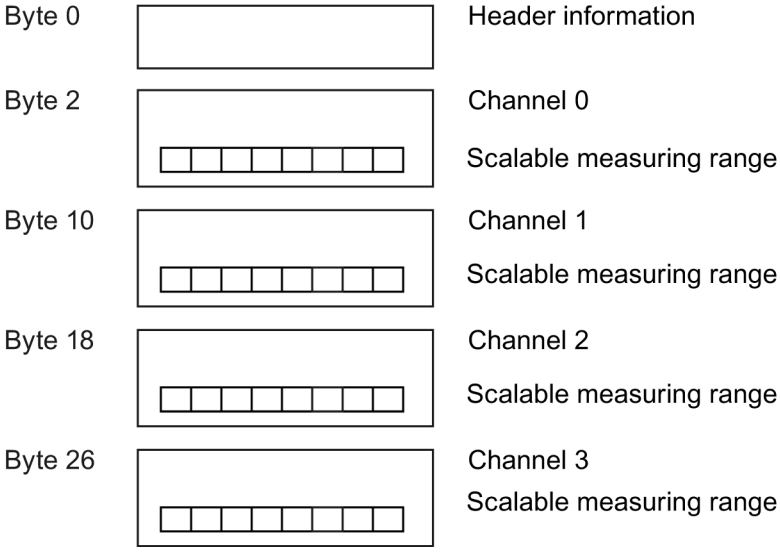


Figure 4-6 Structure of data record 235

Header information

The figure below shows the structure of the header information.

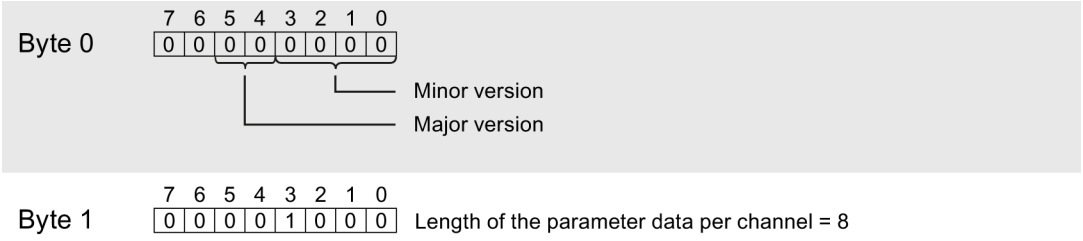


Figure 4-7 Header information of data record 235

Parameters

The figure below shows the structure of the parameter.

If the corresponding bit is set to "1", the parameter is activated.

* x = 2 + (channel number x 8)

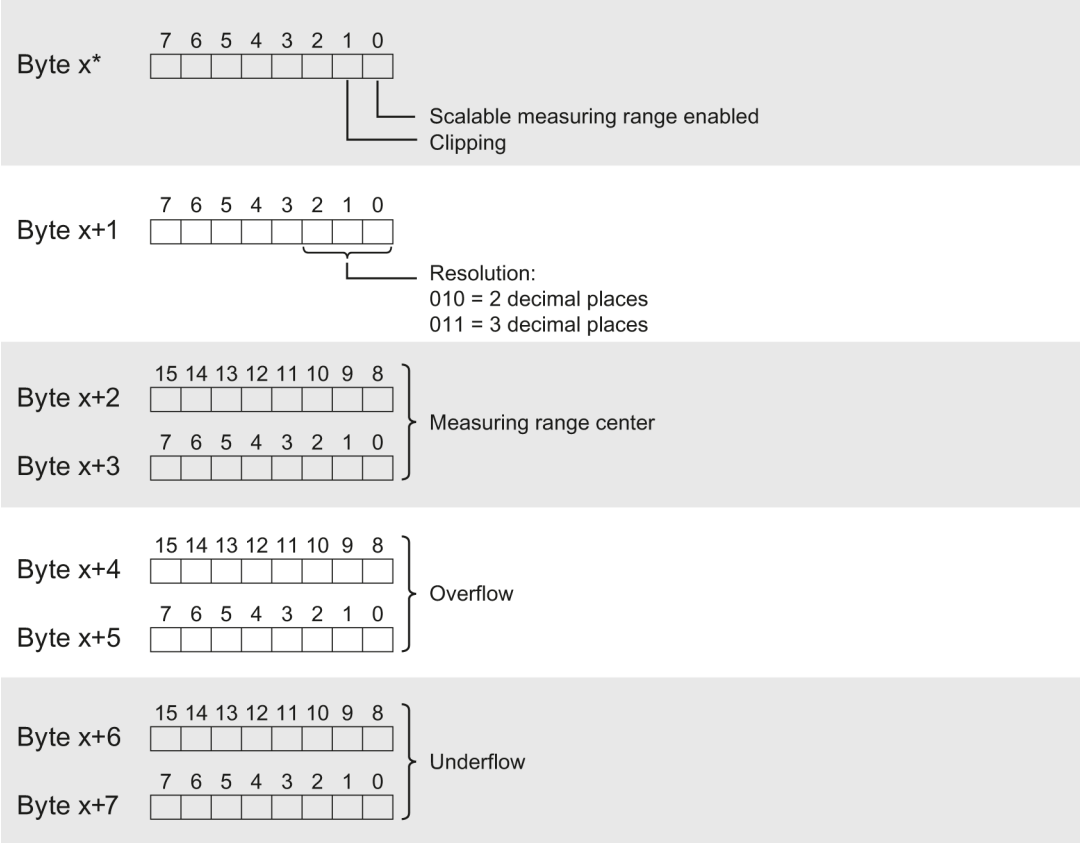


Figure 4-8 Structure of data record 235 - channel parameter byte x to x+7

Description of the parameters

Table 4- 9 Description **of the parameters from data record 235**

Parameter	Description
Scalable measuring range enabled	1 = Function is active for this channel.
Clipping	1 = Scalable measuring range cut off at the overflow / underflow of the underlying measuring range (see Figure (Page 29)).
Resolution	2 or 3 decimal places
Measuring range center	Temperature in whole °C / °F / K ("working point" for the scaling)
Overflow/underflow	Limits of the scalable measuring range

Example

The following example shows the values for a thermal resistor Pt 100 Standard, °C:

Table 4- 10 Example of a thermal resistor Pt 100 Standard

Hex. value	Dec. value	Evaluation of data record 235
00_H	0	V0.0
08_H	8	8 bytes
03_H	3	Scalable measuring range active and clipped (clipping)
02_H	2	Resolution: 2 decimal places
$02EE_H$	750	Measuring range center: 750 °C
$61A8_H$	25000	Overflow (Maximum): 250.00 + 750 = 1000.00 °C Scalable measuring range is clipped at the overflow.
8100_H	-32512	Underflow (Minimum): -325.12 + 750 = 424.88 °C

4.5 Address space

Address space of the analog input module AI 4×RTD/TC 2-/3-/4-wire HF

The following figure shows the assignment of the address space with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

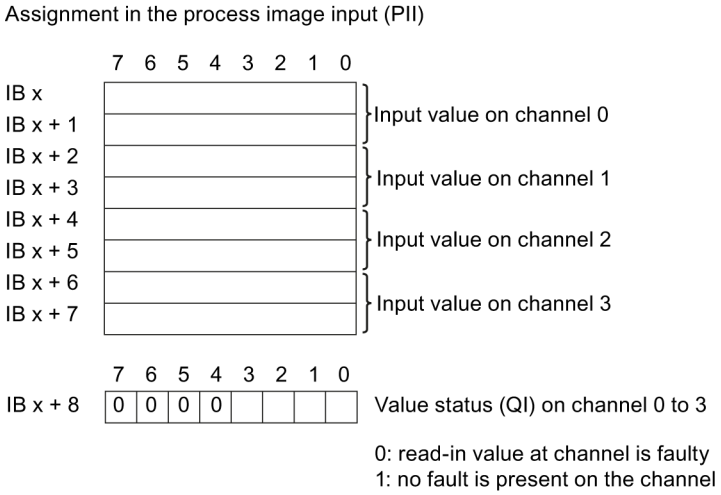


Figure 4-9 Address space AI 4×RTD/TC 2-/3-/4-wire HF with value status

Configuration options of the AI 4xRTD/TC 2-/3-/4-wire HF

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status (as of firmware version V1.01)

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bit 0 to 3 in this byte is assigned to one channel and provides information on the validity of the analog value (0 = value is incorrect).

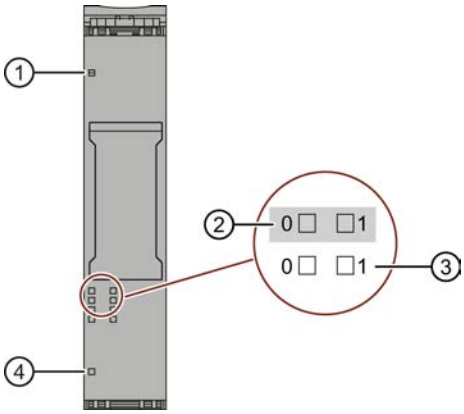
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the AI 4xRTD/TC 2-/3-/4-wire HF:



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 38).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status/channel error LED

Table 5- 2 Status and error display of the LED channel status / channel error

LEDs		Meaning
Channel status	Channel error	
Off	Off	Channel deactivated
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ present

5.2 Interrupts

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Violation of low limit 1
- Violation of high limit 1
- Violation of low limit 2
- Violation of high limit 2

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

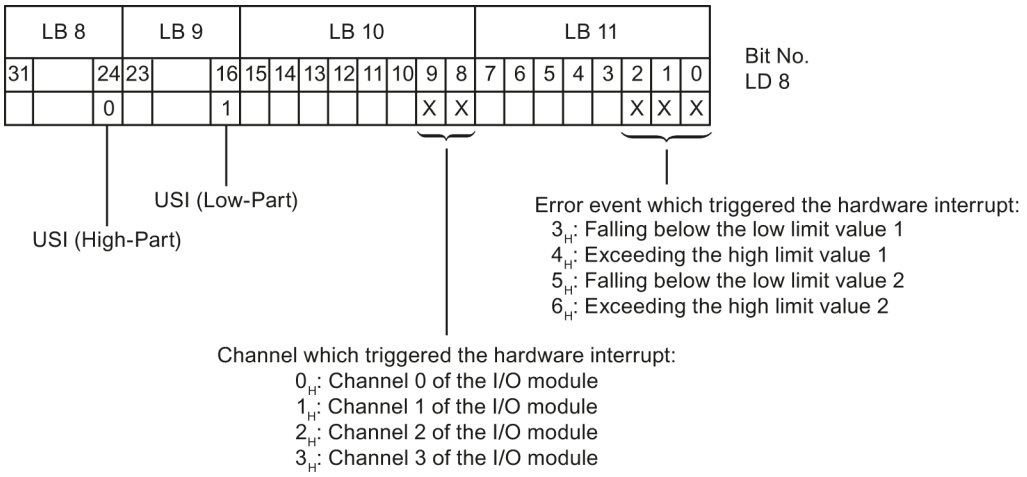


Figure 5-2 OB start information

Structure of the additional interrupt information

Table 5- 4 Structure of the additional interrupt information

Data block name		Content	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	additional interrupt information for hardware interrupts of the I/O module	2
Channel that triggered the hardware interrupt.				
	Channel	B#16#00 to B#16#03	Channel 0 to 3 of the I/O module	1
Event that triggered the hardware interrupt.				
	Event	B#16#03	Violation of low limit 1	1
		B#16#04	Violation of high limit 1	
		B#16#05	Violation of low limit 2	
		B#16#06	Violation of high limit 2	

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Hardware interrupt lost
- Reference channel error
- Error
- Violation of low limit
- Violation of high limit
- Wire break
- Supply voltage missing
- Parameter assignment error

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Diagnostics alarms, their meaning and remedies

Diagnostics alarms	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware update is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	–
		The channel is currently being calibrated.	
Wire break	6_H	Resistance of sensor circuit too high	Use a different sensor type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect or deactivate the channel
Violation of high limit[1]	7_H	Value lies above the overrange.	Correct module/sensor interplay
		Wire break[2]	See Wire break
Violation of low limit[1]	8_H	Value lies below the underrange.	Correct module/sensor interplay
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module

Diagnostics alarms	Error code	Meaning	Remedy
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel: Module plugged in does not match the configuration. Incorrect parameter assignment.	• Correct the configuration (comparison of preset and actual setup). • Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Load voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Reference channel error (reference junction)	15_H	Reference temperature of the reference junction for the TC channel being operated with compensation is invalid.	• Check BaseUnit type • Select correct reference junction through parameter assignment[3] • Check whether the reference junction (reference channel of the group 0, 1, 2, 3) is only assigned once as the sender in the entire setup.
Hardware interrupt lost	16_H	At least one hardware interrupt could not be reported because there were too many pending hardware interrupts.	Correct the program or the process

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 For resistor and thermal resistor measuring ranges with deactivated diagnostics for "Wire break", this is reported by the "Violation of high limit" diagnostic.

3 Shared Device and diagnostics "Reference temperature": If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

Technical specifications

6

6.1 Technical specifications

Technical specifications of AI 4×RTD/TC 2-/3-/4-wire HF

	6ES7134-6JD00-0CA1
Product type designation	AI 4xRTD/TC 2-/3-/4-wire HF
General information	
Firmware version	V2.0
Usable BaseUnits	BU type A0, A1
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12 SP1 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	35 mA
Power loss	
Power loss, typ.	0.75 W
Address area	
Address space per module	
Address space per module, max.	8 bytes; + 1 byte for QI information

	6ES7134-6JD00-0CA1
Analog inputs	
Number of analog inputs	4
Maximum permissible input voltage for voltage input (destruction limit)	30 V
Constant measurement current for resistance-type sensor, typ.	2 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on the parameter assignment of the activated channels); an additional cycle is necessary for cable compensation for a 3-wire connection
Technical unit for temperature measurement can be set	Yes
Input ranges (rated values), voltages	
-1 V to +1 V	Yes; 16 bits incl. sign
Input resistance (-1 V to +1 V)	1 MΩ
-250 mV to +250 mV	Yes; 16 bits incl. sign
Input resistance (-250 mV to +250 mV)	1 MΩ
-50 mV to +50 mV	Yes; 16 bits incl. sign
Input resistance (-50 mV to +50 mV)	1 MΩ
-80 mV to +80 mV	Yes; 16 bits incl. sign
Input resistance (-80 mV to +80 mV)	1 MΩ
Input ranges (rated values), thermocouples	
Type B	Yes; 16 bits incl. sign
Input resistance (Type B)	1 MΩ
Type C	Yes; 16 bits incl. sign
Input resistance (Type C)	1 MΩ
Type E	Yes; 16 bits incl. sign
Input resistance (Type E)	1 MΩ
Type J	Yes; 16 bits incl. sign
Input resistance (Type J)	1 MΩ
Type K	Yes; 16 bits incl. sign
Input resistance (Type K)	1 MΩ
Type L	Yes; 16 bits incl. sign
Input resistance (Type L)	1 MΩ
Type N	Yes; 16 bits incl. sign
Input resistance (Type N)	1 MΩ
Type R	Yes; 16 bits incl. sign
Input resistance (Type R)	1 MΩ
Type S	Yes; 16 bits incl. sign
Input resistance (Type S)	1 MΩ
Type T	Yes; 16 bits incl. sign
Input resistance (Type T)	1 MΩ
Type U	Yes; 16 bits incl. sign
Input resistance (Type U)	1 MΩ

	6ES7134-6JD00-0CA1
Type TXK/TXK(L) according to GOST	Yes; 16 bits incl. sign
Input resistance (Type TXK/TXK(L) according to GOST)	1 MΩ
Input ranges (rated values), resistance thermometer	
Cu 10	Yes; 16 bits incl. sign
Input resistance (Cu 10)	1 MΩ
Ni 100	Yes; 16 bits incl. sign
Input resistance (Ni 100)	1 MΩ
Ni 1000	Yes; 16 bits incl. sign
Input resistance (Ni 1000)	1 MΩ
LG-Ni 1000	Yes; 16 bits incl. sign
Input resistance (LG-Ni 1000)	1 MΩ
Ni 120	Yes; 16 bits incl. sign
Input resistance (Ni 120)	1 MΩ
Ni 200	Yes; 16 bits incl. sign
Input resistance (Ni 200)	1 MΩ
Ni 500	Yes; 16 bits incl. sign
Input resistance (Ni 500)	1 MΩ
Pt 100	Yes; 16 bits incl. sign
Input resistance (Pt 100)	1 MΩ
Pt 1000	Yes; 16 bits incl. sign
Input resistance (Pt 1000)	1 MΩ
Pt 200	Yes; 16 bits incl. sign
Input resistance (Pt 200)	1 MΩ
Pt 500	Yes; 16 bits incl. sign
Input resistance (Pt 500)	1 MΩ
Input ranges (rated values), resistors	
0 to 150 ohms	Yes; 15 bits
Input resistance (0 to 150 ohms)	1 MΩ
0 to 300 ohms	Yes; 15 bits
Input resistance (0 to 300 ohms)	1 MΩ
0 to 600 ohms	Yes; 15 bits
Input resistance (0 to 600 ohms)	1 MΩ
0 to 3000 ohms	Yes; 15 bits
Input resistance (0 to 3000 ohms)	1 MΩ
0 to 6000 ohms	Yes; 15 bits
Input resistance (0 to 6000 ohms)	1 MΩ
PTC	Yes; 15 bits
Input resistance (PTC)	1 MΩ
Thermocouple (TC)	
Technical unit for temperature measurement	°C/°F/K
Temperature compensation	
• Configurable	Yes
• Reference channel of the module	Yes

	6ES7134-6JD00-0CA1
• Internal reference junction	Yes; with BaseUnit type A1
• Reference channel of the group	Yes
• Number of reference channel groups	4; group 0 to 3
• Fixed reference temperature	Yes
Resistance thermometer (RTD)	
Maximum permissible input voltage for voltage input (destruction limit)	30 V
Technical unit for temperature measurement	°C/°F/K
Cable length	
Cable length shielded, max.	200 m; 50 m for thermocouples
Analog value generation	
Measuring principle	Integrating (sigma-delta)
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Integration time configurable	Yes
Basic conversion time including integration time, ms	
• Additional processing time for wire break check	2 ms; in the resistance thermometer, resistor, and thermocouple areas
• Additional wire break check of the power line	2 ms; for 3-/4-wire transducer (resistance thermometer and resistor)
Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
Conversion time (per channel)	180 / 60 / 50 ms
Smoothing of the measured values	
Configurable	Yes
Setting: None	Yes
Setting: Weak	Yes
Setting: Medium	Yes
Setting: Strong	Yes
Sensors	
Wiring the signal transmitters	
For voltage measurement	Yes
for resistance measurement with 2-wire connection	Yes
for resistance measurement with 3-wire connection	Yes
for resistance measurement with 4-wire connection	Yes
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	± 0.01%; +/- 0.1% for resistance thermometer and resistor
Temperature error (in relation to input range)	± 0.0009%/K; +/- 0.005%/K for thermocouple
Crosstalk between inputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	± 0.05%

	6ES7134-6JD00-0CA1
Operational limit in entire temperature range	
Voltage in relation to input range, (+/-)	± 0.1%
Resistance in relation to input range, (+/-)	± 0.1%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	± 0.05%
Resistance in relation to input range, (+/-)	± 0.05%
Interference voltage suppression for f = n x (f1 +/-1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	70 dB
Common mode voltage, max.	10 V
Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic error interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; channel-based
Overflow/underflow	Yes; channel-based
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic insulation)
Between the inputs (UCM)	10 VDC
Insulation	
Insulation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	30 g

Operational and basic error limits for resistance thermometers

Error limits for resistance thermometers	
Operational limit (in the entire temperature range, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	±1.0 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.25 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	± 0.4 K
• Cu 10	±1.5 K
Basic error limit (operational limit at 25 °C, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	± 0.6 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.13 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	± 0.2 K
• Cu 10	±1.0 K

Operational and basic error limits for thermocouples

Error limits for thermocouples	
Operational limit for thermocouples (in the entire temperature range, in relation to the input range)	±1.5 K
Operational limit for type C thermocouples (in the entire temperature range, in relation to the input range)[1]	± 7 K
Basic error limit for thermocouples (operational limit at 25 °C, in relation to the input range)	±1 K
Basic error limit for type C thermocouples (operational limit at 25 °C, in relation to the input range)	± 5 K
Overall error limits when using internal compensation	
• Operational limit (in the entire temperature range at static thermal state, ambient temperature change < 0.3 K/min)[2]	± 2.5 K
• Basic error limit (operational limit at 25 °C at static thermal state, ambient temperature change < 0.3 K/min)[3]	±1.5 K

[1] The indicated error limits apply as of the following temperatures:
Thermocouple type T: -200 °C
Thermocouple type K: -100 °C
Thermocouple type B: +700 °C
Thermocouple type N: -150 °C
Thermocouple type E: -150 °C
Thermocouple type R: +200 °C
Thermocouple type S: +100 °C

[2] For thermocouple type C: ± 8 K

[3] For thermocouple type C: ± 6 K

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Table A- 1 Dependencies of the measurement type / measuring range

Measurement type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
Deactivated	*	*	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*	*	*
Resistor (2, 3, 4-wire connection)	150 Ω, 300 Ω, 600 Ω, 3 kΩ, 6 kΩ	*	*	*	x (with 2-wire connection)
Resistor (2-wire connection)	PTC	*	*	*	*
Thermal resistor (2, 3, 4-wire connection)	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x (with 2-wire connection)
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	
	Pt200 Pt500 Pt1000 climatic		No reference channel mode	Degrees Celsius Degrees Fahrenheit	
	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672			
	LG-Ni 1000 climatic	LG-Ni 0.005			

Measurement type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
(3-wire connection)	Cu 10 climatic	Cu 0.00427			*
Thermal resistor (2, 3, 4-wire connection)	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x (with 2-wire connection)
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672			
	LG-Ni 1000 standard	LG-Ni 0.005			
Thermal resistor (3-wire connection)	Cu 10 standard	Cu 0.00427			*
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	*
			Fixed reference temperature		

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of "Reference channel of the module":
- Channel 0 must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
-For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Reference channel of the module".

2 Use of "Reference channel of group 0, 1, 2, 3":
- An RTD channel must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There must only be one RTD channel with "Reference junction" = "Reference channel of group 0, 1, 2, 3" per group 0, 1, 2, 3 and IO device!
- For each TC channel in the IO device that is intended to use this reference, "Reference junction" must be set to "Reference channel of group 0, 1, 2, 3".
- If the reference channel is on channel 0, it can also be used as "Reference channel of the module" at the same time.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type for PROFINET.

Table A- 2 Dependencies on the measurement type

Measurement type	Scalable measuring range	Measuring range resolution	Diagnostics				
			Underflow	Overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*
Voltage	–	*	x	x	–	x	–
Resistor (2, 3, 4-wire connection)	–	*	x	x	x	x	–
Resistor PTC (2-wire connection)	–	*	x	–	–	x	–
Thermal resistor (2, 3, 4-wire connection)	x	2 and 3 decimal places	x	x	x	x	–
Thermocouple	x	2 and 3 decimal places	x	x	x	x	x[1)]

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Property is not relevant if "Fixed reference temperature" is used

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*	*	x	–	x	–
Resistor (2, 3, 4-wire connection)	150 Ω, 300 Ω, 600 Ω, 3 kΩ, 6 kΩ	*	*	*	x	x	x	–

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Resistor (2-wire connection)	PTC[3]	*	*	*	x	–	x	–
Thermal resistor (2, 3, 4-wire connection)	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x	x	x	–
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Pt200 Pt500 Pt1000 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
Thermal resistor (2, 3, 4-wire connection)	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
Thermal resistor (2, 3, 4-wire connection)	LG-Ni 1000 climatic	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	LG-Ni 1000 standard	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Thermal resistor (3-wire connection)	Cu 10 climatic	Cu 0.00427	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Cu 10 standard	Cu 0.00427	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	x
			Fixed reference temperature	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	*

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be set as "Pt100 climatic" with temperature unit "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There may be only one RTD channel with "Reference junction active" = "Enable" per group and row.
- For each TC channel of this row that is intended to use this reference, "Reference junction active" must be set to "Enable".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

A.2 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

The module parameter settings can be changed in RUN (for example, the voltage or current values of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

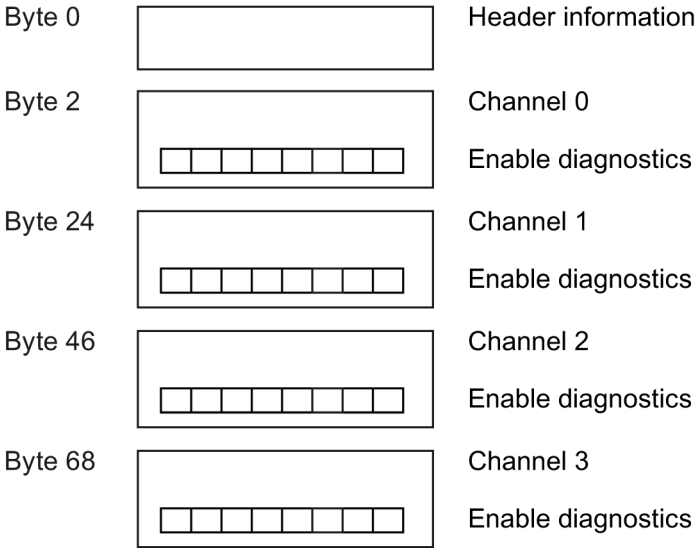


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

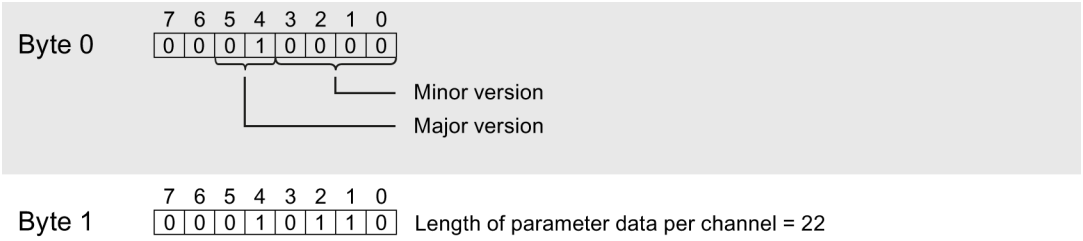


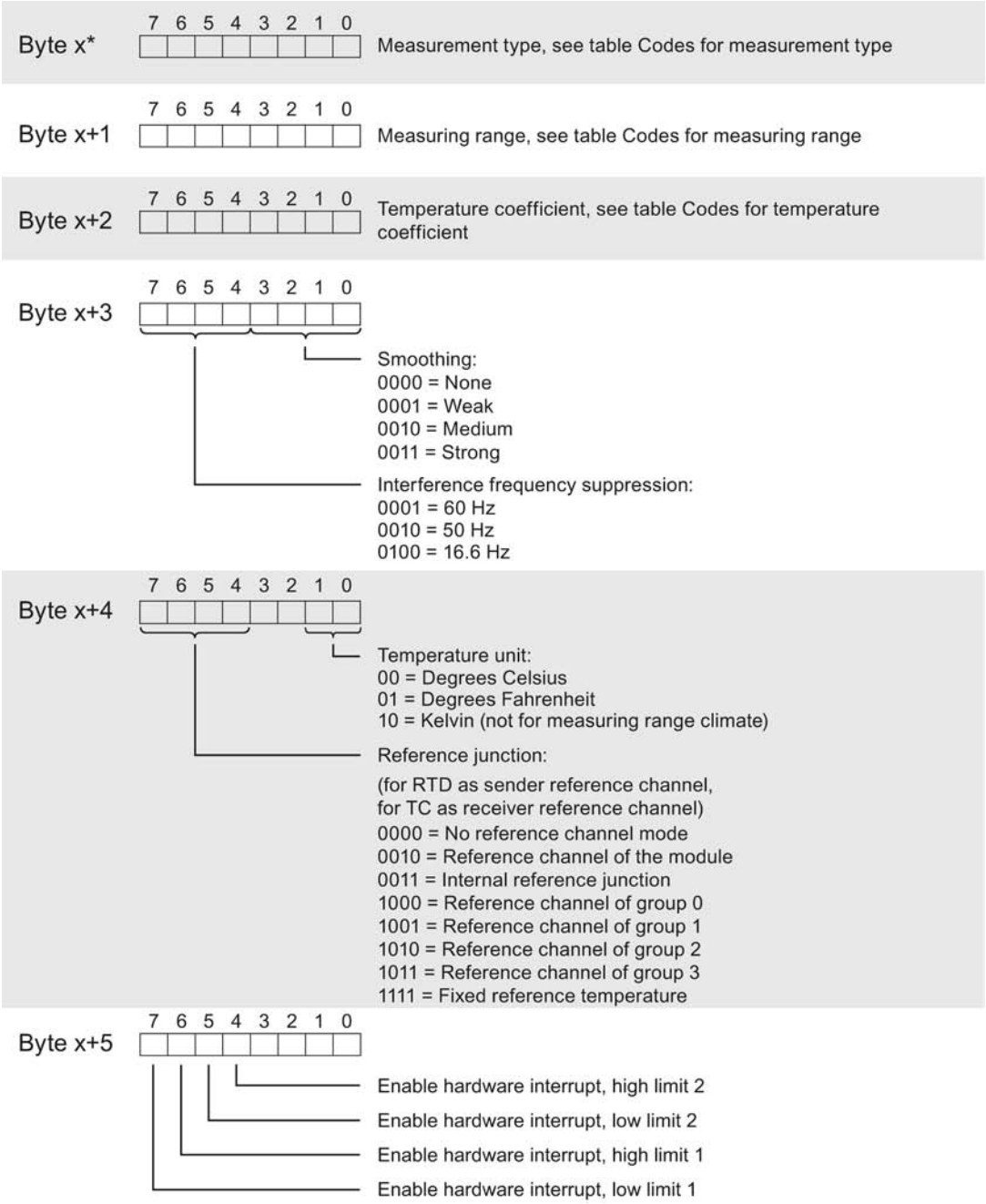
Figure A-2 Header information

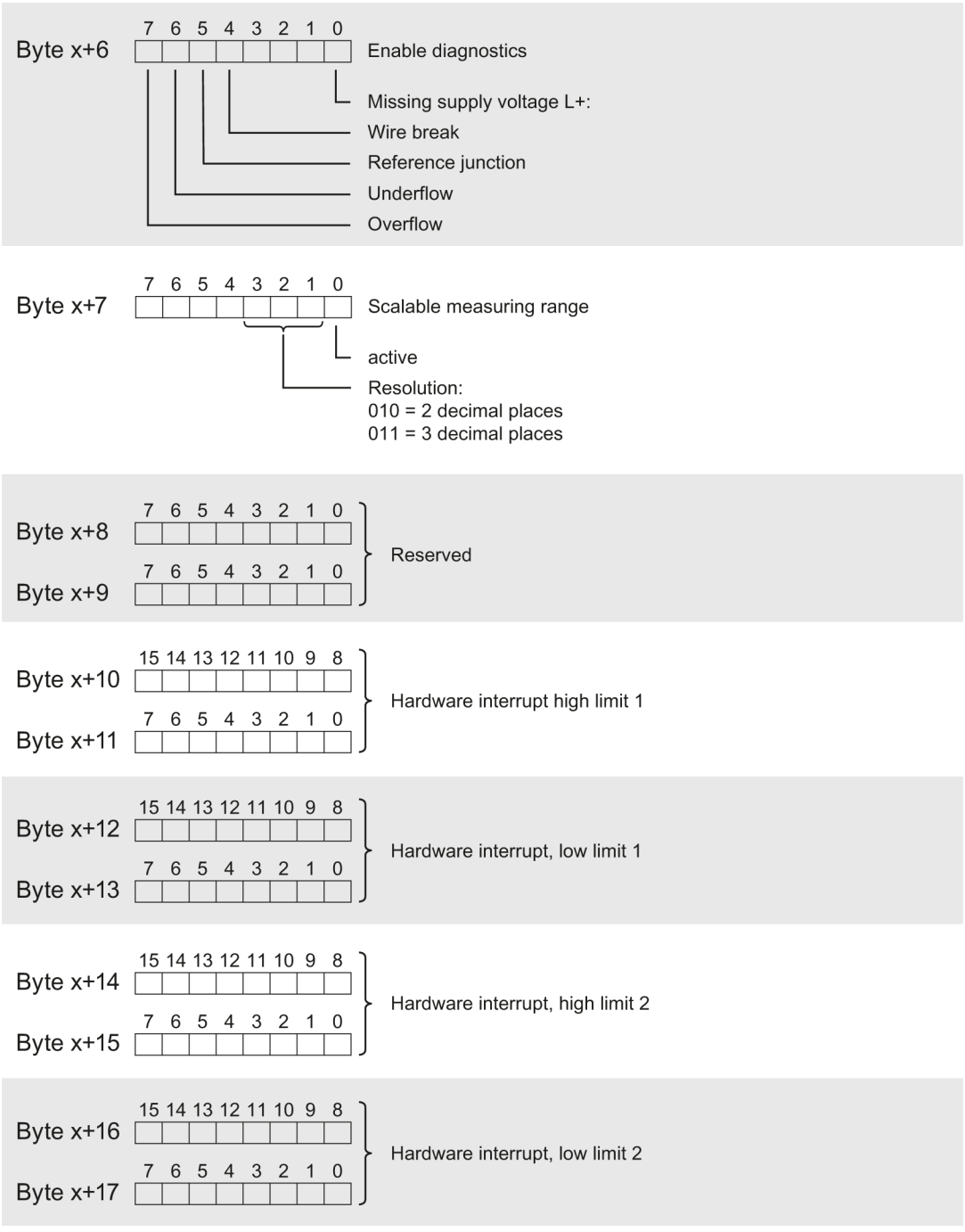
Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number * 22); channel number = 0 to 3




Byte x+6
7 6 5 4 3 2 1 0
Enable diagnostics
Missing supply voltage L+:
Wire break
Reference junction
Underflow
Overflow
Byte x+7
7 6 5 4 3 2 1 0
Scalable measuring range
active
Resolution:
010 = 2 decimal places
011 = 3 decimal places
Byte x+8
Byte x+9
7 6 5 4 3 2 1 0
Reserved
Byte x+10
Byte x+11
15 14 13 12 11 10 9 8
7 6 5 4 3 2 1 0
Hardware interrupt high limit 1
Byte x+12
Byte x+13
Hardware interrupt, low limit 1
Byte x+14
Byte x+15
Hardware interrupt, high limit 2
Byte x+16
Byte x+17
Hardware interrupt, low limit 2

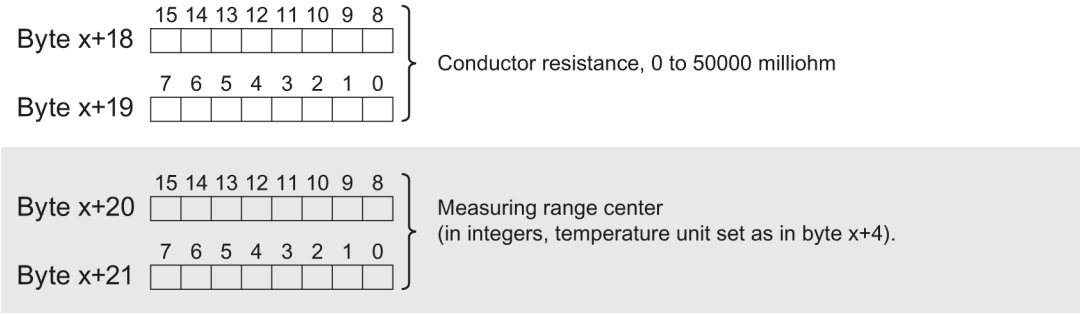


Figure A-3 Structure of byte x to x+21 for channel 0 to 3

Codes for measurement type

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table A- 3 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Resistor, 4-wire connection	0000 0100
Resistor, 3-wire connection	0000 0101
Resistor, 2-wire connection	0000 0110
Thermal resistor, 4-wire connection	0000 0111
Thermal resistor, 3-wire connection	0000 1000
Thermal resistor, 2-wire connection	0000 1001
Thermocouple	0000 1010

Codes for measuring range

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes at byte x+1 (see previous figure).

Table A- 4 Codes for measuring range

Measuring range	Code
Voltage	
50 mV	0000 0001
80 mV	0000 0010
250 mV	0000 0011
1 V	0000 0101
Resistor	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
3 kΩ	0000 0100
6 kΩ	0000 0101
PTC	0000 1111
Thermal resistor climatic	
Pt 100	0000 0000
Pt 200	0000 0111
Pt 500	0000 1000
Pt 1000	0000 1001
Thermal resistor standard	
Pt 100	0000 0010
Pt 200	0000 1011
Pt 500	0000 0100
Pt 1000	0000 0101
Thermal resistor climatic	
Ni 100	0000 0001
Ni 120	0000 1101
Ni 200	0001 0001
Ni 500	0001 0011
Ni 1000	0000 1010
LG-Ni 1000	0001 1101
Thermal resistor standard	
Ni 100	0000 0011
Ni 120	0000 1100
Ni 200	0001 0000
Ni 500	0001 0010
Ni 1000	0000 0110
LG-Ni 1000	0001 1100

Measuring range	Code
Thermal resistor	
Cu 10 climatic	0000 1110
Cu 10 standard	0000 1111
Thermocouple	
Type B	0000 0000
Type N	0000 0001
Type E	0000 0010
Type R	0000 0011
Type S	0000 0100
Type J	0000 0101
Type L	0000 0110
Type T	0000 0111
Type K	0000 1000
Type U	0000 1001
Type C	0000 1010
Type TXK	0000 1011

Codes for temperature coefficient for temperature measurement

The following table contains the codes for the temperature coefficients of the analog input module. You must enter these codes at byte x+2 (see previous figure).

Table A- 5 Codes for temperature coefficient for temperature measurement

Temperature coefficient	Code
Pt 0.00385055	0000 0000
Pt 0.003916	0000 0001
Pt 0.003902	0000 0010
Pt 0.00392	0000 0011
Pt 0.00385	0000 0100
Ni 0.00618	0000 1000
Ni 0.00672	0000 1001
LG-Ni 0.005	0000 1010
Cu 0.00427	0000 1100

Limits for hardware interrupts

The following tables contain the permitted limits for hardware interrupts (in each case, the usable value is given). The limits depend on the selected measurement type and the selected measuring range. The value for the overflow must be larger than the value for the underflow.

Table A- 6 Limits for resistor and voltage

Resistor (all possible measuring range settings)	**Voltage**	
32510	32510	Overflow
1	-32511	Underflow

Table A- 7 Limits for thermocouple types B, C, and E

Thermocouple									
Type B			Type C			Type E			
°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	24999	32765	27731	11999	21919	14731	Overflow
-1199	-1839	1533	-1199	-1839	1533	-2699	-4539	33	Underflow

Table A- 8 Limits for thermocouple types R, S, J, and L

Thermocouple									
Types R, S			Type J			Type L			
°C	°F	K	°C	°F	K	°C	°F	K	
20189	32765	22921	14499	26419	17231	11499	21019	14231	Overflow
-1699	-2739	1033	-2099	-3459	633	-1999	-3279	733	Underflow

Table A- 9 Limits for thermocouple types T, K, and U

Thermocouple									
Type T			Type K			Type U			
°C	°F	K	°C	°F	K	°C	°F	K	
5399	10039	8131	16219	29515	18951	8499	15619	11231	Overflow
-2699	-4539	33	-2699	-4539	33	-1999	-3279	733	Underflow

Table A- 10 Limits for thermocouple types N and TXK

Thermocouple						
Type N			Type TXK			
°C	°F	K	°C	°F	K	
15499	28219	18231	10499	19219	13231	Overflow
-2699	-4539	33	-1999	-3279	733	Underflow

Table A- 11 Limits for thermal resistor

Thermal resistor						
	Standard			Climatic		
	°C	°F	K	°C	°F	
Cu	3119	5935	5851	17999	32765	Overflow
	-2399	-3999	333	-5999	-7599	Underflow
Pt	9999	18319	12731	15499	31099	Overflow
	-2429	-4053	303	-14499	-22899	Underflow
Ni, Ni-LG	2949	5629	5681	29499	32765	Overflow
	-1049	-1569	1683	-10499	-15699	Underflow

A.3 Switchable wire break check

Function

The "Switchable wire break check" is available for thermocouples. It switches off the wire break check for the module.

This is required, for example, to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.

The function has no effect on channels that are not assigned in the thermocouple mode.

Note

Startup and parameter reassignment

The wire break check is switched on again at each startup and during any parameter reassignment of the module.

Switch-off via the user program

You can deactivate the wire break check using data record 237.

Table A- 12 Structure of data record 237, switchable wire break check

Byte	Function	Format	Value	Description
0	Command	UBYTE	80_H	Wire break check
1	Identifier	UBYTE	00_H	Not relevant
2	Channel number	UBYTE	FF_H	All channels
3	Calibration step	UBYTE	FF_H	First triggering
4	Measurement type	UBYTE	00_H	Not relevant
5	Measuring range	UBYTE	00_H	Not relevant
6	Action	UBYTE	01_H	Deactivate wire break check
			02_H	Activate wire break check
7...17	Reserved	UBYTE	00_H	Not relevant

Representation of analog values

B

This appendix shows the analog values for all measuring ranges supported by the analog input module AI 4xRTD/TC 2-/3-/4-wire HF.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its assigned parameters.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Note

The digitized temperature values are the result of a conversion in the analog module. The following resolution therefore does not apply to temperature values.

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table B- 4 Voltage measuring range ±1 V

Values		Voltage measuring range	Range
Dec.	Hex.	±1 V	
32767	7FFF	> 1.176 V	Overflow
32511	7EFF	1.176 V	Overrange
27649	6C01		
27648	6C00	1 V	Nominal range
20736	5100	0.75 V	
1	1	36.17 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-0.75 V	
-27648	9400	-1 V	
-27649	93FF		Underrange
-32512	8100	-1.176 V	
-32768	8000	<-1.176 V	Underflow

Table B- 5 Voltage measuring range ±500 mV to ±50 mV

Values		Voltage measuring range			Range
Dec.	Hex.	±250 mV	±80 mV	±50 mV	
32767	7FFF	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	294.0 mV	94.1 mV	58.8 mV	Overrange
27649	6C01				
27648	6C00	250 mV	80 mV	50 mV	Nominal range
20736	5100	187.5 mV	60 mV	37.5 mA	
1	1	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	
-1	FFFF				
-20736	AF00	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-250 mV	-80 mV	-50 mV	
-27649	93FF				Underrange
-32512	8100	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-294.0 mV	<-94.1 mV	<-58.8 mV	Underflow

B.3 Representation of analog values for resistance-type sensors

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-type sensor ranges.

Table B- 6 Resistance-type sensors from 150 Ω to 6000 Ω

Values		Resistance-type sensor range					Range
Dec.	Hex.	150 Ω	300 Ω	600 Ω	3000 Ω	6000 Ω	
32767	7FFF	> 176.38 Ω	> 352.77 Ω	> 705.53 Ω	> 3527.7 Ω	> 7055.3 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	3527.7 Ω	7055.3 Ω	Overrange
27649	6C01						
27648	6C00	150 Ω	300 Ω	600 Ω	3000 Ω	6000 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	450 Ω	2250 Ω	4500 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	108.5 mΩ	217 mΩ	
0	0	0 Ω	0 Ω	0 Ω	0 Ω	0 Ω	
-32768	8000	(negative values are physically impossible)					Underflow[1]

[1] If the resistors are not connected correctly or the conductor resistance is too high

B.4 Representation of analog values for thermal resistors

Note

A higher resolution can be configured for the measuring range for the standard resistance thermometers, see section Scalable measuring range (Page 28).

The tables below list the decimal and hexadecimal values (codes) of the thermal resistors.

Table B- 7 Thermal resistor Pt 100, 200, 500, 1000 standard

Pt x00 Standard in °C (1 digit = 0.1°C)	Values		Pt x00 Standard in °F (1 digit = 0.1 °F)	Values		Pt x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	> 1273.2	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overrange
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Nominal range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Underrange
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table B- 8 Thermal resistor Pt 100, 200, 500, 1000 climatic

Pt x00 climatic in °C (1 digit = 0.01 °C)	Values		Pt x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Nominal range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Underrange
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table B- 9 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 standard

Ni x00 standard in °C (1 digit = 0.1 °C)	Values		Ni x00 standard in °F (1 digit = 0.1 °F)	Values		Ni x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 295.0	32767	7FFF	> 563.0	32767	7FFF	> 568.2	32767	7FFF	Overflow
295.0 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overrange
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Nominal range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table B- 10 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 climatic

Ni x00 climatic in °C (1 digit = 0.01 °C)	Values		Ni x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 295.00	32767	7FFF	> 327.66	32767	7FFF	Overflow
295.00 : 250.01	29500 : 25001	733C : 61A9	327.66 : 280.01	32766 : 28001	7FFE : 6D61	Overrange
250.00 : -60.00	25000 : -6000	61A8 : E890	280.00 : -76.00	28000 : -7600	6D60 : E250	Nominal range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Underrange
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

Table B- 11 Thermal resistor Cu 10 standard

Cu 10 standard in °C (1 digit = 0.01 °C)	Values		Cu 10 standard in °F (1 digit = 0.01 °F)	Values		Cu 10 standard in K (1 digit = 0.01 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 312.0	32767	7FFF	> 593.6	32767	7FFF	> 585.2	32767	7FFF	Overflow
312.0 : 260.1	3120 : 2601	C30 : A29	593.6 : 500.1	5936 : 5001	1730 : 12D5	585.2 : 533.3	5852 : 5333	16DC : 14D5	Overrange
260.0 : -200.0	2600 : -2000	A28 : F830	500.0 : -328.0	5000 : -3280	1389 : F330	533.2 : 73.2	5332 : 732	14D4 : $2DC_H$	Nominal range
-200.1 : -240.0	-2001 : -2400	F82F : F6A0	-328.1 : -400.0	-3281 : -4000	F32F : F060	73.1 : 33.2	731 : 332	2DB : $14C_H$	Underrange
< -240.0	-32768	8000	< -400.0	-32768	8000	< 33.2	32768	8000	Underflow

Table B- 12 Thermal resistor Cu 10 climatic

Cu 10 climatic in °C (1 digit = 0.01 °C)	Values		Cu 10 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 180.00	32767	7FFF	> 325.11	32767	7FFF	Overflow
180.00 : 150.01	18000 : 15001	4650 : 3A99	327.66 : 280.01	32766 : 28001	7FFE : 6D61A	Overrange
150.00 : -50.00	15000 : -5000	3A98 : EC78	280.00 : - 58.00	28000 : -5800	6D60 : $E958_H$	Nominal range
-50.01 : -60.00	-5001 : -6000	EC77 : E890	-58.01 : -76.00	-5801 : -7600	E957 : E250	Underrange
< - 60.00	-32768	8000	< - 76.00	-32768	8000	Underflow

B.5 Representation of analog values for thermocouples

Note

A higher resolution can be configured for thermocouples, see section Scalable measuring range (Page 28).

The tables below list the decimal and hexadecimal values (codes) of the thermocouples.

Table B- 13 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2070.0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070.0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overrange
1820.0 : 0.0	18200 : 0	4718 : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2093.2 : 273.2	20932 : 2732	51C4 : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table B- 14 Thermocouple type C

Type C in °C	Values		Type C in °F	Values		Type C in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2500.0	32767	7FFF	> 3276.6	32767	7FFF	> 2773.2	32767	7FFF	Overflow
2500.0 : 2315.1	25000 : 23151	61A8 : 5A6F	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2773.2 : 2588.3	27732 : 25883	6C54 : 651B	Overrange
2315.0 : 0.0	23150 : 0	5A6E : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2588.2 : 273.2	25882 : 2732	651A : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table B- 15 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1200.0	32767	7FFF	> 2192.0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200.0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.1	21920 : 18321	55A0 : 4791	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overrange
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 3.2	12732 : 32	31BC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 16 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.1	26420 : 21921	6734 : 55A1	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overrange
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Nominal range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table B- 17 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895.2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overrange
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 3.2	16452 : 32	4044 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 18 Thermocouple type L

Type L in °C	Values		Type L in °F	Values		Type L in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1150.0	32767	7FFF	> 2102.0	32767	7FFF	> 1423.2	32767	7FFF	Overflow
1150.0 : 900.1	11500 : 9001	2CEC : 2329	2102.0 : 1652.1	21020 : 16521	521C : 4089	1423.2 : 1173.3	14232 : 11733	3798 : 2DD5	Overrange
900.0 : -200.0	9000 : -2000	2328 : F830	1652.0 : -328.0	16520 : -3280	4088 : F330	1173.2 : 73.2	11732 : 732	2DD4 : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table B- 19 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1550.0	32767	7FFF	> 2822.0	32767	7FFF	> 1823.2	32767	7FFF	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C : 32C9	2822.0 : 2372.1	28220 : 23721	6E3C : 5CA9	1823.2 : 1573.3	18232 : 15733	4738 : 3D75	Overrange
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 3.2	15732 : 32	3D74 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 20 Thermocouples R and S

Types R, S in °C	Values		Types R, S in °F	Values		Types R, S in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.3	32766 : 32163	7FFE : 7DA3	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overrange
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Nominal range
-50.1 : -170.0	-501 : -1700	FE0B : F95C	-58.1 : -274.0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Underrange
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table B- 21 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 540.0	32767	7FFF	> 1004.0	32767	7FFF	> 813.2	32767	7FFF	Overflow
540.0 : 400.1	5400 : 4001	1518 : 0FA1	1004.0 : 752.1	10040 : 7521	2738 : 1D61	813.2 : 673.3	8132 : 6733	1FC4 : 1AAD	Overrange
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 22 Thermocouple type U

Type U in °C	Values		Type U in °F	Values		Type U in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 850.0	32767	7FFF	> 1562.0	32767	7FFF	> 1123.2	32767	7FFF	Overflow
850.0 : 600.1	8500 : 6001	2134 : 1771	1562.0 : 1112.1	15620 : 11121	2738.0 : 2B71	1123.2 : 873.3	11232 : 8733	2BE0 : 221D	Overrange
600.0 : -200.0	6000 : -2000	1770 : F830	1112.0 : -328.0	11120 : -3280	2B70 : F330	873.2 : 73.2	8732 : 732	221C : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table B- 23 Thermocouple type TXK (GOST)

Type TXK in °C	Values		Type TXK in °F	Values		Type TXK in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1050.0	32767	7FFF	> 1922.0	32767	7FFF	>1323.2	32767	7FFF	Overflow
1050.0 : 800.1	10500 : 8001	2904 : 1F41	1922.0 : 1472.1	19220 : 14721	4B14 : 3981	1323.2 : 1073.3	13232 : 10733	33B0 : 29ED	Overrange
800.0 : 0.0 : -200.0	8000 : 0 : -2000	1F40 : 0000 : F830	1472.0 : 32.0 : -328.0	14720 : 320 : -3280	3980 : 0140 : F330	1073.2 : 273 : 73.2	10732 : 2730 : 732	29EC : 0AAA : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	<73.2	-32768	8000	Underflow

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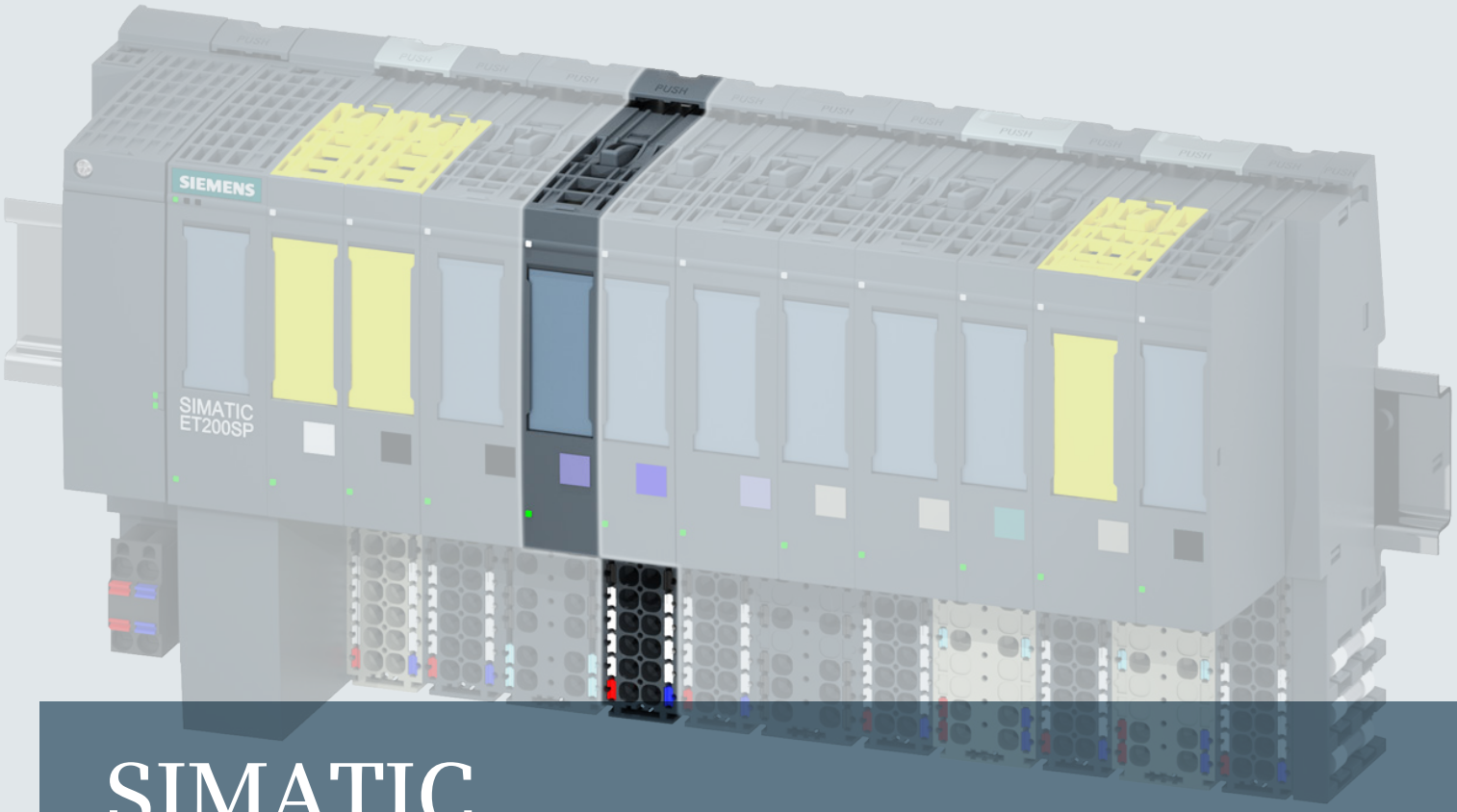

SIMATIC

ET 200SP

Analog input module AI 8xRTD/TC 2-wire HF (6ES7134-6JF00-0CA1)

Manual

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Answers for industry.

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes labeled as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Guide to documentation

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of a system manual, function manuals and product manuals.

The STEP 7 information system (online help) also supports you during the configuration and programming of your automation system.

Overview of documentation for analog input module AI 8×RTD/TC 2-wire HF

The following table shows additional documentation that you will need when using the AI 8×RTD/TC 2-wire HF analog input module.

Table 1- 1 Documentation for analog input module AI 8×RTD/TC 2-wire HF

Topic	Documentation	Key contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
Analog value processing	Function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Key contents
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Amendments and special features of the ET 200SP distributed I/O system	Product information on documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or product manuals.

SIMATIC manuals

All current manuals for SIMATIC products are available to download free of charge on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Article number

6ES7134-6JF00-0CA1

View of the module

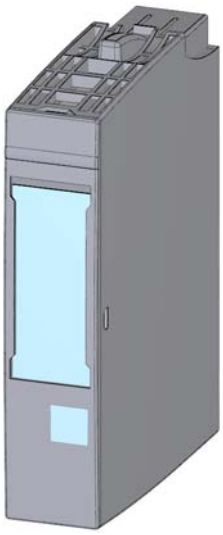


Figure 2-1 View of the module AI 8×RTD/TC 2-wire HF

Properties

The module has the following technical properties:

- Analog input module with 8 inputs
- Resolution: Up to 16 bits including sign
- Voltage measurement type can be set per channel
- Resistor measurement type can be set per channel
- Thermal resistor (RTD) measurement type can be set per channel
- Thermocouple (TC) measurement type can be set per channel
- Configurable diagnostics for each channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- Calibration in runtime
- Value status (PROFINET IO only)
- Selectable conductor resistance for 2-wire connection
- Switchable wire break check

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

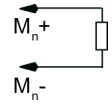
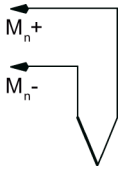
Wiring

3

3.1 Pin assignment

General pin assignment

Table 3- 1 Pin assignment for AI 8×RTD/TC 2-wire HF

Pin assignment for AI 8×RTD/TC 2-wire HF (6ES7134-6JF00-0CA1)						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Notes**	**BaseUnits**[1]	**Color identification label**
1	M_0+	**2**	M_1+	• M_n+: Measuring line positive, channel n • M_n-: Measuring line negative, channel n	A0 A1	---
3	M_2+	**4**	M_3+			
5	M_4+	**6**	M_5+			
7	M_6+	**8**	M_7+			
9	M_0-	**10**	M_1-			
11	M_2-	**12**	M_3-			
13	M_4-	**14**	M_5-			
15	M_6-	**16**	M_7-			
L+	24 VDC	**M**	M			
RTD 2-wire connection 						
TC 						

[1] Usable BaseUnit types, can be identified by the last two digits of the article number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Keep this in mind also during the configuration.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

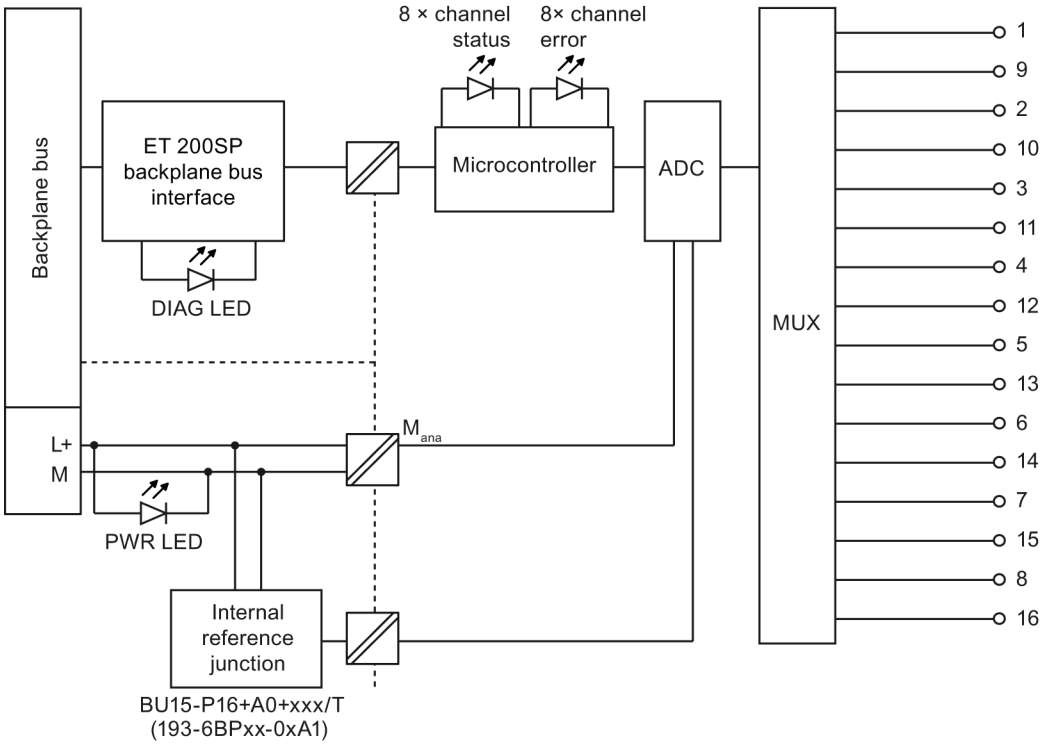


Figure 3-1 Block diagram AI 8×RTD/TC 2-wire HF

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table describes the measuring range and the temperature coefficients you can configure for each measurement type:

Table 4- 1 Measurement types and measuring ranges

Measurement type	Measuring range	Temperature coefficient
Deactivated	–	–
Resistor (2-wire connection)	150 Ω / 300 Ω / 600 Ω / 3 kΩ / 6 kΩ	–
Resistor (2-wire connection)	PTC	–
Thermal resistor RTD (2-wire connection)	Climatic / Standard Pt 100 Pt 200 Pt 500 Pt 1000	Pt 0.00385 / Pt 0.003916 / Pt 0.003902 / Pt 0.00392 / Pt 0.00385055
	Climatic / Standard Ni 100 Ni 120 Ni 200 Ni 500 Ni 1000	Ni 0.00618 / Ni 0.00672
	Climatic[1] / Standard[1] Ni 1000	Ni 0.005
Thermocouple (TC)	Type E, N, J, K, L, S, R, B, T, C, U, TXK (acc. to GOST)	
Voltage	±50 mV / ±80 mV / ±250 mV / ±1 V	

[1] For sensors LG-Ni 1000 from Siemens Building Ltd (Landis & Stäfa).

Special features when using PTC resistors

PTCs are suitable for monitoring temperature and as thermal protection devices for complex drives or transformer windings.

- Choose "Resistor (2-wire)" and "PTC" in the parameter assignment.
- Connect the PTC to the 2-wire connection technology.
- Use the PTC resistors, type A (PTC thermistor) in accordance with DIN/VDE 0660, part 302.
- If "Underflow" diagnostics is enabled, a "Violation of low limit" diagnostics is generated for resistance values < 18 Ω, indicating a short-circuit.
- Sensor data for the PTC resistor:

Table 4- 2 Using PTC resistors

Property	Technical specifications	Comment
Switching points	**Behavior with rising temperature**	
	< 550 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	550 Ω to 1650 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	> 1650 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	Behavior with falling temperature	
	> 750 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	750 Ω to 540 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	< 540 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	Reaction to short-circuit	
	< 18 Ω	• SIMATIC S7: Bit 7 (IB x+1) = "1", Bit 0 = "0" and Bit 2 = "0"
(RRT-5) °C (RRT+5) °C (RRT+15) °C Measuring voltage/ voltage at the PTC	Max. 550 Ω min. 1330 Ω min. 4000 Ω Max. 7.5 V[1]	TNF = Rated response temperature of the sensor (according to DIN/VDE 0660)

[1] Below 23 kΩ

Assignment in the process image input (PII) with SIMATIC S7

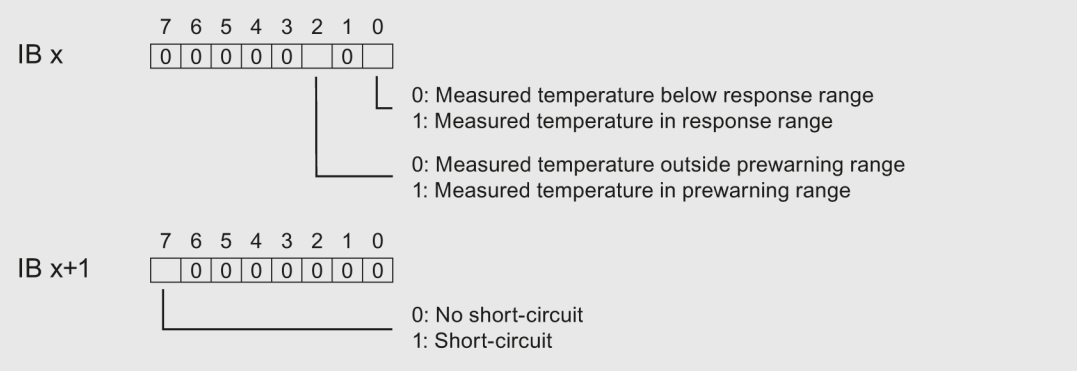


Figure 4-1 Assignment in the process image input (PII)

Notes on programming

- Bits 0+2 are relevant for evaluation in the process image input. You can monitor, for example, the temperature of a motor using bits 0+2.
- Bits 0+2 in the process image input cannot be saved. During parameter assignment, take into consideration that a motor, for example, starts up in a controlled manner (via an acknowledgment).
- Bits 0+2 can never be set at the same time; they are set one after the other.

NOTICE
No measurement is possible in the following cases: • When I/O modules are pulled out • When supply voltage to the I/O module fails • When there is a wire break or short-circuit in the measuring lines You should therefore always evaluate the diagnostic entries of AI 8×RTD/TC 2-wire HF for safety reasons.

Example

The diagram shows the temperature curve and the associated switching points.

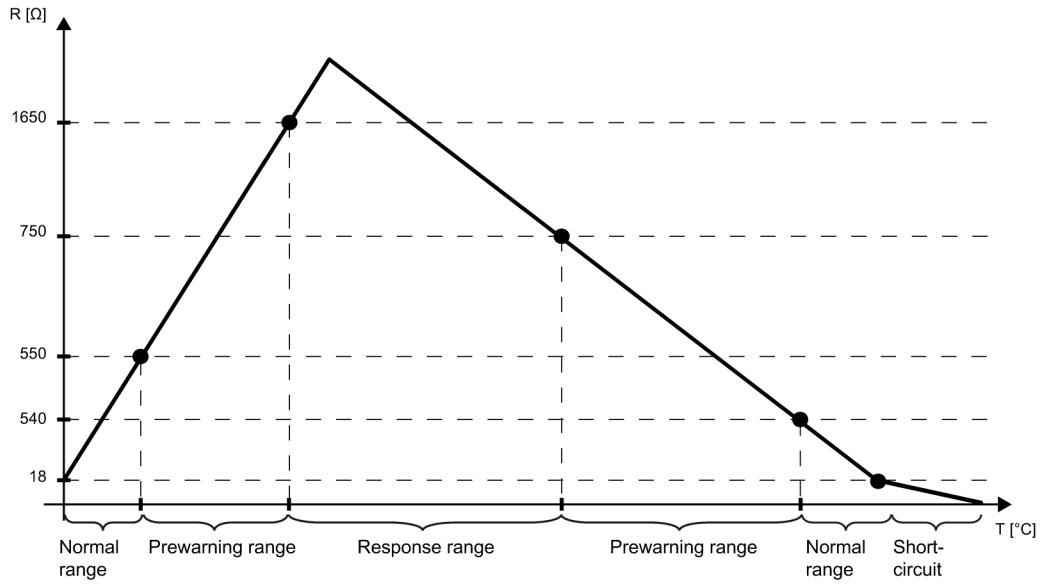


Figure 4-2 Temperature curve with prewarning range

See also

Technical specifications (Page 39)

4.2 Parameters

Parameters of the AI 8xRTD/TC 2-wire HF

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of parameter data record (Page 50). The following parameter settings are possible:

Table 4- 3 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Reference junction	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Type/range of measurement	• Deactivated • Voltage ±50 mV • Voltage ±80 mV • Voltage ±250 mV • Voltage ±1 V Resistor (2-wire connection) • 150 Ω • 300 Ω • 600 Ω • 3 kΩ • 6 kΩ	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
Type/range of measurement	Resistor (2-wire connection) PTC	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
Type/range of measurement	Thermal resistor (2-wire connection) • Pt 100 climatic range • Pt 200 climatic range • Pt 500 climatic range • Pt 1000 climatic range Thermal resistor (2-wire connection) • Pt 100 standard range • Pt 200 standard range • Pt 500 standard range • Pt 1000 standard range	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Type/range of measurement	Thermal resistor (2-wire connection) • Ni 100 climatic range • Ni 120 climatic range • Ni 200 climatic range • Ni 500 climatic range • Ni 1000 climatic range	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2-wire connection) • Ni 100 standard range • Ni 120 standard range • Ni 200 standard range • Ni 500 standard range • Ni 1000 standard range				
Type/range of measurement	Thermocouple • Type B (PtRh-PtRh) • Type N (NiCrSi-NiSi) • Type E (NiCr-CuNi) • Type R (PtRh-Pt) • Type S (PtRh-Pt) • Type J (Fe-CuNi) • Type L (Fe-CuNi) • Type T (Cu-CuNi) • Type K (NiCr-NiAl) • Type U (Cu-CuNi) • Type C (WRe-WRe) • Type TXK	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
Temperature coefficient	• Pt 0.00385055 • Pt 0.003916 • Pt 0.003902 • Pt 0.00392 • Pt 0.00385 • Ni 0.00618 • Ni 0.00672 • LG-Ni 0.005	Pt 0.00385055	Yes	Channel	Channel

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Temperature unit	• Degrees Celsius • Degrees Fahrenheit • Kelvin	Degrees Celsius	Yes	Channel	Module
Reference junction [4]	• No reference channel mode • Reference channel of the module • Internal reference junction • Reference channel of group 0 to 3 • Fixed reference temperature	No reference channel mode	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz • 50 Hz[2] • 16.6 Hz	50 Hz	Yes	Channel	Module
Scalable measuring range	• Disable • Enable	Disable	Yes	Channel	-
Measuring range resolution	• 2 decimal places • 3 decimal places	2 decimal places	Yes	Channel	-
Measuring range center	• Value within the nominal range of the measuring range	0	Yes	Channel	-
Conductor resistance	0 to 50000 mΩ	0	Yes	Channel	-
Hardware interrupt high limit 1 [3]	• Disable • Enable	Disable	Yes	Channel	-
High limit 1 [3]	• Value	8500	Yes	Channel	-
Hardware interrupt low limit 1 [3]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 1 [3]	• Value	-2000	Yes	Channel	-
Hardware interrupt high limit 2 [3]	• Disable • Enable	Disable	Yes	Channel	-
High limit 2 [3]	• Value	8500	Yes	Channel	-

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Hardware interrupt low limit 2 [3]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 2 [3]	• Value	-2000	Yes	Channel	-
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 24 bytes.

4 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

Note

Unused channels

"Deactivate" unused inputs in the parameter assignment to shorten the cycle time of the module.

A deactivated input always returns the value $7FFF_H$.

4.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Reference junction

Enabling of the reference junction diagnostics if the reference temperature of the reference junction needs to be determined for the TC channel being operated.

Reference junction using the PROFINET GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module can be used as reference junction for the TC measurement, if this has the parameter setting "Thermal resistor Pt100 climatic range Degrees Celsius".

A possible parameter assignment is represented below:

Table 4- 4 RTD channel

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of the group. The distribution is performed via the interface module.

Table 4- 5 TC channel

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This must be configured as "Thermal resistor Pt 100 climatic range Degrees Celsius" and "No reference channel mode"; otherwise, Diagnostics: Reference junction is triggered.
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group.
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

Note

Shared Device and "Reference channel of group 0, 1, 2, 3"

If the transmitter and receiver for the reference junction temperature of a group are assigned to different IO controllers, then both IO controllers must be performing data exchange with the IO device to ensure error-free operation of the temperature compensation.

Reference junction using the PROFIBUS GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module can be used as reference junction for the TC measurement, if this has the parameter setting "Thermal resistor Pt100 climatic range Degrees Celsius".

The set temperature unit (e.g. Degrees Celsius) is valid for the entire module with temperature compensation "Reference channel of the module" and "Reference channel of group 0, 1, 2, 3".

Table 4- 6 **RTD channel**

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of a group. The distribution is performed via the interface module.

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "No reference channel mode". • Enable: Channel x is configured with the setting selected above.

Table 4- 7 **TC channel**

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This must be configured as "Thermal resistor Pt 100 climatic range Degrees Celsius" and "No reference channel mode"; otherwise, Diagnostics: Reference junction is triggered.
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of the group.
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "Fixed reference temperature". • Enable: Channel x is configured with the setting selected above.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics if the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or the current is insufficient for measurement at the correspondingly assigned input.

Type/range of measurement

See the section Measurement types and measuring ranges (Page 11).

Temperature coefficient

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The temperature coefficient (α value) indicates by how much the resistance of a specific material changes relatively if the temperature increases by 1 °C.

The other values facilitate a sensor-specific setting of the temperature coefficient and enhance accuracy.

Temperature unit

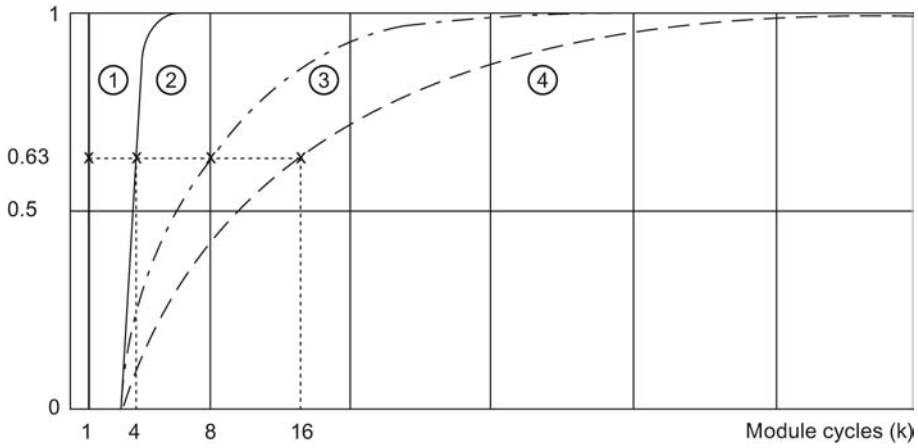
Selection between Degrees Celsius, Fahrenheit and Kelvin as the temperature unit for the selected measuring range.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This specification is valid for all signal changes at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 4-3 Smoothing for AI 8×RTD/TC 2-wire HF

Interference frequency suppression

Suppresses the interferences affecting analog input modules that are caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network is likely to have a negative effect on measured values particularly with measurement in the low voltage range and on thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Measuring range resolution

Parameters for the measurement type thermal resistor standard and thermocouple.

Allows you to increase the resolution to 2 or 3 decimal places for a configurable section of the measuring range. See the Scalable measuring range (Page 25) section.

Measuring range center

Determines the temperature over which the scalable measuring range is symmetrically spanned. The value must be within the nominal range of the underlying measuring range. It is specified in integers.

Maximum / Minimum

Corresponds to overflow / underflow for the scalable measuring range.

Conductor resistance

Parameters for the measurement types resistor and thermal resistor.

Used to compensate for the conductor resistance without having to interfere with the sensor wiring.

If the "Conductor resistor" parameter is configured higher than a value 0 mΩ, the module then automatically uses the factory calibration data.

Hardware interrupt 1 or 2

Enabling of a hardware interrupt if the high limit 1/2 or the low limit 1/2 is violated.

Low limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

Potential group

Specifies that a BaseUnit with incoming voltage supply is located on this slot (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Scalable measuring range

Introduction

The scalable measuring range is available for the temperature measuring ranges of thermal resistors (RTD) standard and thermocouples. The measuring ranges for voltage, resistor and thermal resistor climatic are not supported.

The scalable measuring range is valid for the following ranges:

- Nominal range
- Underrange
- Overrange

Function

The scalable measuring range is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable section.

- The "Measuring range resolution" parameter determines the resolution to 2 or 3 decimal places.
- The "Measuring range center" parameter determines the temperature over which the scalable measuring range is symmetrically spanned.

Value ranges

Table 4- 8 Value ranges

Scalable measuring range	Measuring range resolution		Values hex.
	2 decimal places	3 decimal places	
Overflow	>325.11	>32.511	$7FFF_H$
High limit	325.11	32.511	$7EFF_H$
Measuring range center	0	0	0_H
Low limit	-325.12	-32.512	8100_H
Underflow	<-325.12	<-32.512	8000_H

To obtain an absolute temperature, the measuring range center in the application program (as offset) must be calculated with the value of the user data of the scalable measuring range.

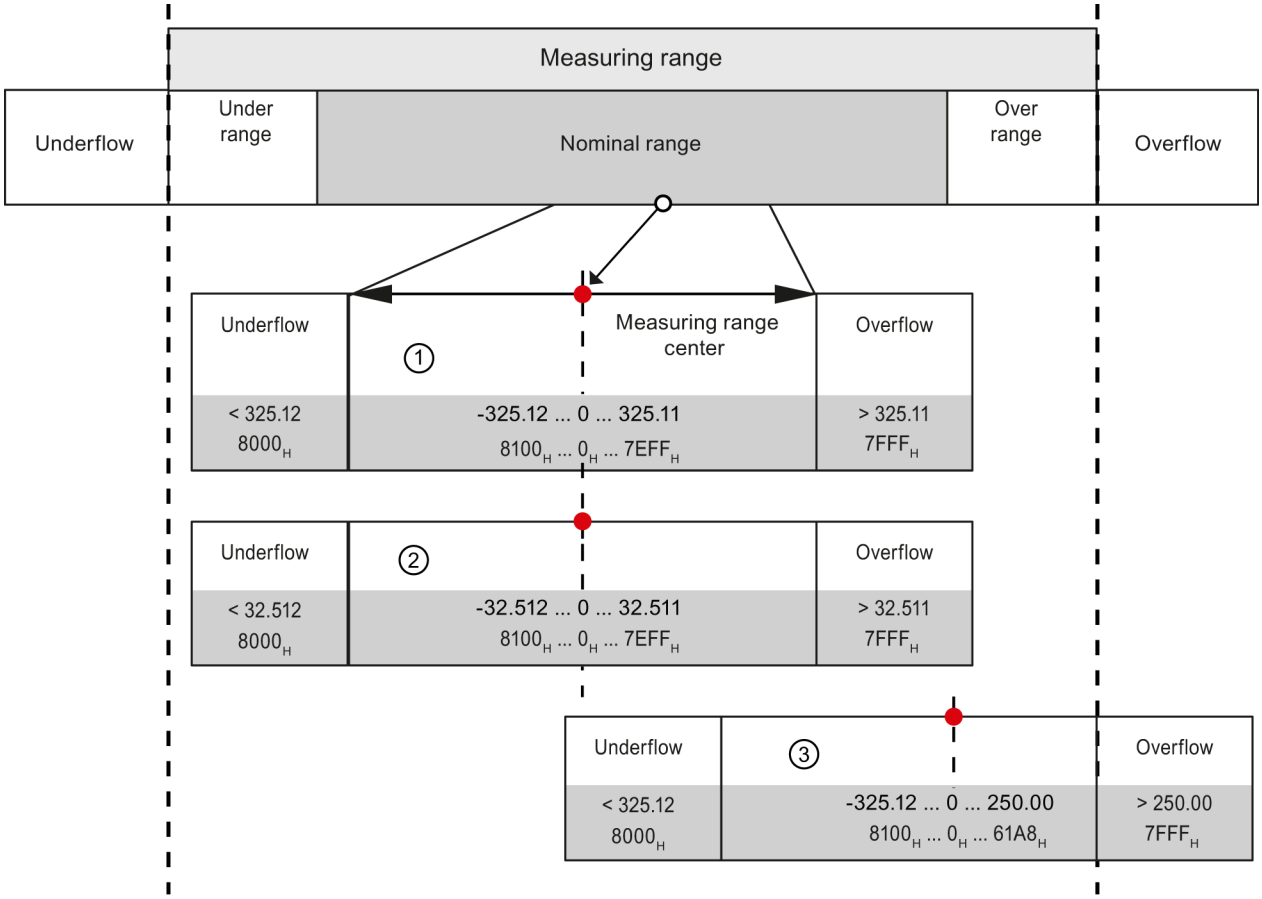
The measuring range center is always output in the user data as the value "0". The user data are correspondingly mapped to the bipolar input ranges in S7 format. Underflow / overflow is also formed in accordance with the limits of S7.

Rules

- The measuring range center must be within the nominal range of the underlying measuring range. It is specified in integers.
- The scalable measuring range is spanned symmetrically over the measuring range center. Depending on the resolution, various value ranges result (①, ②).
- The scalable measuring range is limited by underflow and overflow of the underlying measuring range:
  - It is clipped at the underflow when it falls below the limit.
  - It is clipped at the overflow when it exceeds the limit (③).

Example

The following example illustrates the effect of scalable measuring ranges:



① Scalable measuring range with 2 decimal places in hexadecimal S7 format
② Scalable measuring range with 3 decimal places in hexadecimal S7 format
③ Scalable measuring range which is cut off at the overflow of the underlying measuring range (clipping)

Figure 4-4 Examples of scalable measuring ranges

4.4.1 Configuration

Requirement

You must select a valid temperature measuring range for configuration.

Configuration

The function is activated using the "Scalable measuring range" parameter.

The following figure shows an example of a configuration in STEP 7:

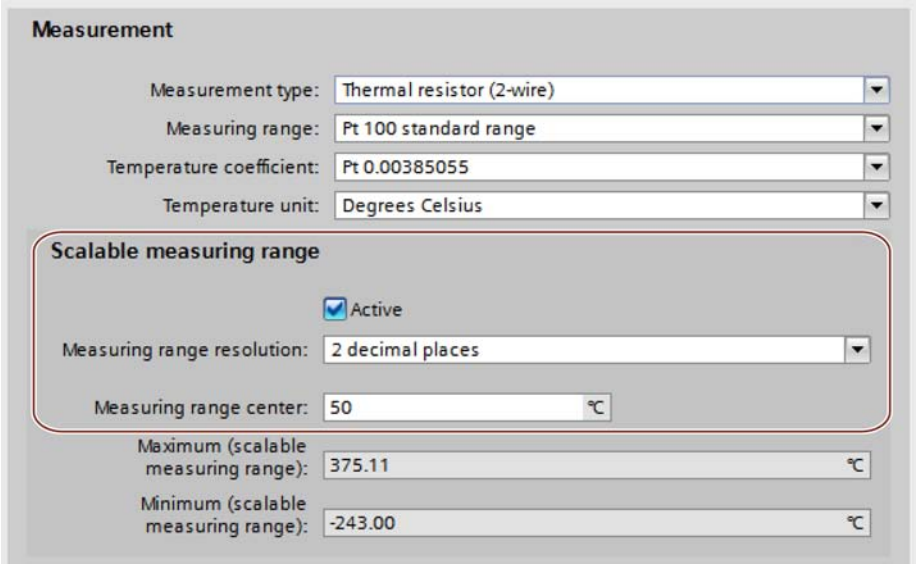


Figure 4-5 Configuration for the scalable measuring range

Reference

You will find more information on the configuration in the STEP 7 online help.

4.4.2 Evaluating data record 235

Evaluation in the user program

In the user program, you can evaluate the status and the limits of the scalable measuring range with data record 235, which may result by reaching underflow/overflow.

Structure of data record 235

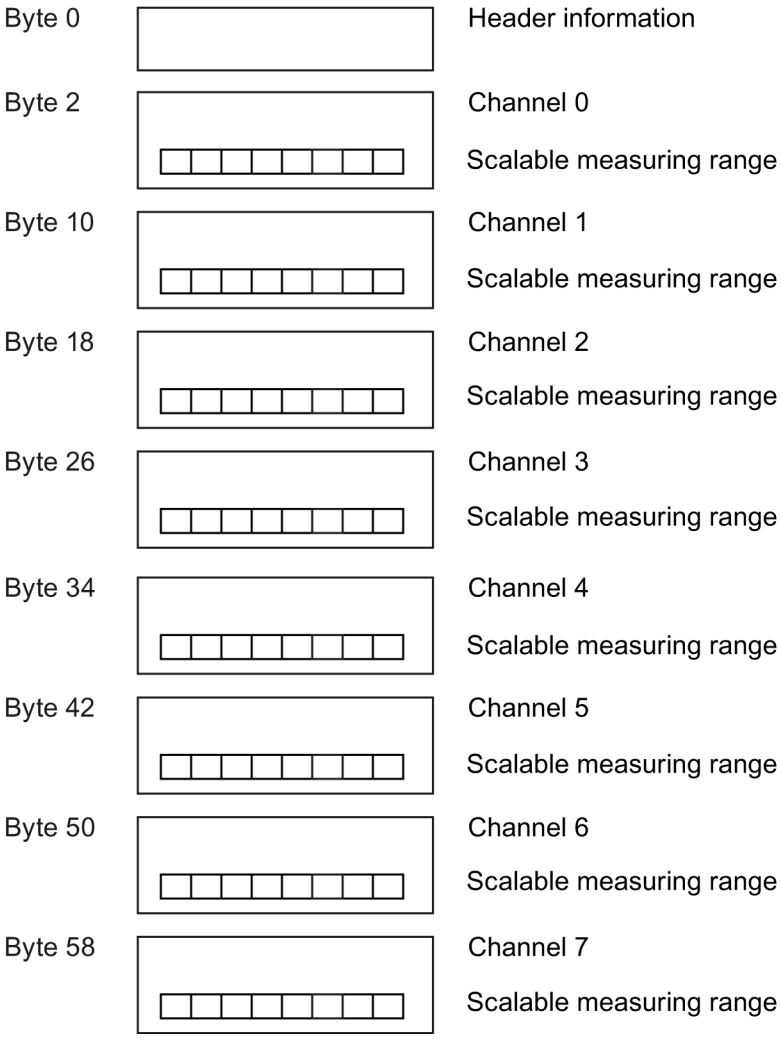


Figure 4-6 Structure of data record 235

Header information

The figure below shows the structure of the header information.

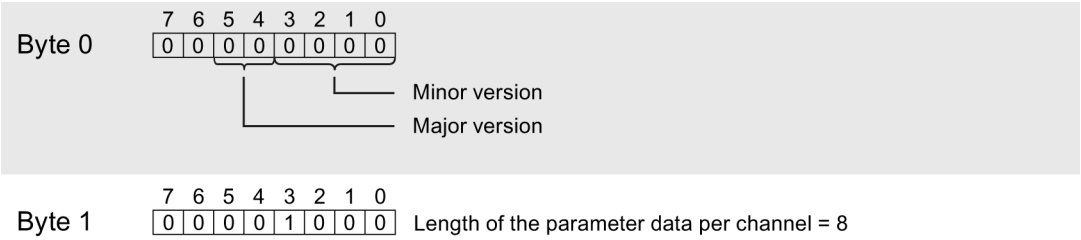


Figure 4-7 Header information of data record 235

Parameters

The figure below shows the structure of the parameter.

If the corresponding bit is set to "1", the parameter is activated.

* x = 2 + (channel number x 8)

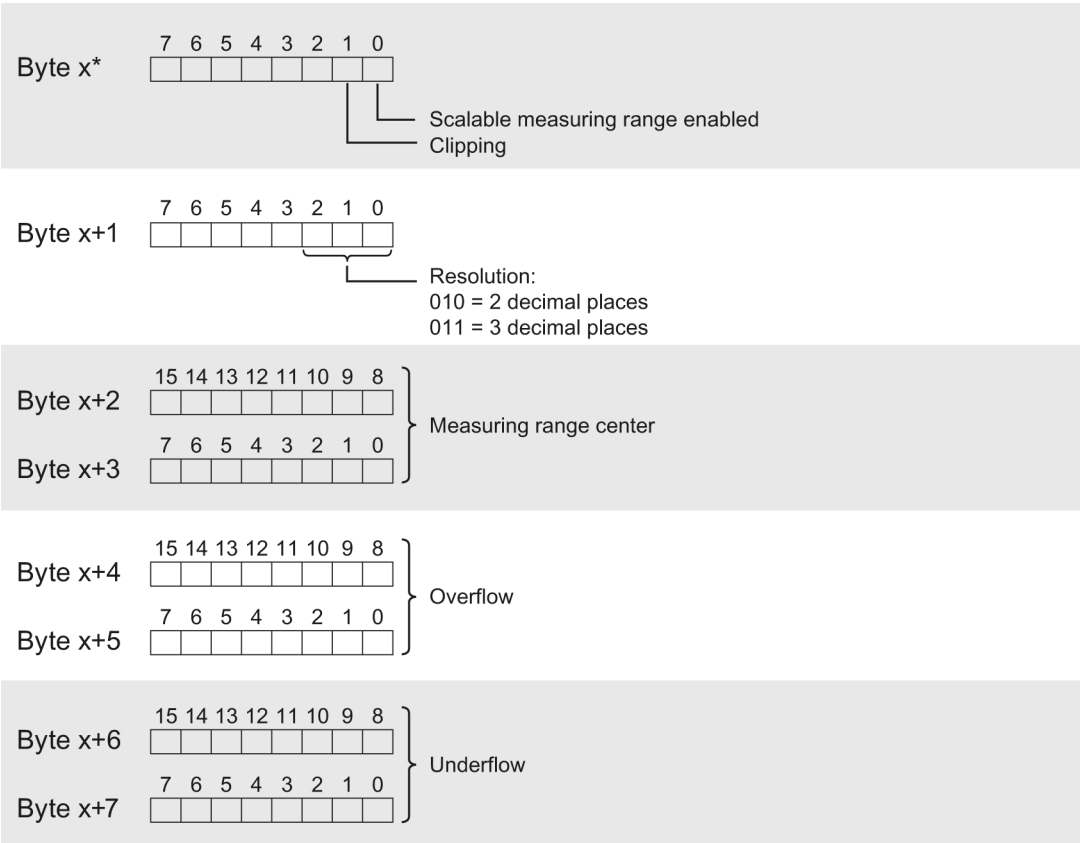


Figure 4-8 Structure of data record 235 - channel parameter byte x to x+7

Description of the parameters

Table 4- 9 Description **of the parameters from data record 235**

Parameter	Description
Scalable measuring range enabled	1 = Function is active for this channel.
Clipping	1 = Scalable measuring range cut off at the overflow / underflow of the underlying measuring range (see Figure (Page 27)).
Resolution	2 or 3 decimal places
Measuring range center	Temperature in whole °C / °F / K ("working point" for the scaling)
Overflow/underflow	Limits of the scalable measuring range

Example

The following example shows the values for a thermal resistor Pt 100 Standard, °C:

Table 4- 10 Example of a thermal resistor Pt 100 Standard

Hex. value	Dec. value	Evaluation of data record 235
00_H	0	V0.0
08_H	8	8 bytes
03_H	3	Scalable measuring range active and clipped (clipping)
02_H	2	Resolution: 2 decimal places
$02EE_H$	750	Measuring range center: 750 °C
$61A8_H$	25000	Overflow (Maximum): 250**.00** + 750 = 1000.00 °C Scalable measuring range is clipped at the overflow.
8100_H	-32512	Underflow (Minimum): -325**.12** + 750 = 424.88 °C

See also

Scalable measuring range (Page 25)

4.5 Address space

Address space of the analog input module AI 8×RTD/TC 2-wire HF

The following figure shows the assignment of the address space with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

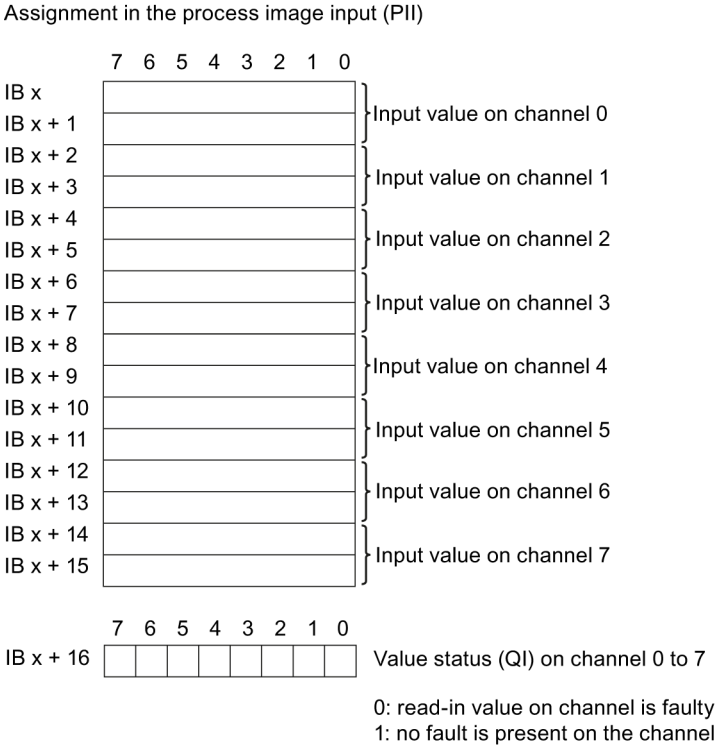


Figure 4-9 Address space of the AI 8×RTD/TC 2-wire HF with value status

Configuration options of the AI 8xRTD/TC 2-wire HF

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Each bit 0 to 7 in this byte is assigned to one channel and provides information on the validity of the analog value (0 = value is incorrect).

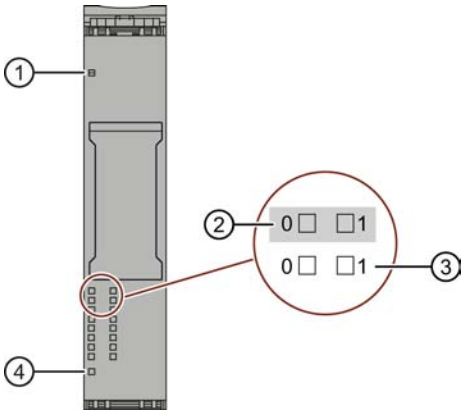
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays of the AI 8xRTD/TC 2-wire HF:



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 37).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status/channel error LED

Table 5- 2 Status and error display of the LED channel status / channel error

LEDs		Meaning
Channel status	Channel error	
Off	Off	Channel deactivated
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ present

5.2 Interrupts

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Violation of low limit 1
- Violation of high limit 1
- Violation of low limit 2
- Violation of high limit 2

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

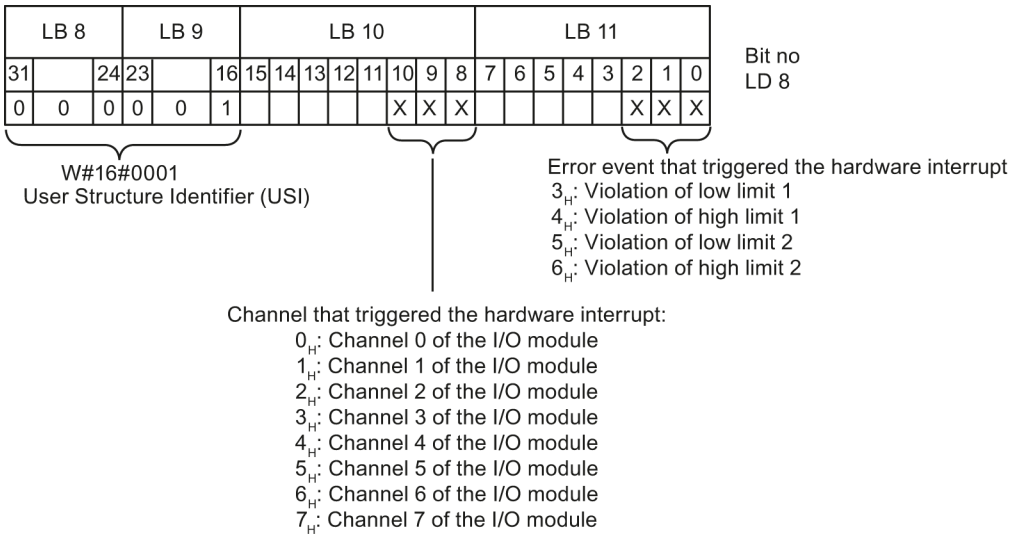


Figure 5-2 OB start information

Structure of the additional interrupt information

Table 5- 4 Structure of the additional interrupt information

Data block name		Content	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	additional interrupt information for hardware interrupts of the I/O module	2
Channel that triggered the hardware interrupt.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
Event that triggered the hardware interrupt.				
	Event	B#16#03	Violation of low limit 1	1
		B#16#04	Violation of high limit 1	
		B#16#05	Violation of low limit 2	
		B#16#06	Violation of high limit 2	

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Hardware interrupt lost
- Reference channel error
- Error
- Violation of low limit
- Violation of high limit
- Wire break
- Supply voltage missing
- Parameter assignment error

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 5 Diagnostics alarms, their meaning and remedies

Diagnostics alarms	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware update is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	–
		The channel is currently being calibrated.	
Wire break	6_H	Resistance of sensor circuit too high	Use a different sensor type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect or deactivate the channel
Violation of high limit[1]	7_H	Value lies above the overrange.	Correct module/sensor interplay
		Wire break[2]	See Wire break
Violation of low limit[1]	8_H	Value lies below the underrange.	Correct module/sensor interplay
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel: Module plugged in does not match the configuration. Incorrect parameter assignment.	• Correct the configuration (comparison of preset and actual setup). • Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Load voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Diagnostics alarms	Error code	Meaning	Remedy
Reference channel error (reference junction)	15_H	Reference temperature of the reference junction for the TC channel being operated with compensation is invalid.	• Check BaseUnit type • Select correct reference junction through parameter assignment[3] • Check whether the reference junction (reference channel of the group 0, 1, 2, 3) is only assigned once as the sender in the entire setup.
Hardware interrupt lost	16_H	At least one hardware interrupt could not be reported because there were too many pending hardware interrupts.	Correct the program or the process

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 For resistor and thermal resistor measuring ranges with deactivated diagnostics for "Wire break", this is reported by the "Violation of high limit" diagnostic.

3 Shared Device and diagnostics "Reference temperature": If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

Technical specifications

6

Technical specifications of the AI 8×RTD/TC 2-wire HF

	6ES7134-6JF00-0CA1
Product type designation	AI 8xRTD/TC 2-wire HF
General information	
Usable BaseUnits	BU type A0, A1
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	35 mA
Power loss	
Power loss, typ.	0.75 W
Address area	
Address space per module	
Address space per module, max.	16 bytes; + 1 byte for QI information

	6ES7134-6JF00-0CA1
Analog inputs	
Number of analog inputs	8
Maximum permissible input voltage for voltage input (destruction limit)	30 V
Constant measurement current for resistance-type sensor, typ.	2 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on parameter assignment of activated channels)
Technical unit for temperature measurement can be set	Yes
Input ranges (rated values), voltages	
-1 V to +1 V	Yes; 16 bits incl. sign
Input resistance (-1 V to +1 V)	1 MΩ
-250 mV to +250 mV	Yes; 16 bits incl. sign
Input resistance (-250 mV to +250 mV)	1 MΩ
-50 mV to +50 mV	Yes; 16 bits incl. sign
Input resistance (-50 mV to +50 mV)	1 MΩ
-80 mV to +80 mV	Yes; 16 bits incl. sign
Input resistance (-80 mV to +80 mV)	1 MΩ
Input ranges (rated values), thermocouples	
Type B	Yes; 16 bits incl. sign
Input resistance (Type B)	1 MΩ
Type C	Yes; 16 bits incl. sign
Input resistance (Type C)	1 MΩ
Type E	Yes; 16 bits incl. sign
Input resistance (Type E)	1 MΩ
Type J	Yes; 16 bits incl. sign
Input resistance (Type J)	1 MΩ
Type K	Yes; 16 bits incl. sign
Input resistance (Type K)	1 MΩ
Type L	Yes; 16 bits incl. sign
Input resistance (Type L)	1 MΩ
Type N	Yes; 16 bits incl. sign
Input resistance (Type N)	1 MΩ
Type R	Yes; 16 bits incl. sign
Input resistance (Type R)	1 MΩ
Type S	Yes; 16 bits incl. sign
Input resistance (Type S)	1 MΩ
Type T	Yes; 16 bits incl. sign
Input resistance (Type T)	1 MΩ
Type U	Yes; 16 bits incl. sign
Input resistance (Type U)	1 MΩ
Type TXK/TXK(L) according to GOST	Yes; 16 bits incl. sign
Input resistance (Type TXK/TXK(L) according to GOST)	1 MΩ

	6ES7134-6JF00-0CA1
Input ranges (rated values), resistance thermometer	
Ni 100	Yes; 16 bits incl. sign
Input resistance (Ni 100)	1 MΩ
Ni 1000	Yes; 16 bits incl. sign
Input resistance (Ni 1000)	1 MΩ
LG-Ni 1000	Yes; 16 bits incl. sign
Input resistance (LG-Ni 1000)	1 MΩ
Ni 120	Yes; 16 bits incl. sign
Input resistance (Ni 120)	1 MΩ
Ni 200	Yes; 16 bits incl. sign
Input resistance (Ni 200)	1 MΩ
Ni 500	Yes; 16 bits incl. sign
Input resistance (Ni 500)	1 MΩ
Pt 100	Yes; 16 bits incl. sign
Input resistance (Pt 100)	1 MΩ
Pt 1000	Yes; 16 bits incl. sign
Input resistance (Pt 1000)	1 MΩ
Pt 200	Yes; 16 bits incl. sign
Input resistance (Pt 200)	1 MΩ
Pt 500	Yes; 16 bits incl. sign
Input resistance (Pt 500)	1 MΩ
Input ranges (rated values), resistors	
0 to 150 ohms	Yes; 15 bits
Input resistance (0 to 150 ohms)	1 MΩ
0 to 300 ohms	Yes; 15 bits
Input resistance (0 to 300 ohms)	1 MΩ
0 to 600 ohms	Yes; 15 bits
Input resistance (0 to 600 ohms)	1 MΩ
0 to 3000 ohms	Yes; 15 bits
Input resistance (0 to 3000 ohms)	1 MΩ
0 to 6000 ohms	Yes; 15 bits
Input resistance (0 to 6000 ohms)	1 MΩ
PTC	Yes; 15 bits
Input resistance (PTC)	1 MΩ
Thermocouple (TC)	
Technical unit for temperature measurement	°C/°F/K
Temperature compensation	
• Configurable	Yes
• Reference channel of the module	Yes
• Internal reference junction	Yes; with BaseUnit type A1
• Reference channel of the group	Yes
• Fixed reference temperature	Yes

	6ES7134-6JF00-0CA1
Resistance thermometer (RTD)	
Maximum permissible input voltage for voltage input (destruction limit)	30 V
Technical unit for temperature measurement	°C/°F/K
Cable length	
Cable length shielded, max.	200 m; 50 m for thermocouples
Analog value generation	
Measuring principle	Integrating (sigma-delta)
Integration and conversion time/resolution per channel	
Resolution with overrange (bit including sign), max.	16 bit
Integration time configurable	Yes
Basic conversion time including integration time, ms	
• Additional processing time for wire break check	2 ms; in the resistance thermometer, resistor, and thermocouple areas
Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
Conversion time (per channel)	180 / 60 / 50 ms
Smoothing of the measured values	
Configurable	Yes
Setting: None	Yes
Setting: Weak	Yes
Setting: Medium	Yes
Setting: Strong	Yes
Sensors	
Wiring the signal transmitters	
For voltage measurement	Yes
for resistance measurement with 2-wire connection	Yes
for resistance measurement with 3-wire connection	No
for resistance measurement with 4-wire connection	No
Errors/accuracies	
Linearity error (in relation to input range), (+/-)	± 0.01%; +/- 0.1% for resistance thermometer and resistor
Temperature error (in relation to input range)	± 0.0009%/K; +/- 0.005%/K for thermocouple
Crosstalk between inputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to input range), (+/-)	± 0.05%
Operational limit in entire temperature range	
Voltage in relation to input range, (+/-)	± 0.1%
Resistance in relation to input range, (+/-)	± 0.1%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to input range, (+/-)	± 0.05%
Resistance in relation to input range, (+/-)	± 0.05%

	6ES7134-6JF00-0CA1
Interference voltage suppression for f = n x (f1 +/-1%), f1 = interference frequency	
Series-mode interference (peak of the interference < rated value of the input range), min.	70 dB
Common mode voltage, max.	10 V
Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic error interrupt	Yes
Limit interrupt	Yes; two high limits and two low limits each
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic insulation)
Between the inputs (UCM)	10 VDC
Insulation	
Insulation tested with	707 VDC (type test)
Ambient conditions	
Operating temperature	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	15 mm

Operational and basic error limits for thermal resistors

Error limits for thermal resistors	
Operational limit (in the entire temperature range, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	±1.0 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.25 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	± 0.4 K
Basic error limit (operational limit at 25 °C, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	± 0.6 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.13 K
• Ni 100, Ni 120, Ni 200, Ni 1000 standard and climatic	± 0.2 K

Operational and basic error limits for thermocouples

Error limits for thermocouples	
Operational limit for thermocouples (in the entire temperature range, in relation to the input range)	±1.5 K
Operational limit for type C thermocouples (in the entire temperature range, in relation to the input range)[1]	± 7 K
Basic error limit for thermocouples (operational limit at 25 °C, in relation to the input range)	±1 K
Basic error limit for type C thermocouples (operational limit at 25 °C, in relation to the input range)	± 5 K
Overall error limits when using internal compensation	
• Operational limit (in the entire temperature range at static thermal state, ambient temperature change < 0.3 K/min)[2]	± 2.5 K
• Basic error limit (operational limit at 25 °C at static thermal state, ambient temperature change < 0.3 K/min)[3]	±1.5 K

[1] The indicated error limits apply as of the following temperatures:
Thermocouple type T: -200 °C
Thermocouple type K: -100 °C
Thermocouple type B: +700 °C
Thermocouple type N: -150 °C
Thermocouple type E: -150 °C
Thermocouple type R: +200 °C
Thermocouple type S: +100 °C

[2] For thermocouple type C: ± 8 K

[3] For thermocouple type C: ± 6 K

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Table A- 1 Dependencies of the measurement type / measuring range

Measure-ment type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
Deactivated	*	*	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*	*	*
Resistor	150 Ω, 300 Ω, 600 Ω, 3 kΩ, 6 kΩ	*	*	*	x
Resistor	PTC	*	*	*	*
Thermal resistor	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	
	Pt200 Pt500 Pt1000 climatic		No reference channel mode	Degrees Celsius Degrees Fahrenheit	
	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672			
	LG-Ni 1000 climatic	LG-Ni 0.005			

Measure-ment type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
Thermal resistor	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672			
	LG-Ni 1000 standard	LG-Ni 0.005			
Thermo-couple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	*
			Fixed reference temperature		

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of "Reference channel of the module":
- Channel 0 must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Reference channel of the module".

2 Use of "Reference channel of group 0, 1, 2, 3":
- An RTD channel must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There must only be one RTD channel with "Reference junction" = "Reference channel of group 0, 1, 2, 3" per group 0, 1, 2, 3 and IO device!
- For each TC channel in the IO device that is intended to use this reference, "Reference junction" must be set to "Reference channel of group 0, 1, 2, 3".
- If the reference channel is on channel 0, it can also be used as "Reference channel of the module" at the same time.

The table lists the properties and their dependencies on the measurement type for PROFINET.

Table A- 2 Dependencies on the measurement type

Measurement type	Scalable measuring range	Measuring range resolution	Diagnostics				
			Underflow	Overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*
Voltage	–	*	x	x	–	x	–
Resistor	–	*	x	x	x	x	–
Resistor	–	*	x	–	–	x	–
Thermal resistor	x	2 and 3 decimal places	x	x	x	x	–
Thermocouple	x	2 and 3 decimal places	x	x	x	x	x[1)]

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Property is not relevant if "Fixed reference temperature" is used

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*	*
Voltage	±50 mV ±80 mV ±250 mV ±1 V	*	*	*	x	–	x	–
Resistor	150 Ω 300 Ω 600 Ω 3 kΩ 6 kΩ	*	*	*	x	x	x	–
Resistor	PTC[3]	*	*	*	x	–	x	–

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Thermal resistor	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x	x	x	–
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Pt200 Pt500 Pt1000 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
Thermal resistor	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
Thermal resistor	LG-Ni 1000 climatic	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	LG-Ni 1000 standard	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Thermo-couple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	x
			Fixed reference temperature	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	*

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be set as "Pt100 climatic" with temperature unit "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There may be only one RTD channel with "Reference junction active" = "Enable" per group and row.
- For each TC channel of this row that is intended to use this reference, "Reference junction active" must be set to "Enable".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

A.2 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

The module parameters can be assigned in RUN (for example, measuring ranges of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

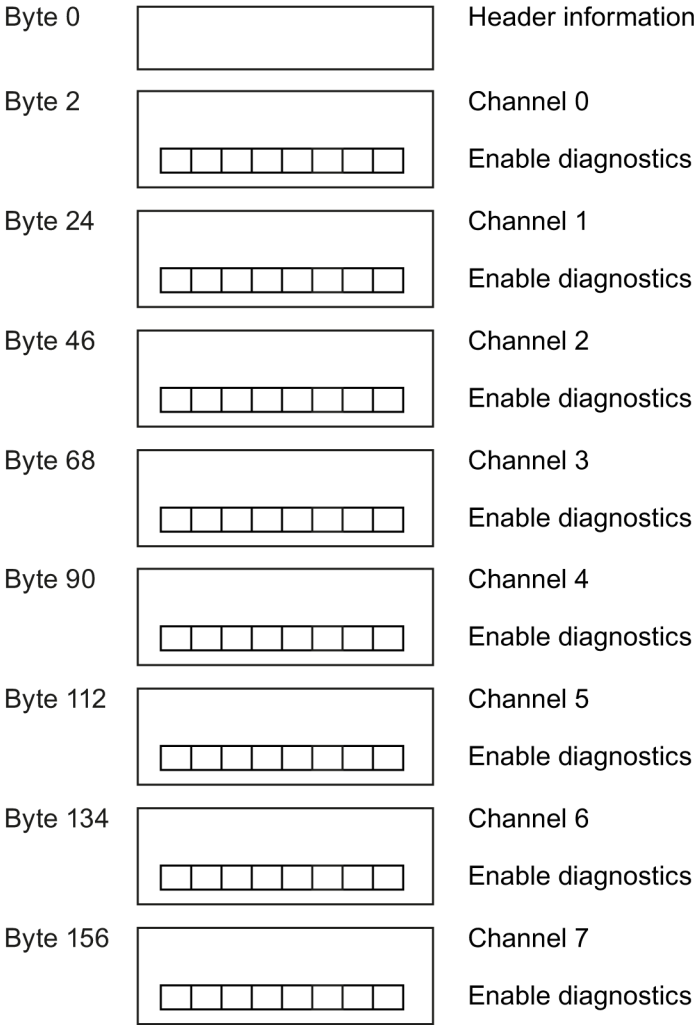


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

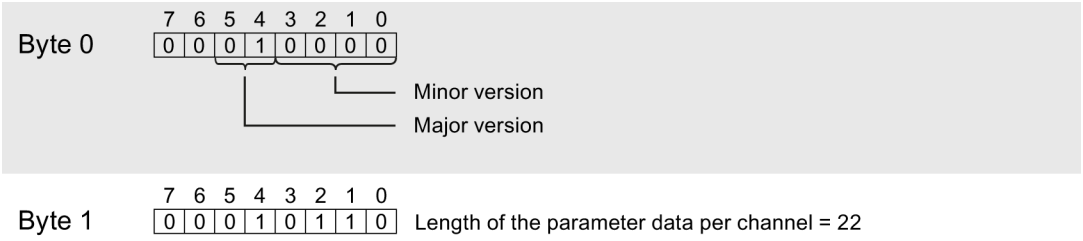


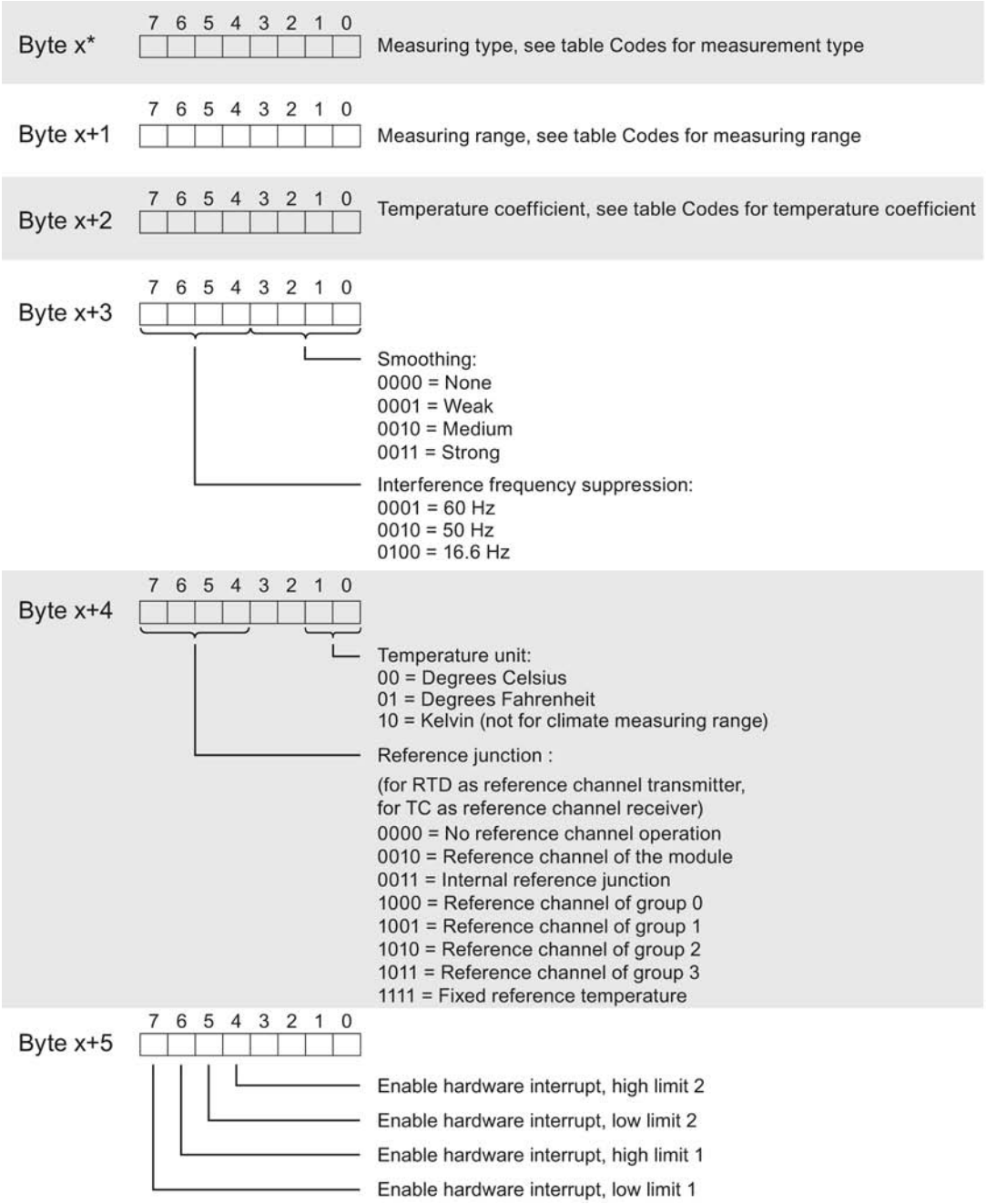
Figure A-2 Header information

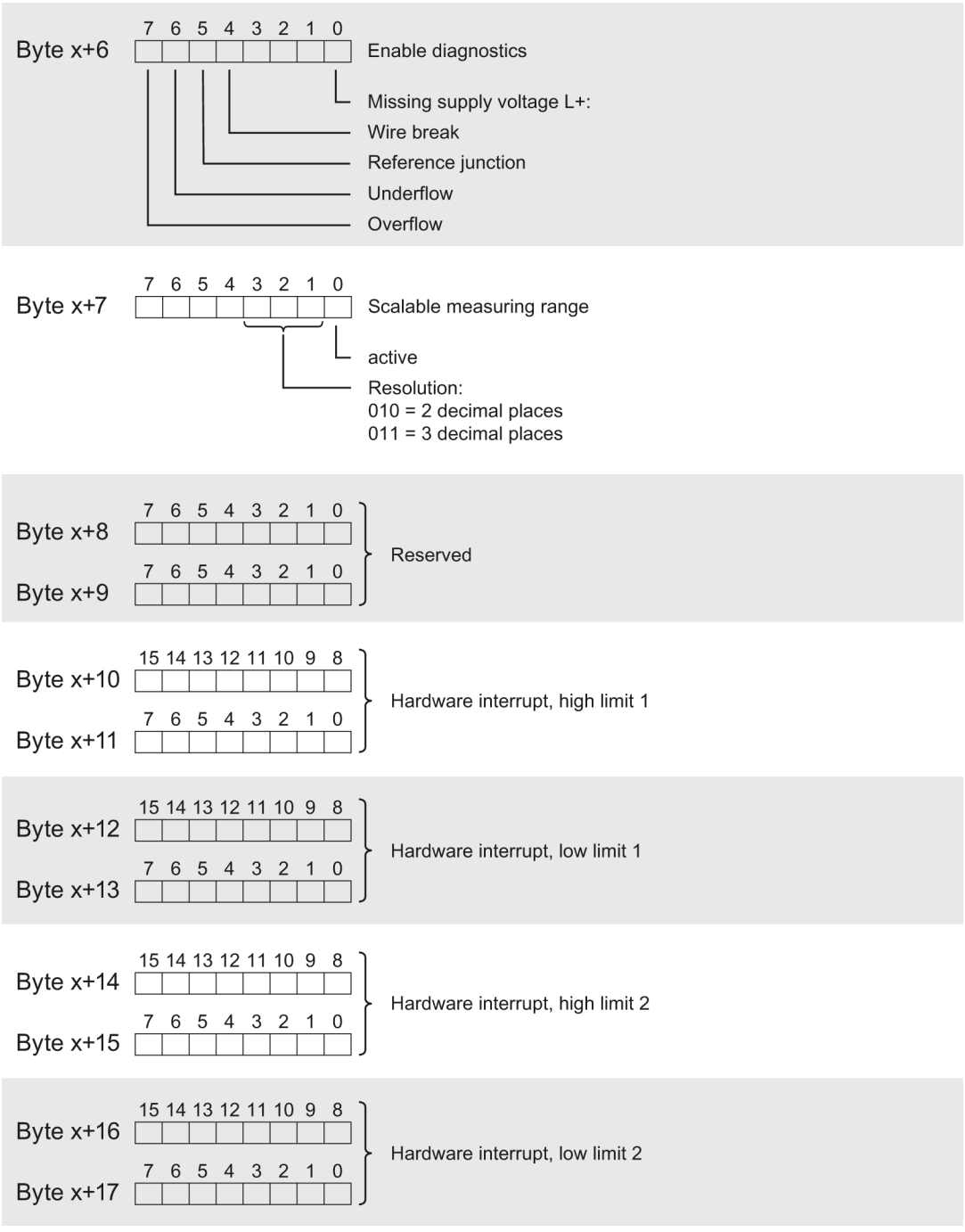
Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 22); channel number = 0 to 7




Byte x+6
7 6 5 4 3 2 1 0
Enable diagnostics
Missing supply voltage L+:
Wire break
Reference junction
Underflow
Overflow
Byte x+7
7 6 5 4 3 2 1 0
Scalable measuring range
active
Resolution:
010 = 2 decimal places
011 = 3 decimal places
Byte x+8
Byte x+9
7 6 5 4 3 2 1 0
Reserved
Byte x+10
Byte x+11
15 14 13 12 11 10 9 8
7 6 5 4 3 2 1 0
Hardware interrupt, high limit 1
Byte x+12
Byte x+13
Hardware interrupt, low limit 1
Byte x+14
Byte x+15
Hardware interrupt, high limit 2
Byte x+16
Byte x+17
Hardware interrupt, low limit 2

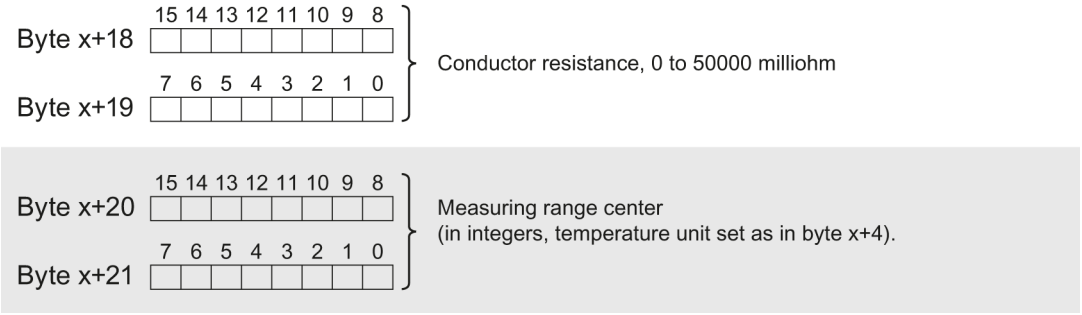


Figure A-3 Structure of byte x to x+21 for channel 0 to 7

Codes for measurement type

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table A- 3 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Resistor, 2-wire connection	0000 0110
Thermal resistor, 2-wire connection	0000 1001
Thermocouple	0000 1010

Codes for measuring range

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes at byte x+1 (see previous figure).

Table A- 4 Codes for measuring range

Measuring range	Code
Voltage	
50 mV	0000 0001
80 mV	0000 0010
250 mV	0000 0011
1 V	0000 0101
Resistor	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
3 kΩ	0000 0100
6 kΩ	0000 0101
PTC	0000 1111
Thermal resistor climatic	
Pt 100	0000 0000
Pt 200	0000 0111
Pt 500	0000 1000
Pt 1000	0000 1001
Thermal resistor standard	
Pt 100	0000 0010
Pt 200	0000 1011
Pt 500	0000 0100
Pt 1000	0000 0101
Thermal resistor climatic	
Ni 100	0000 0001
Ni 120	0000 1101
Ni 200	0001 0001
Ni 500	0001 0011
Ni 1000	0000 1010
Thermal resistor standard	
Ni 100	0000 0011
Ni 120	0000 1100
Ni 200	0001 0000
Ni 500	0001 0010
Ni 1000	0000 0110

Measuring range	Code
Thermal resistor	
LG Ni 1000 climatic	0001 1101
LG Ni 1000 standard	0001 1100
Thermocouple	
Type B	0000 0000
Type N	0000 0001
Type E	0000 0010
Type R	0000 0011
Type S	0000 0100
Type J	0000 0101
Type L	0000 0110
Type T	0000 0111
Type K	0000 1000
Type U	0000 1001
Type C	0000 1010
Type TXK	0000 1011

Codes for temperature coefficient

The following table contains the codes for the temperature coefficients of the analog input module. You must enter these codes at byte x+2 (see previous figure).

Table A- 5 Codes for temperature coefficient for temperature measurement

Temperature coefficient	Code
Pt 0.00385055	0000 0000
Pt 0.003916	0000 0001
Pt 0.003902	0000 0010
Pt 0.00392	0000 0011
Pt 0.00385	0000 0100
Ni 0.00618	0000 1000
Ni 0.00672	0000 1001
LG-Ni 0.005	0000 1010

Limits for hardware interrupts

The following tables contain the permitted limits for hardware interrupts (in each case, the usable value is given). The limits depend on the selected measurement type and the selected measuring range. The value for the overflow must be larger than the value for the underflow.

Table A- 6 Limits for resistor and voltage

Resistor (all possible measuring range settings)	**Voltage**	
32510	32510	Overflow
1	-32511	Underflow

Table A- 7 Limits for thermocouple types B, C, and E

Thermocouple									
Type B			Type C			Type E			
°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	24999	32765	27731	11999	21919	14731	Overflow
-1199	-1839	1533	-1199	-1839	1533	-2699	-4539	33	Underflow

Table A- 8 Limits for thermocouple types R, S, J, and L

Thermocouple									
Types R, S			Type J			Type L			
°C	°F	K	°C	°F	K	°C	°F	K	
20189	32765	22921	14499	26419	17231	11499	21019	14231	Overflow
-1699	-2739	1033	-2099	-3459	633	-1999	-3279	733	Underflow

Table A- 9 Limits for thermocouple types T, K, and U

Thermocouple									
Type T			Type K			Type U			
°C	°F	K	°C	°F	K	°C	°F	K	
5399	10039	8131	16219	29515	18951	8499	15619	11231	Overflow
-2699	-4539	33	-2699	-4539	33	-1999	-3279	733	Underflow

Table A- 10 Limits for thermocouple types N and TXK

Thermocouple						
Type N			Type TXK			
°C	°F	K	°C	°F	K	
15499	28219	18231	10499	19219	13231	Overflow
-2699	-4539	33	-1999	-3279	733	Underflow

Table A- 11 Limits for thermal resistor

Thermal resistor						
	Standard			Climatic		
	°C	°F	K	°C	°F	
Pt	9999	18319	12731	15499	31099	Overflow
	-2429	-4053	303	-14499	-22899	Underflow
Ni, Ni-LG	2949	5629	5681	29499	32765	Overflow
	-1049	-1569	1683	-10499	-15699	Underflow

A.3 Switchable wire break check

Function

The "Switchable wire break check" is available for thermocouples. It switches off the wire break check for the module.

This is required, for example, to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.

The function has no effect on channels that are not assigned in the thermocouple mode.

Note

Startup and parameter reassignment

The wire break check is switched on again at each startup and during any parameter reassignment of the module.

Switch-off via the user program

You can deactivate the wire break check using data record 237.

Table A- 12 Structure of data record 237, switchable wire break check

Byte	Function	Format	Value	Description
0	Command	UBYTE	80_H	Wire break check
1	Identifier	UBYTE	00_H	Not relevant
2	Channel number	UBYTE	FF_H	All channels
3	Calibration step	UBYTE	FF_H	First triggering
4	Measurement type	UBYTE	00_H	Not relevant
5	Measuring range	UBYTE	00_H	Not relevant
6	Action	UBYTE	01_H	Deactivate wire break check
			02_H	Activate wire break check
7...17	Reserved	UBYTE	00_H	Not relevant

Representation of analog values

B

This appendix shows the analog values for all measuring ranges supported by the analog input module AI 8xRTD/TC 2-wire HF.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Note

Temperature values

The digitized temperature values are the result of a conversion in the analog module. The following resolution therefore does not apply to temperature values.

Table B- 1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table B- 2 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table B- 3 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table B- 4 Voltage measuring range ±1 V

Values		Voltage measuring range	Range
Dec.	Hex.	±1 V	
32767	7FFF	> 1.176 V	Overflow
32511	7EFF	1.176 V	Overrange
27649	6C01		
27648	6C00	1 V	Nominal range
20736	5100	0.75 V	
1	1	36.17 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-0.75 V	
-27648	9400	-1 V	
-27649	93FF		Underrange
-32512	8100	-1.176 V	
-32768	8000	<-1.176 V	Underflow

Table B- 5 Voltage measuring range ±500 mV to ±50 mV

Values		Voltage measuring range			Range
Dec.	Hex.	±250 mV	±80 mV	±50 mV	
32767	7FFF	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	294.0 mV	94.1 mV	58.8 mV	Overrange
27649	6C01				
27648	6C00	250 mV	80 mV	50 mV	Nominal range
20736	5100	187.5 mV	60 mV	37.5 mA	
1	1	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	
-1	FFFF				
-20736	AF00	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-250 mV	-80 mV	-50 mV	
-27649	93FF				Underrange
-32512	8100	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-294.0 mV	<-94.1 mV	<-58.8 mV	Underflow

B.3 Representation of analog values for resistance-type sensors

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-type sensors.

Table B- 6 Resistance-type sensors from 150 Ω to 6000 Ω

Values		Resistance-type sensor range					Range
Dec.	**Hex.**	**150 Ω**	**300 Ω**	**600 Ω**	**3000 Ω**	**6000 Ω**	
32767	7FFF	> 176.38 Ω	> 352.77 Ω	> 705.53 Ω	> 3527.7 Ω	> 7055.3 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	3527.7 Ω	7055.3 Ω	Overrange
27649	6C01						
27648	6C00	150 Ω	300 Ω	600 Ω	3000 Ω	6000 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	450 Ω	2250 Ω	4500 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	108.5 mΩ	217 mΩ	
0	0	0 Ω	0 Ω	0 Ω	0 Ω	0 Ω	
-32768	8000	(negative values are physically impossible)					Underflow[1]

[1] If the resistors are not connected correctly or the conductor resistance is too high

B.4 Representation of analog values for thermal resistors

Note

A higher resolution can be configured for the measuring range for the standard thermal resistors, see section Scalable measuring range (Page 25).

The tables below list the decimal and hexadecimal values (codes) of the thermal resistors.

Table B- 7 Thermal resistor Pt 100, 200, 500, 1000 standard

Pt x00 standard in °C (1 digit = 0.1 °C)	Values		Pt x00 standard in °F (1 digit = 0.1 °F)	Values		Pt x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	> 1273.2	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overrange
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Nominal range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Underrange
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table B- 8 Thermal resistor Pt 100, 200, 500, 1000 climatic

Pt x00 climatic in °C (1 digit = 0.01 °C)	Values		Pt x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Nominal range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Underrange
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table B- 9 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 standard

Ni x00 standard in °C (1 digit = 0.1 °C)	Values		Ni x00 standard in °F (1 digit = 0.1 °F)	Values		Ni x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 295.0	32767	7FFF	> 563.0	32767	7FFF	> 568.2	32767	7FFF	Overflow
295.0 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overrange
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Nominal range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table B- 10 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 climatic

Ni x00 climatic in °C (1 digit = 0.01 °C)	Values		Ni x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 295.00	32767	7FFF	> 327.66	32767	7FFF	Overflow
295.00 : 250.01	29500 : 25001	733C : 61A9	327.66 : 280.01	32766 : 28001	7FFE : 6D61	Overrange
250.00 : -60.00	25000 : -6000	61A8 : E890	280.00 : -76.00	28000 : -7600	6D60 : E250	Nominal range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Underrange
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

B.5 Representation of analog values for thermocouples

Note

A higher resolution can be configured for thermocouples, see section Scalable measuring range (Page 25).

The tables below list the decimal and hexadecimal values (codes) of the thermocouples.

Table B- 11 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2070.0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070.0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overrange
1820.0 : 0.0	18200 : 0	4718 : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2093.2 : 273.2	20932 : 2732	51C4 : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table B- 12 Thermocouple type C

Type C in °C	Values		Type C in °F	Values		Type C in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2500.0	32767	7FFF	> 3276.6	32767	7FFF	> 2773.2	32767	7FFF	Overflow
2500.0 : 2315.1	25000 : 23151	61A8 : 5A6F	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2773.2 : 2588.3	27732 : 25883	6C54 : 651B	Overrange
2315.0 : 0.0	23150 : 0	5A6E : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2588.2 : 273.2	25882 : 2732	651A : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table B- 13 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1200.0	32767	7FFF	> 2192.0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200.0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.1	21920 : 18321	55A0 : 4791	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overrange
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 3.2	12732 : 32	31BC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 14 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.1	26420 : 21921	6734 : 55A1	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overrange
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Nominal range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table B- 15 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895.2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overrange
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 3.2	16452 : 32	4044 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 16 Thermocouple type L

Type L in °C	Values		Type L in °F	Values		Type L in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1150.0	32767	7FFF	> 2102.0	32767	7FFF	> 1423.2	32767	7FFF	Overflow
1150.0 : 900.1	11500 : 9001	2CEC : 2329	2102.0 : 1652.1	21020 : 16521	521C : 4089	1423.2 : 1173.3	14232 : 11733	3798 : 2DD5	Overrange
900.0 : -200.0	9000 : -2000	2328 : F830	1652.0 : -328.0	16520 : -3280	4088 : F330	1173.2 : 73.2	11732 : 732	2DD4 : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table B- 17 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1550.0	32767	7FFF	> 2822.0	32767	7FFF	> 1823.2	32767	7FFF	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C : 32C9	2822.0 : 2372.1	28220 : 23721	6E3C : 5CA9	1823.2 : 1573.3	18232 : 15733	4738 : 3D75	Overrange
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 3.2	15732 : 32	3D74 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 18 Thermocouples R and S

Types R, S in °C	Values		Types R, S in °F	Values		Types R, S in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.3	32766 : 32163	7FFE : 7DA3	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overrange
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Nominal range
-50.1 : -170.0	-501 : -1700	FE0B : F95C	-58.1 : -274.0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Underrange
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table B- 19 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 540.0	32767	7FFF	> 1004.0	32767	7FFF	> 813.2	32767	7FFF	Overflow
540.0 : 400.1	5400 : 4001	1518 : 0FA1	1004.0 : 752.1	10040 : 7521	2738 : 1D61	813.2 : 673.3	8132 : 6733	1FC4 : 1AAD	Overrange
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table B- 20 Thermocouple type U

Type U in °C	Values		Type U in °F	Values		Type U in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 850.0	32767	7FFF	> 1562.0	32767	7FFF	> 1123.2	32767	7FFF	Overflow
850.0 : 600.1	8500 : 6001	2134 : 1771	1562.0 : 1112.1	15620 : 11121	2738.0 : 2B71	1123.2 : 873.3	11232 : 8733	2BE0 : 221D	Overrange
600.0 : -200.0	6000 : -2000	1770 : F830	1112.0 : -328.0	11120 : -3280	2B70 : F330	873.2 : 73.2	8732 : 732	221C : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table B- 21 Thermocouple type TXK (GOST)

Type TXK in °C	Values		Type TXK in °F	Values		Type TXK in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1050.0	32767	7FFF	> 1922.0	32767	7FFF	>1323.2	32767	7FFF	Overflow
1050.0 : 800.1	10500 : 8001	2904 : 1F41	1922.0 : 1472.1	19220 : 14721	4B14 : 3981	1323.2 : 1073.3	13232 : 10733	33B0 : 29ED	Overrange
800.0 : 0.0 : -200.0	8000 : 0 : -2000	1F40 : 0000 : F830	1472.0 : 32.0 : -328.0	14720 : 320 : -3280	3980 : 0140 : F330	1073.2 : 273 : 73.2	10732 : 2730 : 732	29EC : 0AAA : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	<73.2	-32768	8000	Underflow

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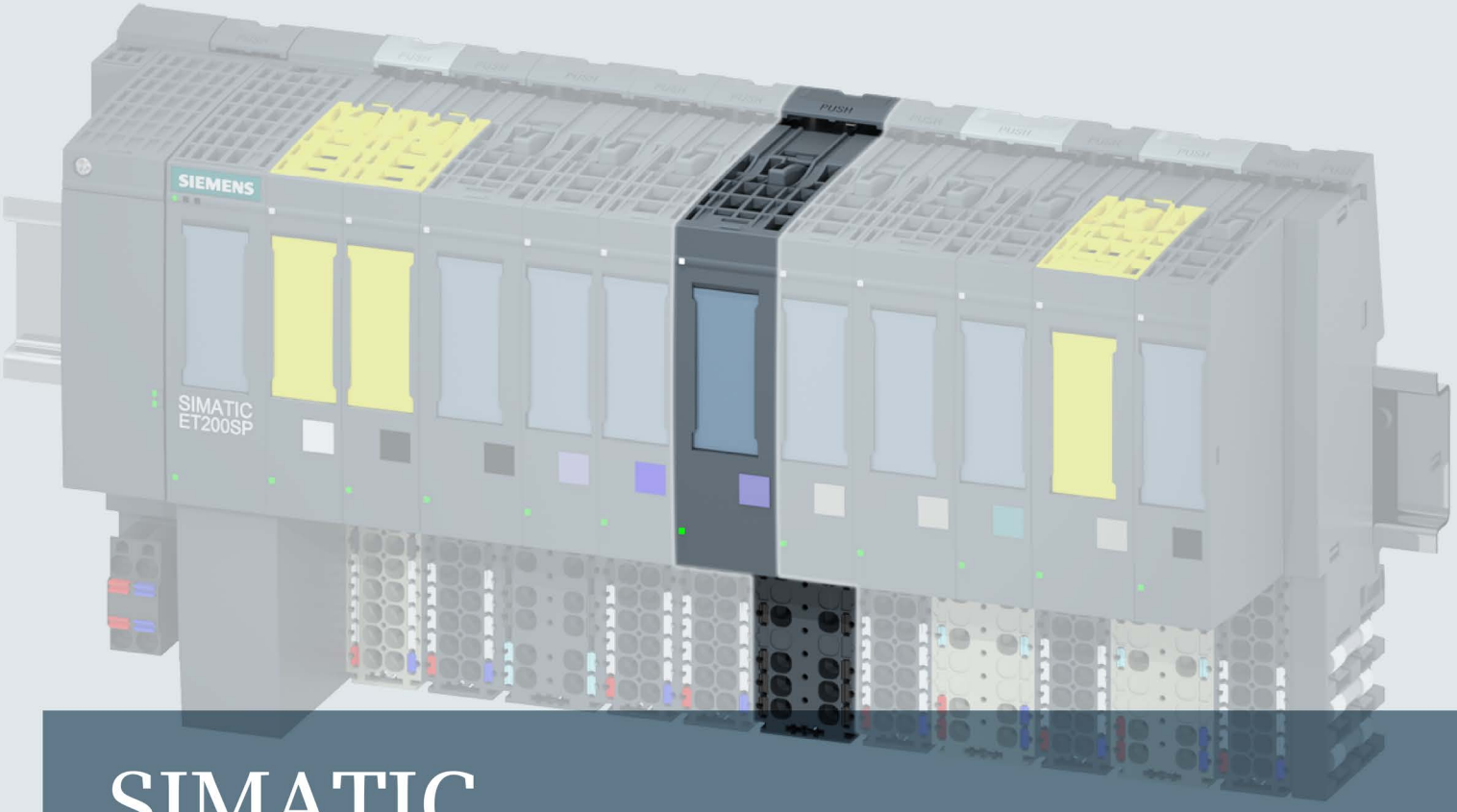

SIMATIC

ET 200SP

Analog input module AI Energy Meter 400VAC ST (6ES7134-6PA01-0BD0)

Manual

Edition 12/2015

Answers for industry.

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SIMATIC

ET 200SP
Analog input module
AI Energy Meter 400VAC ST
(6ES7134-6PA01-0BD0)

Manual

12/2015
A5E36063427-AA

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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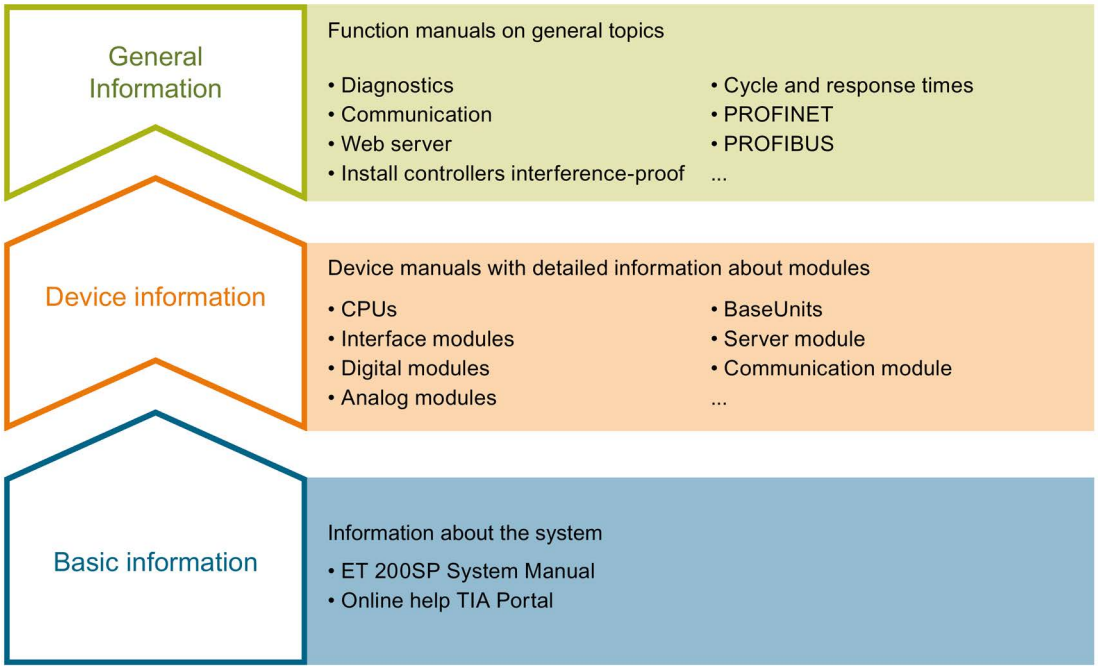
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

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You can export the manual in PDF format or in an editable format.

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"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Area of application

Introduction

Energy efficiency is playing an increasingly important role in industry. Rising energy prices, increasing pressure to improve profitability and the growing awareness of climate protection are important factors for reducing energy costs and for introducing an energy data management system.

Where can you use the AI Energy Meter 400VAC ST?

AI Energy Meter 400VAC ST is designed for machine-level deployment in an ET 200SP distributed I/O system. AI Energy Meter 400VAC ST records over 200 different electrical measurement and energy values. It lets you create transparency about the energy requirements of individual components of a production plant even down to the machine level.

Using the measured values provided by the AI Energy Meter 400VAC ST, you can determine energy consumption and power consumption. You can determine consumption forecasts and efficiency from the measured values. Power consumption measurements are relevant for load management and maintenance. In addition, you can use the measurements for energy reporting and for determining the CO_2 footprint.

Note

Measuring dangerous electrical quantities

The AI Energy Meter 400VAC ST is not tested according to DIN EN 61010-2-030 and may therefore not be used to verify, measure or monitor protective measures according to DIN EN 61557.

Qualified personnel must ensure through additional measures that no danger ensues for humans and the environment in case of an incorrect display.

TN and TT system

The AI Energy Meter 400VAC ST can be used in TN and TT systems.

Measuring with AI Energy Meter 400VAC ST

A typical supply network of a production plant is usually divided into three voltage ranges:

- The infeed of the entire plant
- The subdistribution, for example, to individual lines within the plant
- The end consumers such as the machines in the lines.

The following figure shows the measurement in an electricity supply network:

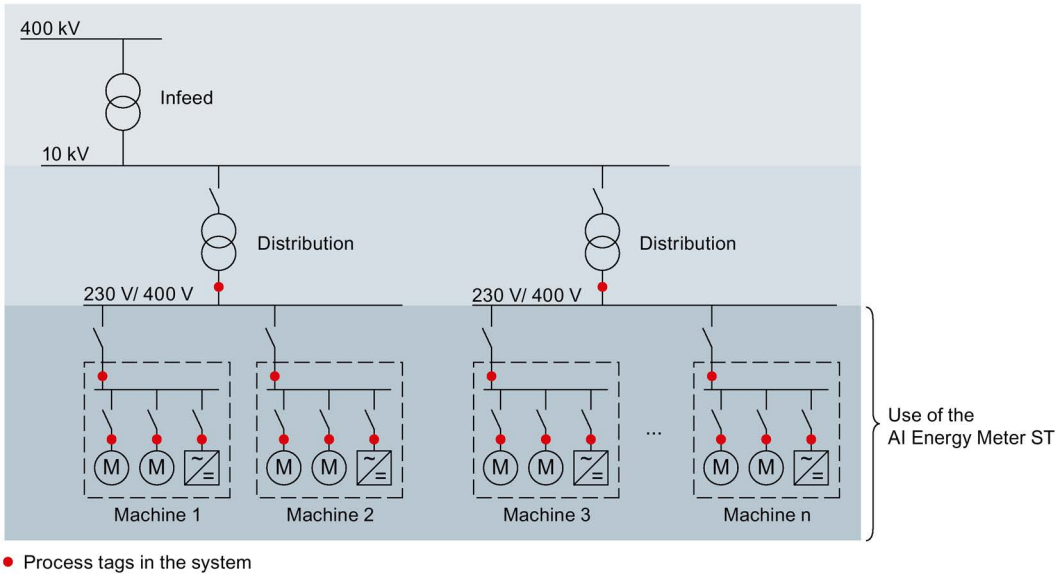


Image 2-1 Use of the AI Energy Meter 400VAC ST

Advantages of the AI Energy Meter 400VAC ST

The AI Energy Meter 400VAC ST has the following advantages:

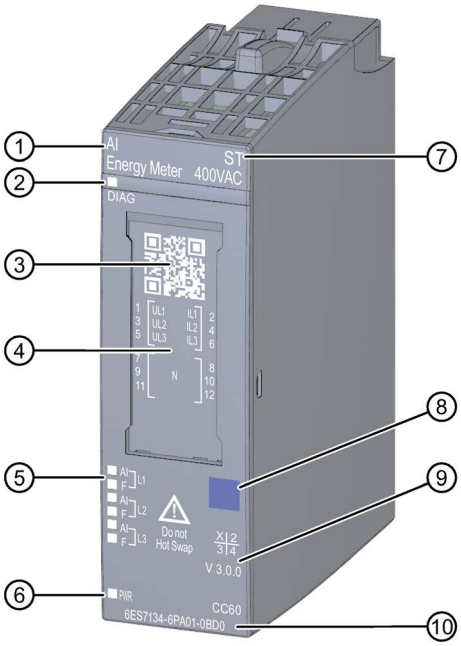
- Space-saving especially for use in control cabinet
- PROFINET IO or PROFIBUS DP (depending on the interface module in use)
- Multiple modules can be used with one interface module
- Extension of existing stations by components for energy recording

2.2 Properties of the AI Energy Meter 400VAC ST

Article number

6ES7134-6PA01-0BD0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color identification label module type
⑨ Function and firmware version
⑩ Article number

Image 2-2 View of the module AI Energy Meter 400VAC ST

Properties

The module has the following technical properties:

- Measurement of electrical variables from single-phase and three-phase supply networks
- Max. nominal voltage between two outer conductors 400 VAC
- Recording of:
  - Voltages
  - Currents
  - Phase angles
  - Power
  - Energy / electrical work
  - Frequencies
  - Power factors

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- Diagnostic error interrupts

Accessories

The following accessories must be ordered separately:

- BaseUnit Type D0
- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/es/58649293) system manual.

Wiring

3

3.1 Terminal and block diagram

In an ET 200SP station, the AI Energy Meter 400VAC ST forms its own potential group together with its dark BaseUnit.

General safety instructions

⚠ WARNING

Danger to life due to electric shock

Touching live parts can lead to death or severe injuries.

Before beginning any work deenergize the system and the Energy Meter and short-circuit installed transformers.

⚠ WARNING

Danger to life, dangerous system conditions and material damage possible

Removing and inserting the Energy Meter under live voltage is prohibited! For this reason the symbol "Do not Hot Swap" is located on the Energy Meter.

If you remove and insert the Energy Meter under live voltage during operation, the transformers used can produce dangerous induction voltages and electric arcs and dangerous system conditions can arise.

The Energy Meter may only be removed and inserted during operation if the measuring voltages applied to the BaseUnit are disconnected at all phases at the terminals U_{L1} , U_{L3}, U_{L3} **and** special current transformer terminals are used that short-circuit the transformer at the secondary side when removed.

⚠ CAUTION

Use only in three-phase and AC networks

The Energy Meter is destroyed if used with direct voltage / direct current.

Use the Energy Meter solely to measure electrical variables in three-phase and AC networks.

Supplying the module

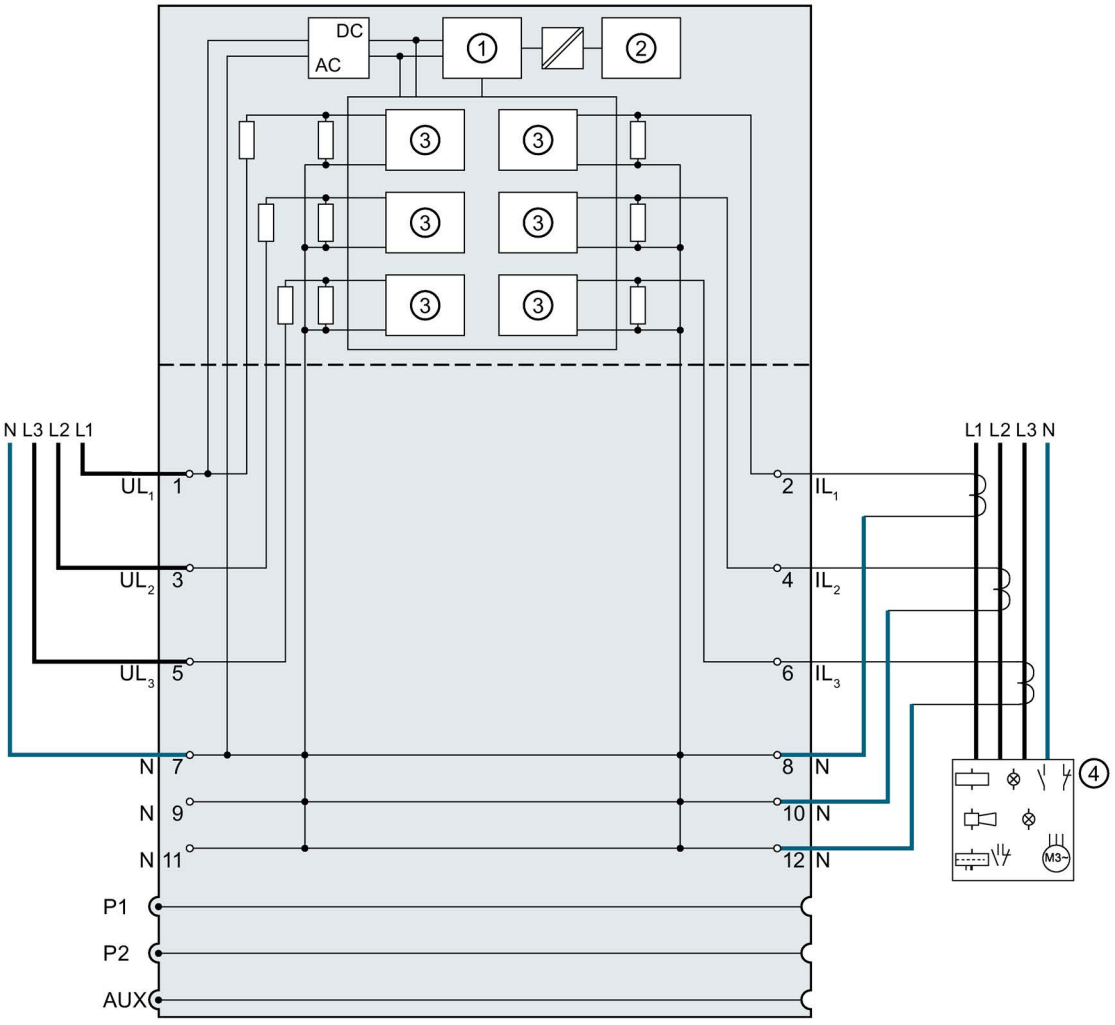
The Energy Meter is supplied through the terminals U_{L1} and N. The required minimum voltage amounts to 85 VAC.

Protecting the connection cables

To protect the connection cables at U_{L1}, U_{L2} and U_{L3}, make sure there is adequate cable protection, especially after cross-section transitions.

If short-circuit resistance according to IEC 61439-1:2009 is ensured by the design, there is no need for separate cable protection for the AI Energy Meter 400VAC ST.

Terminal and block diagram



①	Microcontroller	UL_n	Voltage connection
②	Backplane bus interface	IL_n	Current connection
③	Analog-to-digital converter (ADC)	N	Neutral conductor
④	Power measurement		

Image 3-1 Block diagram of the AI Energy Meter 400VAC ST

Usable BaseUnit

The ET 200SP Distributed I/O System manual explains that a potential group always starts with a light BaseUnit. The AI Energy Meter 400VAC ST makes an exception in this case and only uses the dark BaseUnits type D0, 6ES7193-6BP00-0B**D0**.

The BaseUnit is not in contact with the power bus and passes the potential through from the left to the right slot.

When using some older CPUs / interface modules, note that the first permissible place for AI Energy Meter 400VAC ST is slot 2.

Connection types

The AI Energy Meter 400VAC ST supports the following connection types:

- 3P4W, 3 phases, 4 conductors
- 1P2W, 1 phase, 2 conductors

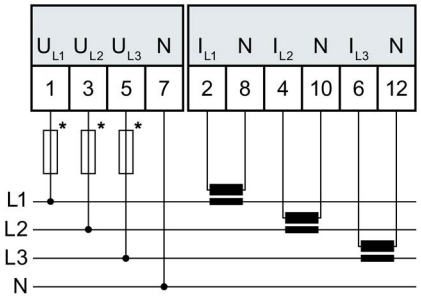
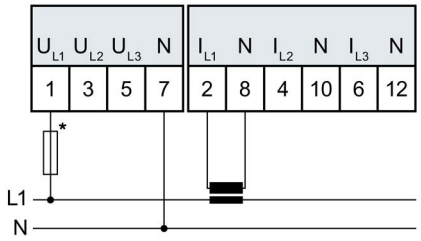
The input circuit of the module must correspond to one of the listed connection types. Select the appropriate connection type for the intended use.

You will find examples of connections in the section Connection examples (Page 17).

Information on the selection of a current transformer is available in the section Current transformer selection data (Page 17).

3.2 Connection examples

The following figures show the connection of the Energy Meter for three-phase, two-phase and single-phase measurements. Note that the Energy Meter must always be connected via a current transformer.

Connection type	Wiring diagram	Comment
3P4W Three-phase measurement, 4 wires		Any load Connection with three current transformers
1P2W Single-phase measurement, 2 conductors		Measurement in an AC network with a current transformer Energy Meter supplies the value "0" for all measured values of Phases 2 and 3 as well as for some cross-phase measured values.

If short-circuit resistance is ensured by conformity to IEC 61439-1:2009, there is no need for separate line protection for the AI Energy Meter 400VAC ST.

3.3 Current transformer selection data

Introduction

Connection via a current transformer is always required for the current measurement. Use toroids with an accuracy class of 0.5, 1 or 3.

Dimensioning of the current transformer

The correct dimensioning of the current transformer is important for the following reasons:

- You achieve correct results from the measurements and
- You do not overload or damage the current transformers.

Selecting a current transformer

Use current transformers with a burden capacity 1.5 to 2 times greater than the power dissipation in the terminal circuit (consisting of resistance of the connection cables and burden of the Energy Meter). 1.5 times the power loss is required in order to prevent the transformer from overloading. 2 times the power dissipation is important to ensure the current limiting in case of a short-circuit.

Maximum length of the connection cable

To avoid overloading or damaging the current transformer, the burden Z_n specified on the data sheet of the current transformer (in VA) must not be exceeded. To prevent this being exceeded, the entire burden resistance (consisting of the resistance of the connection cable and the internal resistance of the AI Energy Meter 400VAC ST (see figure below) must be below a certain resistance value (depending on Z_n and I_{max}).

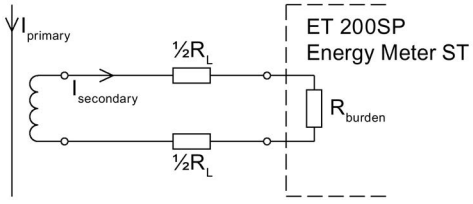


Image 3-2 Maximum length of the connection cable

The maximum value of the resistance of the connection cable is obtained with the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^{\,2}} - R_{burden}$$

R_L	Cable resistance in ohms	I_{max}	Secondary current of the current transformer
Z_n	Rated burden current transformer in VA	R_{burden}	Resistance of the Energy Meter (25 mΩ)

Image 3-3 Maximum value for the resistance of the connection cable

Based on the maximum cable resistance in ohms, you then calculate the maximum length of the connection cable. To do this, check the data sheet of the connection cable you are using.

Note

The length of the connection cable (outwards and return) must not exceed the value of 200 meters.

Example

Current transformer 500/5 A

You use a current transformer with a transmission ration of 500/5 A that has a rated burden Z_n of 5 VA according to the data sheet.

The maximum primary current in the application amounts to 400 A. This means that the maximum secondary current $I_{max.}$ amounts to 4 A. The burden of the AI Energy Meter including connection resistance amounts to R_{Burden} = 25 mΩ.

The maximum value of the resistance of the connection cable (outgoing and incoming line) is obtained using the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^2} - R_{Burden} = \frac{5\ AV}{16\ A^2} - 25\ m\Omega = 312.5\ m\Omega - 25\ m\Omega = 287.5\ m\Omega$$

The maximum cable resistance between the transformer and the terminals of the Energy Meter may not exceed 287.5 mΩ in this case. The corresponding cable length (outgoing and incoming line) depends on the cross-section used of the copper line and can be determined by using the following table.

The following table shows the resistance values of copper cables for typical cross-sections with ρ = 0.017857 Ω x mm²/m

Estimating the length for a connection cable

The value in the table must be less than the calculated terminal resistance $R_{L\ max}$ of the cable. For the resistance R_{Lmax} of 287.5 mΩ used in the above example it is possible to use a connection cable (outgoing and incoming line) with a length of 10 m from a cross-section of 0.75 mm² upward.

Cross-section	AWG	Cable overview for copper				
		0.5 m	1 m	5 m	10 m	50 m
0.25 mm²	24	35.7 mΩ	71.4 mΩ	357.1 mΩ	714.3 mΩ	3571.4 mΩ
0.34 mm²	22	26.3 mΩ	52.5 mΩ	262.6 mΩ	525.2 mΩ	2626.0 mΩ
0.5 mm²	21	17.9 mΩ	35.7 mΩ	178.6 mΩ	357.1 mΩ	1785.7 mΩ
0.75 mm²	19/20	11.9 mΩ	23.8 mΩ	119.0 mΩ	238.1 mΩ	1190.5 mΩ
1.0 mm²	18	8.9 mΩ	17.9 mΩ	89.3 mΩ	178.6 mΩ	892.9 mΩ
1.5 mm²	16	6.0 mΩ	11.9 mΩ	59.5 mΩ	119.0 mΩ	595.2 mΩ
2.5 mm²	14	3.6 mΩ	7.1 mΩ	35.7 mΩ	71.4 mΩ	357.1 mΩ

Checking the ratio of burden load and power loss

The rated burden of the transformer must be 1.5 to 2 times greater than the power loss in the connection circuit to ensure that the transformer is not overloaded and that the current limitation is ensured during a short-circuit.

At a maximum secondary current of 4 A the power loss in the connection circuit is calculated in accordance with the following formula for a connection cable (outgoing and incoming line) with a length of 10 m and a cross-section of 1.0 mm^2 and a burden resistance of the Energy Meter of 25 mΩ:

$$P_{\text{Connection circuit}} = (R_{\text{Connection cable}} + R_{\text{Burden}}) \times I^2_{\text{Max. secondary}}$$

$$P_{\text{Connection circuit}} = (178.6\ m\Omega + 25\ m\Omega) \times 4^2\ A^2\ 3.26\ W$$

The ratio of the rated burden and the power loss in the connection circuit thus amounts to:

$$\frac{Z_{\text{N rated burden}}}{P_{\text{Connection circuit}}} = \frac{5\ VA}{3.26\ W} = 1.54$$

The required ratio of rated burden and power loss in the connection circuit lies within the required range. The transformer is dimensioned sufficiently large.

See also

Technical specifications (Page 61)

Configuration / address space 4

4.1 Configuring

Introduction

To configure the AI Energy Meter 400VAC ST after connecting it, use configuration software such as STEP 7. In addition, you can also change numerous parameters of the AI Energy Meter 400VAC ST in RUN via the user program.

Configuring

You configure the AI Energy Meter 400VAC ST with:

- STEP 7 (TIA Portal) V13 SP1 or higher with Update 4 and HSP
- STEP 7 V5.5 SP4 or higher and Hotfix 7
- GSD file for PROFIBUS or PROFINET

Note

Consistency check of the parameter assignment only with STEP 7

If you configure the AI Energy Meter 400VAC ST using STEP 7, STEP 7 already checks the various parameters for consistency while they are being entered.

If you configure the AI Energy Meter 400VAC ST using a GSD file, a consistency check is not carried out. The module does not recognize incorrect entries until after the parameter data record has been transferred. If the module recognizes an invalid parameter, the module rejects the complete data record.

Preferably use STEP 7 to configure the AI Energy Meter 400VAC ST.

The following instructions show the theoretical procedure for configuring the AI Energy Meter 400VAC ST with STEP 7 (TIA Portal) V13 SP1 or higher with Update 4 and HSP.

1. Select the ET 200SP distributed I/O system you are using in the hardware catalog.
2. Insert the module into your station.
3. Open the device view of the ET 200SP and insert the AI Energy Meter 400VAC ST.
4. Configure the AI Energy Meter 400VAC ST to suit your requirements.

   Once the configuration has been compiled without errors, you can download the configuration to the CPU and commission the ET 200SP station while the AI Energy Meter 400VAC ST is running.

4.2 Selecting the module versions

Introduction

The AI Energy Meter 400VAC ST has different module versions.

During the configuration you use the selection of the module version to specify which measured values can be read.

Each module version supplies quality information via the input user data.

At the module version "32 I / 12 Q" you can read the measured values as user data cyclically from the process image. At each module version you have the option to read measured value records from the AI Energy Meter 400VAC ST by using the RDREC instruction asynchronously.

Influence of the module version on the address space

Note

Influence of the AI Energy Meter 400 VAC ST on the maximum configuration of the ET 200SP

The available address space of the ET 200SP is influenced by the following factors:

- CPU or interface module
- Plugged I/O modules

The address space made **additionally** available by the AI Energy Meter 400 VAC ST is essentially influenced by the length of the user data supplied. The module version determines the length of the user data, which can be supplied by the AI Energy Meter 400VAC ST at maximum.

Module versions of the AI Energy Meter 400VAC configuration with STEP 7

Module version	User data	Address space	Comment
2 I / 2 Q	No cyclic user data. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix Module version "2 I / 2 Q" (Page 77).
32 I / 12 Q	User data selectable through defined user data variants	32 byte inputs / 12 byte outputs	You can change over the user data variant during operation. Information about the structure of the 32 I / 12 Q module version is available in the appendix Module version "32 I / 12 Q" (Page 79). Information about the user data variants at 32 I / 12 Q is available in the appendix User data variants with 32 bytes input data / 12 bytes output data (Page 83).

4.2.1 Changing over the user data variant during operation

Introduction

At the module version 32 I / 12 Q you switch over the user data variant in the output data in Byte 0.

Requirement

- User program has been created.
- AI Energy Meter 400VAC ST is configured as the module version 32 I / 12 Q.
- The start address of the module is known in the process image output.

Procedure

1. Create one constant with the data type BYTE per user data variant.
2. Enter the user data ID as a value in each case.
3. Write the constant to the start address of the module in the process image output.

Result

The user data variant is switched with the next cycle.

Note

Information about user data changeover

The parameterized user data variant is set in the following cases:

- A "0" is written in byte 0 in the output data of a user data variant.
- Byte 0 in the output data of a user data variant contains an invalid value:
  - Coding of the user data variant not available

4.2.2 Recommendations for selecting the module version

The following table shows which module version is suitable for a given purpose.

Module version	Remarks on the field of application
2 I / 2 Q	• Solely acyclic reading of the measured values via the RDREC instruction from a measured value data record. • Use of many modules possible because little address space is used.
32 I / 12 Q	• Cyclic reading of the measured values from the user data. – Various measured variables can be read by switching over the user data variant. – One cycle elapses for each user data changeover. Measured values from the next user data variant are supplied with a slight time offset. – Depending on the user data variant, you must convert the measured values in the CPU to physical values using the supplied scaling factor. • Acyclic reading of the measured values via the RDREC instruction from a measured value data record. • Use of less modules possible because each module uses 32 bytes input and 12 bytes output.

4.3 Applicable modules

The following table shows with which controllers the different module versions can be configured.

	Module version	
Controller	2 I / 2Q	32 I / 12 Q
IM 155-6 PN ST	V1.0 or higher	
IM 155-6 PN HF	V2.0 or higher	
IM 155-6 PN BA	V3.2 or higher	
IM 155-6 PN HS	V4.0 or higher	
IM 155-6 DP HF	V1.0 or higher	
CPU 1510SP-1 PN	V1.6 or higher	
CPU 1510SP F-1 PN	V1.7 or higher	
CPU 1512SP-1 PN	V1.6 or higher	
CPU 1512SP F-1 PN	V1.7 or higher	
CPU 1515SP PC	V1.7 or higher	

Quick start

5

Introduction

This section shows you how to read and view your first measured values on the Energy Meter 400 VAC ST in a particularly quick and easy way.

Requirement

You have already connected the Energy Meter to your network with one of the connection types shown in the section Wiring (Page 14). The Energy Meter 400 VAC ST has already been integrated in your configuration tool (such as STEP 7), or the Energy Meter 400 VAC ST has been integrated in your hardware catalog with the GSD/GSDML file.

Procedure

1. Configure an ET 200SP station

   Configure an ET 200SP station with a CPU 151xSP or an IM 155-6.

2. Plug module in ET 200S station

   Plug the Energy Meter 400 VAC ST into the ET 200SP station and use the module version with 32 bytes inputs and 12 bytes outputs.

3. Set the module parameters

   Set the following parameters for the Energy Meter 400 VAC ST:

   – Connection type that you have used for the Energy Meter 400 VAC ST (e.g. 3P4W)
   – Measuring range, i.e. the phase voltage (UL1-N) of your electrical network (e.g. 230 V AC)
   – Frequency of your network (e.g. 50 Hz)
   – Primary and secondary current of the used current transformer (e.g. 100 A and 1 A)

   Leave all other parameters at their default settings and do not change them.

4. Load configuration

   Switch on the ET 200SP station and download the configuration to the CPU.

Result

Once the Energy Meter has been switch on, it provides the measured values for the user data variant "Basic measurements" with the ID 254 or FE_H.

Read and check the measured values provided by the Energy Meter in the output data.

The table below shows the structure of the user data variant, the measured variables and the data type of the measured values in STEP 7 (TIA Portal) that are stored in the 32 bytes of output data of the module. Each measured variable is referenced via the measured value ID. An overview of all the measured variables with their measured value IDs is provided in the section Measured variables (Page 73).

Table 5- 1 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Total active power L1L2L3	INT	1 W	-27648 … 27648	66035
10 ... 11	Total reactive power L1L2L3	INT	1 var	-27648 … 27648	66036
12 ... 13	Total apparent power L1L2L3	INT	1 VA	-27648 … 27648	66034
14 ... 17	Total active energy L1L2L3	UDINT	1 Wh	0 … 4294967295	200
18 ... 21	Total reactive energy L1L2L3	UDINT	1 varh	0 … 4294967295	202
22	Reserved	BYTE	-	0	-
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling total active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling total reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling total apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Additional information

If you require further information about the evaluation and interpretation of the measured values, please refer to the section Reading and processing measured values (Page 27).

Reading and processing measured values

6

6.1 Basics for reading measured values

Introduction

The AI Energy Meter 400VAC ST provides the measured values and variables through the following methods:

- Cyclic: User data
- Acyclic: Measured value data records

User data

User data provide pre-defined measured values depending on the configured user data variant. The supplied measured values are cyclically written to the process image of the CPU. With some user data variants, the measured values are supplied as raw data, which you have to convert to the corresponding physical values using a supplied scaling factor.

Measured value data records

Each measured value data record supplies physical values that you can further process immediately. You read the values of a measured value data record acyclically with the RDREC instruction in a PLC tag of the STRUCT data type. You need a corresponding PLC tag for each measured value data record to be read.

You can display the read measured values in a watch table in STEP 7. Address the tag with the STRUCT data type directly.

Note

If you are using CPUs other than S7-1200 or S7-1500, convert 64-bit measured values to 32-bit measured values. Note the conversion can cause loss of accuracy.

For more information, read FAQ: Processing 64-bit-floating-point numbers in S7-300/400 (https://support.industry.siemens.com/cs/ww/en/view/56600676)

Validity of the measured values

After turning on the supply voltage UL1, the first measured values are available after approximately 2 seconds. In the input user data, the content of byte 0 is set to the selected user data variant. You can use this change in byte 0 as a trigger event.

As soon as the module has valid measured values, the value of this byte changes to a value within the value range.

Initial startup of the module

After the first startup or restart of the module, the parameters are transferred to the module. You can preset a user data variant in the parameters of the hardware configuration. This remains in effect until a different user data variant is selected in the output data (byte 0). This allows input user data to be modified dynamically according to the requirements of the process.

The user data variant defined in parameter data record 128 is used under the following conditions:

- A "0" is written in byte 0 in the output data of a user data variant.
- Byte 0 in the output data of a user data variant contains an invalid value: Coding of the user data variant not available

Current measured values become "0"

The current and all other measured values based on it are suppressed (or set "0") in the data records and in the user data in the following cases:

- The incoming current of the current transformer is less than the configured "Low limit for measuring current" parameter
- Incoming secondary current at the channel is higher than 12 A

The following measured values and derived measured variables of the phase involved become "0":

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A floating mean value is formed from the power values. These only become "0" after a corresponding time. The energy meter for active, reactive and apparent energy of the reset phase does not count any longer.

Substitute value behavior

The substitute values for input values of the AI Energy Meter 400VAC ST amount to "0".

See also

Reading measured values from user data cyclically (Page 31)

Read measured value from a measured value data record (Page 33)

Selecting the module versions (Page 22)

6.2 Quality information

Introduction

The AI Energy Meter 400VAC ST supplies quality information about the measurement in a status word. This information can be used to evaluate the status:

- Currents (I_{L1}, I_{L2}, I_{L3}) and voltages (U_1, U_2, U_3) lie within the valid measuring range
- Operating quadrants for Phase 1.

You can evaluate the quality information at every module version in Byte 1 of the output user data.

Structure of the quality information

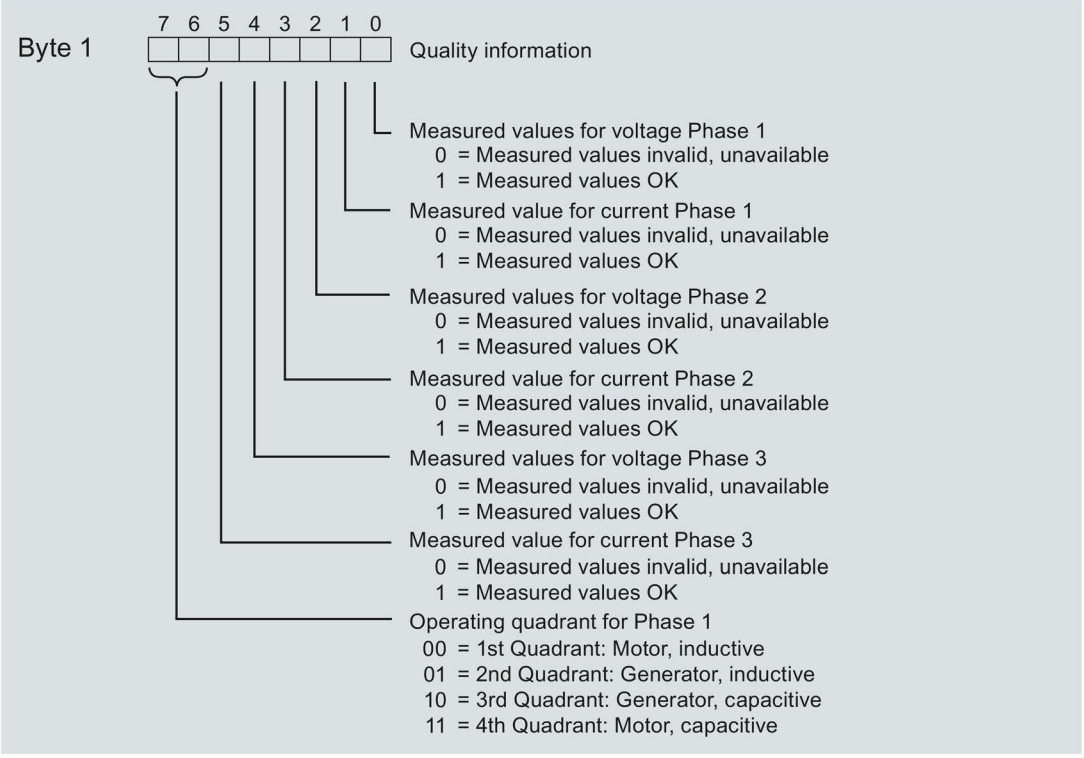


Image 6-1 Quality information

Operating quadrant

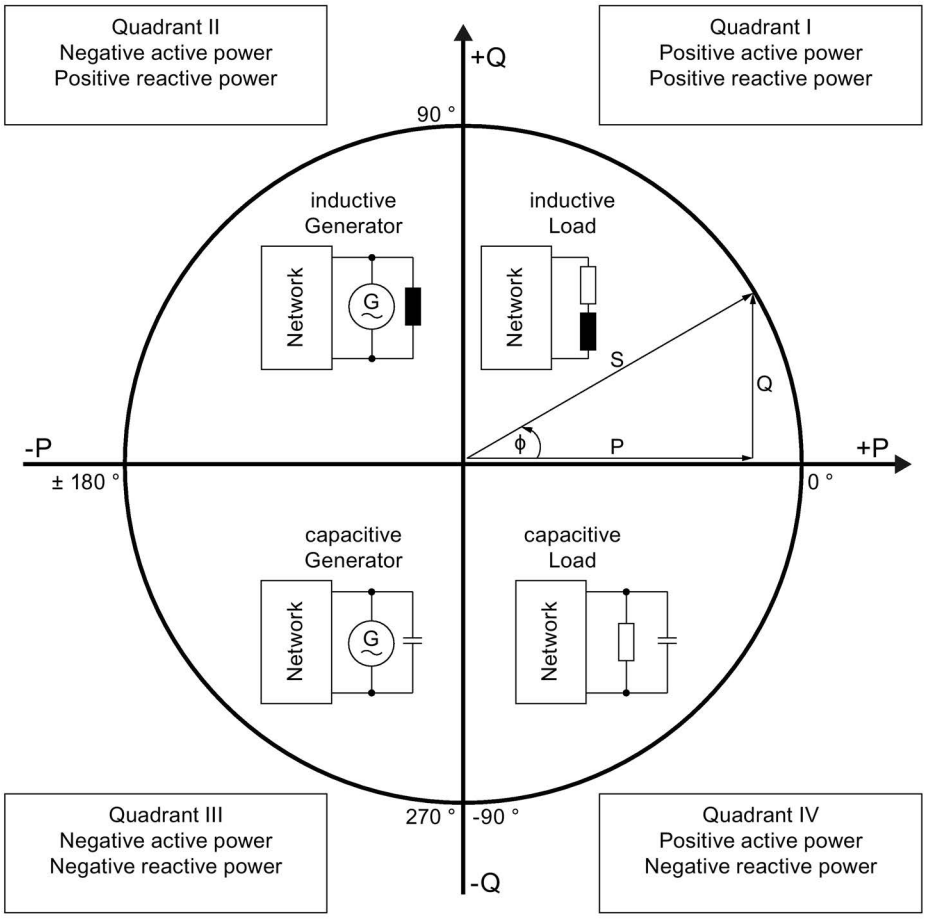


Image 6-2 Quadrant in the quality bits

See also

Module version "32 I / 12 Q" (Page 79)

6.3 Reading measured values from user data cyclically

Requirement

- STEP 7 is open.
- AI Energy Meter 400VAC ST is configured.

Scaling of measured values in the user data

Since the value range of 16-bit values is often smaller than the value range of the physical value, a scaling factor is supplied together with the basic value in the user data for the respective measured or calculated values. You determine the actual value of the measured variable with the following formula:

Actual value of measured quantity = measured value in the user data x $10^{\text{scaling factor}}$

Procedure

To read measured values from the user data cyclically, proceed as follows:

1. Read the relevant measured value from the input data.
2. Observe the scaling factor at scaled measured values and convert the read measured value using the scaling factor.

Example

The user data variant 254 (FE_H) "Total power L1L2L3" is configured on the AI Energy Meter 400VAC ST. The measured value for "Current L1" should be read.

Table 6- 1 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
:	:	:	:	:	:
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
:	:	:	:	:	:
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

In the user data variant FE_H (254) the measured value for the current L1 is stored in Byte 2 + 3. The current is supplied by the module as a 16-bit-fixed-point number in the value range from 0 to 65535 in the unit 1 mA. In addition the scaling factor for the current L1 has to be considered additionally. The module supplies the related scaling factor in Byte 24.

The actual value for current L1 is calculated as follows:

Actual value for current L1 = Current L1 x $10^{\text{Scaling current L1}}$

See also

Basics for reading measured values (Page 27)

6.4 Read measured value from a measured value data record

Introduction

To read measured values of a measured value data record, use the RDREC instruction. The read values are stored in a PLC variable with user-defined data type (UDT).

You can find more information on this in the STEP 7 documentation, under the keyword "RDREC".

Requirement

- STEP 7 is open.
- AI Energy Meter 400VAC ST is configured.

Procedure

1. Create a PLC tag of the STRUCT data type in STEP 7.
2. Insert the number of structural elements, which corresponds to the number of entries contained in the measured value data record.
3. Insert the RDREC instruction in the user program.
4. Configure the RDREC instruction as follows:
   - ID: Hardware identifier or start address of the Energy Meter (depending on the CPU used).
   - INDEX: Number of measured value data record whose entries are read.
   - MLEN: Length of the measured value data record in bytes. "0" if all the entries are to be read.
   - RECORD: Target range for the read data record Length depends on MLEN.
5. Call the RDREC instruction with REQ = 1.

Result

The values from the measured value data record were transferred into the target data area.

See also

Basics for reading measured values (Page 27)

Energy counters

7

7.1 How the energy meter works

Introduction

The AI Energy Meter 400VAC ST provides 42 energy counters that detect both line-based and phase-based energy values.

- Active energy (total, outflow, inflow)
- Reactive energy (total, outflow, inflow)
- Apparent energy (total)

How energy recording works

Based on the measured currents and voltages and the calculation cycle the Energy Meter calculates the active, reactive and apparent energy. The active, reactive and apparent energies are updated in each calculation cycle.

Configuring

You configure the following settings for the energy counters:

- Activation of the gate for the energy counter

  The gate allows you to start and stop the counters via output data (DQ bit). If you deactivate the gate, the count starts immediately when the Energy Meter is switched on.
- Modes of the energy counters

  The energy counter count endlessly.

The settings apply to the energy counter of all phases.

Changing properties in RUN

You can change the following properties of energy counters in runtime:

- Enable / disable energy counter
- Reset energy counter
- Set initial values for the energy counter

Automatic reset of the energy counter

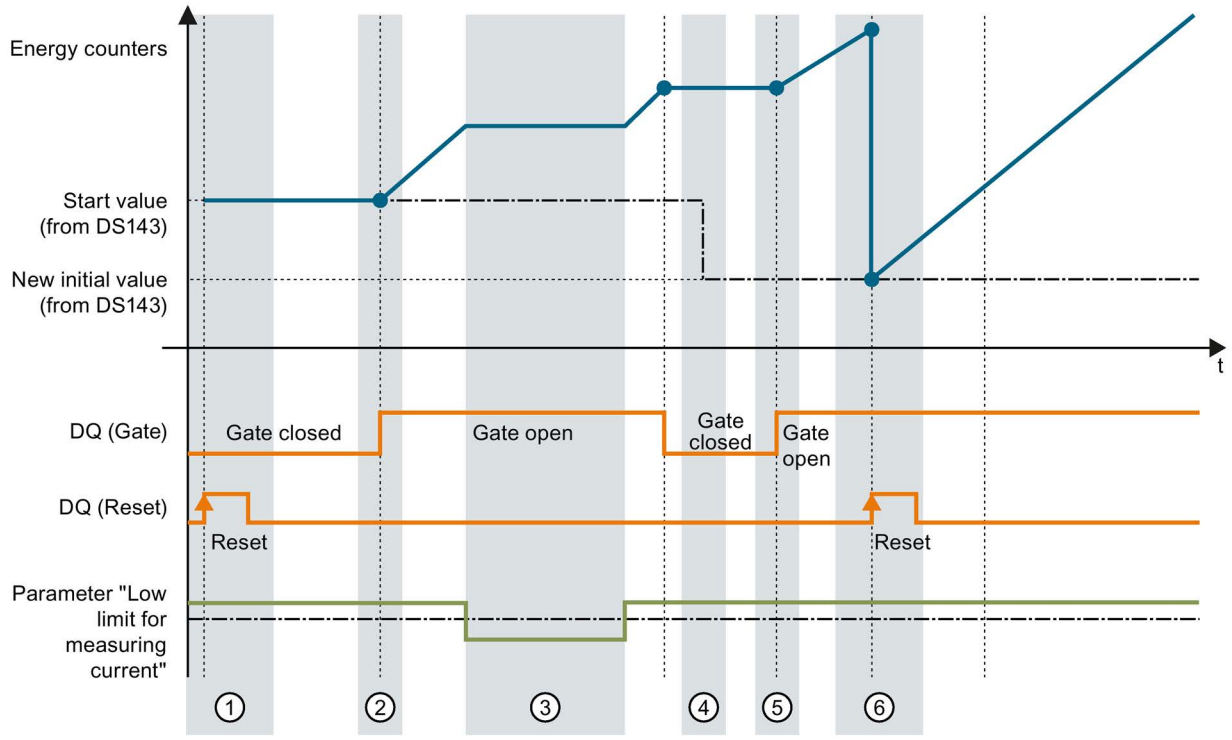
The energy counters are automatically reset to "0" when parameter settings relevant to the energy counter are changed. In the case of phase-specific changing of parameter settings relevant to the energy counter only the energy counters of the respective phases are reset.

Changing of the following parameters results in resetting of the energy counters:

- Measurement type or range
- Current transformer (primary current/secondary current)
- Direction of current

Example

The following figure shows the effect of initial value, reset and start/stop parameters with activated gating using the energy counter as an example:



① The counter is reset to the value specified in the configuration. The gate is closed. The counter does not count.

② The gate is opened via the control byte 1 in the output data of the user data variant. The counter counts.

③ The configured current low limit has been violated. The counter does not count.

④ The gate is closed. The counter does not count. A new start value is written to the measured value data record 143 with the WRREC instruction.

⑤ The gate is opened again via the control byte 1 in the output data of the user data variant. The counter counts with the new start value.

⑥ The counter is reset via the control byte 1 in the output data of the user data variant. The counter counts from the new start value that was transferred via the measured value data record 143.

See also

Evaluating energy counters (Page 38)

7.2 Configuring counters

Overview

You can configure the energy counters of the AI Energy Meter 400VAC ST as follows:

- Activate / Deactivate
- Start / stop counters using gate
- Set and reset start value

Energy counter gate

You have the option of starting and stopping the energy counter using the gate. To this purpose you have to:

- Select the "Enable gate control for the energy counter" parameter in the configuration of the AI Energy Meter 400VAC ST.
- Set the DQ bit for the "counter gate" in the user data in Control byte 1 of the output data (Bit 6 in Control byte 1).

The "Enable gate control for the energy counter" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

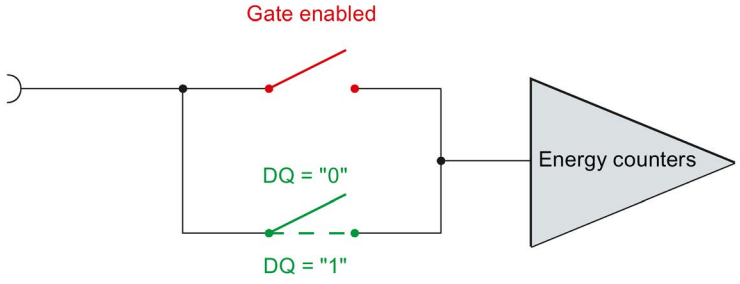


Image 7-1 Gate enabled

If you deselect the "Enable gate control for the energy counter" parameter in the configuration of the AI Energy Meter 400VAC ST, the energy counters operate independently of the DQ bit as long as the current value lies above the configured "Low limit for measuring current".

Gate disabled: Gate is always "open" (signal path closed)

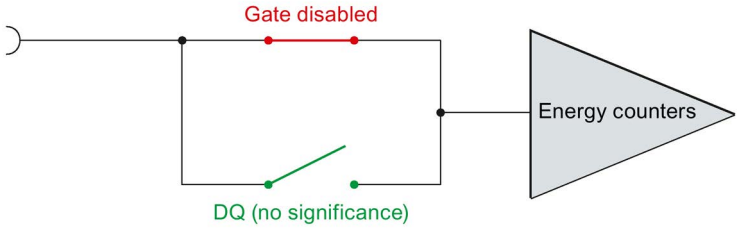


Image 7-2 Gate disabled

Set and reset start value

The counters can be set to their start value via the output data of each user data variant. With energy counters, you have to reset the bit of the energy counter in control byte 2 of the data record 143.

You can reset each energy counter to the start value or also specify a new start value via the data record 143. You define the moment for updating of the start values in the data record 143 and in Control byte 1 in the user data. Start values are either applied immediately or after a reset bit has been set from 0 to 1.

You can find a detailed description for this in section Data record for energy counter (DS 143) (Page 45).

7.3 Evaluating energy counters

Evaluating energy counters

The energy counters are evaluated by

- Using the input data of the user data variants for energy
  - User data variant "Total energy L1 L2 L3" (ID 249 or $F9_H$)
  - User data variant "Energy L1" (ID 248 or $F8_H$)
  - User data variant "Energy L2" (ID 247 or $F7_H$)
  - User data variant "Energy L3" (ID 246 or $F6_H$)
- By reading data records
  - "Data record for basic measured values (DS 142)" for evaluation of the total energies L1 L2 L3
  - "Data record for energy counter (DS 143)" for evaluation of the phase-specific energies
  - "Data record for phase-specific measured values L1 - L3 (DS 147 - 149) for evaluation of the phase-specific energies.

Evaluate measured values

The evaluation of measured values via the input data of user data variants and reading of data records with the RDREC instruction is described in the section Reading and processing measured values (Page 27).

7.4 Reset energy counter

7.4.1 Introduction

Introduction

At the beginning of a new work order, it may be useful to reset the energy counter of the Energy Meter Reset here means that the energy counters are reset to their start value.

The following section describes how you

- Reset energy counters via the outputs of the user data.
- Reset energy counters via data record 143.

7.4.2 Reset energy counters via user data

Introduction

Due to the differing lengths of the output data resetting of the energy counters depends on the configured module version.

If you use module versions with 12 bytes output data, you can reset the energy counters for **all** the phases separately by active, reactive and apparent energy.

If you use the module version with 2 bytes output data, you always reset **all** the energy counters simultaneously. Differentiated resetting of the counters by active, reactive and apparent energy is only possible via data set DS 143 for this module version, see section Structure for energy counters (DS 143) (Page 45).

Procedure at module version with 12 bytes of output data

1. Set the category of the energy counters (active, reactive, apparent energy) to 1 in Control byte 2 via Bit 0 to 2.
2. Set the reset bit (Bit 7) in Control byte 1 from 0 to 1 through an edge change.

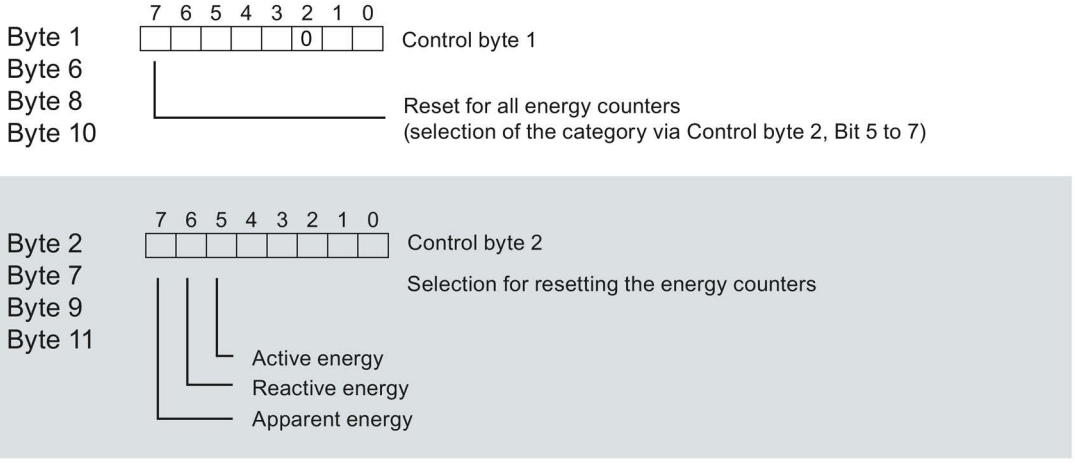


Image 7-3 Resetting the energy counters at module version with 12 bytes of output data

Procedure at module version with 2 bytes of output data

Set the reset bit (Bit 7) in Control byte 1 from 0 to 1 through an edge change.

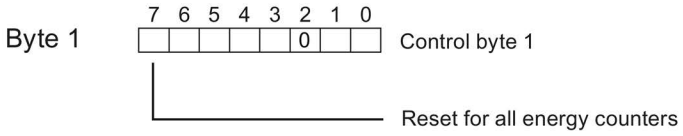


Image 7-4 Resetting the energy counters at module version with 2 bytes of output data

Start values

After the reset the energy counters count with the specified start values (default = 0). You can change the start values for the energy counters via data record DS 143, see section Structure for energy counters (DS 143) (Page 45).

7.4.3 Resetting energy counters via data record DS 143

Introduction

At all the module versions you can reset the energy counters via the data record DS 143. Resetting is possible for:

- Energy counters for each **individual** phase separately by active, reactive and apparent energy.

Procedure at all module versions via data record DS 143

1. In Control byte 1 of the DS 143 set the reset bit (Bit 2) to 1 and Bit 0 to 1 for the overflow counter.
2. In Control byte 2 of the DS 143 set the category of the energy counters (active, reactive, apparent energy) to 1 via Bits 5 to 7.
3. In Control byte 1 of the DS 143 set Bit 7 for the moment of application of the start values:
   - Bit 7 to 0, if the start value are to be applied immediately after the transfer of the data record
   - Bit 7 to 1, if the start value are only to be applied after the reset bit has been set in the output data of the user data.
4. Transfer the data record with the WRREC instruction.

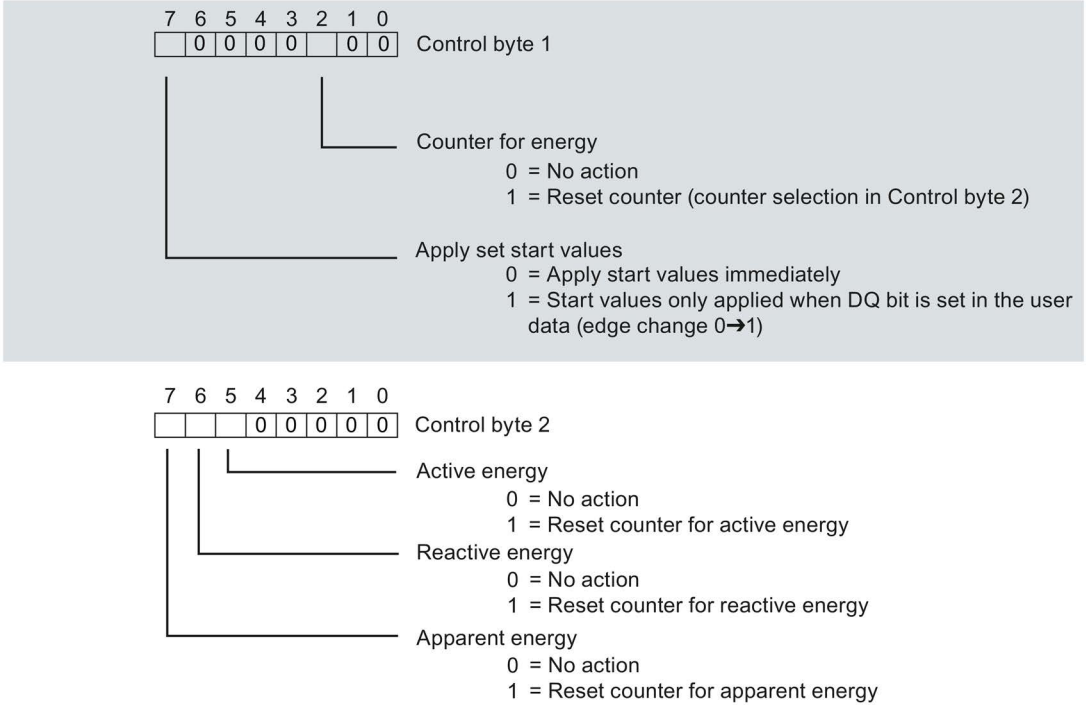


Image 7-5 Energy counter control information DS 143

Start values

You specify the moment for the application of the start values in Control byte 1 via Bit 7. After the reset the energy counters count with the specified start values (default = 0). You can change the start values for the energy counters via data record DS 143.

7.4.4 Example for resetting energy counters via data record DS 143

Introduction

Before you can transfer the data record DS 143 to the CPU you have to create a PLC data type in your user program that has an identical structure to data record DS 143.

Procedure

1. Create a PLC data type that has an identical structure to data record DS 143.

   Detailed information on the structure of data record 143 is available in section Structure for energy counters (DS 143) (Page 45).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	See Section Structure for energy counters (DS 143) (Page 45)	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
:	:	:	:	:	:

2. Create a DB or instance DB and allocate the values of the data record

   Byte 0 and byte 1:

   Enter the value 01_H in Byte 0 and the value 00_H to Byte 1.

   Byte 2 ... byte 7: Control bytes for energy and overflow counter

   In the control byte for the respective phases, specify which energy and overflow counters you want to reset.

   The control bytes specify for each phase (L1, L2, L3) separately if and which energy meter values are to be reset.

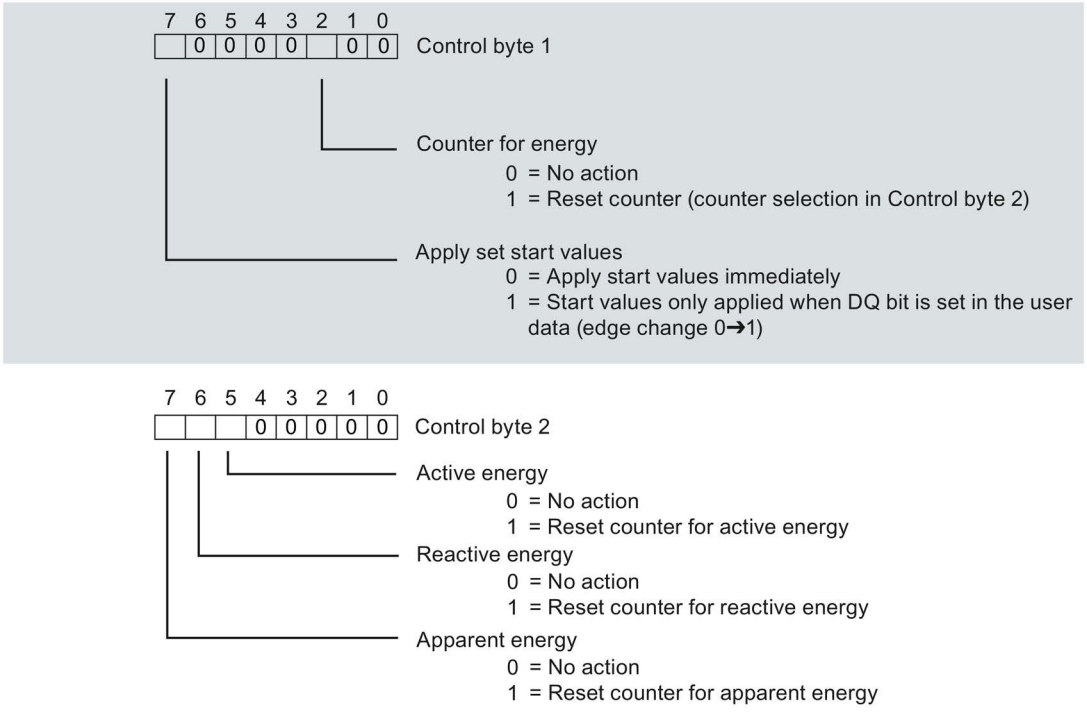


Image 7-6 Control information DS 143 for energy and overflow counter

Byte 8 ... byte 127: Start values for the individual energy meters

The start values for energy counters in data record 143 are 64-bit floating point numbers. This corresponds to the data type LREAL in S7-1200 and in S7-1500.

3. Write the data record to the AI Energy Meter 400VAC ST module using the "WRREC" instruction.

   The input parameters must be allocated as follows:

   – REQ: A new write job is triggered if REQ = TRUE.
   – ID: Hardware identifier or start address of the Energy Meter (depending on the CPU used).
   – INDEX: The data record number: 143
   – LEN: The maximum length of the data record: 128
   – RECORD: A pointer to the data area in the CPU which includes data record 143.

Note

If you want to write or read several AI Energy Meter 400VAC ST at the same time, keep in mind the maximum number of active jobs in communication with SFB52/SFB53.

7.5 Data record for energy counter (DS 143)

7.5.1 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy counter to user-specific value (e.g. "0")
- Reading the current values of the energy counters

Energy meter data record 143

Table 7- 1 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: 0.0...1.8 x 10^{308} During writing: 0.0...3.4 x 10^{12}	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204
88...95	Active energy inflow (initial value) L3	LREAL	Wh		61220
96...103	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...111	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...119	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...127	Apparent energy (initial value) L3	LREAL	VAh		61224

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

7.5.2 Structure of the control and feedback interface for DS 143

Introduction

Bytes 2 to 7 of data record 143 form the phase-based control and feedback interface for the measured value data record of the energy counter.

- Bytes 2 and 3: Control and feedback interface for phase 1
- Bytes 4 and 5: Control and feedback interface for phase 2
- Bytes 6 and 7: Control and feedback interface for phase 3

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

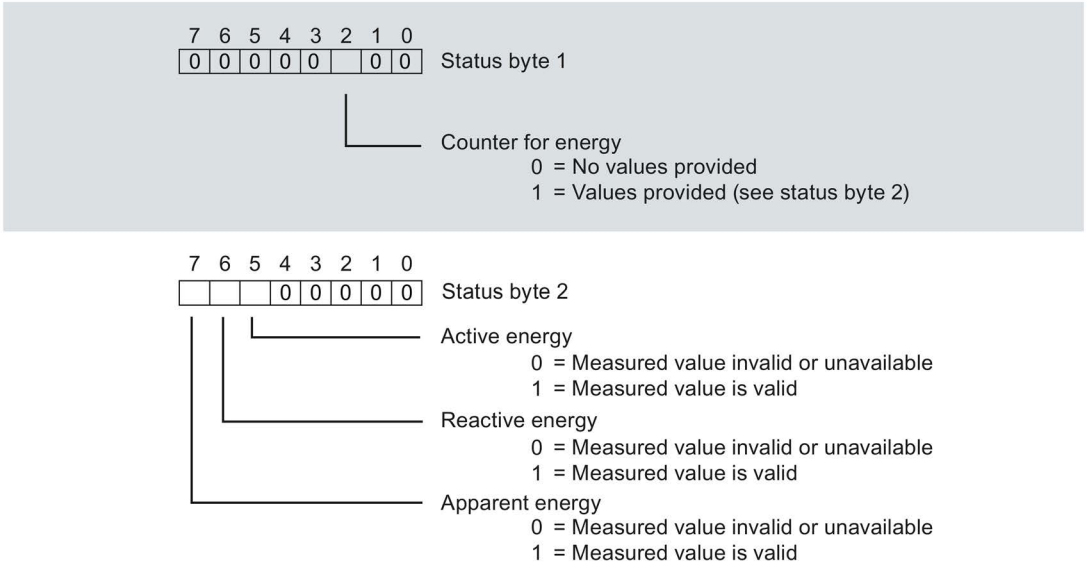


Image 7-7 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters. The length of the control information amounts to 2 bytes for each phase:

- In Control byte 1 you determine how you reset the counter and the time at which the counter is reset.
- In Control byte 2 you determine which energy counter you want to reset.

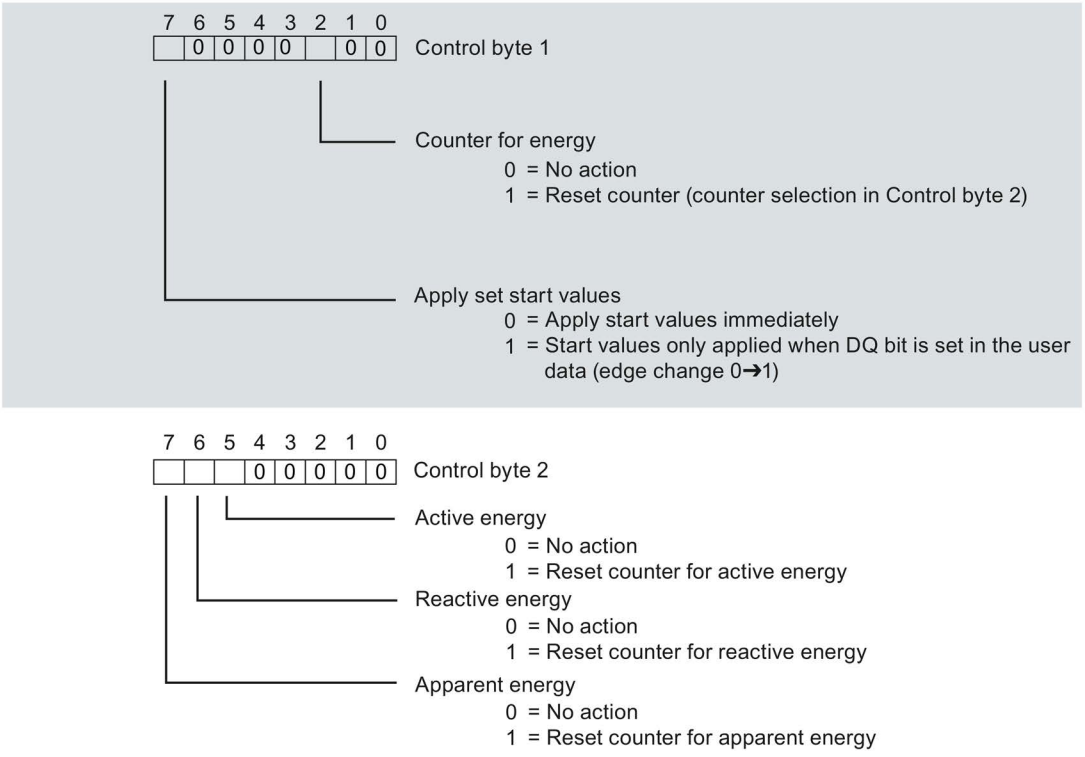


Image 7-8 Control information DS 143 (write access)

Parameters

8

8.1 Parameters

Parameters of the AI Energy Meter 400VAC ST (DS 128)

As a rule the AI Energy Meter 400VAC ST is already integrated in the hardware catalog of STEP 7 (TIA Portal) or STEP 7 V5.5 or higher. In this case STEP 7 (TIA Portal) or STEP 7 V5.5 or higher checks the parameterized properties for plausibility during designing.

However, you can also assign parameters to the module by means of the GSD file and the configuration software of any provider. The module does not check the validity of the parameterized properties until after the configuration has been loaded. Note that some parameters depend on the selected connection type of the Energy Meter. For example in the connection type 1P2W for measurements in single-phase AC network it does not make sense to enter parameters for Phases 2 and 3 and they are also not checked by the system in this case.

The effective range of the parameters that can be set using a GSD file depends on the type of bus system used:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition you can change the parameterized properties via the user program in RUN mode. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records (refer to the appendix Configuration via parameter data records (Page 65)). The following table summarizes all the configurable parameters.

Table 8- 1 AI Energy Meter 400VAC ST parameters

Parameters	Value range	Default setting	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics line voltage	• Disable • Enable	Disable	Yes	Module	Module
Connection type	• Disabled • 1P2W - 1-phase alternating current • 3P4W - 3 phases, 4 conductors	3P4W - 3 phases, 4 conductors	Yes	Module	Module (only 1P2W, 3P4W and deactivated)

Parameters	Value range	Default setting	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Voltage measuring range	• 100 V • 110 V • 115 V • 120 V • 127 V • 190 V • 200 V • 208 V • 220 V • 230 V	230 V	Yes	Module	Module
Line voltage tolerance [%]	• 1 ... 50 %	10 %	Yes	Module	Module
Line frequency	• 50 Hz • 60 Hz	50 Hz	Yes	Module	Module
Enable gate energy counter	• No • Yes	No	Yes	Module	-
User data variant	See the table Overview of the user data variants (Page 83)	Total energy L1 L2 L3 (ID 254 or FE_H)	Yes	Module	Module (only user data variant
Diagnostics overflow current	• Disable • Enable	Disable	Yes	Channel/phase	Module
Diagnostics overflow voltage	• Disable • Enable	Disable	Yes	Channel/phase	Module
Diagnostics underflow voltage	• Disable • Enable	Disable	Yes	Channel/phase	Module
Diagnostics low limit voltage	• Disable • Enable	Disable	Yes	Channel/phase	- (blocking is preset)
Diagnostics overflow cumulative values	• Disable • Enable	Disable	Yes	Channel/phase	Module
Overcurrent tolerance factor [0.1 A]	• 10 ... 100 [0.1 A]	100 [0.1 A]	Yes	Channel/phase	Module
Overcurrent tolerance time [ms]	• 1 ... 60000 ms	40000 ms	Yes	Channel/phase	Module
Low limit for current measurement [mA]	• 20 ... 250 mA	50 mA	Yes	Module	- (Default setting: 20 mA)

Parameters	Value range	Default setting	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Current transformer primary current [A]	• 1 ... 10000 A	1 A	Yes	Channel/phase	Module (Value range: 1...65535)
Current transformer secondary current	• 1 A • 5 A	1 A	Yes	Channel/phase	Module
Reverse current direction	• Disable • Enable	Disable	Yes	Channel/phase	Module

8.2 Description of parameters

Diagnostics line voltage

Activate the diagnostics line voltage here. If there is no voltage or too little voltage at L1, the message "No supply voltage at L1" is output and a diagnostic interrupt is triggered.

Connection type

Specify the connection type you used for the Energy Meter here.

For more detailed information, refer to "Connection examples (Page 17)".

Voltage measuring range

Here you can set the voltage measuring range of the power supply system.

Line voltage tolerance

Monitoring the supply voltage based on this tolerance band is a positive or negative value.

Line frequency

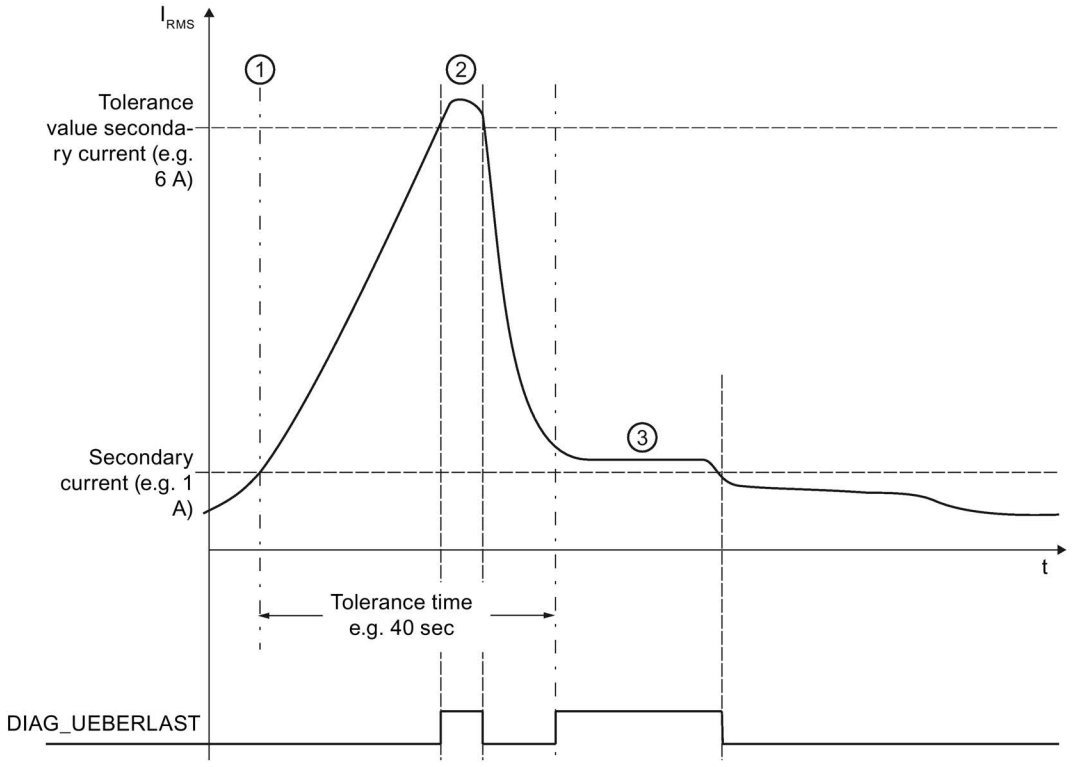
Here you can set the line frequency of the power supply system.

Enable gate energy counter

Enable the gate for the energy counter here. When the gate is enabled, the energy counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Diagnostics overflow current

The measured current is monitored after expiration of the "Tolerance time" for "Measured current x 0.1 x Tolerance factor". A violation results in a current overflow.



① The tolerance time starts as soon as the secondary current value (1 A, 5 A) is exceeded.

② DIAG_UEBERLAST diagnoses the affected phase if the tolerance value of the secondary current has been exceeded within the assigned tolerance time (or the maximum value of the secondary current (10 A) is exceeded).

③ After the set tolerance time has elapsed, the secondary current value (1 A, 5 A) is monitored. A violation of the secondary current value also returns DIAG_UEBERLAST.

Image 8-1 Diagnostics response in the event of a current overload

Diagnostics overflow voltage

Line voltage (measuring range) is monitored for tolerance. A violation of the overflow triggers a diagnostic interrupt.

Diagnostics underflow voltage

Line voltage (measuring range) is monitored for tolerance. A violation of the underflow triggers a diagnostic interrupt.

Diagnostics low limit voltage

Low limit for voltage is monitored. A violation of the low limit triggers a diagnostic interrupt.

Diagnostics overflow cumulative values

A cumulative overflow in the calculated variables is displayed. The values stop at the high or low limit. A violation triggers a diagnostic interrupt.

Overcurrent tolerance factor

The tolerance factor secondary overcurrent parameter (10 to 100) indicates the tolerable value of the secondary current in 0.1 A increments (10 = 1 A to 100 = 10 A). Always take note of the current class of the current transformer being used (1 A, 5 A).

Overcurrent tolerance time

Monitoring time in which the overcurrent is tolerated. 0 means that the monitoring time has been disabled.

Low limit for measuring current

The configurable low limit for measuring current refers to the secondary currents and is used to avoid incorrect calculations in the case of very low currents. Incorrect measurements of very low currents in particular are a cause of inaccuracies in the current transformer used. Set the low limit for the current measurement to the required value depending on your process.

Tip: If you want to find the low limit for the current measurement experimentally, set it to a lower value. Then, feed in a very precise low current and determine the measurement error that can no longer be tolerated. Afterwards, set the low limit for the current measurement to the limit value you have determined.

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy of the reset phase do not measure any longer.

Current transformer primary current

Enter here the nominal value for the primary current of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Current transformer secondary current

Enter here the nominal value for the secondary current (1 A or 5 A) of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Reverse current direction

Setting to determine whether or not to reverse the direction of current.

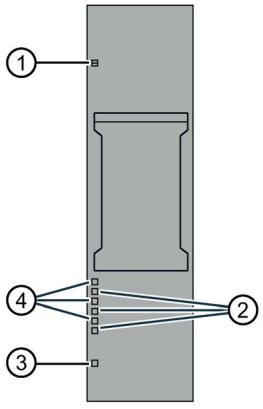
In the event of inadvertent incorrect connection, this parameter can be used to correct the measured values, thus saving the hassle of rewiring. The direction of the current is only evident from the power measurement values. The current measurement value is an rms value.

Interrupts/diagnostic alarms

9

9.1 Status and error display

LED display



① DIAG (green/red)
② Error (red)
③ PWR (green)
④ Status (green)

Image 9-1 LED display

Meaning of the LED displays

The following table explains the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic alarms (Page 58).

DIAG LED

Table 9- 1 Meaning of the DIAG LED

DIAG	Meaning
Off	Supply voltage of the ET 200SP not OK
Flashes	Module not ready for operation (no parameters assigned)
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Status LED

Table 9- 2 Meaning of the Status LED

Status	Meaning
Off	Channel deactivated or error
On	Channel activated and no error

Error LED

Table 9- 3 Meaning of the Error LED

Status	Meaning
Off	Channel is OK
On	Channel is faulty

PWR LED

Table 9- 4 Meaning of the PWR LED

PWR	Meaning
Off	Line voltage missing
On	Line voltage available

9.2 Interrupts

The AI Energy Meter ST analog input module supports diagnostics interrupts.

9.2.1 Diagnostics interrupt

Diagnostic interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel is temporarily unavailable
- Error
- Supply voltage missing
- Parameter assignment error
- Low limit voltage violated (measuring voltage < 80 V)
- High limit value voltage exceeded
- Underflow voltage (tolerance for supply voltage) violated
- Overflow voltage (tolerance for supply voltage) exceeded
- Overload (current measurement > 12 A or tolerance overcurrent exceeded after expiry of the tolerance time)
- Overflow of the calculated values (measured or calculated values screen exceed the representable range of values)

See also

Diagnostic alarms (Page 58)

9.3 Diagnostic alarms

Diagnostic alarms

Note

Assignment channel in diagnostics alarm ⇔ Phase

In the diagnostic messages the channels are counted from "Channel "0" on, in the AI Energy Meter 400VAC ST from Phase "1" on.

Note the following assignment:

- Channel "0" ⇔ Phase "1"
- Channel "1" ⇔ Phase "2"
- Channel "2" ⇔ Phase "3"

Table 9- 5 Error types

Diagnostic message	Error code	Meaning	Solution
Undervoltage[1]	2_H	Line voltage (measuring range) is monitored for tolerance. Violation leads to voltage overflow/underflow	Observe the line voltage range
Overvoltage	3_H		
Overload	4_H	The measured current is monitored after expiration of the "Tolerance time" for "Tolerance factor × Measured current". Exceeding this results in overflow current. The maximum value of the secondary current (12 A) has been exceeded.	Observe the current range
High limit	7_H	Cumulative overflow in the calculated values	-
Low limit[1]	8_H	Violation of the low limit for voltage measurement. The message occurs when the configured minimum current or voltage is below 80 V.	Observe the voltage range
Error	9_H	Internal module error (diagnostic alarm on channel 0 applies to the entire module).	Replace the module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Missing or insufficient line voltage on phase L1	Check supply
Channel is temporarily unavailable	$1F_H$	Firmware upgrade is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	--
		A user calibration is being executed at the channel.	Complete the user calibration

[1] If the "Undervoltage" and "Low limit" diagnostics are active at the same time, the "Low limit" diagnostics has higher priority and deletes the "Undervoltage" diagnostics.

9.4 Diagnostics response

Diagnostics response

This section describes the response of the AI Energy Meter 400VAC ST when diagnostics information is reported.

Measured values in the case of diagnostics

Even in the case of diagnostics, measured values continue to be displayed as long as they can still be acquired. If measured values cannot be measured or calculated, "0" is displayed.

Zero suppression

If the supplied current is less than the configured "Low limit for measuring current" parameter, the current measurement and all dependent variables are suppressed or set to "0".

Overload limitation

If the secondary current fed in at the channel is higher than 12 A, the module changes to limitation and the measured value of the current and all dependent variables are set to "0".

Value falls below "Low limit current measurement"

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy of the reset phase do not measure any longer.

Loss of the supply voltage

At a loss of supply voltage at U_{L1} (phase 1), all measurements are interrupted.

After the supply voltage is restored, the AI Energy Meter 400VAC ST operates again with the configuration / parameter assignment stored in the CPU. The energy counter is used for retentively stored values.

Input data to "0"

Note

If the AI Energy Meter 400VAC ST is no longer recognized by the interface module (for example, because it is defective or not plugged in), all input data are set to "0".

Technical specifications

10

10.1 Technical specifications

Technical specifications of the AI Energy Meter 400VAC ST 6ES7134-6PA01-0BD0

	6ES7134-6PA01-0BD0
General information	
Product type designation	AI Energy Meter 400VAC ST
Usable BaseUnits	BU type D0, BU20-P12+A0+0B
Color code for module-specific color identification label	CC00
Product function	
Voltage measurement	Yes
Voltage measurement with voltage transformer	No
Current measurement	Yes
Phase current measurement without current transformer	No
Phase current measurement with current transformer	Yes
Energy measurement	Yes
Frequency measurement	Yes
Power measurement	Yes
Active power measurement	Yes
Reactive power measurement	Yes
I&M data	Yes
Isochronous mode	No
Operating mode	
Cyclic measurement	Yes
Acyclic measurement	Yes
Configuration control	
Via user data	Yes
Via data record	Yes
Installation type / mounting	
Installation position	Any
Supply voltage	
Description	Supply via voltage measurement channel L1
Type of supply voltage	100 - 240 VAC
Permissible range, low limit (AC)	90 V
Permissible range, high limit (AC)	264 V

	6ES7134-6PA01-0BD0
Line frequency	
Valid range, low limit	47 Hz
Valid range, high limit	63 Hz
Power loss	
Power loss, typ.	0.6 W
Address area	
Address space per module	
Address space per module, max.	44 bytes; 32 bytes input / 12 bytes output
Hardware configuration	
Automatic code	
• Mechanical coding element	Yes
Time	
Operating hours counter	
Available	No
Analog inputs	
Cycle time (all channels), typ.	50 ms. Time for the consistent updating of all measured and calculated values (cyclic and acyclic data)
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic interrupt	Yes
Limit interrupt	No
Hardware interrupt	No
Diagnostic indicator LED	
Monitoring of supply voltage (PWR LED)	Yes
Channel status display	Yes
For channel diagnostics	Yes
For module diagnostics	Yes
Integrated functions	
Measuring functions	
Buffering of measured variables	No
Parameter length	38 bytes
Measuring method for voltage measurement	TRMS
Measuring method for current measurement	TRMS
Type of measured data acquisition	Complete
Voltage wave form	Sinusoidal or distorted
Band width of the measured value detection	2 kHz. Harmonic: 39 / 50 Hz, 32 / 60 Hz
Operating mode for measured value acquisition	
• Automatic line frequency acquisition	No; can be assigned
• Fixing at 50 Hz	No; default setting
• Fixing at 60 Hz	No

	6ES7134-6PA01-0BD0
Measuring range	
• Frequency measurement, min.	45 Hz
• Frequency measurement, max.	65 Hz
Measuring inputs for voltage	
• Measurable line voltage between phase and neutral conductor	230 V
• Measurable line voltage between the line conductors	400 V
• Measurable line voltage between phase and neutral conductor, min.	90 V
• Measurable line voltage between phase and neutral conductor, max.	264 V
• Measurable line voltage between the line conductors, min.	155 V
• Measurable line voltage between the line conductors, max.	460 V
• Measuring category for voltage measurement in accordance with IEC 61010-2-030	CAT II. CAT III with prescribed protective elements
• Internal resistance line conductor and N-conductor	3.4 mΩ
• Power consumption, per phase	20 mW
• Surge voltage strength 1.2/50µs	1 kV
Measuring inputs for current	
• Relative measurable current for AC, min.	5%; in relation to the secondary rated current; 1 A, 5 A
• Relative measurable current for AC, max.	100%; in relation to the secondary rated current; 1 A, 5 A
• Continuous current for AC, maximum permissible	5 A
• Apparent power consumption per phase for measuring range 5 A	0.6 VA
• Rated value of short-time current carrying capacity is restricted to 1 s	100 A
• Input resistance measuring range 0 to 5 A	25 mΩ; at the terminal
• Zero point suppression	Configurable: 20 - 250 mA, default 50 mA
• Impulse withstand capability	10 A; for 1 minute

	6ES7134-6PA01-0BD0
Error limits	
• Reference condition for measuring accuracy	Symmetrical loading, rated current: 20-100%, 50 Hz; active power: LF = 1, reactive power: LF = 0
• For voltage measured variable	±0.5 %
• For current measured variable	±0.5 %
• For active power measured variable	±0.5 %
• For reactive power measured variable	±0.5 %
• For total active energy measured variable	Class 1 according to IEC 62053-21:2003
• For total reactive energy measured variable	Class 2 according to IEC 62053-23:2003
Electrical isolation	
Electrical isolation of channels	
Between the channels and backplane bus	Yes. 3700 VAC (type test) CATIII
Insulation	
Insulation tested with	2300 VAC 1 min. (type test)
Ambient conditions	
Ambient temperature in operation	
Horizontal mounting position, min.	0 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, min.	0 °C
Vertical mounting position, max.	50 °C
Dimensions	
Width	20 mm
Weights	
Weight (without packaging)	45 g
Miscellaneous	
Current transformer selection data	
Cable length (clamp-type transformer) depending on Zn and Imax	200 m

ATEX approval

In accordance with EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC Tx Gc
DEKRA 12ATEX0038X

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521) manual

Parameter data records

A

A.1 Configuration via parameter data records

The parameter data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You can reassign the module parameters in RUN mode, for example change the diagnostics behavior.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module via the respective data record. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

If you reconfigure a module (so that the user data size changes) and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

STATUS output parameter

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

A.2 Structure of the parameter data record 128 for the entire module

Structure of data record 128

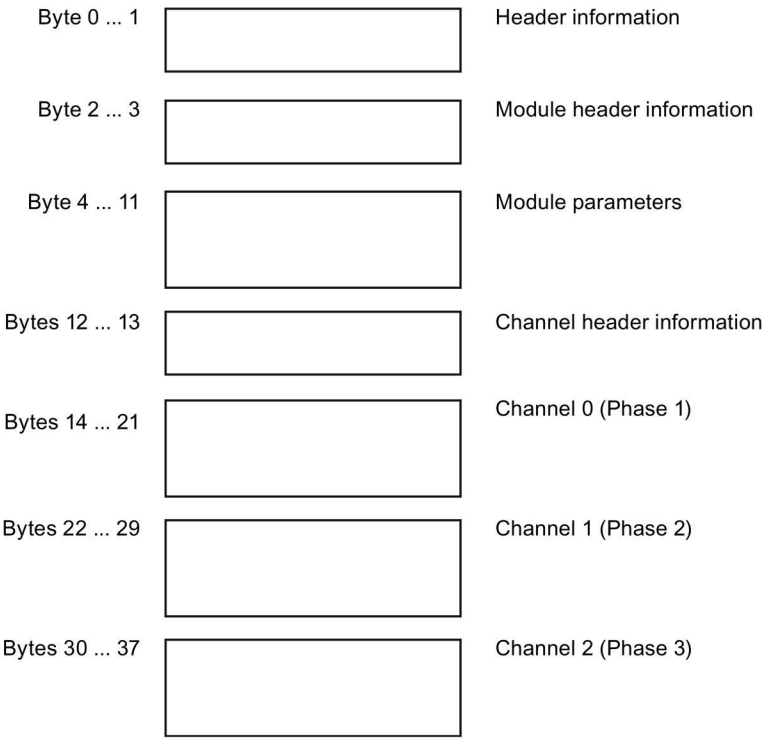


Image A-1 Parameter data record 128

Header information

The figure below shows the structure of the header information.

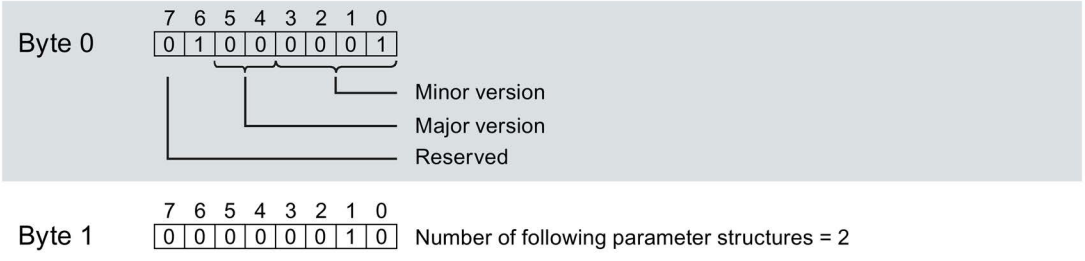


Image A-2 Header information

Module header information

The figure below shows the structure of the header information for a module.

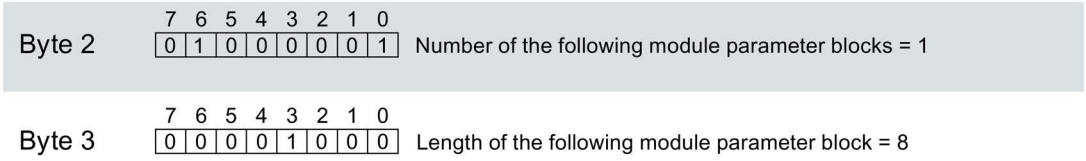
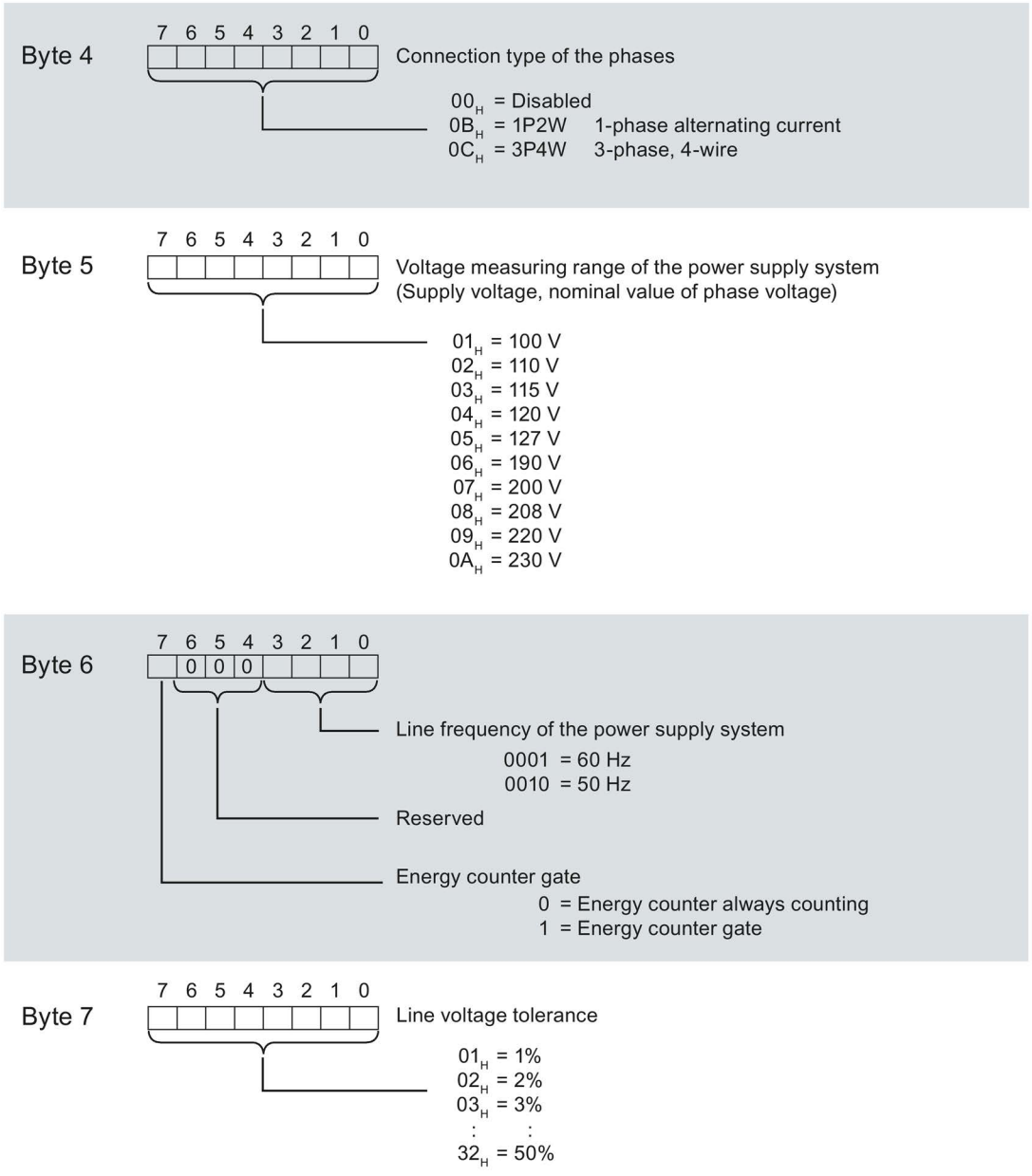


Image A-3 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Enable a parameter by setting the corresponding bit to "1".



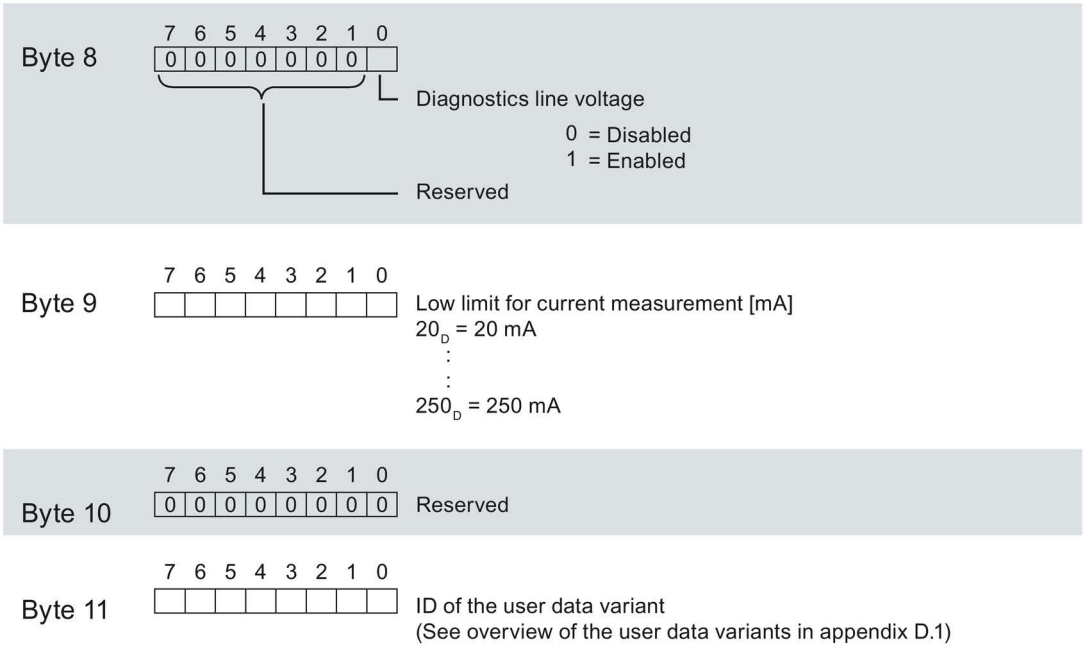


Image A-4 Module parameter block

You can find the user data variant in the section Overview of the user data variants (Page 83).

Channel header information

The following figure shows the structure of the header information for a channel.

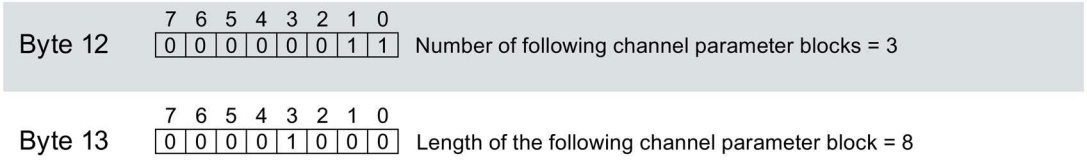
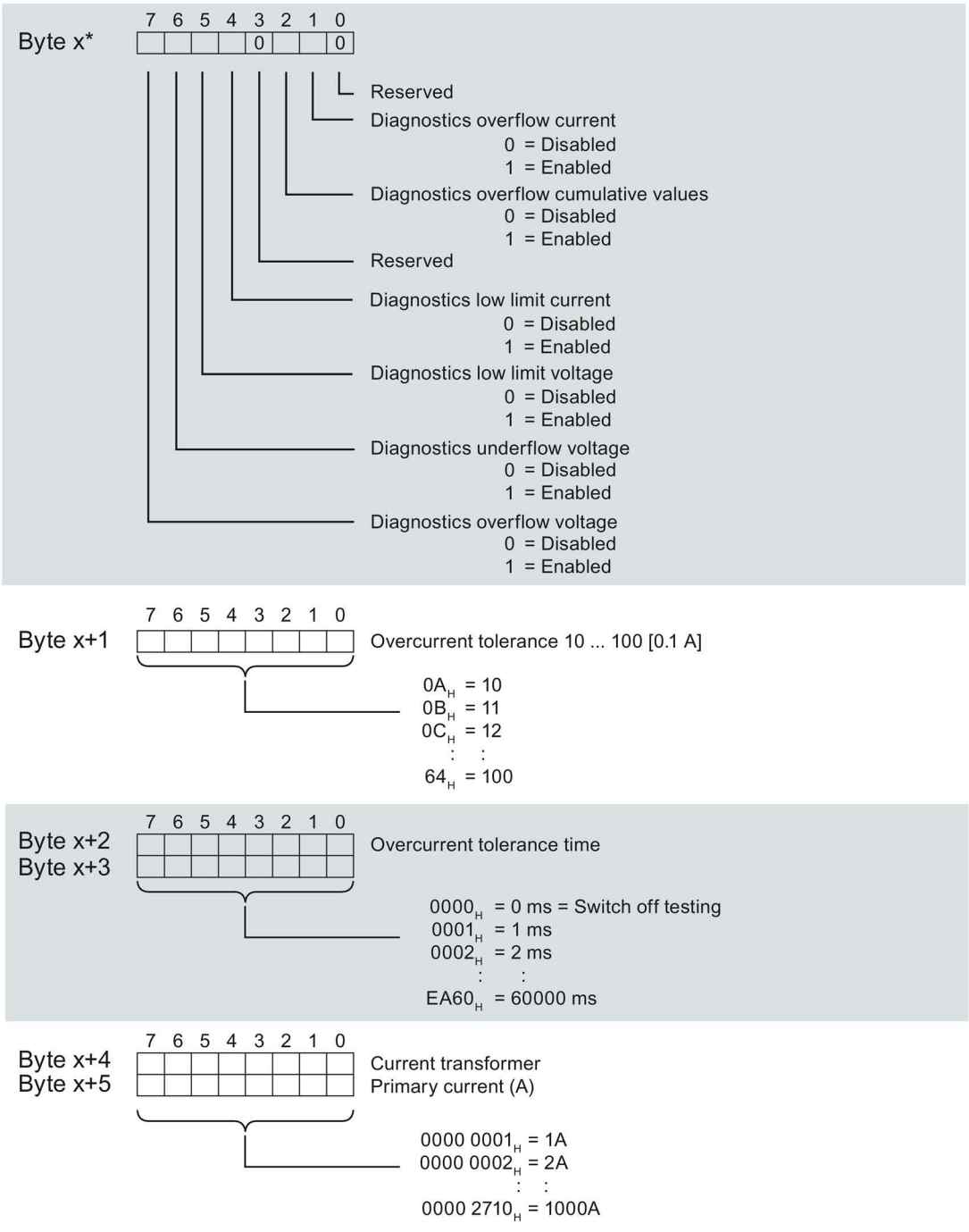


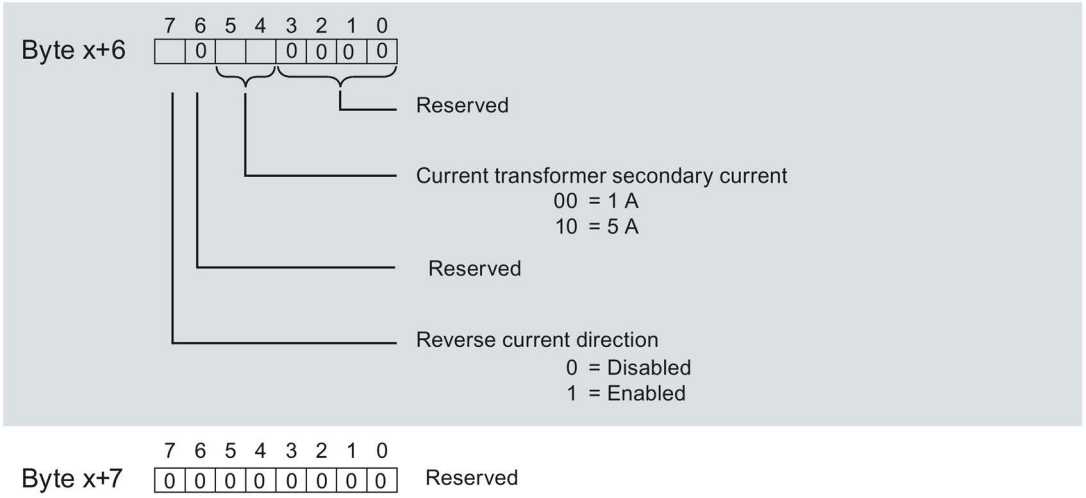
Image A-5 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".





* x = 14 for Channel 0 (Phase 1); 22 for Channel 1 (Phase 2); 30 for Channel 2 (Phase 3)

Image A-6 Channel parameter block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 6, 10, 20...21, 28...30, 36 and 37 and set the reserved bits back to 0.
DF	80	E1	02	Reserved bits are not 0.	Check Byte 8, 14, 22, and 30 and set the reserved bits back to 0.
DF	80	E1	05	Measuring range for voltage invalid.	Check Byte 5. Permitted values: 01_H to $0C_H$
DF	80	E1	20	Connection type invalid.	Check Byte 4. Permitted values: 00_H, $0B_H$ ... 01_H
DF	80	E1	21	Parameter for user data variant not possible.	Check Byte 11. Select a different user data variant or change the configuration.
DF	80	E1	22	Parameter for user data variant is invalid.	Check Byte 11. Select a valid code for the user data variant.
DF	80	E1	23	Parameter for frequency is invalid.	Check Byte 6. Enter valid values.
DF	80	E1	24	Parameter for tolerance line voltage is invalid.	Check Byte 7. Enter valid values.
DF	80	E1	25	Parameter for current transformer secondary is invalid.	Check Bit 4...5 in Byte 20, 28, 36. Enter valid values.
DF	80	E1	29	Parameter for tolerance factor overcurrent invalid.	Check Byte 15, 23, 31. Enter valid values.
DF	80	E1	30	Parameter for tolerance time overcurrent invalid.	Check Bytes 16...17, 24...25, 32...33. Enter valid values.
DF	80	E1	2B	Parameter for low limit measuring current invalid	Check Byte 9. Enter valid values.
DF	80	E1	2C	Parameter for current transformer primary current is invalid.	Check Bytes 18...19, 26...27, 34...35. Enter valid values.
DF	80	E1	30	Invalid data record number.	Check the data record number. Enter a valid data record number.

Measured variables

B

Measured variables for data records and user data

The following table provides an overview of all measured variables that are used in the data records and user data.

Note that the format and unit differ in the evaluation of records and user data.

Table B- 1 Measured variables for data records and user data

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type	
					1P2W	3P4W
1	Voltage UL1-N [1]	REAL	V	0.0 ... 300.0	✓	✓
2	Voltage UL2-N [1]	REAL	V	0.0 ... 300.0		✓
3	Voltage UL3-N [1]	REAL	V	0.0 ... 300.0		✓
4	Voltage UL1-L2 [2]	REAL	V	0.0 ... 600.0		✓
5	Voltage UL2-L3 [2]	REAL	V	0.0 ... 600.0		✓
6	Voltage UL3-L1 [2]	REAL	V	0.0 ... 600.0		✓
7	Current L1 [1]	REAL	A	0.0 … 10000.0	✓	✓
8	Current L2 [1]	REAL	A	0.0 … 10000.0		✓
9	Current L3 [1]	REAL	A	0.0 … 10000.0		✓
10	Apparent power L1 [3]	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓
11	Apparent power L2 [3]	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$		✓
12	Apparent power L3 [3]	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$		✓
13	Active power L1 [3]	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓
14	Active power L2 [3]	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$		
15	Active power L3 [3]	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$		✓
16	Reactive power L1 [3]	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓
17	Reactive power L2 [3]	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$		✓
18	Reactive power L3 [3]	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$		✓
19	Power factor L1 [3]	REAL	-	0.0 ... 1.0	✓	✓
20	Power factor L2 [3]	REAL	-	0.0 ... 1.0		✓
21	Power factor L3 [3]	REAL	-	0.0 ... 1.0		✓
30	Frequency [4]	REAL	Hz	45.0 ... 65.0	✓	✓
34	Total apparent power L1L2L3 [5]	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓
35	Total active power L1L2L3 [5]	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓
36	Total reactive power L1L2L3 [5]	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓
37	Total power factor L1L2L3 [6] [7]	REAL	-	0.0 ... 1.0	✓	✓
38	Amplitude balance for voltage [2]	REAL	%	0 ... 100		✓

Meas-ured value ID	Measured variables	Data type	Unit	Value range	Connection type	
					1P2W	3P4W
39	Amplitude symmetry for current [2]	REAL	%	0 ... 200		✓
200	Total active energy inflow L1L2L3 [6]	REAL	Wh	0.0 ... 3.4 x 10^{38}	✓	✓
201	Total active energy outflow L1L2L3 [6]	REAL	Wh	0.0 ... 3.4 x 10^{38}	✓	✓
202	Total reactive energy inflow L1L2L3 [6]	REAL	varh	0.0 ... 3.4 x 10^{38}	✓	✓
203	Total reactive energy outflow L1L2L3 [6]	REAL	varh	0.0 ... 3.4 x 10^{38}	✓	✓
204	Total apparent energy L1L2L3 [6]	REAL	VAh	0.0 ... 3.4 x 10^{38}	✓	✓
205	Total active energy L1L2L3 [6]	REAL	Wh	0.0 ... 3.4 x 10^{38}	✓	✓
206	Total reactive energy L1L2L3 [6]	REAL	varh	0.0 ... 3.4 x 10^{38}	✓	✓
210	Total active energy inflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓
211	Total active energy outflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓
212	Total reactive energy inflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓
213	Total reactive energy outflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓
214	Total apparent energy L1L2L3 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}	✓	✓
215	Total active energy L1L2L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓
216	Total reactive energy L1L2L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓
220	Total active energy inflow L1L2L3 [6]	UDINT	Wh	0 ... 4294967295	✓	✓
221	Total active energy outflow L1L2L3 [6]	UDINT	varh	0 ... 4294967295	✓	✓
222	Total reactive energy inflow L1L2L3 [6]	UDINT	varh	0 ... 4294967295	✓	✓
223	Total reactive energy outflow L1L2L3 [6]	UDINT	VAh	0 ... 4294967295	✓	✓
224	Total apparent energy L1L2L3 [6]	UDINT	Wh	0 ... 4294967295	✓	✓
225	Total active energy L1L2L3 [6]	UDINT	Wh	0 ... 4294967295	✓	✓
226	Total reactive energy L1L2L3 [6]	UDINT	varh	0 ... 4294967295	✓	✓
61178	Phase angle L1 [3]	REAL	°	0.0 ... 360.0	✓	✓
61180	Active energy inflow L1 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓
61181	Active energy outflow L1 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓
61182	Reactive energy inflow L1 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓
61183	Reactive energy outflow L1 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓
61184	Apparent energy L1 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}	✓	✓
61185	Active energy L1 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓
61186	Reactive energy L1 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓
61198	Phase angle L2 [3]	REAL	°	0.0 ... 360.0		✓
61200	Active energy inflow L2 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓
61201	Active energy outflow L2 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓
61202	Reactive energy inflow L2 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓
61203	Reactive energy outflow L2 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓
61204	Apparent energy L2 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}		✓
61205	Active energy L2 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓
61206	Reactive energy L2 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type	
					1P2W	3P4W
61218	Phase angle L3 [3]	REAL		0.0 ... 360.0		✓
61220	Active energy inflow L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓
61221	Active energy outflow L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓
61222	Reactive energy inflow L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓
61223	Reactive energy outflow L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓
61224	Apparent energy L3 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}		✓
61225	Active energy L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓
61226	Reactive energy L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓
62110	Active energy inflow L1 [6]	UDINT	Wh	0 ... 4294967295	✓	✓
62111	Active energy outflow L1 [6]	UDINT	Wh	0 ... 4294967295	✓	✓
62112	Reactive energy inflow L1 [6]	UDINT	Varh	0 ... 4294967295	✓	✓
62113	Reactive energy outflow L1 [6]	UDINT	Varh	0 ... 4294967295	✓	✓
62114	Apparent energy L1 [6]	UDINT	Wh	0 ... 4294967295	✓	✓
62210	Active energy inflow L2 [6]	UDINT	Wh	0 ...4.294.967.296		✓
62211	Active energy outflow L2 [6]	UDINT	Wh	0 ...4.294.967.296		✓
62212	Reactive energy inflow L2 [6]	UDINT	Varh	0 ...4.294.967.296		✓
62213	Reactive energy outflow L2 [6]	UDINT	Varh	0 ...4.294.967.296		✓
62214	Apparent energy L2 [6]	UDINT	VAh	0 ...4.294.967.296		✓
62310	Active energy inflow L3 [6]	UDINT	Wh	0 ...4.294.967.296		✓
62311	Active energy outflow L3 [6]	UDINT	Wh	0 ...4.294.967.296		✓
62312	Reactive energy inflow L3 [6]	UDINT	Varh	0 ...4.294.967.296		✓
62313	Reactive energy outflow L3 [6]	UDINT	Varh	0 ...4.294.967.296		✓
62314	Apparent energy L3 [6]	UDINT	VAh	0 ...4.294.967.296		✓
66001	Voltage UL1-N [1]	UINT	0.01 V	0 ... 30000	✓	✓
66002	Voltage UL2-N [1]	UINT	0.01 V	0 ... 30000		✓
66003	Voltage UL3-N [1]	UINT	0.01 V	0 ... 30000		✓
66004	Voltage UL1-L2 [2]	UINT	0.01 V	0 ... 30000		✓
66005	Voltage UL2-L3 [2]	UINT	0.01 V	0 ... 30000		✓
66006	Voltage UL3-L1 [2]	UINT	0.01 V	0 ... 30000		✓
66007	Current L1 [1]	UINT	1 mA	0 ... 65535	✓	✓
66008	Current L2 [1]	UINT	1 mA	0 ... 65535		✓
66009	Current L3 [1]	UINT	1 mA	0 ... 65535		✓
66010	Apparent power L1 [3]	INT	1 VA	-27648 ... 27648	✓	✓
66011	Apparent power L2 [3]	INT	1 VA	-27648 ... 27648		✓
66012	Apparent power L3 [3]	INT	1 VA	-27648 ... 27648		✓
66013	Active power L1 [3]	INT	1 W	-27648 ... 27648	✓	✓
66014	Active power L2 [3]	INT	1 W	-27648 ... 27648		✓
66015	Active power L3 [3]	INT	1 W	-27648 ... 27648		✓
66016	Reactive power L1 [3]	INT	1 var	-27648 ... 27648	✓	✓
66017	Reactive power L2 [3]	INT	1 var	-27648 ... 27648		✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type	
					1P2W	3P4W
66018	Reactive power L3 [3]	INT	1 var	-27648 ... 27648		✓
66019	Power factor L1 [3]	USINT	0.01	0 ... 100	✓	✓
66020	Power factor L2 [3]	USINT	0.01	0 ... 100		✓
66021	Power factor L3 [3]	USINT	0.01	0 ... 100		✓
66030	Frequency [4]	USINT	1 Hz	45 ... 65	✓	✓
66034	Total apparent power L1L2L3 [5]	INT	1 VA	-27648 ... 27648	✓	✓
66035	Total active power L1L2L3 [5]	INT	1 W	-27648 ... 27648	✓	✓
66036	Total reactive power L1L2L3 [5]	INT	1 var	-27648 ... 27648	✓	✓
66037	Total power factor L1L2L3 [6]	USINT	0.01	0 ... 100	✓	✓
66038	Frequency [4]	UINT	0.01 Hz	4500 ... 6500	✓	✓

1 Effective value

2 IEC 61557-12

3 Arithmetical mean value over 200 ms as floating mean

4 Arithmetical mean value over 10 s as floating mean

5 Simple summation

6 Calculation from the start/restart (inflow and outflow values are positive numbers)

7 Determined from ratio of active and apparent power

Format

Table B- 2 Format and its length in bytes

Format in STEP 7 (TIA Portal)	Format to IEEE	Length in bytes	Comment
BYTE	BYTE	1 byte	Bit field with 8 bit
WORD	WORD	2 bytes	Bit field with 16 bit
USINT	INT8 (unsigned)	1 byte	Fixed-point number 8 bits without sign
INT	INT16 (signed)	2 bytes	Fixed-point number 16 bits with sign
UINT	INT16 (unsigned)	2 bytes	Fixed-point number 16 bits without sign
UDINT	INT32 (unsigned)	4 bytes	Fixed-point number 32 bits without sign
REAL	Float32	4 bytes	Floating-point number 32 bits with sign
LREAL	Float64	8 bytes	Floating-point number 64 bits with sign

Module versions

C

C.1 Module version "2 I / 2 Q"

User data of the module

The module has 2 bytes of input user data and 2 bytes of output user data for status and control information. At this module version measured variables can be read solely via measured value data records (no measured variables can be evaluated via user data).

Structure of input user data

The structure of the input user data is fixed.

Table C- 1 Structure of input user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Constant = 0x80
1	Module	Quality information	Quality bits to describe the quality of the basic measured values

Allocation of the input user data

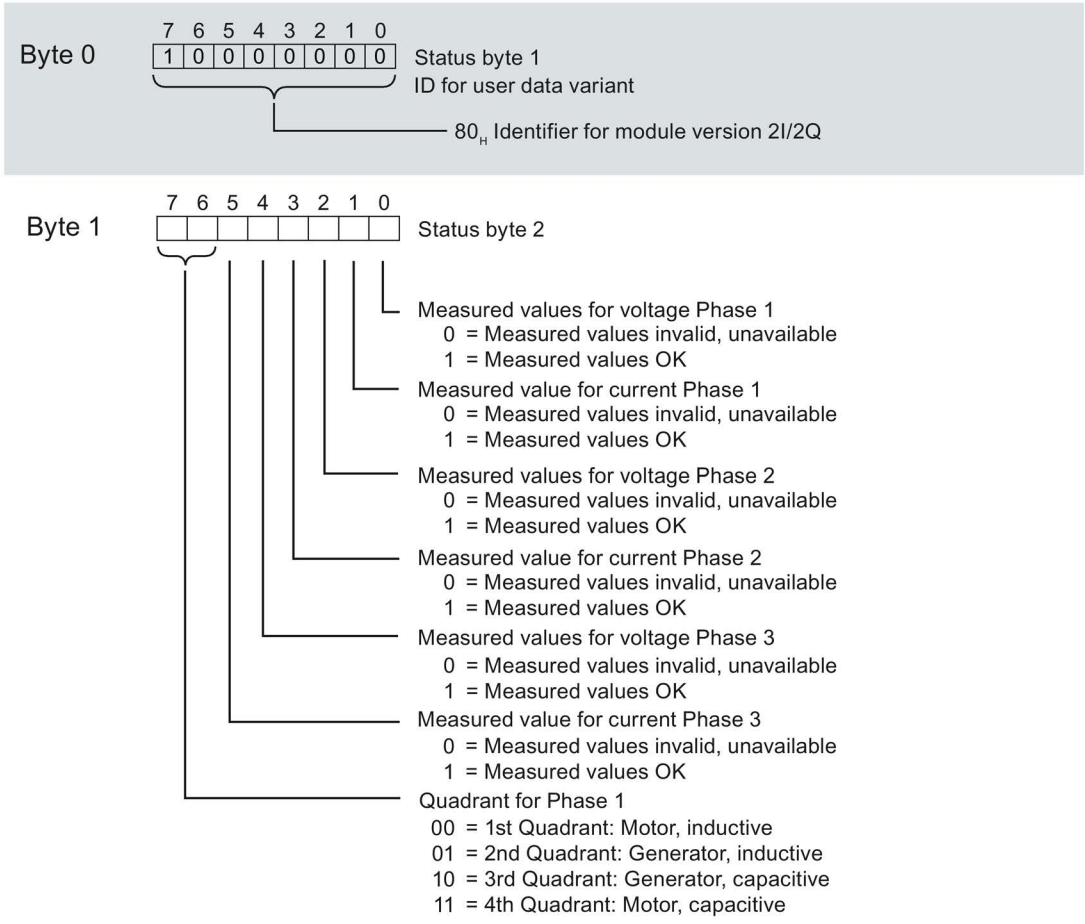


Image C-1 Allocation of the status bytes in the input user data (2 bytes)

Structure of output user data

The structure of the output user data is fixed.

Table C- 2 Structure of output user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	Reserved	Reserved
1	Module	Control outputs	Reset of values and counters, gate

Assignment of the output user data

You control the counter gate for the energy counter via the output user data.

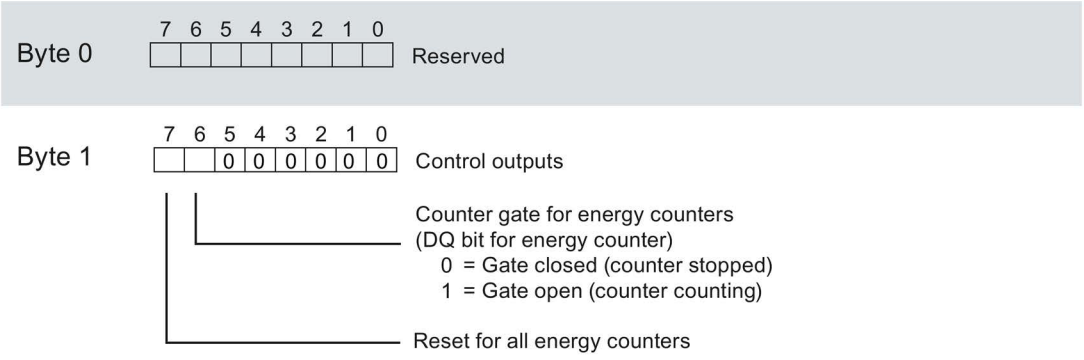


Image C-2 Allocation of the control byte in the output user data (1 byte)

Note

For module version 2 I / 2 Q, a reset always acts on **all** energy counters of the three phases.

C.2 Module version "32 I / 12 Q"

User data of the module

The module occupies 32 bytes of input user data and 12 bytes of output user data. Of these the module uses 2 bytes input data for status information and 12 bytes output data for control information. Measured variables can be read cyclically via user data (Bytes 2 to 31) or acyclically via measured value data records

Structure of input user data

You can set the contents of the input user data dynamically. You can choose between different user data variants.

Table C- 3 Structure of input user data (32 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Display of the utilized user data variant
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 31	Module or phase	Data	2 or 4 bytes of measured values or calculated values according to user data variant

Allocation of the input user data

You can change the measured variables during operation. You can choose between different user data variants.

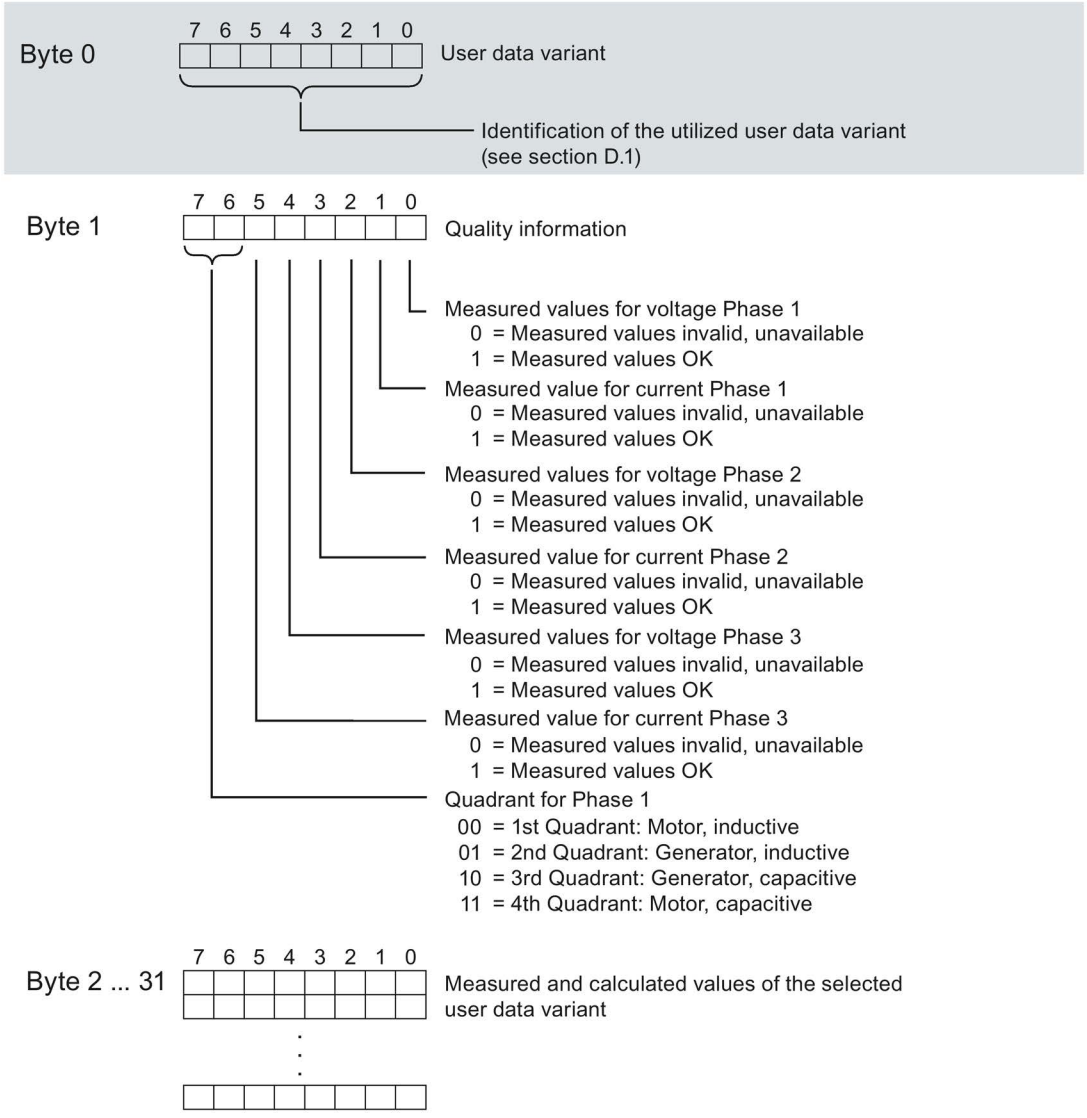


Image C-3 Assignment of the input user data (32 bytes)

Structure of output user data

The structure of the output user data is fixed and is the same at all the selectable user data variants.

Via the output user data you globally control

- Resetting for energy counter (reset via Byte 1 and selection via Byte 2)
- The counter gate for the energy counter.

Table C- 4 Structure of output user data (12 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Switching the user data variant
1	Module	Control byte 1	Reset of values and counters, gate
2	Module	Control byte 2	Selection for resetting the energy counters
3 ... 11	Reserved		

Control byte for user data variant

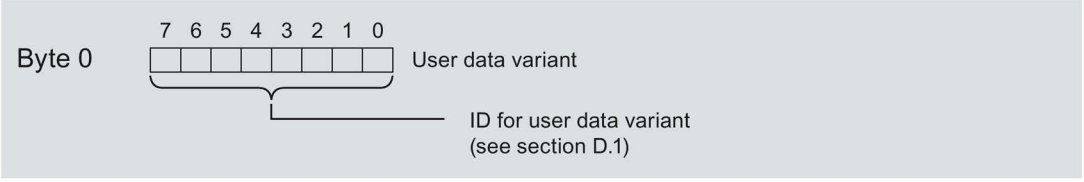


Image C-4 Allocation of the control bytes for user data variant (Byte 0)

Control bytes for all three phases

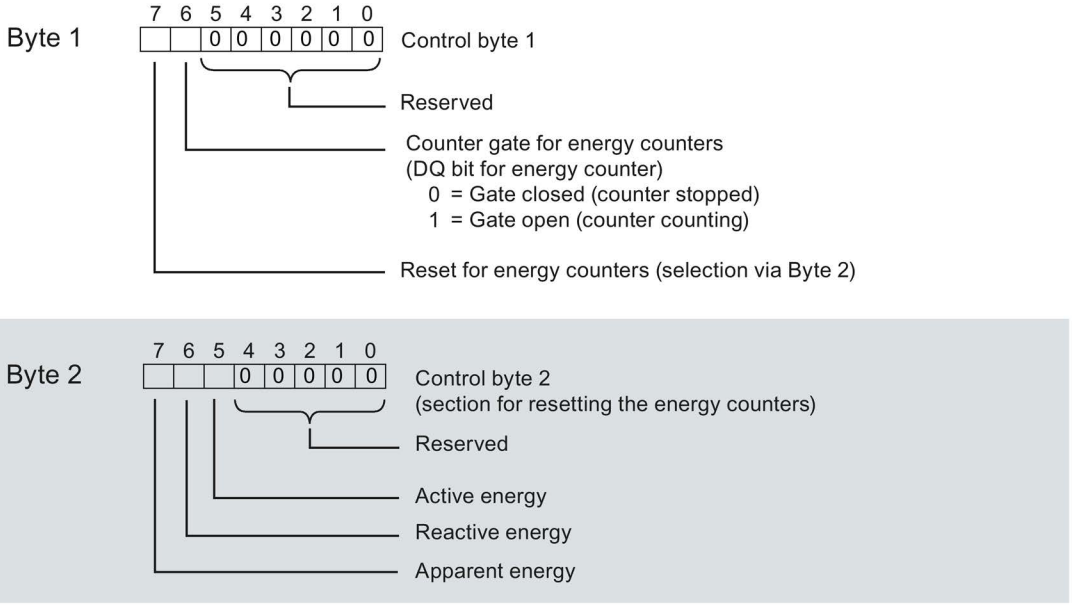


Image C-5 Allocation of the control bytes for all three phases (bytes 1 and 2)

User data variants

D

D.1 User data variants with 32 bytes input data / 12 bytes output data

User data

30 bytes are available for transferring the measured values in a cycle at the module version 32 I / 12 Q. Therefore this module version supports dynamic switching between 22 preconfigured user data variants that contain a specific selection of measured values.

For more detailed information, refer to "Selecting the module versions (Page 22)".

Table D- 1 Overview of the user data variants

User data	User data variant
Total power L1L2L3	254 (FE_H) - default setting
Active power L1L2L3	253 (FD_H)
Reactive power L1L2L3	252 (FC_H)
Apparent power L1L2L3	251 (FB_H)
Basic measured values L1L2L3	250 (FA_H)
Total energy L1L2L3	249 ($F9_H$)
Energy L1	248 ($F8_H$)
Energy L2	247 ($F7_H$)
Energy L3	246 ($F6_H$)
Basic variables three-phase measurement L1L2L3	245 ($F5_H$)

Total power L1L2L3 (ID 254 or FE_H)

Table D- 2 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Total active power L1L2L3	INT	1 W	-27648 … 27648	66035
10 ... 11	Total reactive power L1L2L3	INT	1 var	-27648 … 27648	66036
12 ... 13	Total apparent power L1L2L3	INT	1 VA	-27648 … 27648	66034
14 ... 17	Total active energy L1L2L3	UDINT	1 Wh	0 …4294967295	225
18 ... 21	Total reactive energy L1L2L3	UDINT	1 varh	0 …4294967295	226
22	Reserved	BYTE	-	0	-
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling total active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling total reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling total apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Active power L1L2L3 (ID 253 or FD_H)

Table D- 3 Active power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	253 (FD_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Active power L1	INT	1 W	-27648 … 27648	66013
10 ... 11	Active power L2	INT	1 W	-27648 … 27648	66014
12 ... 13	Active power L3	INT	1 W	-27648 … 27648	66015
14 ... 15	Total active power L1L2L3	INT	1 W	-27648 … 27648	66035
16 ... 19	Total active energy L1L2L3	UDINT	1 Wh	0 …4294967295	225
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1	USINT	-	0 ... 255	-
28	Scaling active power L2	USINT	-	0 ... 255	-
29	Scaling active power L3	USINT	-	0 ... 255	-
30	Scaling active power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-

Reactive power L1L2L3 (ID 252 or FC_H)

Table D- 4 Reactive power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	252 (FC_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Reactive power L1	INT	1 var	-27648 … 27648	66016
10 ... 11	Reactive power L2	INT	1 var	-27648 … 27648	66017
12 ... 13	Reactive power L3	INT	1 var	-27648 … 27648	66018
14 ... 15	Total reactive power L1L2L3	INT	1 var	-27648 … 27648	66036
16 ... 19	Total reactive energy L1L2L3	UDINT	1 varh	0 ... 4294967295	226
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling reactive power L1	USINT	-	0 ... 255	-
28	Scaling reactive power L2	USINT	-	0 ... 255	-
29	Scaling reactive power L3	USINT	-	0 ... 255	-
30	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Apparent power L1L2L3 (ID 251 or FB_H)

Table D- 5 Apparent power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	251 (FB_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Apparent power L1	INT	1 VA	-27648 … 27648	66010
10 ... 11	Apparent power L2	INT	1 VA	-27648 … 27648	66011
12 ... 13	Apparent power L3	INT	1 VA	-27648 … 27648	66012
14 ... 15	Total apparent power L1L2L3	INT	1 VA	-27648 … 27648	66034
16 ... 19	Total apparent energy L1L2L3	UDINT	1 VAh	0 ... 4294967295	224
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling apparent power L2	USINT	-	0 ... 255	-
29	Scaling apparent power L3	USINT	-	0 ... 255	-
30	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total apparent energy L1L2L3	USINT	-	0 ... 255	-

Basic measured values L1L2L3 (ID 250 or FA_H)

Table D- 6 Basic measured values L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	250 (FA_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Voltage UL1-N	UINT	0.01 V	0 … 30000	66001
10 ... 11	Voltage UL2-N	UINT	0.01 V	0 … 30000	66002
12 ... 13	Voltage UL3-N	UINT	0.01 V	0 … 30000	66003
14 ... 15	Voltage UL1-UL2	UINT	0.01 V	0 … 60000	66004
16 ... 17	Voltage UL2-UL3	UINT	0.01 V	0 … 60000	66005
18 ... 19	Voltage UL3-UL1	UINT	0.01 V	0 … 60000	66006
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Reserved	BYTE	-	-	-
28	Reserved	BYTE	-	-	-
29	Reserved	BYTE	-	-	-
30 ... 31	Frequency	UINT	0.01 Hz	0 ... 65535	66038

Total energy L1L2L3 (ID 249 or $F9_H$)

Table D- 7 Total energy L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	249 ($F9_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Reserved	BYTE	-	-	-
3	Reserved	BYTE	-	-	-
4 ... 7	Total active energy inflow L1L2L3	UDINT	1 Wh	0 … 4294967295	220
8 ... 11	Total active energy outflow L1L2L3	UDINT	1 Wh	0 … 4294967295	221
11 ... 15	Total reactive energy inflow L1L2L3	UDINT	1 varh	0 … 4294967295	222
16 ... 19	Total reactive energy outflow L1L2L3	UDINT	1 varh	0 … 4294967295	223
20 ... 23	Total apparent energy L1L2L3	UDINT	1 VAh	0 … 4294967295	224
24	Reserved	BYTE	-	-	-
25	Scaling active energy, inflow	USINT	-	0 ... 255	-
26	Scaling active energy, outflow	USINT	-	0 ... 255	-
27	Scaling reactive energy, inflow	USINT	-	0 ... 255	-
28	Scaling reactive energy, outflow	USINT	-	0 ... 255	-
29	Scaling apparent energy	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	-	-
31	Total power factor L1L2L3	USINT	0.01	0 … 100	66037

Energy L1 (ID 248 or $F8_H$)

Table D- 8 Energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	248 ($F8_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 7	Active energy inflow L1	UDINT	1 Wh	0 … 4294967295	62110
8 ... 11	Active energy outflow L1	UDINT	1 Wh	0 … 4294967295	62111
11 ... 15	Reactive energy inflow L1	UDINT	1 varh	0 … 4294967295	62112
16 ... 19	Reactive energy outflow L1	UDINT	1 varh	0 … 4294967295	62113
20 ... 23	Apparent energy L1	UDINT	1 VAh	0 … 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active energy inflow L1	USINT	-	0 ... 255	-
26	Scaling active energy outflow L1	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L1	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L1	USINT	-	0 ... 255	-
29	Scaling apparent energy L1	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	-	-
31	Power factor L1	USINT	0.01	0 … 100	66019

Energy L2 (ID 247 or $F7_H$)

Table D- 9 Energy L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	247 ($F7_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 … 65535	66008
4 ... 7	Active energy inflow L2	UDINT	1 Wh	0 … 4294967295	62210
8 ... 11	Active energy outflow L2	UDINT	1 Wh	0 … 4294967295	62211
11 ... 15	Reactive energy inflow L2	UDINT	1 varh	0 … 4294967295	62212
16 ... 19	Reactive energy outflow L2	UDINT	1 varh	0 … 4294967295	62213
20 ... 23	Apparent energy L2	UDINT	1 VAh	0 … 4294967295	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active energy inflow L2	USINT	-	0 ... 255	-
26	Scaling active energy outflow L2	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L2	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L2	USINT	-	0 ... 255	-
29	Scaling apparent energy L2	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	-	-
31	Power factor L2	USINT	0.01	0 … 100	66020

Energy L3 (ID 246 or $F6_H$)

Table D- 10 Energy L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	246 ($F6_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 … 65535	66009
4 ... 7	Active energy inflow L3	UDINT	1 Wh	0 … 4294967295	62310
8 ... 11	Active energy L3, outflow	UDINT	1 Wh	0 … 4294967295	62311
11 ... 15	Reactive energy inflow L3	UDINT	1 varh	0 … 4294967295	62312
16 ... 19	Reactive energy outflow L3	UDINT	1 varh	0 … 4294967295	62313
20 ... 23	Apparent energy L3	UDINT	1 VAh	0 … 4294967295	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active energy inflow L3	USINT	-	0 ... 255	-
26	Scaling active energy outflow L3	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L3	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L3	USINT	-	0 ... 255	-
29	Scaling apparent energy L3	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
30	Reserved	BYTE	-	-	-
31	Power factor L3	USINT	0.01	0 … 100	66021

Basic variables three-phase measurements (ID 245 or $F5_H$)

Table D- 11 Basic variables three-phase measurements

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	245 ($F5_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Total active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	66034
6 ... 9	Total active energy outflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	62418
10 ... 13	Total active energy inflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	62417
14 ... 17	Current L1	REAL	1 A	0.0 … 10000.0	7
18 ... 21	Current L2	REAL	1 A	0.0 … 10000.0	8
22 ... 25	Current L3	REAL	1 A	0.0 … 10000.0	9
26 ... 27	Voltage UL1-N	UINT	0.01 V	0 … 30000	66001
28 ... 29	Voltage UL2-N	UINT	0.01 V	0 … 30000	66002
30 ... 31	Voltage UL3-N	UINT	0.01 V	0 … 30000	66003

Measured value data records

E

E.1 Overview of all measured value data records

Energy Meter 400VAC ST writes the measured values in several data records that you can read acyclically using the RDREC instruction in the user program.

The following tables show the structure of the individual data records:

- Data record DS 142 for basic measured values (read only).
- Data record DS 143 for energy counters (read and write).

E.2 Measured value data record for base measurements (DS 142)

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Please note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in appendix B (Measured variables (Page 73)).

Table E- 1 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2...5	Voltage UL1-N	REAL	V	0.0 ... 300.0	1
6...9	Voltage UL2-N	REAL	V	0.0 ... 300.0	2
10...13	Voltage UL3-N	REAL	V	0.0 ... 300.0	3
14...17	Voltage UL1-L2	REAL	V	0.0 ... 600.0	4
18...21	Voltage UL2-L3	REAL	V	0.0 ... 600.0	5
22...25	Voltage UL3-L1	REAL	V	0.0 ... 600.0	6
26...29	Current L1	REAL	A	0.0 … 10000.0	7
30...33	Current L2	REAL	A	0.0 … 10000.0	8
34...37	Current L3	REAL	A	0.0 … 10000.0	9
38...41	Power factor L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor L2	REAL	-	0.0 ... 1.0	20
46...49	Power factor L3	REAL	-	0.0 ... 1.0	21
50...53	Total power factor L1L2L3	REAL	-	0.0 ... 1.0	37

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
54...57	Frequency	REAL	1 Hz	45.0 ... 65.0	30
58...61	Amplitude unbalance for voltage	REAL	%	0 ... 100	38
62...65	Amplitude unbalance for current	REAL	%	0 ... 200	39
66...69	Apparent power L1	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	12
78...81	Total apparent power L1L2L3	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	34
82...85	Reactive power L1	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	16
86...89	Reactive power L2	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	17
90...93	Reactive power L3	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	18
94...97	Total reactive power L1L2L3	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	36
98...101	Active power L1	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	15
110...113	Total active power L1L2L3	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	35
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Total apparent energy L1L2L3	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3	REAL	varh	0.0 ... 3.4×10^{38}	206
134...137	Total active energy L1L2L3	REAL	Wh	0.0 ... 3.4×10^{38}	205
138...141	Total reactive energy inflow L1L2L3	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Total reactive energy outflow L1L2L3	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Total active energy inflow L1L2L3	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Total active energy outflow L1L2L3	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Total apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214
162...169	Total reactive energy L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	216
170...177	Total active energy L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	215
178...185	Total reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Total reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Total active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Total active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211

Note

- The cumulative value of the energy counters in 3-phase operation is obtained from the sums of the individual values of the phases.
- Inflow and outflow energy meters are always positive values.

Procedure

Data record 142 is located on the AI Energy Meter 400VAC ST. Use SFB "RDREC" to read out the data record from the module. This system function block is stored in the STEP 7 library.

Measured values in STEP 7 as of V5.5

Measured values are represented as negative values in STEP 7 as of V5.5 if the value range of the integer format (32767 dec) is exceeded. This is not an error in the measured value. Solution: Select hexadecimal representation.

Conversion of 64-bit floating-point numbers

If you cannot process 64-bit floating-point numbers in your automation system, we recommend conversion to 32-bit floating-point numbers. Note the conversion can cause loss of accuracy. For a description of the conversion of the 64-bit floating-point numbers (data type LREAL) into 32-bit floating-point numbers (data type REAL) please refer to the Internet (http://support.automation.siemens.com/WW/view/en/56600676).

E.3 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy counter to user-specific value (e.g. "0")
- Reading the current values of the energy counters

Energy meter data record 143

Table E- 2 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: 0.0...1.8 x 10^{308} During writing: 0.0...3.4 x 10^{12}	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204
88...95	Active energy inflow (initial value) L3	LREAL	Wh		61220
96...103	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...111	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...119	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...127	Apparent energy (initial value) L3	LREAL	VAh		61224

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

Tips and tricks

F

F.1 Tips and tricks

FAQ and application examples

Several FAQs and application examples are available to help you at work with the AI Energy Meter .

Measuring and visualizing energy data

You can find these application example at Internet (http://support.automation.siemens.com/WW/view/en/86299299)

IT network

You must create an artificial N-conductor (for example, by means of a 1:1 voltage transformer) in IT networks due to the missing neutral conductor. You can then use the module.

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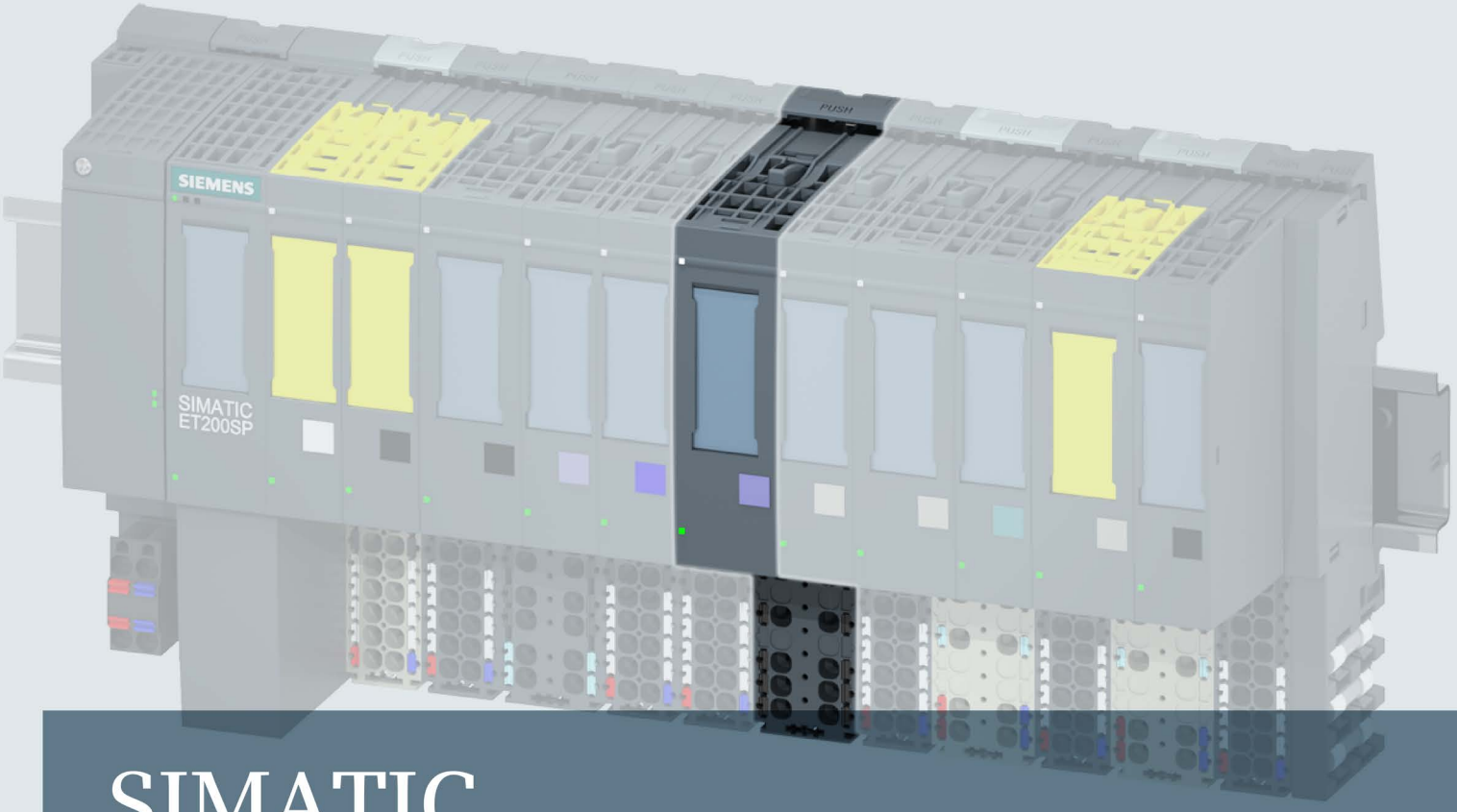

SIMATIC

ET 200SP

Analog input module AI Energy Meter 480VAC ST (6ES7134-6PA20-0BD0)

Manual

Edition 12/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Analog input module
AI Energy Meter 480VAC ST
(6ES7134-6PA20-0BD0)

Manual

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A5E36061895-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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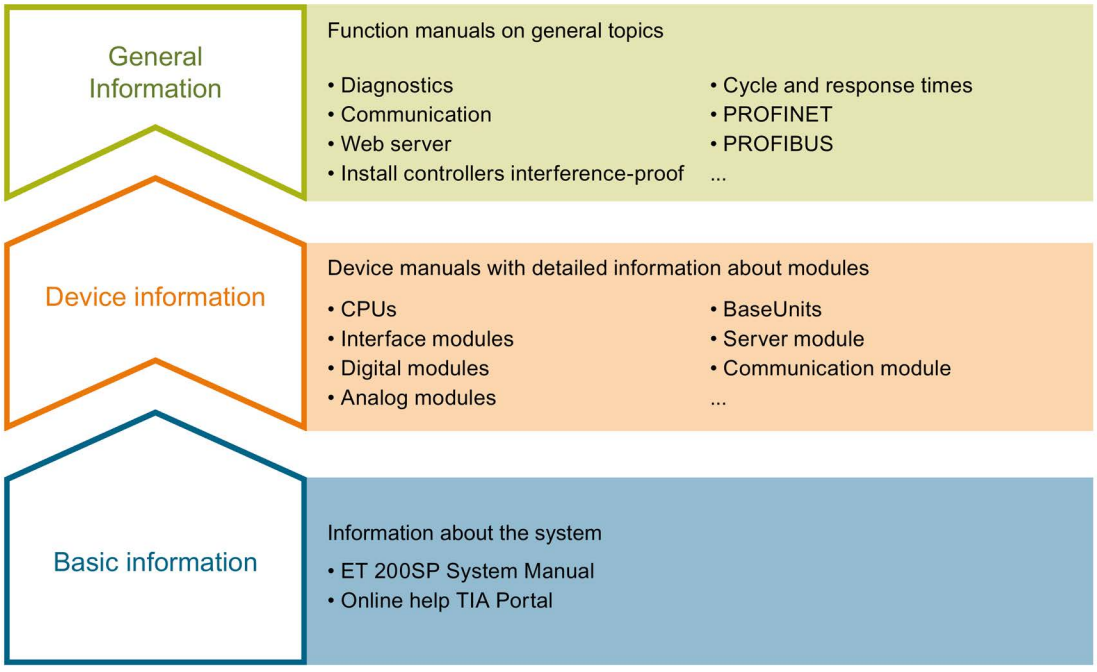
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Area of application

Introduction

Energy efficiency is playing an increasingly important role in industry. Rising energy prices, increasing pressure to improve profitability and the growing awareness of climate protection are important factors for reducing energy costs and for introducing an energy data management system.

Where can you use the AI Energy Meter 480VAC ST?

AI Energy Meter 480VAC ST is designed for machine-level deployment in an ET 200SP distributed I/O system. AI Energy Meter 480VAC ST records over 200 different electrical measurement and energy values. It lets you create transparency about the energy requirements of individual components of a production plant even down to the machine level.

Using the measured values provided by the AI Energy Meter 480VAC ST, you can determine energy consumption and power consumption. You can determine consumption forecasts and efficiency from the measured values. Power consumption measurements are relevant for load management and maintenance. In addition, you can use the measurements for energy reporting and for determining the CO_2 footprint.

Note

Measuring dangerous electrical quantities

The AI Energy Meter 480VAC ST is not tested according to DIN EN 61010-2-030 and may therefore not be used to verify, measure or monitor protective measures according to DIN EN 61557.

Qualified personnel must ensure through additional measures that no danger ensues for humans and the environment in case of an incorrect display.

TN and TT system

The AI Energy Meter 480VAC ST can be used in TN and TT systems.

Measuring with AI Energy Meter 480VAC ST

A typical supply network of a production plant is usually divided into three voltage ranges:

- The infeed of the entire plant
- The subdistribution, for example, to individual lines within the plant
- The end consumers such as the machines in the lines.

The following figure shows the measurement in an electricity supply network:

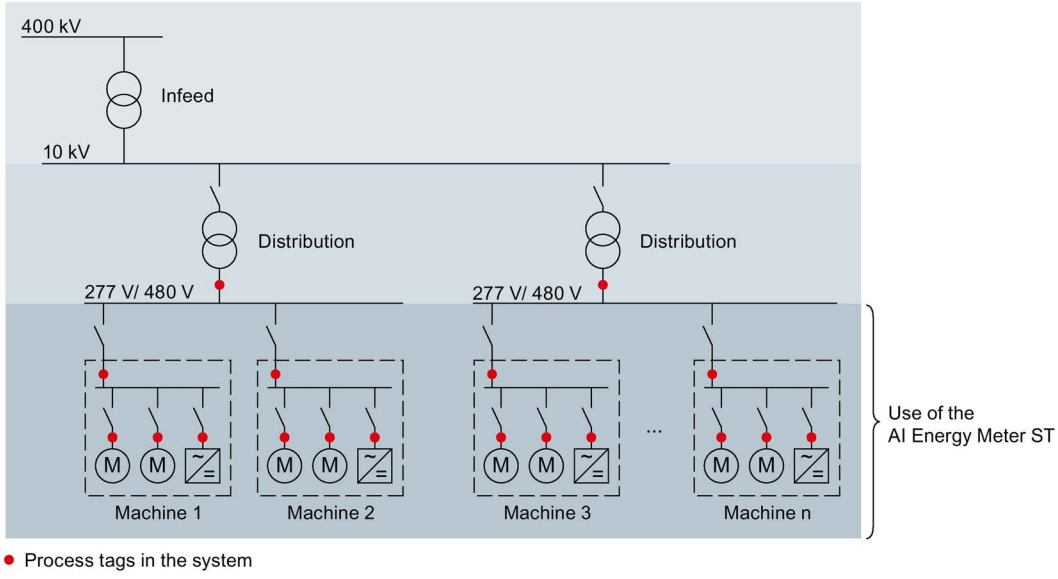


Image 2-1 Use of the AI Energy Meter 480VAC ST

Advantages of the AI Energy Meter 480VAC ST

The AI Energy Meter 480VAC ST has the following advantages:

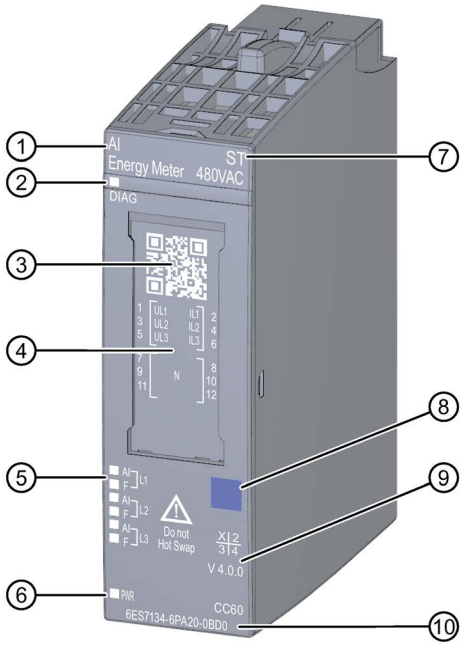
- Space-saving especially for use in control cabinet
- PROFINET IO or PROFIBUS DP (depending on the interface module in use)
- Multiple modules can be used with one interface module
- Extension of existing stations by components for energy recording

2.2 Properties of the AI Energy Meter 480VAC ST

Article number

6ES7134-6PA20-0BD0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color identification label module type
⑨ Function and firmware version
⑩ Article number

Image 2-2 View of the module AI Energy Meter 480VAC ST

Properties

The module has the following technical properties:

- Measurement of electrical variables from single-phase, two-phase and three-phase supply networks
- Max. nominal voltage between two outer conductors 480 VAC
- Retentive storage of the counter values
- Recording of:
  - Voltages
  - Currents
  - Phase angles
  - Power
  - Energy / electrical work
  - Frequencies
  - Minimum and maximum values
  - Power factors
  - Operating hours
  - Limits

The module supports the following functions:

- Firmware update
- Calibration in runtime
- I&M identification data
- Reconfiguration in RUN
- Diagnostics and hardware interrupts

Accessories

The following accessories must be ordered separately:

- BaseUnit Type D0
- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/es/58649293) system manual.

Wiring

3

3.1 Terminal and block diagram

In an ET 200SP station, the AI Energy Meter 480VAC ST forms its own potential group together with its dark BaseUnit.

General safety instructions

⚠ WARNING

Danger to life due to electric shock

Touching live parts can lead to death or severe injuries.

Before beginning any work deenergize the system and the Energy Meter and short-circuit installed transformers.

⚠ WARNING

Danger to life, dangerous system conditions and material damage possible

Removing and inserting the Energy Meter under live voltage is prohibited! For this reason the symbol "Do not Hot Swap" is located on the Energy Meter.

If you remove and insert the Energy Meter under live voltage during operation, the transformers used can produce dangerous induction voltages and electric arcs and dangerous system conditions can arise.

The Energy Meter may only be removed and inserted during operation if the measuring voltages applied to the BaseUnit are disconnected at all phases at the terminals U_{L1} , U_{L3}, U_{L3} **and** special current transformer terminals are used that short-circuit the transformer at the secondary side when removed.

⚠ CAUTION

Use only in three-phase and AC networks

The Energy Meter is destroyed if used with direct voltage / direct current.

Use the Energy Meter solely to measure electrical variables in three-phase and AC networks.

Supplying the module

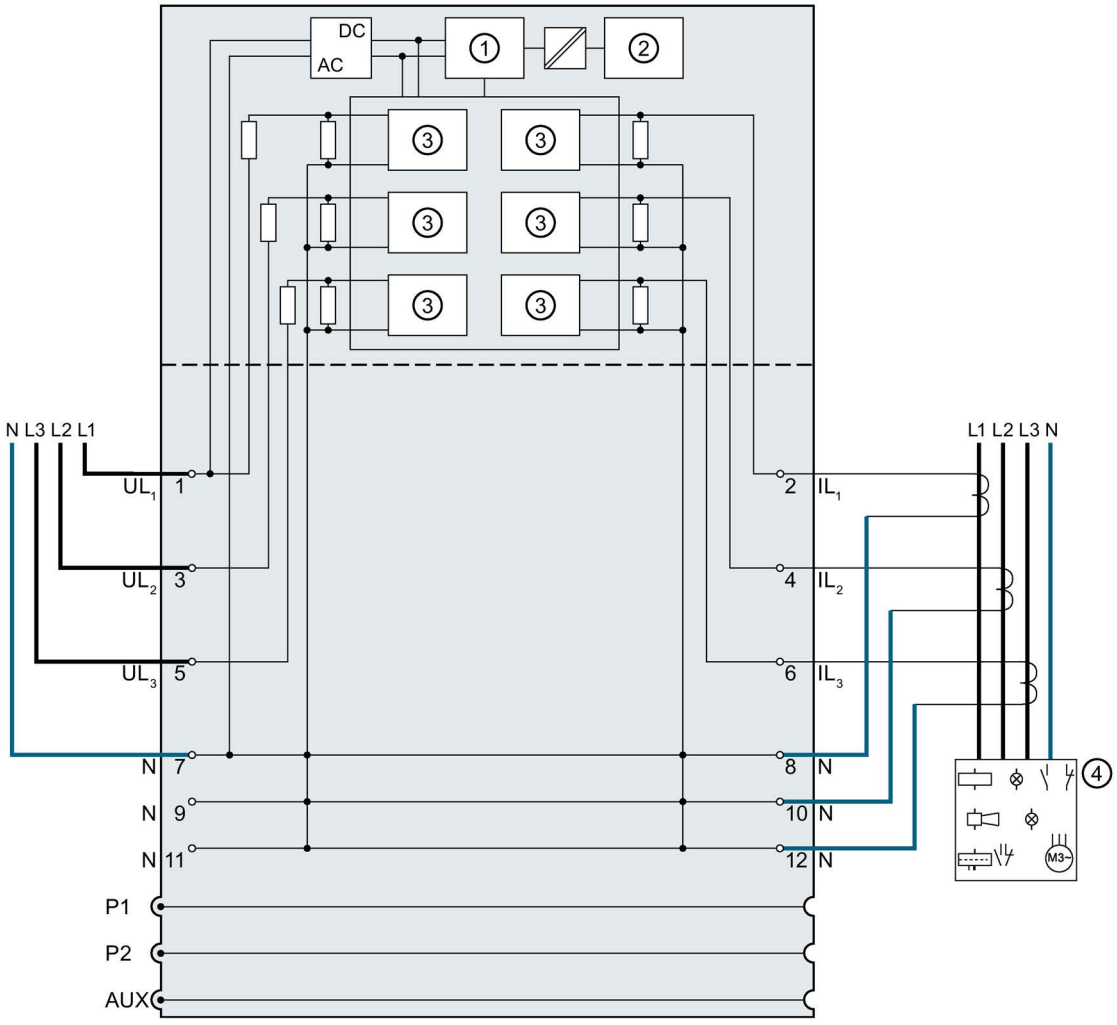
The Energy Meter is supplied through the terminals U_{L1} and N. The required minimum voltage amounts to 85 VAC.

Protecting the connection cables

To protect the connection cables at U_{L1}, U_{L2} and U_{L3}, make sure there is adequate cable protection, especially after cross-section transitions.

If short-circuit resistance according to IEC 61439-1:2009 is ensured by the design, there is no need for separate cable protection for the AI Energy Meter 480VAC ST.

Terminal and block diagram



①	Microcontroller	UL_n	Voltage connection
②	Backplane bus interface	IL_n	Current connection
③	Analog-to-digital converter (ADC)	N	Neutral conductor
④	Power measurement		

Image 3-1 Block diagram of the AI Energy Meter 480VAC ST

Usable BaseUnit

The ET 200SP Distributed I/O System manual explains that a potential group always starts with a light BaseUnit. The AI Energy Meter 480VAC ST makes an exception in this case and only uses the dark BaseUnits type D0, 6ES7193-6BP00-0B**D0**.

The BaseUnit is not in contact with the power bus and passes the potential through from the left to the right slot.

When using some older CPUs / interface modules, note that the first permissible place for AI Energy Meter 480VAC ST is slot 2.

Connection types

The AI Energy Meter 480VAC ST supports the following connection types:

- 3P4W1, 3 phases, 4 conductors, balanced load
- 3P4W, 3 phases, 4 conductors
- 2P3W, 2 phases, 3 conductors
- 1P2W, 1 phase, 2 conductors
- 3 x 1P2W, 3 x 1 phase, 2 conductors

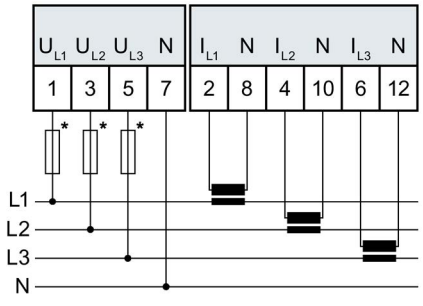
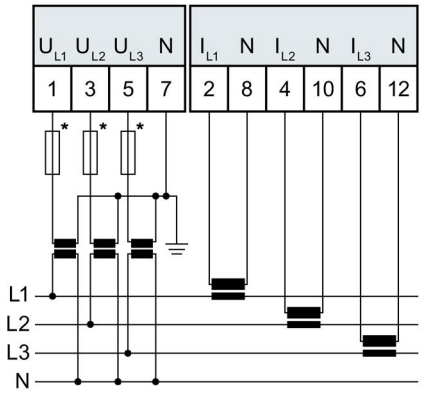
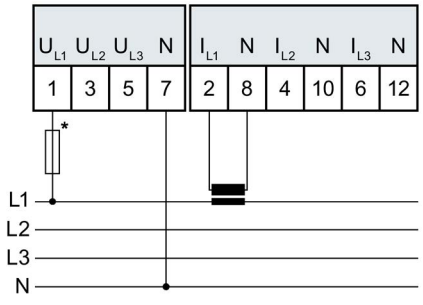
The input circuit of the module must correspond to one of the listed connection types. Select the appropriate connection type for the intended use.

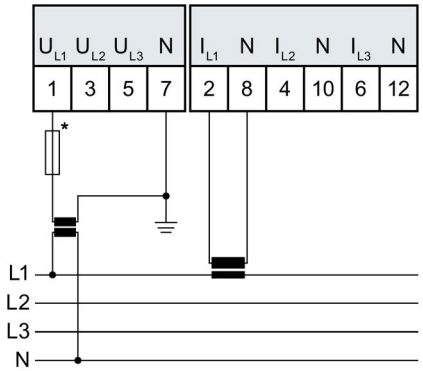
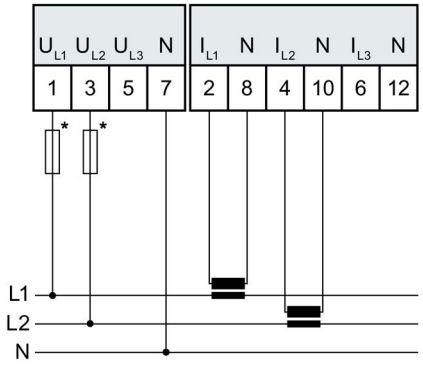
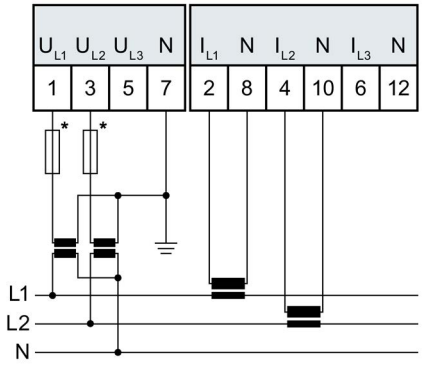
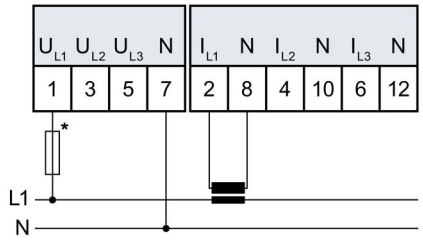
You will find examples of connections in the section Connection examples (Page 18).

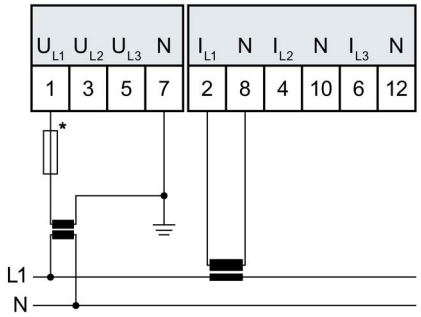
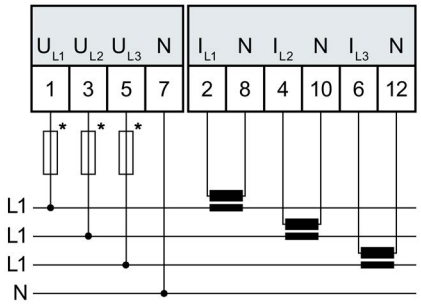
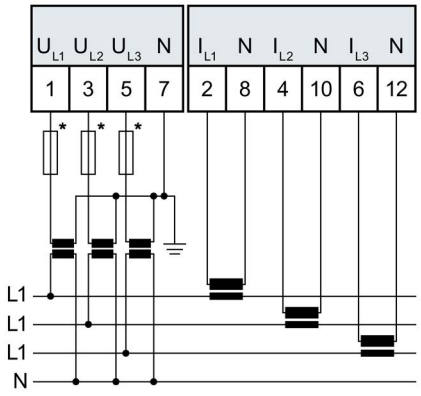
Information on the selection of a current transformer is available in the section Current transformer selection data (Page 21).

3.2 Connection examples

The following figures show the connection of the Energy Meter for three-phase, two-phase and single-phase measurements. Note that the Energy Meter must always be connected via a current transformer. The use of voltage transformers is optional.

Connection type	Wiring diagram	Comment
3P4W Three-phase measurement, 4 wires		Any load Connection with three current transformers
3P4W Three-phase measurement, 4 wires		Any load Connection with three current and three voltage transformers
3P4W1 Three-phase measurement, 4 wires		Balanced load Connection with one current transformer

Connection type	Wiring diagram	Comment
3P4W1 Three-phase measurement, 4 wires		Balanced load Connection with one current and one voltage transformer
2P3W Two-phase measurement, 3 conductors		Any load Connection with two current transformers Energy Meter supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
2P3W Two-phase measurement, 3 conductors		Any load Connection with two current and two voltage transformers Energy Meter supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors		Measurement in an AC network with a current transformer Energy Meter supplies the value "0" for all measured values of Phases 2 and 3 as well as for some cross-phase measured values.

Connection type	Wiring diagram	Comment
1P2W Single-phase measurement, 2 conductors		Measuring the load in an AC network with a current and a voltage converter Energy Meter supplies the value "0" for all measured values of Phases 2 and 3 as well as for some cross-phase measured values.
3 x 1P2W 3 x single-phase measurement		Measurement with three current transformers for any three loads that are each connected to one of the three phases Max. permissible secondary current of the current transformer is 1 A
3 x 1P2W 3 x single-phase measurement		Measurement with three current transformers and three voltage transformers for any three loads that are each connected to one of the three phases Max. permissible secondary current of the current transformer is 1 A

If short-circuit resistance is ensured by conformity to IEC 61439-1:2009, there is no need for separate line protection for the AI Energy Meter 480VAC ST.

3.3 Current transformer selection data

Introduction

Connection via a current transformer is always required for the current measurement. Use toroids with an accuracy class of 0.5, 1 or 3.

Dimensioning of the current transformer

The correct dimensioning of the current transformer is important for the following reasons:

- You achieve correct results from the measurements and
- You do not overload or damage the current transformers.

Selecting a current transformer

Use current transformers with a burden capacity 1.5 to 2 times greater than the power dissipation in the terminal circuit (consisting of resistance of the connection cables and burden of energy meter). 1.5 times the power loss is required in order to prevent the transformer from overloading. 2 times the power dissipation is important to ensure the current limiting in case of a short-circuit.

Maximum length of the connection cable

To avoid overloading or damaging the current transformer, the burden Z_n specified on the data sheet of the current transformer (in VA) must not be exceeded. To prevent this being exceeded, the entire burden resistance (consisting of the resistance of the connection cable and the internal resistance of the AI Energy Meter 480VAC ST (see figure below) must be below a certain resistance value (depending on Z_n and I_{max}).

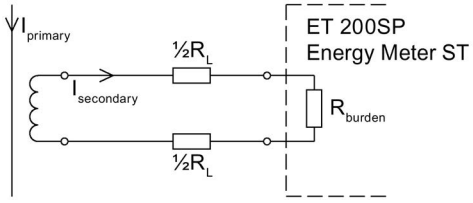


Image 3-2 Maximum length of the connection cable

The maximum value of the resistance of the connection cable is obtained with the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^{\,2}} - R_{burden}$$

R_L	Cable resistance in ohms	I_{max}	Secondary current of the current transformer
Z_n	Rated burden current transformer in VA	R_{burden}	Resistance of the Energy Meter (25 mΩ)

Image 3-3 Maximum value for the resistance of the connection cable

Based on the maximum cable resistance in ohms, you then calculate the maximum length of the connection cable. To do this, check the data sheet of the connection cable you are using.

Note

The length of the connection cable (outwards and return) must not exceed the value of 200 meters.

Example: Usage of a current transformer 500/5 A

You use a current transformer with a transmission ration of 500/5 A that has a rated burden Z_n of 5 VA according to the data sheet.

The maximum primary current in the application amounts to 400 A. This means that the maximum secondary current $I_{max.}$ amounts to 4 A. The burden of the AI Energy Meter including connection resistance amounts to R_{Burden} = 25 mΩ.

The maximum value of the resistance of the connection cable (outgoing and incoming line) is obtained using the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^{\,2}} - R_{Burden} = \frac{5\ AV}{16\ A^2} - 25\ m\Omega = 312.5\ m\Omega - 25\ m\Omega = 287.5\ m\Omega$$

The maximum cable resistance between the transformer and the terminals of the Energy Meter may not exceed 287.5 mΩ in this case. The corresponding cable length (outgoing and incoming line) depends on the cross-section used of the copper line and can be determined by using the following table.

The following table shows the resistance values of copper cables for typical cross-sections with ρ = 0.017857 Ω x mm²/m

Estimating the length for a connection cable

The value in the table must be less than the calculated terminal resistance $R_{L\ max}$ of the cable. For the resistance R_{Lmax} of 287.5 mΩ used in the above example it is possible to use a connection cable (outgoing and incoming line) with a length of 10 m from a cross-section of 0.75 mm² upward.

Cross-section	AWG	Cable overview for copper				
		0.5 m	1 m	5 m	10 m	50 m
0.25 mm²	24	35.7 mΩ	71.4 mΩ	357.1 mΩ	714.3 mΩ	3571.4 mΩ
0.34 mm²	22	26.3 mΩ	52.5 mΩ	262.6 mΩ	525.2 mΩ	2626.0 mΩ
0.5 mm²	21	17.9 mΩ	35.7 mΩ	178.6 mΩ	357.1 mΩ	1785.7 mΩ
0.75 mm²	19/20	11.9 mΩ	23.8 mΩ	119.0 mΩ	238.1 mΩ	1190.5 mΩ
1.0 mm²	18	8.9 mΩ	17.9 mΩ	89.3 mΩ	178.6 mΩ	892.9 mΩ
1.5 mm²	16	6.0 mΩ	11.9 mΩ	59.5 mΩ	119.0 mΩ	595.2 mΩ
2.5 mm²	14	3.6 mΩ	7.1 mΩ	35.7 mΩ	71.4 mΩ	357.1 mΩ

Checking the ratio of burden load and power loss

The rated burden of the transformer must be 1.5 to 2 times greater than the power loss in the connection circuit to ensure that the transformer is not overloaded and that the current limitation is ensured during a short-circuit.

At a maximum secondary current of 4 A the power loss in the connection circuit is calculated in accordance with the following formula for a connection cable (outgoing and incoming line) with a length of 10 m and a cross-section of 1.0 mm^2 and a burden resistance of the Energy Meter of 25 mΩ:

$$P_{\text{Connection circuit}} = (R_{\text{Connection cable}} + R_{\text{Burden}}) \times I^2_{\text{Max. secondary}}$$

$$P_{\text{Connection circuit}} = (178.6\ m\Omega + 25\ m\Omega) \times 4^2\ A^2\ 3.26\ W$$

The ratio of the rated burden and the power loss in the connection circuit thus amounts to:

$$\frac{Z_{\text{N rated burden}}}{P_{\text{Connection circuit}}} = \frac{5\ VA}{3.26\ W} = 1.54$$

The required ratio of rated burden and power loss in the connection circuit lies within the required range. The transformer is dimensioned sufficiently large.

See also

Technical specifications (Page 92)

Configuration / address space

4

4.1 Configuring

Introduction

To configure the AI Energy Meter 480VAC ST after connecting it, use configuration software such as STEP 7. In addition, you can also change numerous parameters of the AI Energy Meter 480VAC ST in RUN via the user program.

Configuring

You configure the AI Energy Meter 480VAC ST with:

- STEP 7 (TIA Portal) V13 SP1 or higher with Update 4 and HSP
- STEP 7 V5.5 SP4 or higher and Hotfix 7
- GSD file for PROFIBUS or PROFINET

Note

Consistency check of the parameter assignment only with STEP 7

If you configure the AI Energy Meter 480VAC ST using STEP 7, STEP 7 already checks the various parameters for consistency while they are being entered.

If you configure the AI Energy Meter 480VAC ST using a GSD file, a consistency check is not carried out. The module does not recognize incorrect entries until after the parameter data record has been transferred. If the module recognizes an invalid parameter, the module rejects the complete data record.

Preferably use STEP 7 to configure the AI Energy Meter 480VAC ST.

The following instructions show the theoretical procedure for configuring the AI Energy Meter 480VAC ST with STEP 7 (TIA Portal) V13 SP1 or higher with Update 4 and HSP.

1. Select the ET 200SP distributed I/O system you are using in the hardware catalog.
2. Insert the module into your station.
3. Open the device view of the ET 200SP and insert the AI Energy Meter 480VAC ST.
4. Configure the AI Energy Meter 480VAC ST to suit your requirements.

   Once the configuration has been compiled without errors, you can download the configuration to the CPU and commission the ET 200SP station while the AI Energy Meter 480VAC ST is running.

4.2 Selecting the module versions

Introduction

The AI Energy Meter 480VAC ST has different module versions.

During the configuration you use the selection of the module version to specify which measured values can be read.

Each module version supplies quality information via the input user data.

With the exception of the module version "2 I / 2 Q" you can read the measured values as user data cyclically from the process image. At each module version you have the option to read measured value records from the AI Energy Meter 480VAC ST by using the RDREC instruction asynchronously.

Influence of the module version on the address space

Note

Influence of the AI Energy Meter 480 VAC ST on the maximum configuration of the ET 200SP

The available address space of the ET 200SP is influenced by the following factors:

- CPU or interface module
- Plugged I/O modules

The address space made **additionally** available by the AI Energy Meter 480 VAC ST is essentially influenced by the length of the user data supplied. The module version determines the length of the user data, which can be supplied by the AI Energy Meter 480VAC ST at maximum.

4.2.1 Module versions at configuration with STEP 7

Module versions with fixed user data assignment

Module version	User data	Address space	Comment
2 I / 2 Q	No cyclic user data. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix Module version "2 I / 2 Q" (Page 122).
EE@Industry E0	User data in accordance with EE@Industry measurement data profiles	12 byte inputs / 12 byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3" (Page 133).
EE@Industry E1		4 byte inputs / 12 byte outputs	
EE@Industry E2		12 byte inputs / 12 byte outputs	
EE@Industry E3		104 byte inputs / 12 byte outputs	

Module versions with selectable user data variants

Module version	User data	Address space	Comment
32 I / 12 Q	User data selectable through defined user data variants	32 byte inputs / 12 byte outputs	You can change over the user data variant during operation. Information about the structure of the 32 I / 12 Q module version is available in the appendix Module version "32 I / 12 Q" (Page 125). Information about the user data variants at 32 I / 12 Q is available in the appendix User data variants with 32 bytes input data / 12 bytes output data (Page 135).
User-specific	User data selectable through user data mapping or through defined user data variant	Variable* / 12 byte outputs	You have to activate the check box "User data-mapping" in STEP 7 to use the module version user-specifically. You can change over the user data variant during operation. Information about the structure of the user-specific module version is available in the appendix "User-specific" module version (Page 131).

* 16 ... 256 bytes in steps of 16 bytes, depending on the mapped measured values

4.2.2 Module versions at configuration with GSD file

Module versions with fixed user data assignment

Module version	User data	Address space	Comment
2 I / 2 Q	No cyclic user data. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix Module version "2 I / 2 Q" (Page 122).
E0	User data in accordance with EE@Industry measurement data profiles	12 byte inputs / 12 byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3" (Page 133).
E1		4 byte inputs / 12 byte outputs	
E2		12 byte inputs / 12 byte outputs	
E3		104 byte inputs / 12 byte outputs	

Module versions with selectable user data variants

Module version	User data	Address space	Comment
32 I / 12 Q	User data selectable through user data variants or through user-specific user data*	32 byte inputs / 12 byte outputs	You can change over the user data variant during operation. If you use user-specific user data, you write your measured value profile into the AI Energy Meter 480VAC ST with the data record 130. To do this use the WRREC instruction. Information about the structure of data record 130 is available in appendix Structure of the parameter data record 130 for user-data mapping (Page 110).
64 I / 12 Q		64 byte inputs / 12 byte outputs	
128 I / 12 Q		128 byte inputs / 12 byte outputs	
256 I / 12 Q		256 byte inputs / 12 byte outputs	

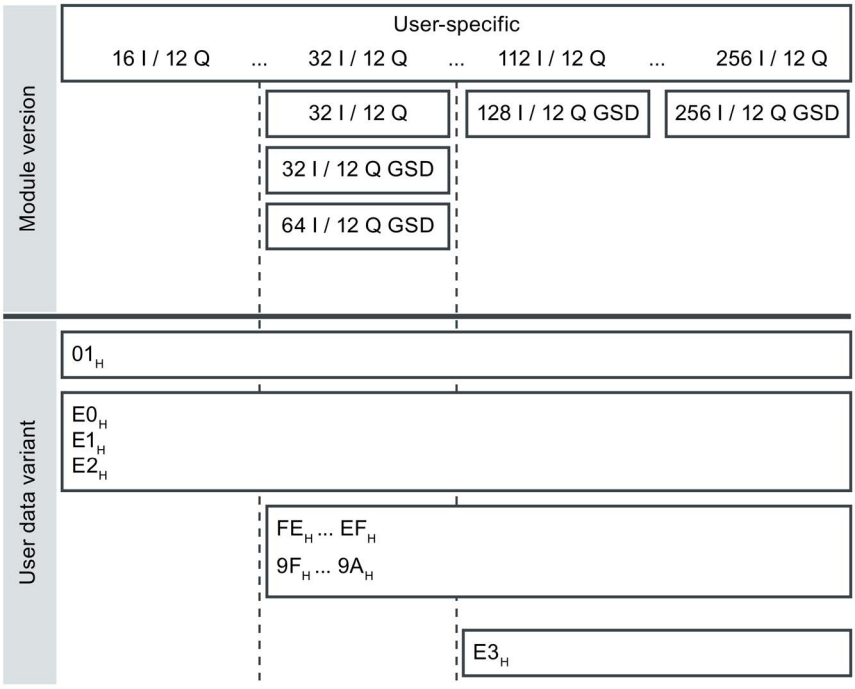
*Ensure that the user data do not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

4.2.3 Changing over the user data variant during operation

Introduction

You change the user data variant in the output data of each user data variant in Byte 0.

The following figure shows to which user data you can change over at various module versions during operation.



Requirement

- User program has been created.
- AI Energy Meter 480VAC ST is configured as one of the module versions mentioned in the illustration above.
- The start address of the module is known in the process image output.

Procedure

1. Create one constant with the data type BYTE per user data variant.
2. Enter the user data ID as a value in each case.
3. Write the constant to the start address of the module in the process image output.

Result

The user data variant is switched with the next cycle.

Note

Information about user data changeover

The parameterized user data variant is set in the following cases:

- A "0" is written in byte 0 in the output data of a user data variant.
- Byte 0 in the output data of a user data variant contains an invalid value:
  - Coding of the user data variant not available

    or
  - Available address space is not sufficient for the selected user data variant.

4.2.4 Recommendations for selecting the module version

The following table shows which module version is suitable for a given purpose.

Module version	Application	Note
2 I / 2 Q	• Use of many AI Energy Meter 480VAC ST in an ET 200SP or little address space is available	• Read the measured values solely via the RDREC instruction from a measured value data record. • Quality information about the measured values is always available.
EE@Industry measurement data profile E0 / E1 / E2 / E3	• Cyclic measurement per phase • Supplied measured values in accordance with the EE@Industry measured data profile	• Available measured values depend on the configured measurement data profile. • The user data are fixed and cannot be changed dynamically. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. • No quality information
32 I / 12 Q	• Cyclic measurement per phase • Flexibility by switching predefined user data variants	• Quality information about the measured values is always available. • Depending on the user data variant, you must convert the measured values in the CPU to physical values using the supplied scaling factor. • One cycle elapses for each user data changeover. Measured values from the next user data variant are thus supplied with a slight time offset. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. Consistent measured values of a measuring cycle are supplied.
User-specific With GSD configuration • 32 I / 12 Q • 64 I / 12 Q • 128 I / 12 Q • 256 I / 12 Q	• Cyclic measurement of up to 64 measured values configurable • Flexibility by switching predefined user data variants	

4.3 Applicable modules

Configuring with STEP 7

The following table shows with which controllers the different module versions can be configured with STEP 7.

Table 4- 1 Module versions configured with STEP 7

Controller	Module version						
	2 I / 2Q	32 I / 12 Q	User-specific	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V1.0 or higher		V1.0 or higher* V3.1 or higher	V1.0 or higher			V3.1 or higher
IM 155-6 PN HF	V2.0 or higher		V2.0 or higher* V3.1 or higher	V2.0 or higher			V3.1 or higher
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher						
IM 155-6 DP HF	V1.0 or higher		---	V1.0 or higher			---
CPU 1510SP-1 PN	V1.6 or higher		V1.6 or higher* V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1510SP F-1 PN	V1.7 or higher		V1.7 or higher* V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1512SP-1 PN	V1.6 or higher		V1.6 or higher* V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1512SP F-1 PN	V1.7 or higher		V1.7 or higher* V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1515SP PC	V1.7 or higher		V1.7 or higher* V2.0 or higher	V1.7 or higher			V2.0 or higher

* Only up to 32 bytes

Configuring with GSD file

The following table shows with which controllers the different module versions can be configured using a GSD file.

Table 4- 2 Module versions configuring with GSD file

Controller	Module version						
	2 I / 2Q	32 I / 12 Q	64 I / 12 Q 128 I / 12 Q 256 I / 12 Q	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V1.0 or higher		V3.1 or higher	V1.0 or higher			V3.1 or higher
IM 155-6 PN HF	V2.0 or higher		V3.1 or higher	V2.0 or higher			V3.1 or higher
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher						---
IM 155-6 DP HF	V1.0 or higher		---	V1.0 or higher			---
CPU 1510SP-1 PN	V1.6 or higher		V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1510SP F-1 PN	V1.7 or higher		V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1512SP-1 PN	V1.6 or higher		V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1512SP F-1 PN	V1.7 or higher		V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1515SP PC	V1.7 or higher		V2.0 or higher	V1.7 or higher			V2.0 or higher

Quick start

5

Introduction

This section shows you how to read and view your first measured values on the Energy Meter 480 VAC ST in a particularly quick and easy way.

Requirement

You have already connected the Energy Meter to your network with one of the connection types shown in the section Wiring (Page 15). The Energy Meter 480 VAC ST has already been integrated in your configuration tool (such as STEP 7), or the Energy Meter 480 VAC ST has been integrated in your hardware catalog with the GSD/GSDML file.

Procedure

1. Configure an ET 200SP station

   Configure an ET 200SP station with a CPU 151xSP or an IM 155-6.

2. Plug module in ET 200S station

   Plug the Energy Meter 480 VAC ST into the ET 200SP station and use the module version with 32 bytes inputs and 12 bytes outputs.

3. Set the module parameters

   Set the following parameters for the Energy Meter 480 VAC ST:

   – Connection type that you have used for the Energy Meter 480 VAC ST (e.g. 3P4W)
   – Measuring range, i.e. the phase voltage (UL1-N) of your electrical network (e.g. 230 V AC)
   – Frequency of your network (e.g. 50 Hz)
   – Primary and secondary current of the used current transformer (e.g. 100 A and 1 A)
   – Primary and secondary voltages of the used voltage transformer (e.g. 230 V and 230 V)

   Leave all other parameters at their default settings and do not change them.

4. Load configuration

   Switch on the ET 200SP station and download the configuration to the CPU.

Result

Once the Energy Meter has been switch on, it provides the measured values for the user data variant "Basic measurements" with the ID 254 or FE_H.

Read and check the measured values provided by the Energy Meter in the output data.

The table below shows the structure of the user data variant, the measured variables and the data type of the measured values in STEP 7 (TIA Portal) that are stored in the 32 bytes of output data of the module. Each measured variable is referenced via the measured value ID. An overview of all the measured variables with their measured value IDs is provided in the section Measured variables (Page 113).

Table 5- 1 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Total active power L1L2L3	INT	1 W	-27648 … 27648	66035
10 ... 11	Total reactive power L1L2L3	INT	1 var	-27648 … 27648	66036
12 ... 13	Total apparent power L1L2L3	INT	1 VA	-27648 … 27648	66034
14 ... 17	Total active energy L1L2L3	UDINT	1 Wh	0 … 4294967295	200
18 ... 21	Total reactive energy L1L2L3	UDINT	1 varh	0 … 4294967295	202
22	Reserved	BYTE	-	0	-
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling total active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling total reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling total apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Additional information

If you require further information about the evaluation and interpretation of the measured values, please refer to the section Reading and processing measured values (Page 35).

Reading and processing measured values

6

6.1 Basics for reading measured values

Introduction

The AI Energy Meter 480VAC ST provides the measured values and variables through the following methods:

- Cyclic: User data
- Acyclic: Measured value data records

User data

User data provide pre-defined measured values depending on the configured user data variant. The supplied measured values are cyclically written to the process image of the CPU. With some user data variants, the measured values are supplied as raw data, which you have to convert to the corresponding physical values using a supplied scaling factor.

Measured value data records

Each measured value data record supplies physical values that you can further process immediately. You read the values of a measured value data record acyclically with the RDREC instruction in a PLC tag. You need a corresponding PLC tag for each measured value data record to be read.

You can display the read measured values in a watch table in STEP 7.

Note

If you are using CPUs other than S7-1200 or S7-1500, convert 64-bit measured values to 32-bit measured values. Note the conversion can cause loss of accuracy.

For more information, read FAQ: Processing 64-bit-floating-point numbers in S7-300/400 (https://support.industry.siemens.com/cs/ww/en/view/56600676)

Validity of the measured values

After turning on the supply voltage UL1, the first measured values are available after approximately 2 seconds. In the input user data, the content of byte 0 is set to the selected user data variant. You can use this change in byte 0 as a trigger event.

As soon as the module has valid measured values, the value of this byte changes to a value within the value range.

Initial startup of the module

After the first startup or restart of the module, the parameters are transferred to the module. You can preset a user data variant in the parameters of the hardware configuration. This remains in effect until a different user data variant is selected in the output data (byte 0). This allows input user data to be modified dynamically according to the requirements of the process.

The user data variant defined in parameter data record 128 is used under the following conditions:

- A "0" is written in byte 0 in the output data of a user data variant.
- Byte 0 in the output data of a user data variant contains an invalid value:
  - Coding of the user data variant not available

    or
  - Available address space is not sufficient for the selected user data variant.

    See "Selecting the module versions (Page 26)".

Current measured values become "0"

The current and all other measured values based on it are suppressed (or set "0") in the data records and in the user data in the following cases:

- The incoming current of the current transformer is less than the configured "Low limit for measuring current" parameter
- Incoming secondary current at the channel is higher than 12 A

The following measured values and derived measured variables of the phase involved become "0":

- Effective current value
- Active power
- Reactive power
- Apparent power
- Neutral conductor current
- Phase angle
- Power factor

A floating mean value is formed from the power values. These only become "0" after a corresponding time. The operating hours counter and the energy counter for active, reactive and apparent energy of the reset phase stops counting.

Substitute value behavior

The substitute values for input values of the AI Energy Meter 480VAC ST amount to "0".

See also

Reading measured values from user data cyclically (Page 40)

Read measured value from a measured value data record (Page 42)

6.2 Quality information

Introduction

The AI Energy Meter 480VAC ST supplies quality information about the measurement in a status word. This information can be used to evaluate the status:

- Currents (I_{L1}, I_{L2}, I_{L3}) and voltages (U_1, U_2, U_3) lie within the valid measuring range
- Operating quadrants for each of the 3 phases
- Direction of rotation of the 3-phase system

Quality information for 3-phase system

The module saves the quality information that can be evaluated under the measuring value ID 65503 as a bit string in 2 bytes.

You can access the quality information via:

- User data variant "Basic variables quality values three-phase measurement (ID 240 or $F0_H$)
- User data (measured value ID 66503)
- Measured value data record 150

In addition you can evaluate the quality information for the low byte in all the user data variants for the module version 32 I / 12 Q.

Quality information for individual phases

You can also evaluate the quality information for individual phases via the measured value data records 147 to 149 or use the user-defined user data variant. You obtain the phase-specific quality information for the user-defined user data variant under:

- Measured value ID 65500 for Phase 1 (Channel 0).
- Measured value ID 65501 for Phase 2 (Channel 1).
- Measured value ID 65502 for Phase 3 (Channel 2).

In contrast to the allocation for measured value 65503, the measured value IDs only contain the phase-specific information for current, voltage and operating quadrant. The information about the other phases and the rotating field have the value 0.

Structure of the quality information

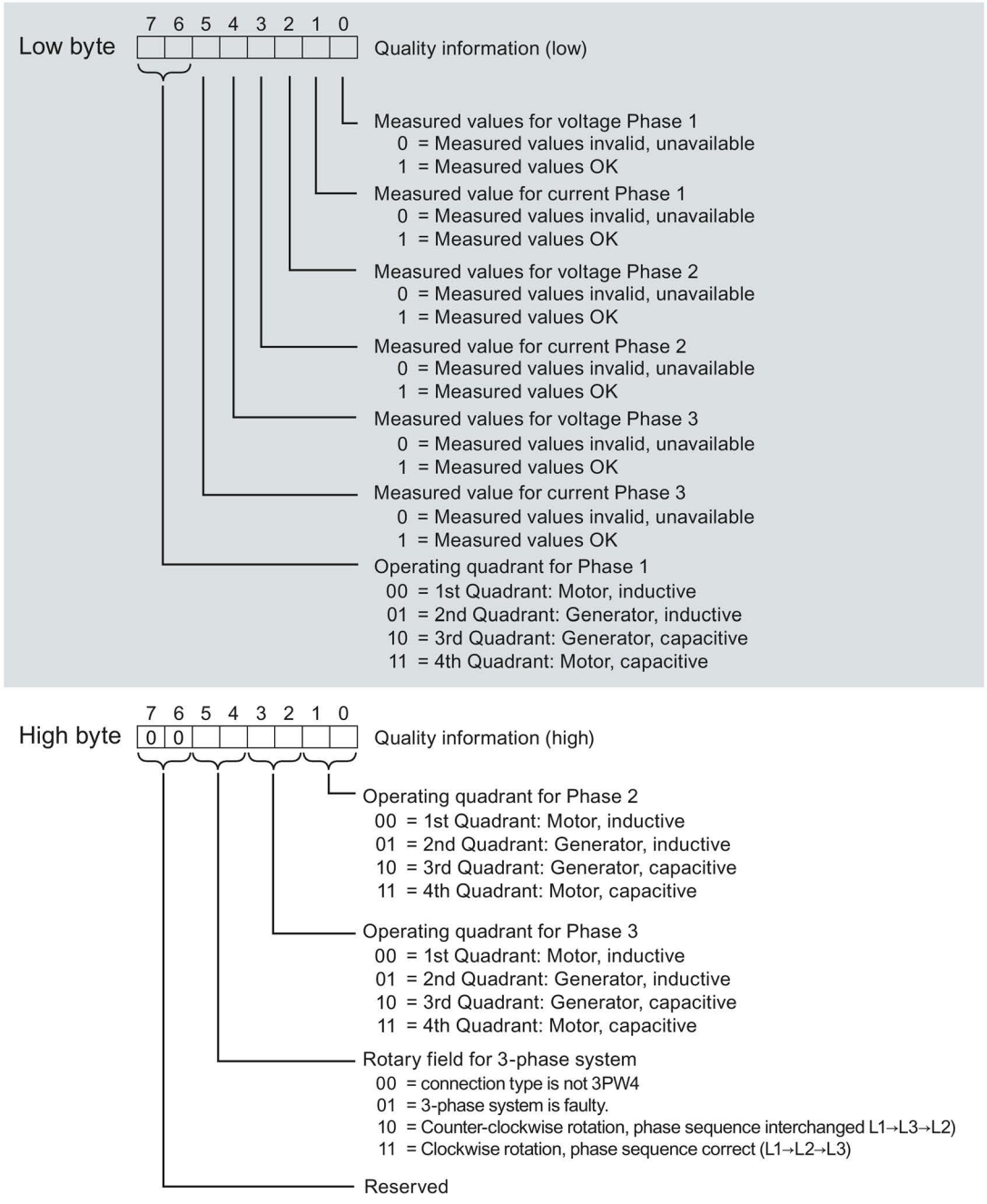


Image 6-1 Quality information for low and high byte of the measured value ID 65503

Operating quadrant

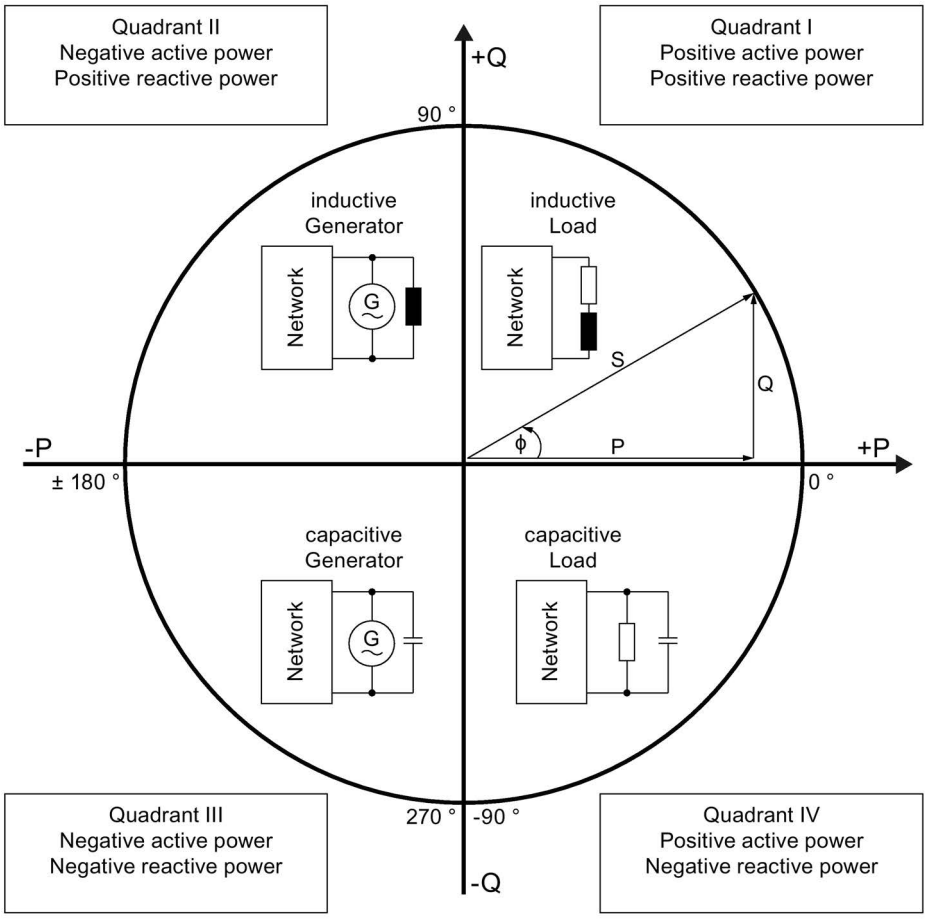


Image 6-2 Quadrant in the quality bits

See also

Module version "32 I / 12 Q" (Page 125)

6.3 Reading measured values from user data cyclically

Requirement

- STEP 7 is open.
- AI Energy Meter 480VAC ST is configured.

Scaling of measured values in the user data

Since the value range of 16-bit values is often smaller than the value range of the physical value, a scaling factor is supplied together with the basic value in the user data for the respective measured or calculated values. You determine the actual value of the measured variable with the following formula:

Actual value of measured quantity = measured value in the user data x $10^{\text{scaling factor}}$

Procedure

To read measured values from the user data cyclically, proceed as follows:

1. Read the relevant measured value from the input data.
2. Observe the scaling factor at scaled measured values and convert the read measured value using the scaling factor.

Example

The user data variant 254 (FE_H) "Total power L1L2L3" is configured on the AI Energy Meter 480VAC ST. The measured value for "Current L1" should be read.

Table 6- 1 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
:	:	:	:	:	:
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
:	:	:	:	:	:
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

In the user data variant FE_H (254) the measured value for the current L1 is stored in Byte 2 + 3. The current is supplied by the module as a 16-bit-fixed-point number in the value range from 0 to 65535 in the unit 1 mA. In addition the scaling factor for the current L1 has to be considered additionally. The module supplies the related scaling factor in Byte 24.

The actual value for current L1 is calculated as follows:

Actual value for current L1 = Current L1 x $10^{\text{Scaling current L1}}$

See also

Basics for reading measured values (Page 35)

6.4 Read measured value from a measured value data record

Introduction

To read measured values of a measured value data record, use the RDREC instruction. The read values are stored in a PLC variable with user-defined data type (UDT).

You can find more information on this in the STEP 7 documentation, under the keyword "RDREC".

Requirement

- STEP 7 is open.
- AI Energy Meter 480VAC ST is configured.

Procedure

1. In STEP 7 create a user-defined data type with the structure of the data record to be read.
2. Insert the number of structural elements, which corresponds to the number of entries contained in the measured value data record.
3. Insert the RDREC instruction in the user program.
4. Configure the RDREC instruction as follows:
   - ID: Hardware identifier or start address of the Energy Meter (depending on the CPU used).
   - INDEX: Number of measured value data record whose entries are read.
   - MLEN: Length of the measured value data record in bytes. "0" if all the entries are to be read.
   - RECORD: Target range for the read data record Length depends on MLEN.
5. Call the RDREC instruction with REQ = 1.

Result

The values from the measured value data record were transferred into the target data area.

See also

Basics for reading measured values (Page 35)

Energy counters

7

7.1 How the energy meter works

Introduction

The AI Energy Meter 480VAC ST provides 42 energy counters that detect both line-based and phase-based energy values.

- Active energy (total, outflow, inflow)
- Reactive energy (total, outflow, inflow)
- Apparent energy (total)

How energy recording works

Based on the measured currents and voltages and the calculation cycle the Energy Meter calculates the active, reactive and apparent energy. The active, reactive and apparent energies are updated in each calculation cycle.

Retentivity

All the counter states of the module are stored retentively in the Energy Meter. After an interruption (e.g. Power System Off → Power System On), the energy counting resumes with the retentively stored values.

Configuring

You configure the following settings for the energy counters:

- Activation of the gate for the energy counter

  The gate allows you to start and stop the counters via output data (DQ bit). If you deactivate the gate, the count starts immediately when the Energy Meter is switched on.

- Modes of the energy counters

  The energy counters count either infinitely or periodically. For periodic counting, the adjustable full-scale values are 10^3, 10^6, 10^{12} and 10^{15}. When the full-scale value is exceeded, the energy counter begins again at 0. At the same time the overflow counter is increased by 1 (see Resetting energy counters and overflow counters (Page 48)).

The settings apply to the energy counter of all phases.

Changing properties in RUN

You can change the following properties of energy counters in runtime:

- Enable / disable energy counter
- Reset energy counter
- Set initial values for the energy counter
- Change the mode of the energy counter

Automatic reset of the energy counter

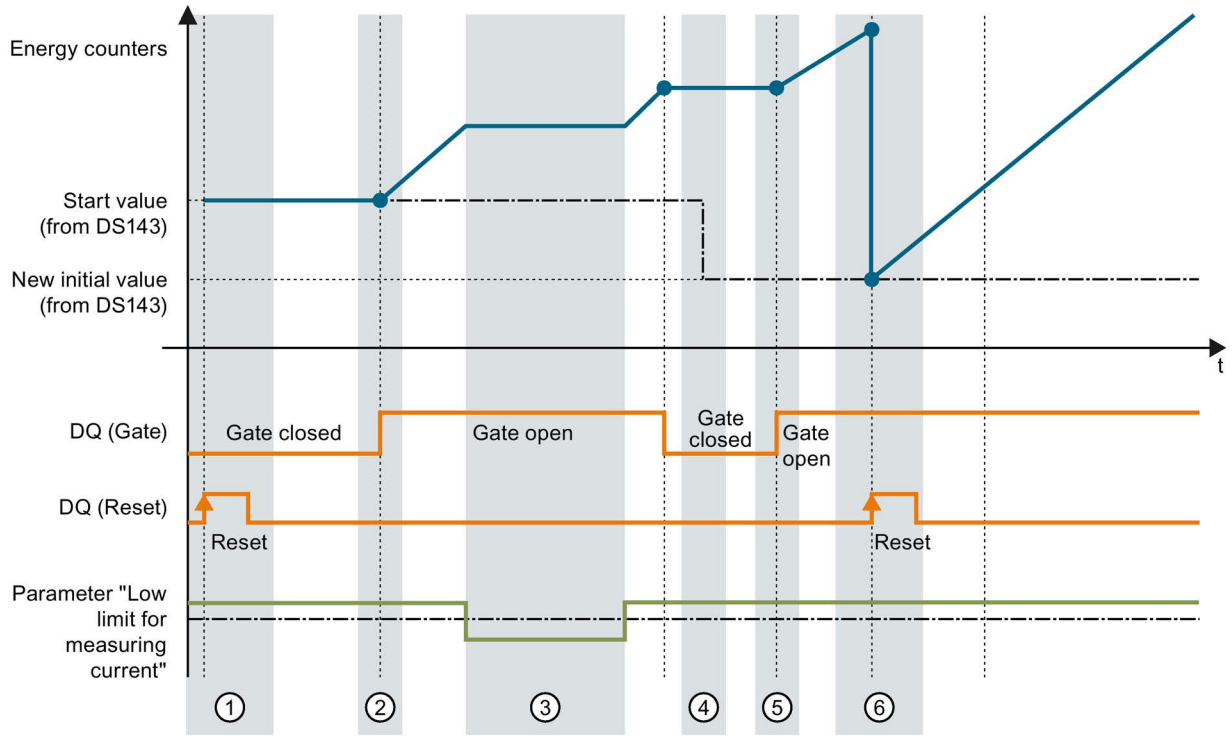
The energy counters are automatically reset to "0" when parameter settings relevant to the energy counter are changed. In the case of phase-specific changing of parameter settings relevant to the energy counter only the energy counters of the respective phases are reset.

Changing of the following parameters results in resetting of the energy counters:

- Measurement type or range
- Current transformer (primary current/secondary current)
- Voltage transformer (primary voltage/secondary voltage)
- Direction of current
- Full-scale value for energy counter
- Mode of the energy counter (infinite / periodic)

Example

The following figure shows the effect of initial value, reset and start/stop parameters with activated gating using the energy counter as an example:



① The counter is reset to the value specified in the configuration. The gate is closed. The counter does not count.

② The gate is opened via the control byte 1 in the output data of the user data variant. The counter counts.

③ The configured current low limit has been violated. The counter does not count.

④ The gate is closed. The counter does not count. A new start value is written to the measured value data record 143 with the WRREC instruction.

⑤ The gate is opened again via the control byte 1 in the output data of the user data variant. The counter counts with the new start value.

⑥ The counter is reset via the control byte 1 in the output data of the user data variant. The counter counts from the new start value that was transferred via the measured value data record 143.

See also

Evaluate energy counter and overflow counter (Page 47)

7.2 Configuring counters

Overview

You can configure the energy counters of the AI Energy Meter 480VAC ST as follows:

- Activate / Deactivate
- Start / stop counters using gate
- Set and reset start value

Energy counter gate

You have the option of starting and stopping the energy counter using the gate. To this purpose you have to:

- Select the "Enable gate control for the energy counter" parameter in the configuration of the AI Energy Meter 480VAC ST.
- Set the DQ bit for the "counter gate" in the user data in Control byte 1 of the output data (Bit 6 in Control byte 1).

The "Enable gate control for the energy counter" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

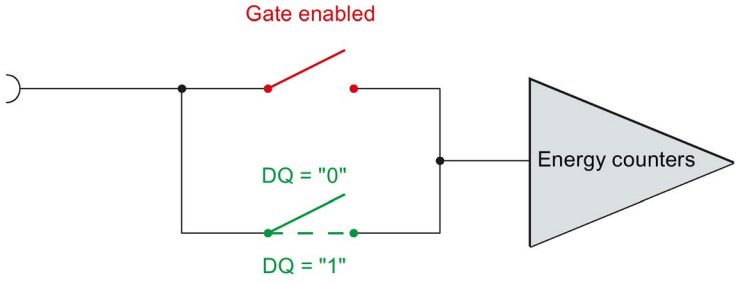


Image 7-1 Gate enabled

If you deselect the "Enable gate control for the energy counter" parameter in the configuration of the AI Energy Meter 480VAC ST, the energy counters operate independently of the DQ bit as long as the current value lies above the configured "Low limit for measuring current".

Gate disabled: Gate is always "open" (signal path closed)

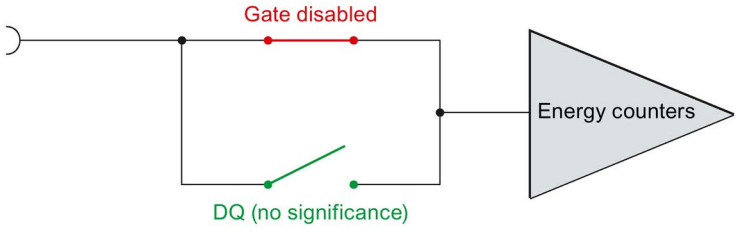


Image 7-2 Gate disabled

Set and reset start value

The counters can be set to their start value via the output data of each user data variant. With energy counters, you have to reset the bit of the energy counter in control byte 2 of the data record 143.

You can reset each energy counter to the start value or also specify a new start value via the data record 143. You define the moment for updating of the start values in the data record 143 and in Control byte 1 in the user data. Start values are either applied immediately or after a reset bit has been set from 0 to 1.

You can find a detailed description for this in section Resetting energy counters and overflow counters (Page 48).

7.3 Evaluate energy counter and overflow counter

Evaluate energy counter and overflow counter

The energy counters are evaluated by

- Using the input data of the user data variants for energy
  - User data variant "Total energy L1 L2 L3" (ID 249 or $F9_H$)
  - User data variant "Energy L1" (ID 248 or $F8_H$)
  - User data variant "Energy L2" (ID 247 or $F7_H$)
  - User data variant "Energy L3" (ID 246 or $F6_H$)
- Using the input data of the user-defined user data variant with the use of the respective measuring value IDs for energy counters
- By reading data records
  - "Data record for basic measured values (DS 142)" for evaluation of the total energies L1 L2 L3.
  - "Data record for energy counter (DS 143)" for evaluation of the phase-specific energy.
  - "Data record for phase-specific measured values L1 - L3 (DS 147 - 149) for evaluation of the phase-specific energies.

The overflow counters are evaluated by:

- Using the input data of the user-defined user data variant with the use of the respective measuring value IDs for overflow counters
- Reading the "Data record for energy counter (DS 143)".

Evaluate measured values

The evaluation of measured values via the input data of user data variants and reading of data records with the RDREC instruction is described in the section Reading and processing measured values (Page 35).

7.4 Resetting energy counters and overflow counters

Introduction

At the beginning of a new work order, it may be useful to reset the energy and overflow counter of the Energy Meters Resetting here means setting the energy counters to their start values and resetting the overflow counters to 0.

The following section describes how you

- Reset energy counters via the outputs of the user data.
- Reset energy counters and overflow counters via data record 143.

See also

Structure for energy counters (DS 143) (Page 55)

7.4.1 Reset energy counters via user data

Introduction

Due to the differing lengths of the output data resetting of the energy counters depends on the configured module version.

If you use module versions with 12 bytes output data, you can

- Reset energy counters for **all** phases separately by active, reactive and apparent energy.
- Reset energy counters for each **individual** phase separately by active, reactive and apparent energy.

If you use the module version with 2 bytes output data, you always reset **all** the energy counters simultaneously. Differentiated resetting of the counters by active, reactive and apparent energy is only possible via data set DS 143 for this module version, see section Resetting energy counters and overflow counters via data record DS 143 (Page 50).

Requirements

Resetting of the energy counters is enabled via user data in the default setting and may not be blocked n Control byte 1 of the data record 143.

Procedure at module version with 12 bytes of output data

1. Set the category of the energy counters (active, reactive, apparent energy) to 1 in Control byte 2 via Bit 0 to 2 (in Byte 1, 6, 8 or 10 of the output data).
2. Set the reset bit (Bit 7) in Control byte 1 from 0 to 1 through an edge change (in Byte 2, 7, 9 or 11 of the output data).

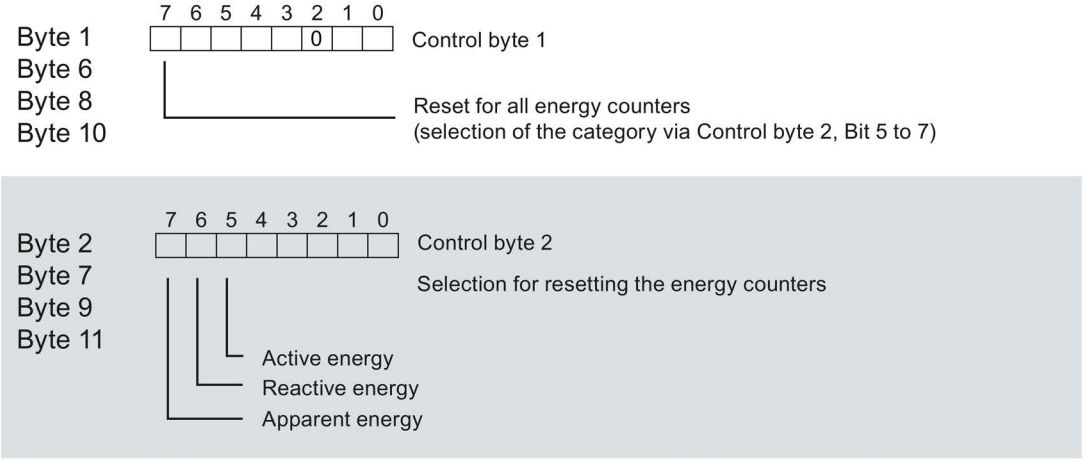


Image 7-3 Resetting the energy counters at module version with 12 bytes of output data

Procedure at module version with 2 bytes of output data

Set the reset bit (Bit 7) in Control byte 1 from 0 to 1 through an edge change.

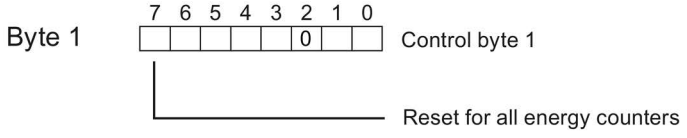


Image 7-4 Resetting the energy counters at module version with 2 bytes of output data

Start values

After the reset the energy counters count with the specified start values (default = 0). You can change the start values for the energy counters via data record DS 143, see section Resetting energy counters and overflow counters via data record DS 143 (Page 50).

7.4.2 Resetting energy counters and overflow counters via data record DS 143

Introduction

At all the module versions you can reset the energy counters and their overflow counters via the data record DS 143. Resetting is possible for:

- Energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Procedure at all module versions via data record DS 143

1. In Control byte 1 of the DS 143 set the reset bit (Bit 2) to 1 and Bit 0 to 1 for the overflow counter.
2. In Control byte 2 of the DS 143 set the category of the energy counters (active, reactive, apparent energy) to 1 via Bits 5 to 7.

3. In Control byte 1 of the DS 143 set Bit 7 for the moment of application of the start values of the desired energy counters:
   - Bit 7 to 0, if the start value are to be applied immediately after the transfer of the data record
   - Bit 7 to 1, if the start value are only to be applied after the reset bit has been set in the output data of the user data.

   In Control byte 1 of the DS 143 set the reset bit (Bit 2) to 1 and Bit 0 to 1 for the overflow counter.

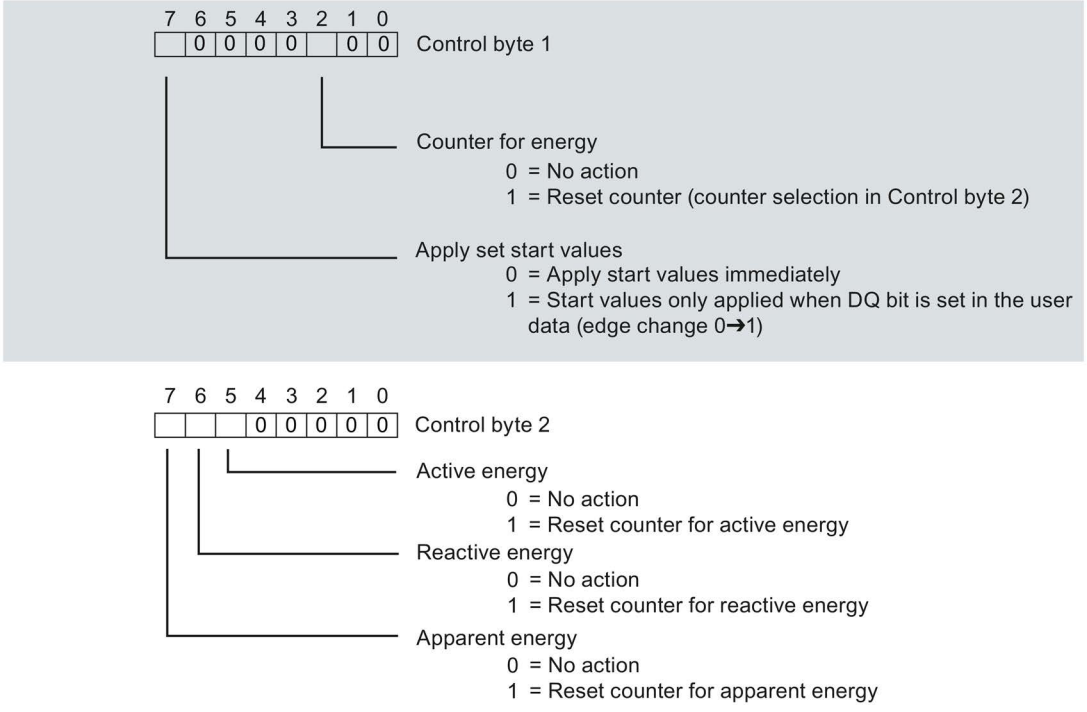


Image 7-5 Energy counter control information DS 143

4. Transfer the data record with the WRREC instruction.

Start values

You specify the moment for the application of the start values in Control byte 1 via Bit 7. After the reset the energy counters count with the specified start values (default = 0) and the overflow counters begin again with 0. You can change the start values for the energy counters via data record DS 143.

7.4.3 Example for energy counters and overflow counters via data record DS 143

Introduction

Before you can transfer the data record DS 143 to the CPU you have to create a user-defined PLC data type in your user program that has an identical structure to data record DS 143.

Procedure

1. Create a PLC data type that has an identical structure to data record DS 143.

   Detailed information on the structure of data record 143 is available in section Structure for energy counters (DS 143) (Page 159).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	See Section Structure for energy counters (DS 143) (Page 159)	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
:	:	:	:	:	:
162...165	Operating hours counter L2 (initial value)	REAL	h	See Section Structure for energy counters (DS 143) (Page 159)	65506
166...169	Operating hours counter L3 (initial value)	REAL	h		65507

2. Create a user-defined PLC data type and allocate the values of the data record in a DB or instance DB.

   Byte 0 and byte 1:

   Enter the value 01_H in Byte 0 and the value 00_H to Byte 1.

   Byte 2 ... byte 7: Control bytes for energy and overflow counter

   In the control byte for the respective phases, specify which energy and overflow counters you want to reset.

   The control bytes specify for each phase (L1, L2, L3) separately if and which energy meter values are to be reset.

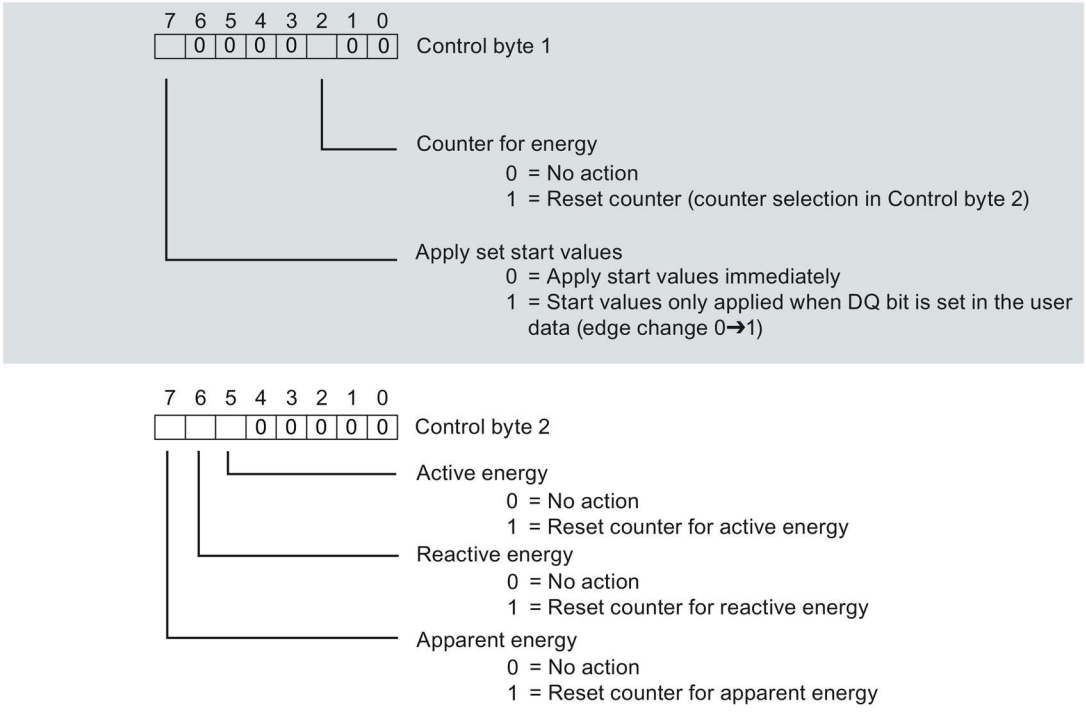


Image 7-6 Control information DS 143 for energy and overflow counter

Byte 8 ... byte 127: Start values for the individual energy meters

The start values for energy counters in data record 143 are 64-bit floating point numbers. This corresponds to the data type LREAL in S7-1200 and in S7-1500.

Byte 128 ... byte 157: Initial values for overflow counters

The initial values for overflow counters in data record 143 are 16-bit integers. This corresponds to the data type UINT in S7-1200 and in S7-1500.

3. Write the data record to the AI Energy Meter 480VAC ST module using the "WRREC" instruction.

   The input parameters must be allocated as follows:

   – REQ: A new write job is triggered if REQ = TRUE.
   – ID: Hardware identifier or start address of the Energy Meter (depending on the CPU used).
   – INDEX: The data record number: 143
   – LEN: The maximum length of the data record: 170
   – RECORD: A pointer to the data area in the CPU which includes data record 143.

   Note

   If you want to write or read several AI Energy Meter 480VAC ST at the same time, keep in mind the maximum number of active jobs in communication with SFB52/SFB53.

See also

Structure for energy counters (DS 143) (Page 55)

7.5 Data record for energy counter (DS 143)

7.5.1 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy counter to user-specific value (e.g. "0")
- Reading the current values of the energy counters
- Reading the overflow counters
- Reading the operating hours

Energy meter data record 143

Table 7- 1 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Status / control byte 1 - L1	BYTE	Bit string	-	-
3	Status / control byte 2 - L1	BYTE	Bit string		
4	Status / control byte 1 - L2	BYTE	Bit string		
5	Status / control byte 2 - L2	BYTE	Bit string		
6	Status / control byte 1 - L3	BYTE	Bit string		
7	Status / control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: 0.0...1.8 x 10^{308} During writing For continuous counting: 0.0...3.4 x 10^{12} During writing For periodic counting: 0...configured full-scale value (10^3 ...10^{15})	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204
88...95	Active energy inflow (initial value) L3	LREAL	Wh		61220
96...103	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...111	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...119	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...127	Apparent energy (initial value) L3	LREAL	VAh		61224

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
128...129	Overflow counter active energy inflow L1	UINT	-	During reading: 0...65535 During writing for continuous counting: 0 During writing for periodic counting: 0...65500	61190
130..131	Overflow counter active energy outflow L1	UINT	-		61191
132...133	Overflow counter reactive energy inflow L1	UINT	-		61192
134...135	Overflow counter reactive energy outflow L1	UINT	-		61193
136...137	Overflow counter apparent energy L1	UINT	-		61194
138...139	Overflow counter active energy inflow L2	UINT	-		61210
140...141	Overflow counter active energy outflow L2	UINT	-		61211
142...143	Overflow counter reactive energy inflow L2	UINT	-		61212
144...145	Overflow counter reactive energy outflow L2	UINT	-		61213
146...147	Overflow counter apparent energy L2	UINT	-		61214
148...149	Overflow counter active energy inflow L3	UINT	-		61230
150...151	Overflow counter active energy outflow L3	UINT	-		61231
152...153	Overflow counter reactive energy inflow L3	UINT	-		61232
154...155	Overflow counter reactive energy outflow L3	UINT	-		61233
156...157	Overflow counter apparent energy L3	UINT	-		61234
158...161	Operating hours counter L1 (initial value)	REAL	h	During reading: 0...3.4x10^{38} During writing: 0...10^{9}	65505
162...165	Operating hours counter L2 (initial value)	REAL	h		65506
166...169	Operating hours counter L3 (initial value)	REAL	h		65507

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

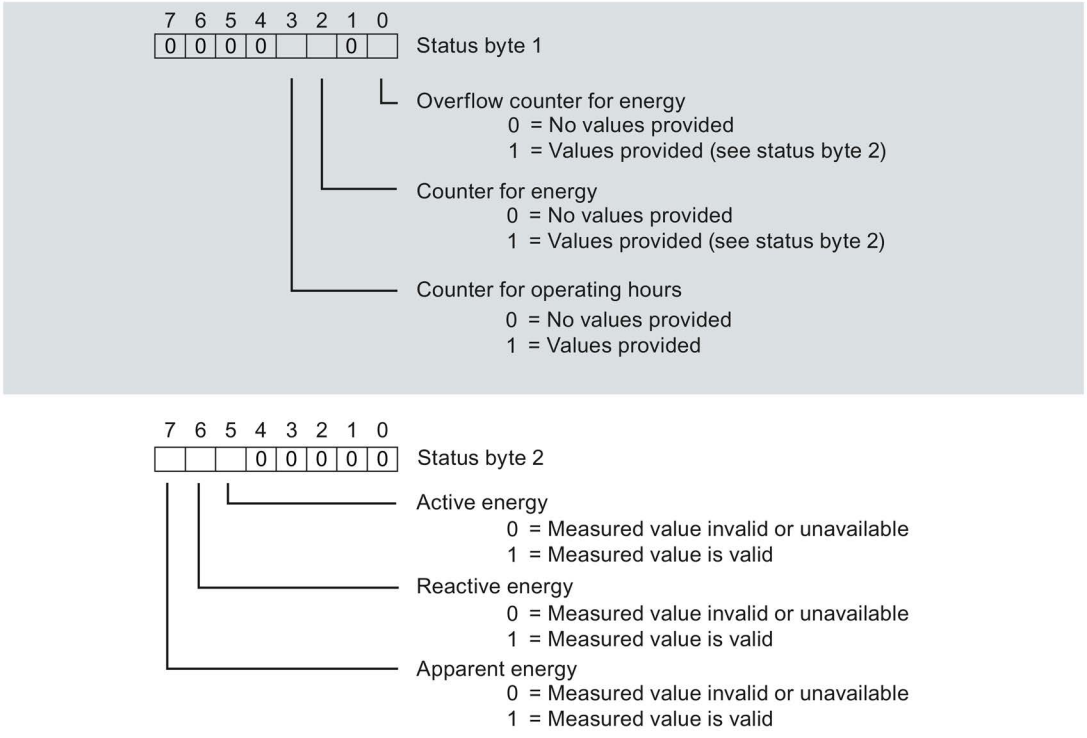


Image 7-7 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters, overflow counters and operating hours counter. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to reset and the time at which counters are reset.
- In Control byte 2 you determine which energy counters and which overflow counters you want to reset.

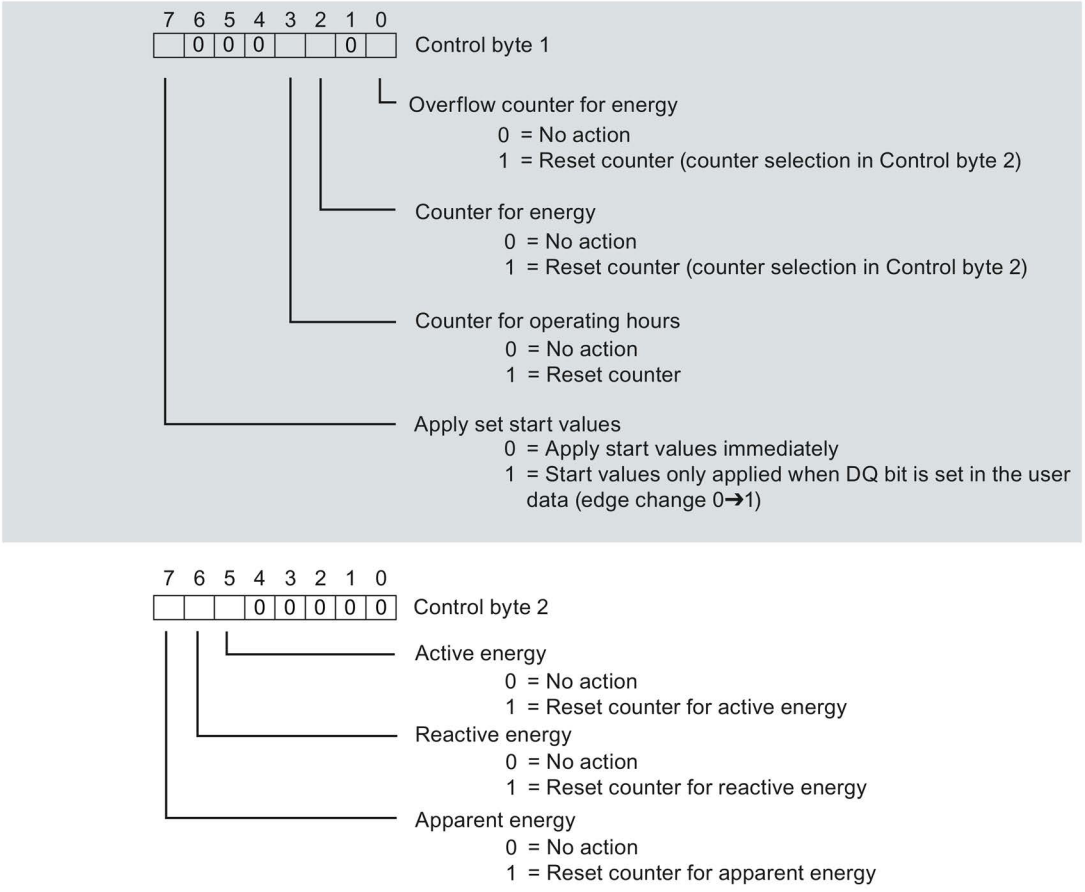


Image 7-8 Control information DS 143 (write access)

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

7.5.2 Structure of the control and feedback interface for DS 143

Introduction

Bytes 2 to 7 of data record 143 form the phase-based control and feedback interface for the measured value data record of the energy counter.

- Bytes 2 and 3: Control and feedback interface for phase 1
- Bytes 4 and 5: Control and feedback interface for phase 2
- Bytes 6 and 7: Control and feedback interface for phase 3

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

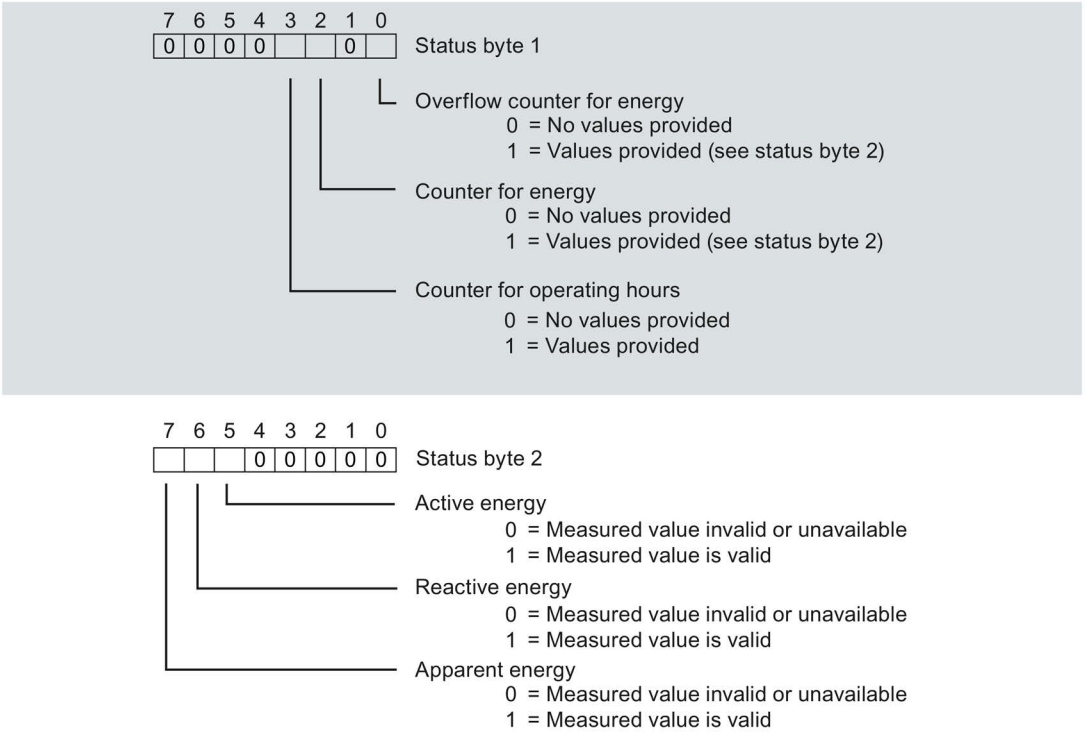


Image 7-9 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters, overflow counters and operating hours counter. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to reset and the time at which counters are reset.
- In Control byte 2 you determine which energy counters and which overflow counters you want to reset.

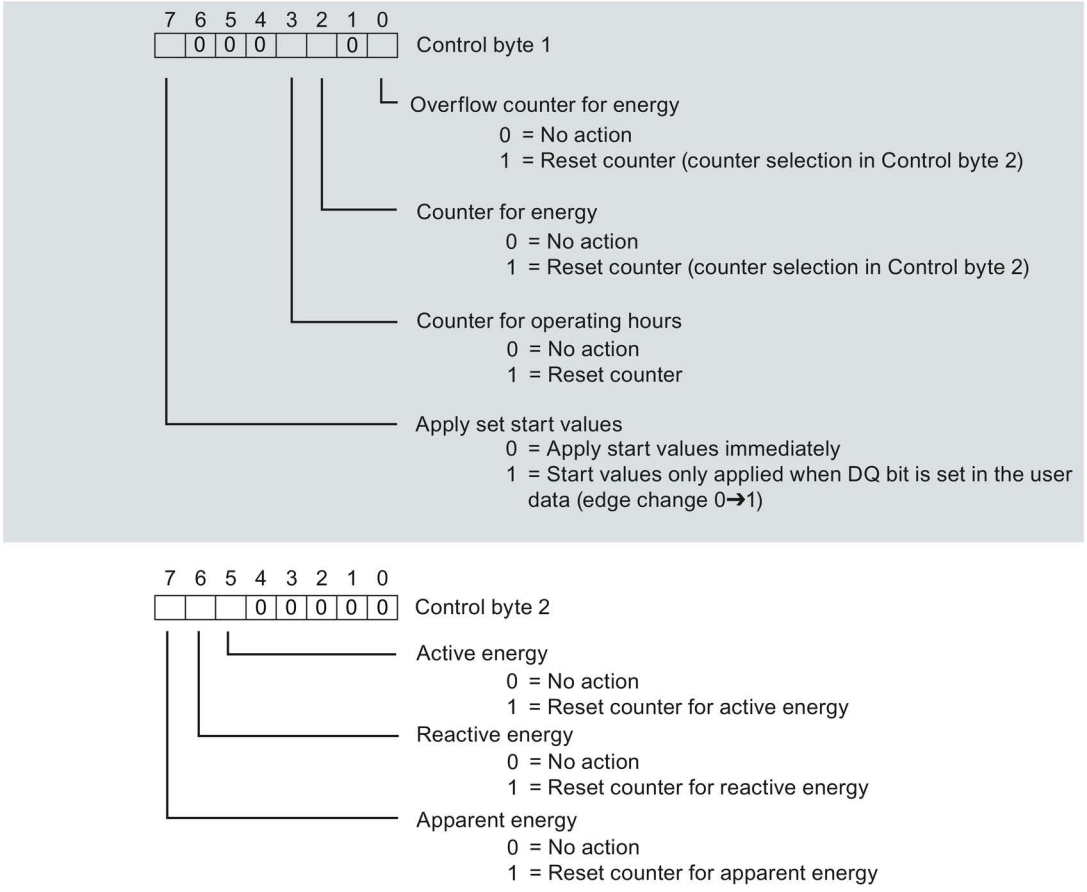


Image 7-10 Control information DS 143 (write access)

Operating hours counter

8

8.1 How the operating hours counter works

Introduction

The AI Energy Meter 480VAC ST provides one operating hours counter for each phase, which counts the operating hours of the load connected to a phase when there is current greater than the configurable "Low limit for measuring current". The operating hours counter for the entire module is calculated from the sum of the operating hours of the individual phases. The operating hours counter has a value range from 0 to 3.4 x 10^{38}. The values are stored retentively in the module and can be read via the data record 143 (energy counter data record) and data record 150 (measured value for extended measuring and status values).

Configuring

You configure the following operating hours counter settings in STEP 7:

- Activation of the gate for the operating hours counter

Changing properties in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Open / close operating hours counter [1]	Closed	Module version starting at 2 bytes of output data
Set initial value	0	Data record 143
Reset operating hours counter	0	Module version starting at 2 bytes of output data [2]

[1] Effective only with enabled gate

[2] Only module-wide resetting is supported in module version "2 I / 2 Q".

See also

Resetting energy counters and overflow counters (Page 48)

Module version "2 I / 2 Q" (Page 122)

Structure for energy counters (DS 143) (Page 159)

Measured value data record for advanced measurement and status values (DS 150) (Page 170)

8.2 Reset operating hours counters

Introduction

At the beginning of a new work order, it may be useful to reset the operating hours counters of the Energy Meter. Resetting here means that the operating hours counters are reset to their start value.

The following section describes how you

- Reset operating hours counters via the outputs of the user data.
- Reset operating hours counters via data record 143.

8.2.1 Reset operating hours counters via user data

Introduction

Due to the differing lengths of the output data resetting of the operating hours counters depends on the configured module version.

If you use module versions with 12 bytes output data, you can

- Reset operating hours counters for **all** phases.
- Reset operating hours counters for each **individual** phase.

If you use the module version with 2 bytes output data, you always reset **all** the operating hours counters simultaneously. Differentiated resetting of the counters by phases is only possible via data set DS 143 for this module version, see section Structure for energy counters (DS 143) (Page 159).

Procedure at module version with 12 bytes of output data

Set the reset bit (Bit 5) in Control byte 1 from 0 to 1 through an edge change.

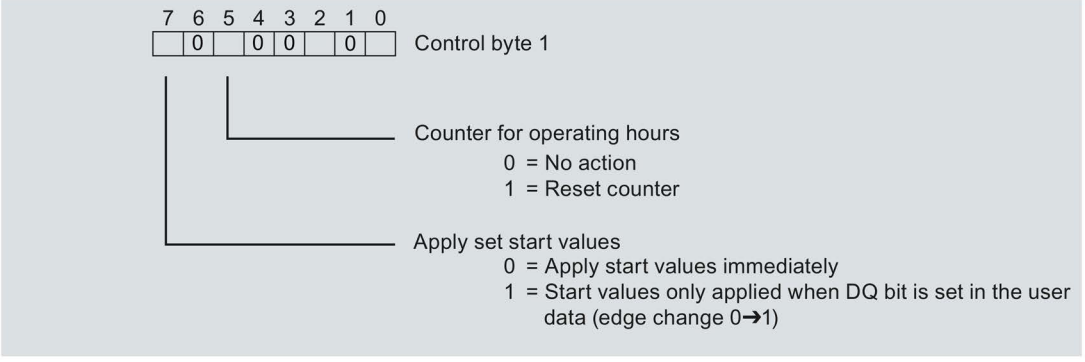


Image 8-1 Resetting the operating hours counters at module version with 12 bytes of output data

Procedure at module version with 2 bytes of output data

Set the reset bit (Bit 5) in Control byte 1 from 0 to 1 through an edge change.

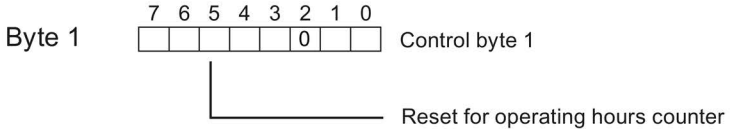


Image 8-2 Resetting the operating hours counters at module version with 2 bytes of output data

Start values

After the reset the operating hours counters count with the specified start values (default = 0). You can change the start values for the operating hours counters via data record DS 143, see section Structure for energy counters (DS 143) (Page 159).

8.2.2 Resetting operating hours counters via data record DS 143

Introduction

At all the module versions you can reset the operating hours counters via the data record DS 143. Resetting is possible for:

- Operating hours counters for each **individual** phase.

Procedure at all module versions via data record DS 143

1. Set the reset bit (Bit 3) in Control byte 1 to 1.
2. In Control byte 1 set Bit 7 for the moment of application of the start values:
   - Bit 7 to 0, if the start value are to be applied immediately after the transfer of the data record
   - Bit 7 to 1, if the start value are only to be applied after the reset bit has been set in the output data of the user data.

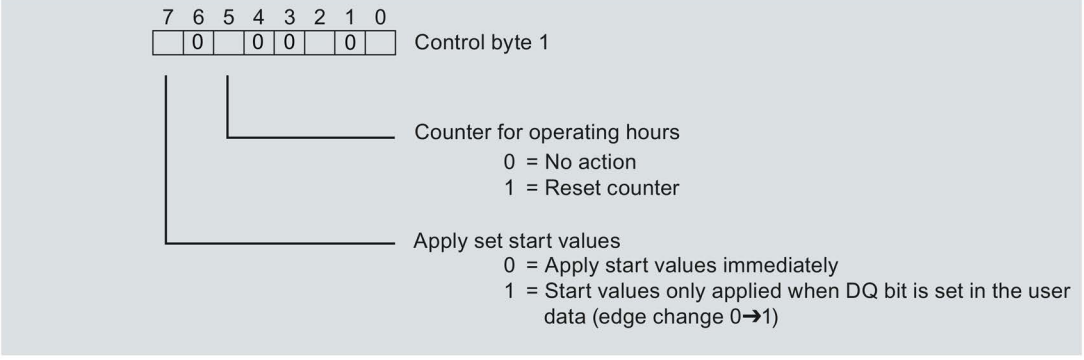


Image 8-3 Operating hours counter control information DS 143

Start values

You specify the moment for the application of the start values in Control byte 1 via Bit 7. After the reset the operating hours counters count with the specified start values (default = 0). You can change the start values for the operating hours counters via data record DS 143.

Limit monitoring

9

9.1 How limit monitoring works

Introduction

The AI Energy Meter 480VAC ST supports monitoring of parameterizable low **or** high limits for up to 16 analog measured or calculated variables.

You can also define multiple limits for each measured or calculated variable, in order to define a high or low value range.

The measured value data record 150 returns the current status limit violations and per limit one counter that displays the number of limit violations. In addition, a hardware interrupt may be generated for each limit violation.

The status of the limit violations can also be evaluated in the user data variant 240 ($F0_H$) or via the user-defined user data variant via the measured value ID 65509.

Benefits

With activated limit monitoring you can already detect any irregularities in the measured value acquisition already in field level.

Retentivity

All the counter states of the module are stored retentively in the Energy Meter. After an interruption (e.g. Power System Off → Power System On), the counting resumes with the retentively stored values.

Configuring

You configure the following limit monitoring settings in STEP 7:

- Measured variable that is to be monitored.
- Activate / Deactivate limit monitoring.
- High or low limit values.
- Delay time and hysteresis for each limit.
- Activate / Deactivate hardware interrupts at limit violation.
- Measured value that is subject to limit monitoring.

Hardware interrupt at a limit violation

The hardware interrupt provides the following information:

- Measured value ID of the monitored measured or calculated variable
- Number of the limit (0 = Limit 1. 15 = Limit 16)
- Information on whether limit was exceeded or fallen below

For more detailed information, refer to section Hardware interrupts (Page 87).

Changing properties in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Enable/disable monitoring per limit[1]	Disabled	Module version with 12 bytes of output data
Reset number of total limit violations	0	Module version starting at 2 bytes of output data

[1] Effective only with enabled gate

9.2 Influence of hysteresis and delay time on limit monitoring

Delay time and hysteresis

In order to prevent the triggering of limit violations with small fluctuations, you have the following configuration options in STEP 7:

- Delay time in seconds (0 to 10 s)

  With the delay time, you filter faults and thereby prevent limit value monitoring from triggering too frequently. The limit violation is counted only when the limit violation is present for longer than the configured delay time. The deceleration time is also taken into consideration during outgoing of the limit violation.

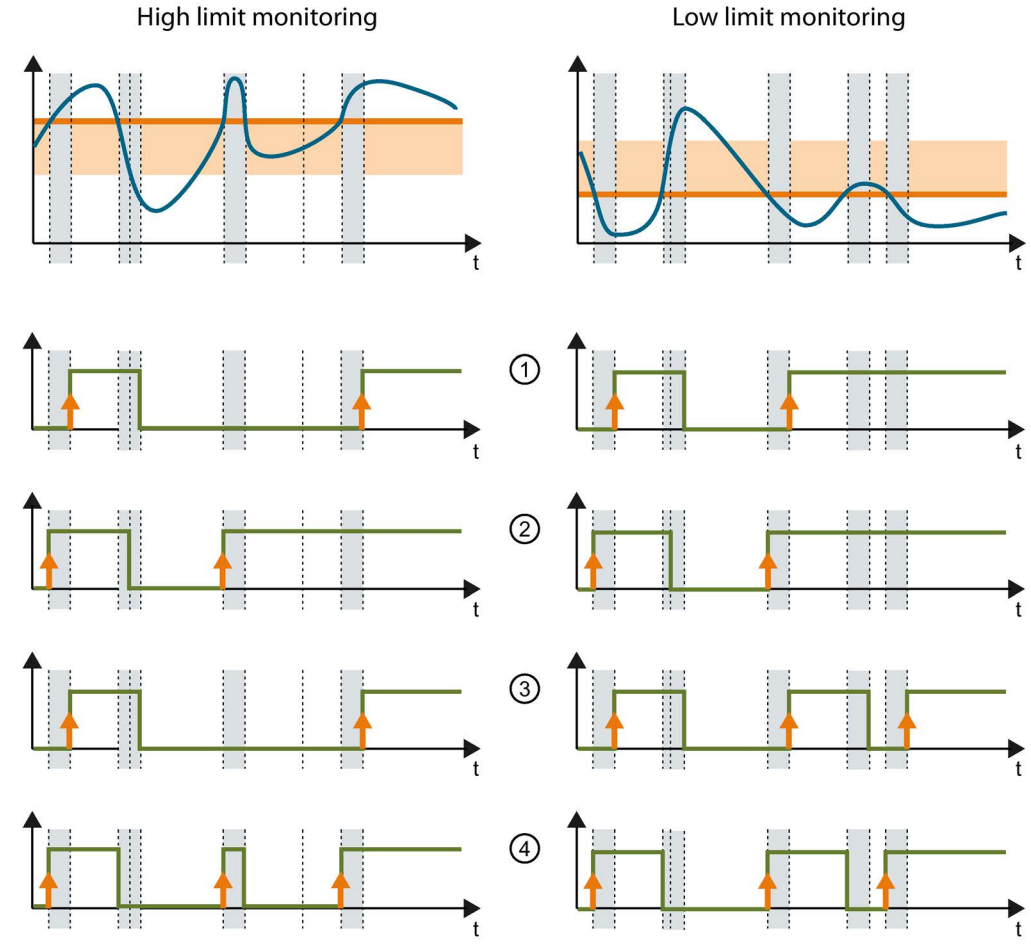
- Hysteresis as a percentage (0 to 20%)

  With the hysteresis, you suppress fluctuations around the limit. The hysteresis is a tolerance range that you define as a percentage deviation of the configured limit. The limit violation is considered to be corrected only when the monitored value leaves the tolerance range.

Note

You can get information about transient underflow and overflow from the calculation of minimum (Page 165) and maximum values (Page 164) of selected measured variables.

The following figure shows the value-over-time for two measured values using the example of a high and low limit as well as the influence of hysteresis and delay time on the counting of the limit violations.



- Configured limit.
- Configured delay time. Is taken into consideration during coming and going.
- Hysteresis range. Only considered for outgoing.
- Value-over-time for which the limit is monitored.
- Edge change. Counter for limit violations is incremented by 1. If parameterized, a hardware interrupt is triggered.
- Signal wave
- ① Limit monitoring with hysteresis and delay time
- ② Limit monitoring with hysteresis, but without delay time
- ③ Limit monitoring without hysteresis, but with delay time
- ④ Limit monitoring without hysteresis and delay time

Image 9-1 Influence of hysteresis and delay time on the limit

See also

How limit monitoring works (Page 66)

Minimum and maximum values (Page 71)

9.3 Reset, activate and deactivate counters for limit violation

Introduction

At the beginning of a new work order, it may be useful to reset or also activate / deactivate the counters for limit violations of the Energy Meter.

Resetting here means that the counters for limit violations are reset to 0.

Due to the differing lengths of the output data resetting of the counters for limit violations depends on the configured module version.

Resetting at module version with 12 bytes of output data

1. Select the counters for limit violations that you want to reset in Control bytes 3 and 4.
2. Set the reset bit (Bit 3) in Control byte 1 from 0 to 1 through an edge change.

Resetting at module version with 2 bytes of output data

Set the reset bit (Bit 3) in Control byte 1 from 0 to 1 through an edge change. Resetting acts globally on all the configured counters for limit violation.

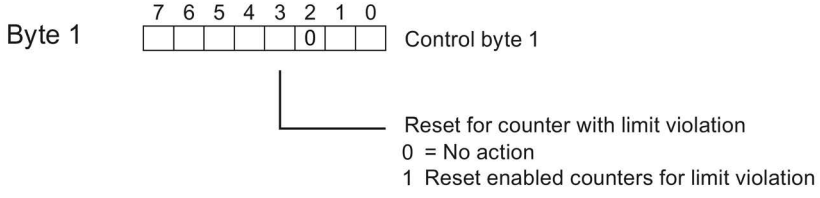


Image 9-2 Resetting of the counters for limit violations

Activating / Deactivating counters for limit violations

Activating / Deactivating of the counters for limit violations is only possible for module versions with 12 bytes of output data.

Requirements: "Gate for limit value monitoring" was parameterized during configuration of the module using STEP 7 or by writing the data record DS 128.

Select the counters for limit violations that you want to activate / deactivate in Control bytes 3 and 4.

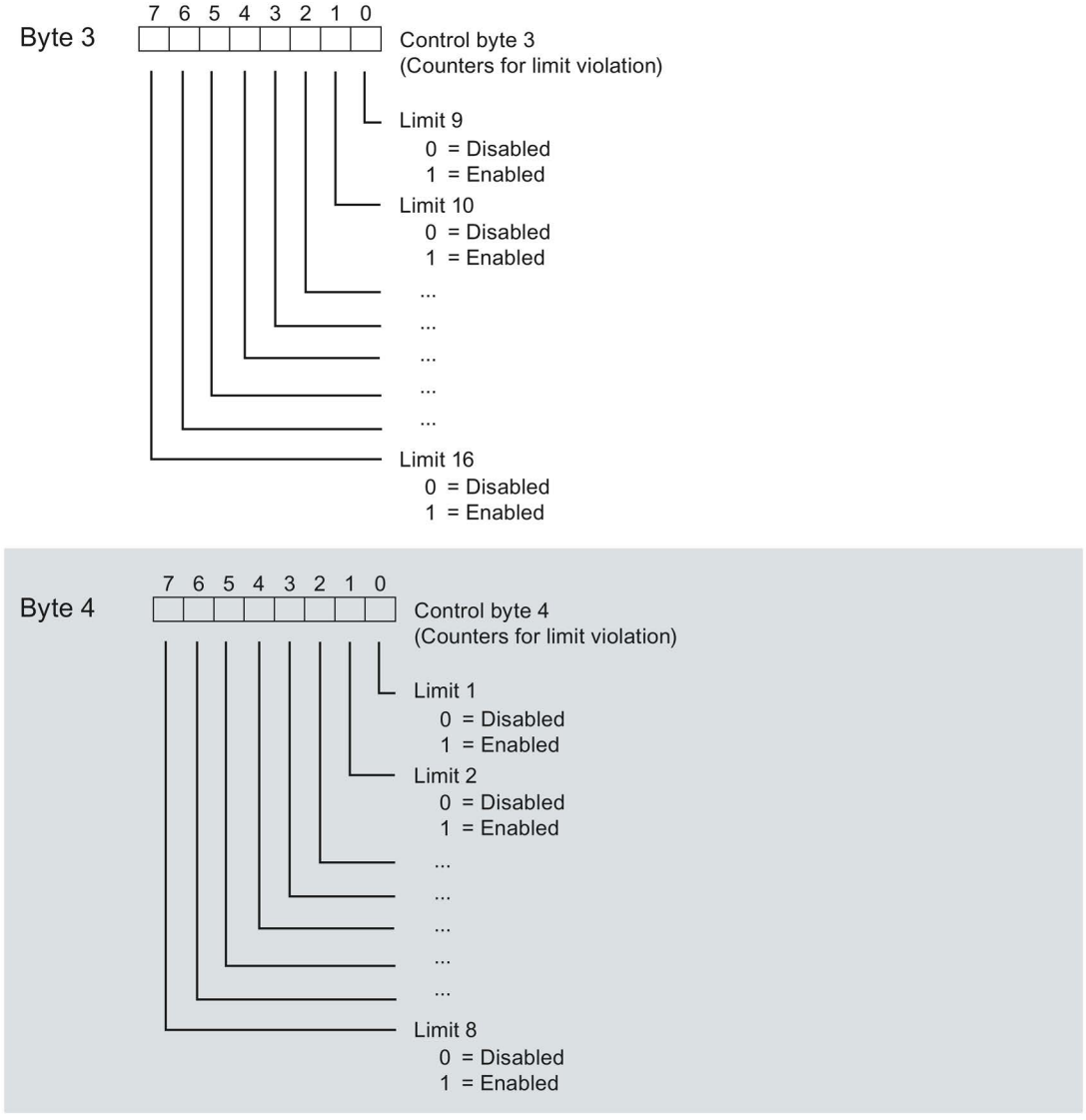


Image 9-3 Activating / deactivating of the counters for limit violations

Minimum and maximum values 10

10.1 Minimum and maximum values

Introduction

The AI Energy Meter 480VAC ST determines the respective highest and lowest measured or calculated value for a series of measured and calculated values. The values are stored retentively in the module and can be read using measured value data records 144 and 145.

Benefits

Using the stored minimum and maximum values, for example, you can detect further irregularities in addition to limit monitoring.

Calculation of minimum and maximum values

Minimum and maximum values are only calculated for the phases in accordance with the configured connection type. Existing minimum and maximum values that have not been calculated are initialized with 0. If faults such as under or overcurrent occur during operation, new minimum and maximum values are calculated.

The measured and calculated values are initialized as follows during commissioning of the AI Energy Meter 480VAC ST so that the first calculation of minimum and maximum values supplies a plausible result:

- Maximum values for measured and calculated values: Minimum values
- Minimum values for measured and calculated values: Maximum values

Configuring

You configure the following settings in STEP 7:

- Enable calculation of minimum and maximum values

Changing properties in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Reset saved maximum values	0	Module version starting at 2 bytes of output data
Reset saved minimum values	0	Module version starting at 2 bytes of output data

Note

Automatic reset

If you change the parameters for current or voltage transformers, the minimum and maximum values are reset automatically to their initial values.

10.2 Resetting minimum and maximum values

Description

At the beginning of a new work order, it may be useful to reset the minimum and maximum values of the Energy Meter. Resetting means that the minimum and maximum values are reset to their initial values. Initial values are described, see section Measured value data record for maximum values (DS 144) (Page 164) and section Measured value data record for minimum values (DS 145) (Page 165).

Due to the differing lengths of the output data resetting of the minimum and maximum values depends on the configured module version. If you use module versions with 12 bytes output data, you can

- Reset the minimum and maximum values for **all** phases.
- Reset minimum and maximum values for each **individual** phase.

If you use the module version with 2 bytes output data, you always reset all the minimum and maximum values simultaneously.

Procedure at module version with 12 bytes of output data

1. Set the category of the measured values to 1 in Control byte 2 via Bit 0 to 4 in the output data.
2. Set the reset bit (Bit 0 or Bit 1) in Control byte 1 of the output data from 0 to 1 through an edge change in the output data.

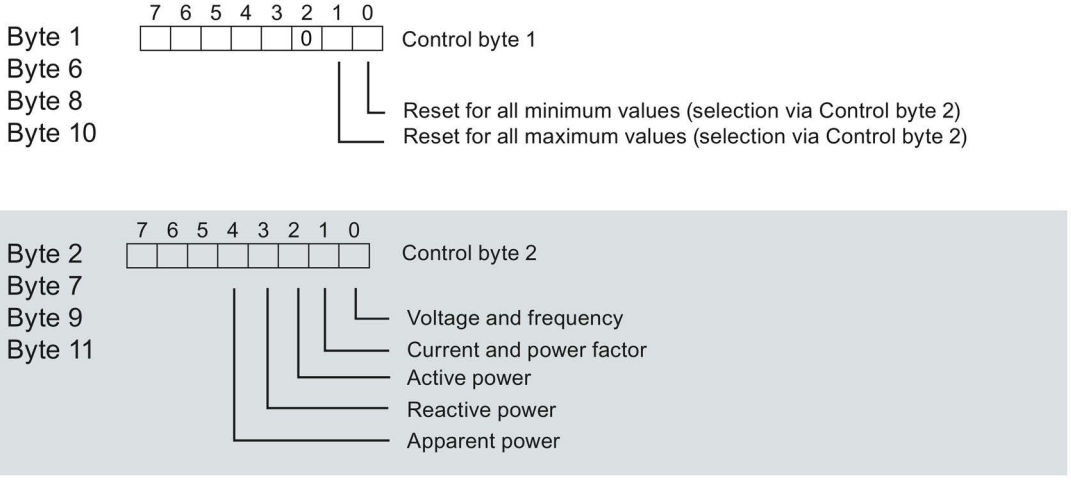


Image 10-1 Resetting the minimum and maximum values at module version with 12 bytes of output data

Procedure at module version with 2 bytes of output data

Set the reset bit (Bit 0 or Bit 1) in Control byte 1 from 0 to 1 through an edge change.

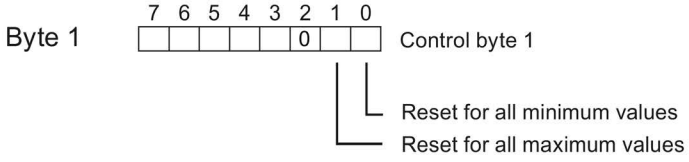


Image 10-2 Resetting the minimum and maximum values at module version with 2 bytes of output data

Phase-based measured values 11

11.1 Phase-based measured values

Introduction

The AI Energy Meter 480VAC ST makes the measured values of individual phases available.

- Through the user data variants
  - Phase-specific measurement Phase L1 with user data variants 154 ($9A_H$) and 155 ($9B_H$)
  - Phase-specific measurement Phase L2 with user data variants 156 ($9C_H$) and 157 ($9D_H$)
  - Phase-specific measurement Phase L3 with user data variants 158 ($9E_H$) and 159 ($9F_H$)
- Via measured value data records
  - Phase-specific measurement for the phases L1, L2 and L3 with data record 142
  - Phase-specific measurement for phase L1 with data record 147
  - Phase-specific measurement for phase L2 with data record 148
  - Phase-specific measurement for phase L3 with data record 149

User data variants

Through the user data variants 154 ($9A_H$) to 159 ($9F_H$) you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor

You can find the structure of the user data variants in section Measured value data record for phase-based measured values L1 (DS 147) (Page 166).

Measured value data records

Through the measured value data records DS 142, DS 147, DS 148 and DS 149 you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Minimum current and minimum voltage
- Maximum current and maximum voltage
- Active, reactive and apparent power
- Minimum active, reactive and apparent power
- Maximum active, reactive and apparent power
- Active, reactive and apparent energy
- Minimum active, reactive and apparent energy
- Maximum active, reactive and apparent energy
- Power factor
- Minimum power factor
- Maximum power factor

You can find the structure of the measured value data records in section Measured value data record for phase-based measured values L1 (DS 147) (Page 166).

See also

Measured value data record for phase-based measured values L2 (DS 148) (Page 167)

Measured value data record for phase-based measured values L3 (DS 149) (Page 169)

Minimum and maximum values (Page 71)

User data variants with 32 bytes input data / 12 bytes output data (Page 135)

Overview of all measured value data records (Page 155)

Parameters 12

12.1 Parameters

Parameters of the AI Energy Meter 480VAC ST (DS 128, DS 129, DS 130)

As a rule the AI Energy Meter 480VAC ST is already integrated in the hardware catalog of STEP 7 (TIA Portal) or STEP 7 V5.5 or higher. In this case STEP 7 (TIA Portal) or STEP 7 V5.5 or higher checks the parameterized properties for plausibility during designing.

However, you can also assign parameters to the module by means of the GSD file and the configuration software of any provider. The module does not check the validity of the parameterized properties until after the configuration has been loaded. Note that some parameters depend on the selected connection type of the Energy Meter. For example in the connection type 1P2W for measurements in single-phase AC network it does not make sense to enter parameters for Phases 2 and 3 and they are also not checked by the system in this case.

The effective range of the parameters that can be set using a GSD file depends on the type of bus system used:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition you can change the parameterized properties via the user program in RUN mode. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records (refer to the appendix Configuration via parameter data records (Page 97)). The following table summarizes all the configurable parameters.

Table 12- 1 AI Energy Meter 480VAC ST parameters

Parameters	Value range	Default setting	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics line voltage	• Disable • Enable	Disable	Yes	Module	Module

Parameters	Value range	Default setting	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Connection type	• Disabled • 1P2W - 1-phase alternating current • 3x1P2W - 3x1 phase, 2 conductors each • 2P3W - 2 phases, 3 conductors • 3P4W - 3 phases, 4 conductors • 3P4W1 - 3 phases, 4 conductors, balanced load	3P4W - 3 phases, 4 conductors	Yes	Module	Module (only 1P2W, 3P4W, 3P4W1 and deactivated)
Voltage measuring range	• 100 V • 110 V • 115 V • 120 V • 127 V • 190 V • 200 V • 208 V • 220 V • 230 V • 240 V • 277 V	230 V	Yes	Module	Module
Line voltage tolerance [%]	• 1 ... 50 %	10 %	Yes	Module	Module
Line frequency	• 50 Hz • 60 Hz	50 Hz	Yes	Module	Module
Enable gate energy counter	• No • Yes	No	Yes	Module	-

Parameters	Value range	Default setting	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Full-scale value for energy counter	• No full-scale value - infinite counting • 10^3 - count periodically • 10^6 - count periodically • 10^9 - count periodically • 10^{12} - count periodically • 10^{15} - count periodically	No full-scale value - infinite counting	Yes	Module	- (Default setting. No full-scale value - infinite counting)
User data variant	See the table Overview of the user data variants (Page 135)	Total energy L1 L2 L3 (ID 254 or FE_H)	Yes	Module	Module (only user data variant FE_H, FA_H, $F9_H$, $F8_H$, $9F_H$, $F5_H$, 80_H)
Minimum and maximum value calculation	• Disable • Enable	Disable	Yes	Module	- (Default setting: Disable)
Diagnostics overflow current	• Disable • Enable	Disable	Yes	Channel/phase	Module
Diagnostics overflow voltage	• Disable • Enable	Disable	Yes	Channel/phase	Module
Diagnostics underflow voltage	• Disable • Enable	Disable	Yes	Channel/phase	Module
Diagnostics low limit voltage	• Disable • Enable	Disable	Yes	Channel/phase	- (blocking is preset)
Diagnostics overflow cumulative values	• Disable • Enable	Disable	Yes	Channel/phase	Module
Overcurrent tolerance factor [0.1 A]	• 10 ... 100 [0.1 A]	100 [0.1 A]	Yes	Channel/phase	Module
Overcurrent tolerance time [ms]	• 1 ... 60000 ms	40000 ms	Yes	Channel/phase	Module
Low limit for current measurement [mA]	• 2 ... 250 mA	50 mA	Yes	Channel/phase	- (Default setting: 2 mA)
Operating hours counter	• Disable • Enable	Disable	Yes	Channel/phase	- (Default setting: Disable)

Parameters	Value range	Default setting	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Enable gate of operating hours counter	• No • Yes	No	Yes	Channel/phase	-
Current transformer primary current [A]	• 1 ... 99999 A	1 A	Yes	Channel/phase	Module (Value range: 1...65535)
Current transformer secondary current	• 1 A • 5 A	1 A	Yes	Channel/phase	Module
Voltage transformer primary voltage [V]	• 1 ... 999999 V	230 V	Yes	Channel/phase	Module
Voltage transformer secondary voltage [V]	• 1 ... 500 V	230 V	Yes	Channel/phase	- (same value as Voltage measuring range parameter)
Reverse current direction	• Disable • Enable	Disable	Yes	Channel/phase	Module
Number of limits	• 0 ... 16	0	Yes	Module	-
Limit monitoring for limit	• Disable • Enable	Disable	Yes	Module	-
Measured variable for limit	• Measured value ID, see Table B-1	None	Yes	Limit	-
Gate for limit via DQ	• Disable • Enable	Disable	Yes	Channel/phase	-
Hardware interrupt for limit	• Disable • Enable	Disable	Yes	Channel/phase	-
Limit	• depending on the selected measured variable	0	Yes	Limit	-
Type of limit	• High limit • Low limit	High limit	Yes	Channel/phase	-
Hysteresis for limit monitoring [%]	• 0 ... 200 [0.1%]	0%	Yes	Channel/phase	-
Delay time for limit monitoring [s]	• 0 ... 10 s	0 s	Yes	Channel/phase	-
Number of measured values for user data mapping	• 0 ... 64	0	Yes	Module	- (no user data mapping)
Measured variable	• Measured value ID, see Table B-1	None	Yes	Measured variable	- (no user data mapping)

12.2 Description of parameters

Hardware interrupt

Enable the hardware interrupt for the entire module here.

Diagnostics line voltage

Activate the diagnostics line voltage here. If there is no voltage or too little voltage at L1, the message "No supply voltage at L1" is output and a diagnostic interrupt is triggered.

Connection type

Specify the connection type you used for the Energy Meter here.

For more detailed information, refer to "Connection examples (Page 18)".

Voltage measuring range

Here you can set the voltage measuring range of the power supply system.

Line voltage tolerance

Monitoring the supply voltage based on this tolerance band is a positive or negative value.

Line frequency

Here you can set the line frequency of the power supply system.

Enable gate energy counter

Enable the gate for the energy counter here. When the gate is enabled, the energy counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Full-scale value for energy counter

Select here the full-scale value for the periodic counting of the energy counter. You can also specify that the energy counter is to count without a full-scale value (infinite counting). The calculated energy counter values are stored retentively in the module.

User data variant

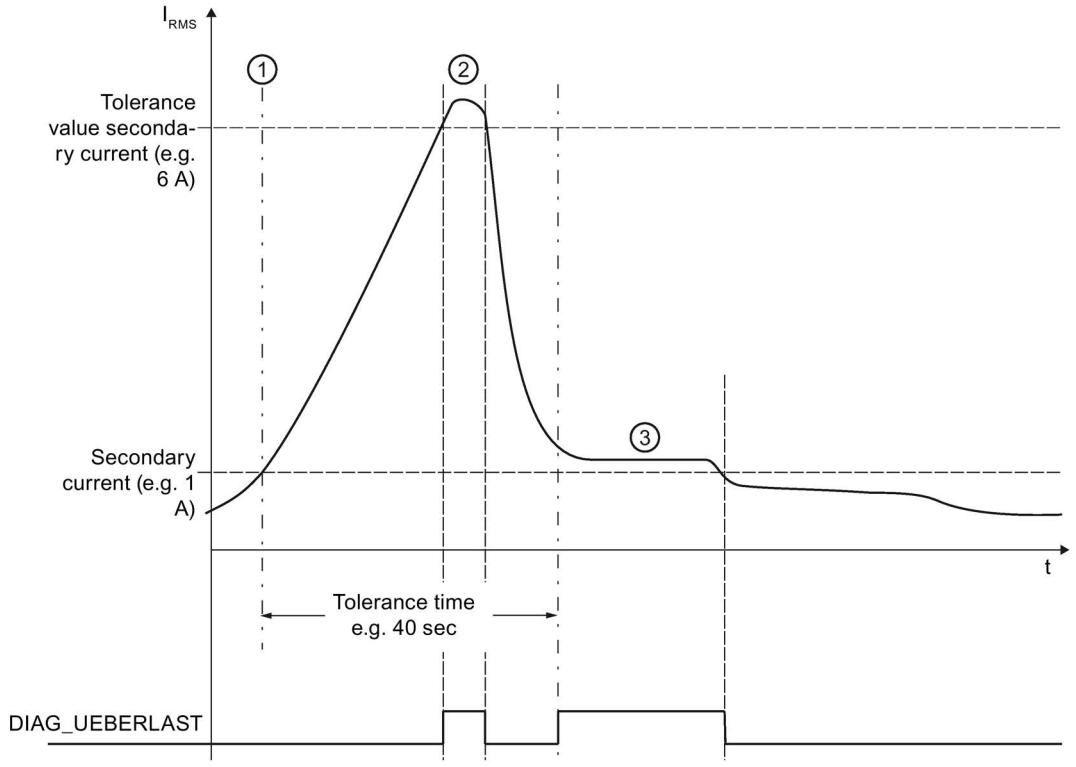
Select here the user data variant with which the module is to operate once it is switched on.

Minimum and maximum value calculation

Enable calculation of the minimum and maximum values here. The minimum and maximum value are calculated from the start of the measurement. The calculated values are stored retentively in the Energy Meter.

Diagnostics overflow current

The measured current is monitored after expiration of the "Tolerance time" for "Measured current x 0.1 x Tolerance factor". A violation results in a current overflow.



① The tolerance time starts as soon as the secondary current value (1 A, 5 A) is exceeded.

② DIAG_UEBERLAST diagnoses the affected phase if the tolerance value of the secondary current has been exceeded within the assigned tolerance time (or the maximum value of the secondary current (10 A) is exceeded).

③ After the set tolerance time has elapsed, the secondary current value (1 A, 5 A) is monitored. A violation of the secondary current value also returns DIAG_UEBERLAST.

Image 12-1 Diagnostics response in the event of a current overload

Diagnostics overflow voltage

Line voltage (measuring range) is monitored for tolerance. A violation of the overflow triggers a diagnostic interrupt.

Diagnostics underflow voltage

Line voltage (measuring range) is monitored for tolerance. A violation of the underflow triggers a diagnostic interrupt.

Diagnostics low limit voltage

Low limit for voltage is monitored. A violation of the low limit triggers a diagnostic interrupt.

Diagnostics overflow cumulative values

A cumulative overflow in the calculated variables is displayed. The values stop at the high or low limit. A violation triggers a diagnostic interrupt.

Overcurrent tolerance factor

The tolerance factor secondary overcurrent parameter (10 to 100) indicates the tolerable value of the secondary current in 0.1 A increments (10 = 1 A to 100 = 10 A). Always take note of the current class of the current transformer being used (1 A, 5 A).

Overcurrent tolerance time

Monitoring time in which the overcurrent is tolerated. 0 means that the monitoring time has been disabled.

Low limit for measuring current

The configurable low limit for measuring current refers to the secondary currents and is used to avoid incorrect calculations in the case of very low currents. Incorrect measurements of very low currents in particular are a cause of inaccuracies in the current transformer used. Set the low limit for the current measurement to the required value depending on your process.

Tip: If you want to find the low limit for the current measurement experimentally, set it to a lower value. Then, feed in a very precise low current and determine the measurement error that can no longer be tolerated. Afterwards, set the low limit for the current measurement to the limit value you have determined.

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Neutral conductor current
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy of the reset phase do not measure any longer.

Operating hours counter

Enable the operating hours counter here. The counting starts from a programmable minimum current value. The counter can be reset or pre-defined using data record or output bit.

Enable gate of operating hours counter

Enable the gate for the operating hours counter here. When the gate is activated, the operating hours counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Current transformer primary current

Enter here the nominal value for the primary current of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Current transformer secondary current

Enter here the nominal value for the secondary current (1 A or 5 A) of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Voltage transformer primary voltage

To determine the voltage transformer ratio, enter the primary voltage here. The transformer ratio is calculated from the primary and secondary voltage.

Voltage transformer secondary voltage

Enter the secondary voltage to determine the voltage transformer ratio here. The transformer ratio is calculated from the primary and secondary voltage.

Reverse current direction

Setting to determine whether or not to reverse the direction of current.

In the event of inadvertent incorrect connection, this parameter can be used to correct the measured values, thus saving the hassle of rewiring. The direction of the current is only evident from the power measurement values. The current measurement value is an rms value.

Number of limits

Enter the number of measured values that you want to monitor for limits.

Limit monitoring

Enable the monitoring of the limit for a freely definable measured value here. Limit violations are counted and the count values stored retentively.

Measured value ID for limit

Enter the ID of a measured value that you want to use for limit monitoring.

Limit gate via DQ

Enable the gate via DQ here. When the gate is enabled, the limit monitoring is only started when the corresponding bit of the associated output user data is set to "1".

Hardware interrupt for limit

Enable the hardware interrupt here. The hardware interrupt is triggered if a high or low limit is violated. Without activation of a hardware interrupt, a limit violation is only displayed in the user data and in DS 150.

Limit

Enter the limit here that is to trigger a limit violation when exceeded or fallen below. Limit violations are displayed in the user data and in DS 150.

Type of limit

Select here, whether it is an high or low limit. Depending on this selection, the limit violation or hardware interrupt is triggered when a value exceeds (high limit) or falls below (low limit) the limit.

Hysteresis for limit monitoring

Enter the hysteresis for limit in percent here. The percentage refers to the numerical value of the limit when the limit violation occurs. A message is only canceled if the measured value is outside the limit and its hysteresis range. As long as the measured value is in the hysteresis range, no new message is output.

Delay time for limit monitoring

Here you can select the delay time for limit violation. The delay refers to the time that must elapse before an occurrence of a limit violation is reported. Faults can be filtered out by selection of the delay time. The deceleration time is also taken into consideration during outgoing of the limit violation.

Number of measured values for user data mapping

Specify the number of measured values/variables that you want to use for the user-specific user data mapping.

Measured variable

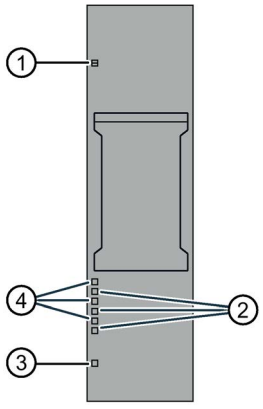
Select the measured variable (with the measured value ID) that you want to use for the user-specific user data mapping.

Interrupts/diagnostic alarms

13

13.1 Status and error display

LED display



① DIAG (green/red)
② Error (red)
③ PWR (green)
④ Status (green)

Image 13-1 LED display

Meaning of the LED displays

The following table explains the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic alarms (Page 88).

DIAG LED

Table 13- 1 Meaning of the DIAG LED

DIAG	Meaning
Off	Supply voltage of the ET 200SP not OK
Flashes	Module not ready for operation (no parameters assigned)
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Status LED

Table 13- 2 Meaning of the Status LED

Status	Meaning
Off	Channel deactivated or error
On	Channel activated and no error

Error LED

Table 13- 3 Meaning of the Error LED

Status	Meaning
Off	Channel is OK
On	Channel is faulty

PWR LED

Table 13- 4 Meaning of the PWR LED

PWR	Meaning
Off	Line voltage missing
On	Line voltage available

13.2 Interrupts

The AI Energy Meter ST analog input module supports hardware and diagnostic interrupts.

13.2.1 Hardware interrupts

Hardware interrupts

The module generates a hardware interrupt at the following events:

- Violation of low limit 1 to 16
- Violation of high limit 1 to 16

You can find detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment of the local data double word 8 by the start information of the hardware interrupt organization block.

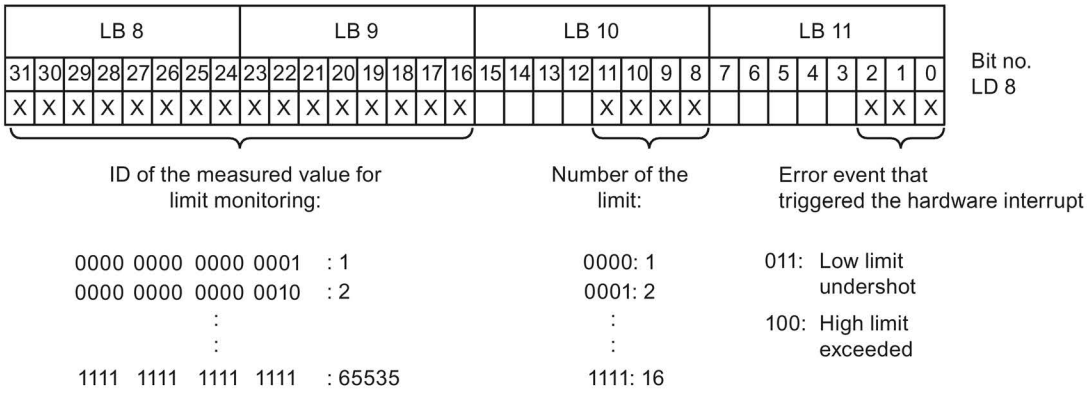


Image 13-2 Start information of the organization block

Structure of the additional interrupt information

Table 13- 5 Structure of the additional interrupt information

Data block name		Contents	Comment	Bytes
Identifier		W#16#0001 to W#16#FFFF	ID of the measured value for limit monitoring	2
Number of the limit (1 to 16), which has triggered the hardware interrupt				
	Channel	B#16#00 to B#16#0F	Number of the limit	1
Event that triggered the hardware interrupt.				
	Event	B#16#03	Violation of low limit	1
		B#16#04	Violation of high limit	

13.2.2 Diagnostics interrupt

Diagnostic interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel is temporarily unavailable
- Hardware interrupt lost
- Error
- Supply voltage missing
- Parameter assignment error
- Low limit voltage violated (measuring voltage < 80 V)
- High limit value voltage exceeded
- Underflow voltage (tolerance for supply voltage) violated
- Overflow voltage (tolerance for supply voltage) exceeded
- Overload (current measurement > 12 A or tolerance overcurrent exceeded after expiry of the tolerance time)
- Overflow of the calculated values (measured or calculated values screen exceed the representable range of values)

See also

Diagnostic alarms (Page 88)

13.3 Diagnostic alarms

Diagnostic alarms

Note

Assignment channel in diagnostic message ⇔ Phase

In the diagnostic messages the channels are counted from "Channel "0" on, in the AI Energy Meter 480VAC ST from Phase "1" on.

Note the following assignment:

- Channel "0" ⇔ Phase "1"
- Channel "1" ⇔ Phase "2"
- Channel "2" ⇔ Phase "3"

Table 13- 6 Error types

Diagnostic message	Error code	Meaning	Solution
Undervoltage[1]	2_H	Line voltage (measuring range) is monitored for tolerance. Violation leads to voltage overflow/underflow	Observe the line voltage range
Overvoltage	3_H		
Overload	4_H	The measured current is monitored after expiration of the "Tolerance time" for "Tolerance factor × Measured current". Exceeding this results in overflow current. The maximum value of the secondary current (12 A) has been exceeded.	Observe the current range
High limit	7_H	Cumulative overflow in the calculated values	-
Low limit[1]	8_H	Violation of the low limit for voltage measurement. The message occurs when the configured minimum current or voltage is below 80 V.	Observe the voltage range
Error	9_H	Internal module error (diagnostic alarm on channel 0 applies to the entire module).	Replace the module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Missing or insufficient line voltage on phase L1	Check supply
Channel is temporarily unavailable	$1F_H$	Firmware upgrade is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	--
		A user calibration is being executed at the channel.	Complete the user calibration

[1] If the "Undervoltage" and "Low limit" diagnostics are active at the same time, the "Low limit" diagnostics has higher priority and deletes the "Undervoltage" diagnostics.

13.4 Diagnostics response

Diagnostics response

This section describes the response of the AI Energy Meter 480VAC ST when diagnostics information is reported.

Measured values in the case of diagnostics

Even in the case of diagnostics, measured values continue to be displayed as long as they can still be acquired. If measured values cannot be measured or calculated, "0" is displayed.

Zero suppression

If the supplied current is less than the configured "Low limit for measuring current" parameter, the current measurement and all dependent variables are suppressed or set to "0".

Overload limitation

If the secondary current fed in at the channel is higher than 12 A, the module changes to limitation and the measured value of the current and all dependent variables are set to "0".

Value falls below "Low limit current measurement"

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Neutral conductor current
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy of the reset phase do not measure any longer.

Loss of the supply voltage

At a loss of supply voltage at U_{L1} (phase 1), all measurements are interrupted.

After the supply voltage is restored, the AI Energy Meter 480VAC ST operates again with the configuration / parameter assignment stored in the CPU. The retentively stored values are used at the following counters and calculations:

- Energy and overflow counters
- Operating hours counters
- Counters for limit violation
- Minimum values
- Maximum values

Input data to "0"

Note

If the AI Energy Meter 480VAC ST is no longer recognized by the interface module (for example, because it is defective or not plugged in), all input data are set to "0".

Technical specifications

14

14.1 Technical specifications

Technical specifications of the AI Energy Meter 480VAC ST 6ES7134-6PA20-0BD0

	6ES7134-6PA20-0BD0
General information	
Product type designation	AI Energy Meter 480VAC ST
Usable BaseUnits	BU type D0, BU20-P12+A0+0B
Color code for module-specific color identification label	CC00
Product function	
Voltage measurement	Yes
Voltage measurement with voltage transformer	Yes
Current measurement	Yes
Phase current measurement without current transformer	No
Phase current measurement with current transformer	Yes
Energy measurement	Yes
Frequency measurement	Yes
Power measurement	Yes
Active power measurement	Yes
Reactive power measurement	Yes
I&M data	Yes
Isochronous mode	No
Operating mode	
Cyclic measurement	Yes
Acyclic measurement	Yes
Configuration control	
Via user data	Yes
Via data record	Yes
Installation type / mounting	
Installation position	Any
Supply voltage	
Description	Supply via voltage measurement channel L1
Type of supply voltage	100 - 277 V AC
Permissible range, low limit (AC)	90 V
Permissible range, high limit (AC)	293 V

	6ES7134-6PA20-0BD0
Line frequency	
Valid range, low limit	47 Hz
Valid range, high limit	63 Hz
Power loss	
Power loss, typ.	0.6 W
Address area	
Address space per module	
Address space per module, max.	256 bytes; for input and output data each
Hardware configuration	
Automatic code	
• Mechanical coding element	Yes
Time	
Operating hours counters	
Available	Yes
Analog inputs	
Cycle time (all channels), typ.	50 ms. Time for the consistent updating of all measured and calculated values (cyclic and acyclic data)
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic alarm	Yes
Limit interrupt	Yes
Hardware interrupt	Yes
Diagnostic indicator LED	
Monitoring of supply voltage (PWR LED)	Yes
Channel status display	Yes
For channel diagnostics	Yes
For module diagnostics	Yes
Integrated functions	
Measuring functions	
Buffering of measured variables	No
Parameter length	74 bytes
Measuring method for voltage measurement	TRMS
Measuring method for current measurement	TRMS
Type of measured data acquisition	Complete
Voltage wave form	Sinusoidal or distorted
Band width of the measured value detection	2 kHz. Harmonic: 39 / 50 Hz, 32 / 60 Hz
Operating mode for measured value acquisition	
• Automatic line frequency acquisition	No; can be assigned
• Fixing at 50 Hz	No; default setting
• Fixing at 60 Hz	No

	6ES7134-6PA20-0BD0
Measuring range	
• Frequency measurement, min.	45 Hz
• Frequency measurement, max.	65 Hz
Measuring inputs for voltage	
• Measurable line voltage between phase and neutral conductor	277 V
• Measurable line voltage between the line conductors	480 V
• Measurable line voltage between phase and neutral conductor, min.	90 V
• Measurable line voltage between phase and neutral conductor, max.	293 V
• Measurable line voltage between the line conductors, min.	155 V
• Measurable line voltage between the line conductors, max.	508 V
• Measuring category for voltage measurement in accordance with IEC 61010-2-030	CAT II. CAT III with prescribed protective elements
• Internal resistance line conductor and N-conductor	3.4 mΩ
• Power consumption, per phase	20 mW
• Surge voltage strength 1.2/50µs	1 kV
Measuring inputs for current	
• Relative measurable current for AC, min.	1%; in relation to the secondary rated current 5 A
• Relative measurable current for AC, max.	100%; in relation to the secondary rated current 5 A
• Continuous current for AC, maximum permissible	5 A
• Apparent power consumption per phase for measuring range 5 A	0.6 VA
• Rated value of short-time current carrying capacity is restricted to 1 s	100 A
• Input resistance measuring range 0 to 5 A	25 mΩ; at the terminal
• Zero point suppression	Configurable: 2 - 250 mA, default 50 mA
• Impulse withstand capability	10 A; for 1 minute

	6ES7134-6PA20-0BD0
Accuracy class to IEC 61557-12	
• Measured variable voltage	0.2
• Measured variable current	0.2
• Measured variable apparent power	0.5
• Measured variable active power	0.5
• Measured variable reactive power	1
• Measured variable power factor	0.5
• Measured variable active energy	0.5
• Measured variable reactive energy	1
• Measured variable neutral current	0.5. Calculated
• Measured variable phase angle	+/-1°. Not covered by IEC 61577-12
• Measured variable frequency	0.05
Electrical isolation	
Electrical isolation of channels	
Between the channels and backplane bus	Yes. 3700 VAC (type test) CATIII
Insulation	
Insulation tested with	2300 VAC 1 min. (type test)
Ambient conditions	
Ambient temperature in operation	
Horizontal mounting position, min.	0 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, min.	0 °C
Vertical mounting position, max.	50 °C
Dimensions	
Width	20 mm
Weights	
Weight (without packaging)	45 g
Miscellaneous	
Current transformer selection data	
Cable length (clamp-type transformer) depending on Zn and Imax	200 m

ATEX approval

In accordance with EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC Tx Gc
DEKRA 12ATEX0038X

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521) manual

Parameter data records

A

A.1 Configuration via parameter data records

The parameter data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You can reassign the module parameters in RUN mode, for example change the diagnostics behavior, define new limits or configure a modified user data mapping.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module via the respective data record. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

If you reconfigure a module (so that the user data size changes) and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

STATUS output parameter

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

A.2 Structure of the parameter data record 128 for the entire module

Structure of data record 128

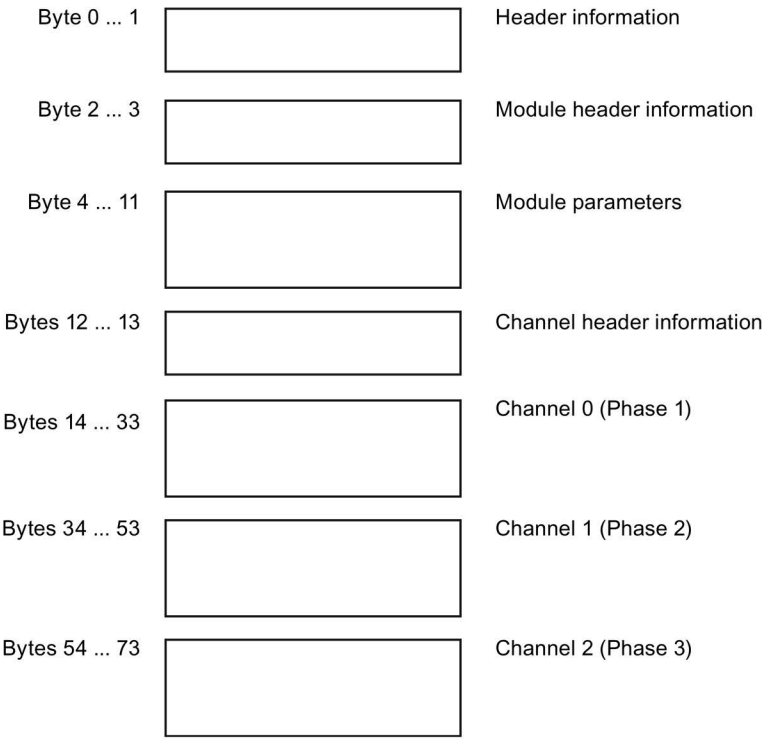


Image A-1 Parameter data record 128

Header information

The figure below shows the structure of the header information.

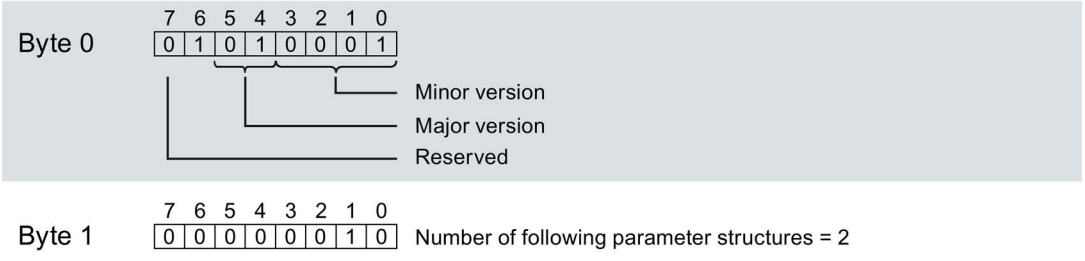


Image A-2 Header information

Module header information

The figure below shows the structure of the header information for a module.

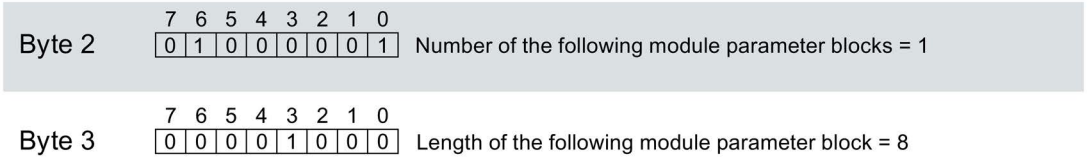
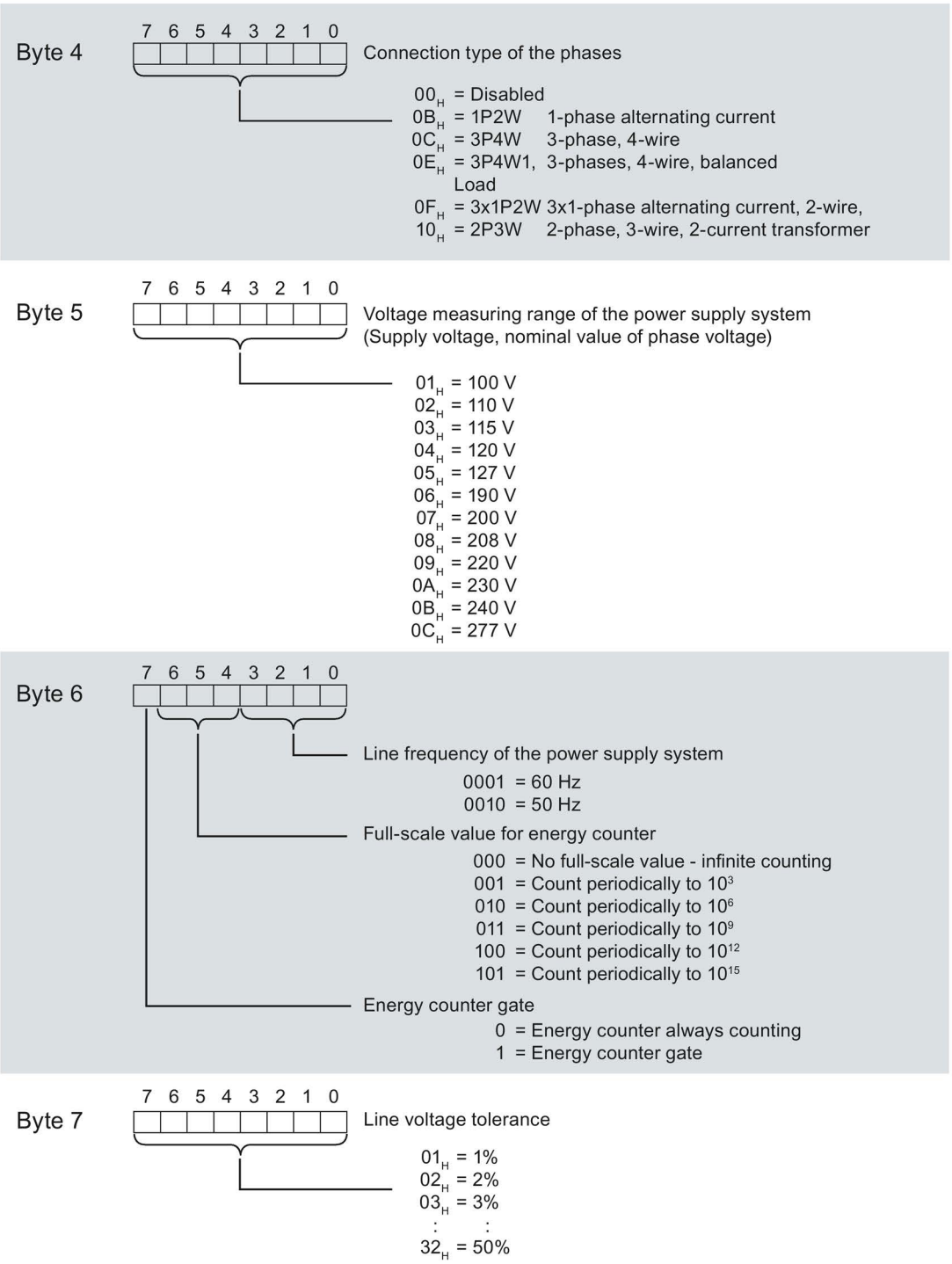


Image A-3 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Enable a parameter by setting the corresponding bit to "1".



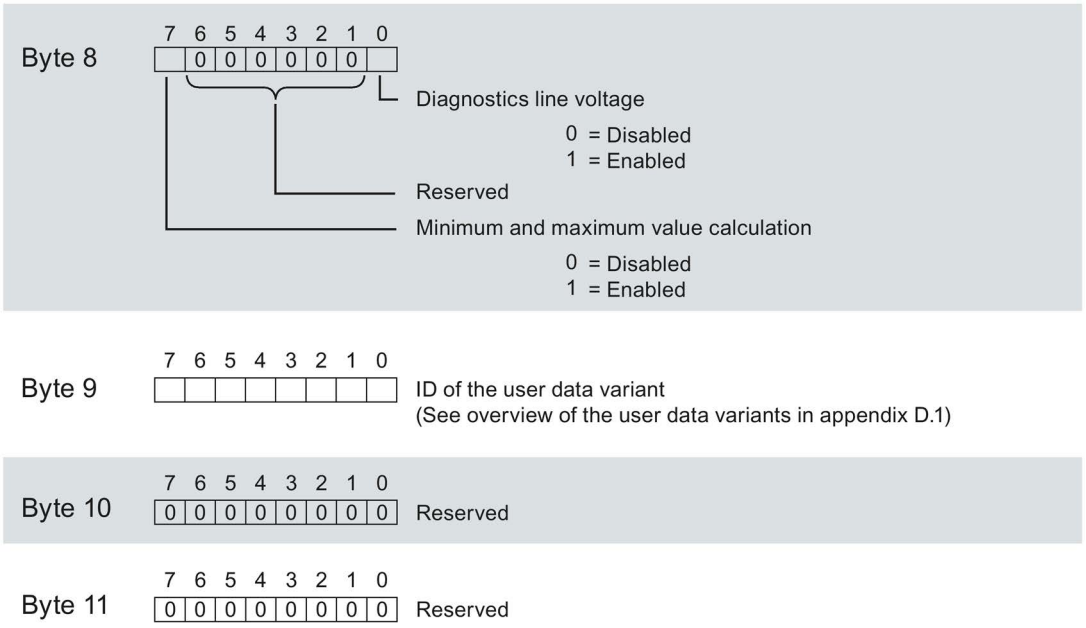


Image A-4 Module parameter block

You can find the user data variant in the section Overview of the user data variants (Page 135).

Channel header information

The following figure shows the structure of the header information for a channel.

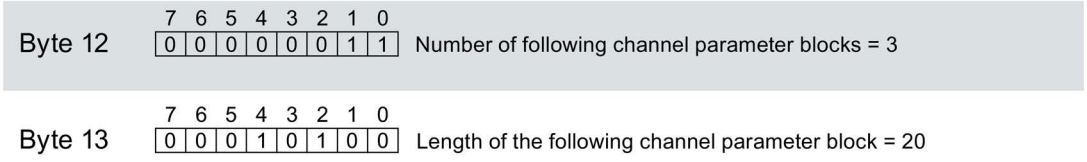
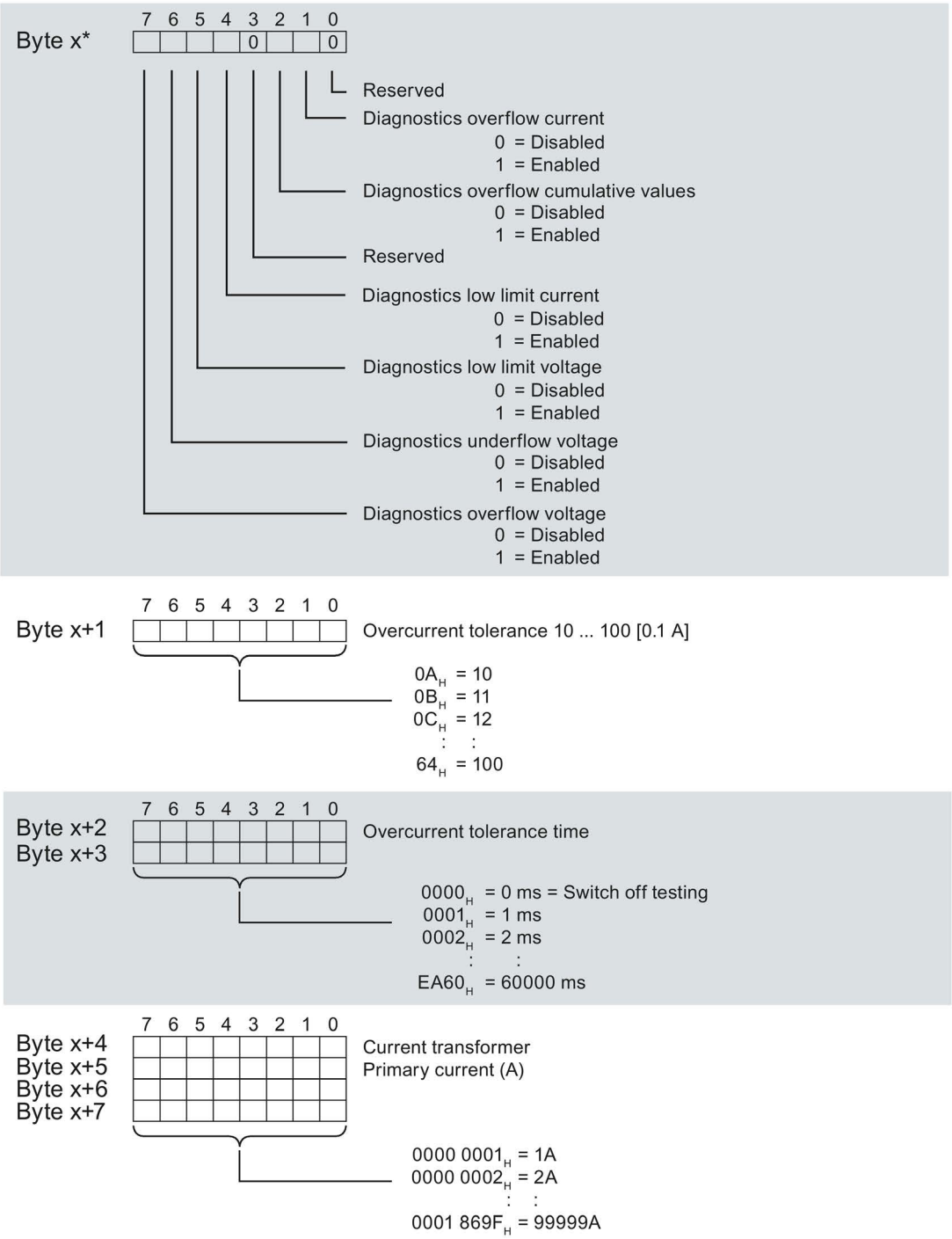


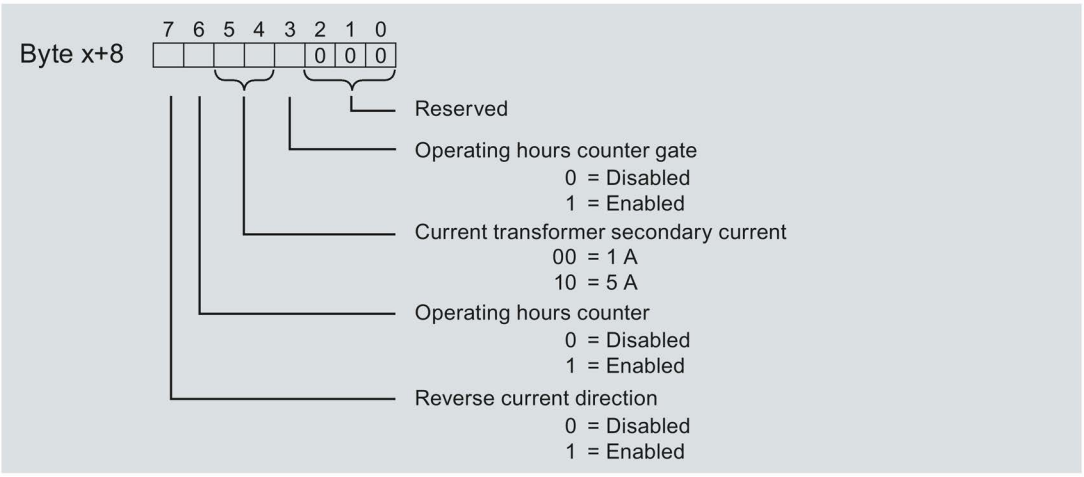
Image A-5 Channel header information

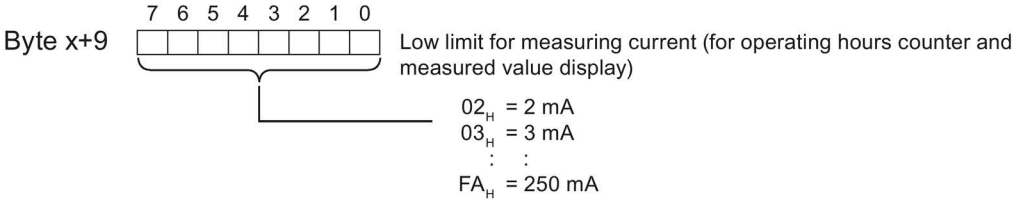
Channel parameter block

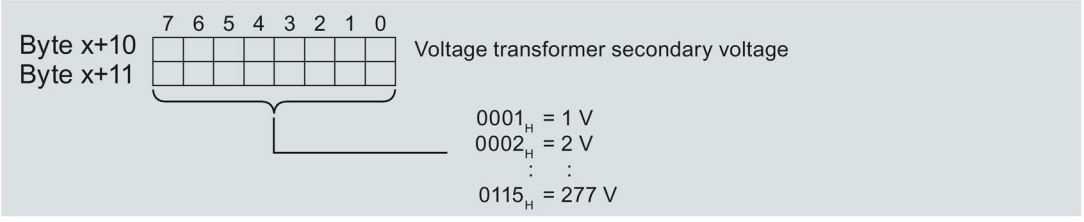
The figure below shows the structure of the channel parameter block.

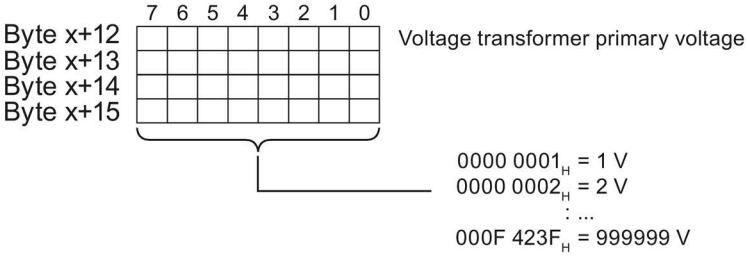
Enable a parameter by setting the corresponding bit to "1".




Byte x+8
7 6 5 4 3 2 1 0
0 0 0
Reserved
Operating hours counter gate
0 = Disabled
1 = Enabled
Current transformer secondary current
00 = 1 A
10 = 5 A
Operating hours counter
0 = Disabled
1 = Enabled
Reverse current direction
0 = Disabled
1 = Enabled


Byte x+9
7 6 5 4 3 2 1 0
Low limit for measuring current (for operating hours counter and measured value display)
02H = 2 mA
03H = 3 mA
FAH = 250 mA


Byte x+10
Byte x+11
7 6 5 4 3 2 1 0
Voltage transformer secondary voltage
0001H = 1 V
0002H = 2 V
0115H = 277 V


Byte x+12
Byte x+13
Byte x+14
Byte x+15
7 6 5 4 3 2 1 0
Voltage transformer primary voltage
0000 0001H = 1 V
0000 0002H = 2 V
000F 423FH = 999999 V

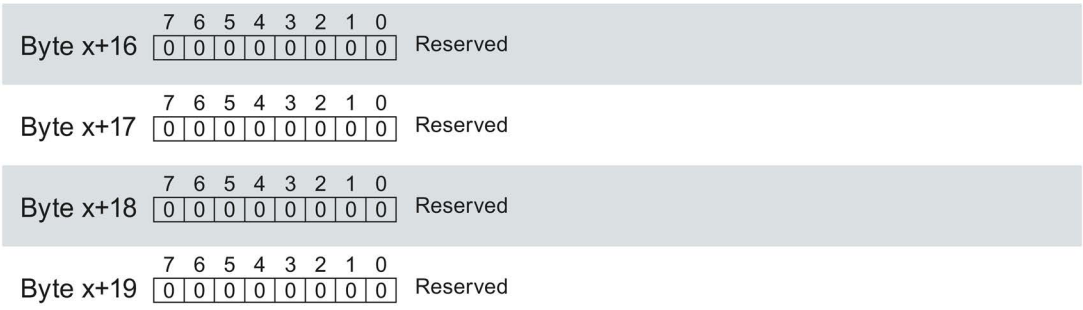


Image A-6 Channel parameter block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 10, 11, 14, 22, 30...34, 42, 50...54, 70...74 and set the reserved bits back to 0.
DF	80	E1	02	Reserved bits are not 0.	Check Byte 8 and set the reserved bits back to 0.
DF	80	E1	05	Measuring range for voltage invalid.	Check Byte 5. Permitted values: 01_H to $0C_H$
DF	80	E1	20	Connection type invalid.	Check Byte 4. Permitted values: 00_H, $0B_H$ ... 01_H

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	21	Parameter for user data variant not possible.	Check Byte 9. Select a different user data variant or change the configuration.
DF	80	E1	22	Parameter for user data variant is invalid.	Check Byte 9. Select a valid code for the user data variant.
DF	80	E1	23	Parameter for frequency is invalid.	Check Byte 6. Enter valid values.
DF	80	E1	24	Parameter for tolerance line voltage is invalid.	Check Byte 7. Enter valid values.
DF	80	E1	25	Parameter for current transformer secondary is invalid.	Check Bit 4...5 in Byte 22, 42...62. Enter valid values.
DF	80	E1	29	Parameter for tolerance factor overcurrent invalid.	Check Byte 15, 35...55. Enter valid values.
DF	80	E1	2A	Parameter for tolerance time overcurrent invalid.	Check Byte 16...17, 36...37, 56...57. Enter valid values.
DF	80	E1	2B	Parameter for low limit measuring current invalid	Check Byte 23, 43...63. Enter valid values.
DF	80	E1	2C	Parameter for current transformer primary current is invalid.	Check Byte 18...21, 38...41, 48...61. Enter valid values.
DF	80	E1	2D	Parameter for voltage converter primary voltage invalid.	Check Byte 26...29, 46...49, 66...69. Enter valid values.
DF	80	E1	2E	Parameter for voltage converter secondary voltage invalid.	Check Byte 24...25, 44...45, 64...65. Enter valid values.
DF	80	E1	2F	Parameter for full-scale value for energy counters invalid.	Check Bit 4...6 in Byte 6. Enter valid values.
DF	80	E1	30	Invalid data record number.	Check the data record number. Enter a valid data record number.
DF	80	E1	3E	Only for connection type 3P4W1. Parameters for the different phases are not identical.	Check Bytes 14...33, 34...53, 54...73. Enter identical values at all three phases.
DF	80	E1	3F	Full-scale value for energy counter too small or transmission ratio of current and voltage too high.	Increase the full-scale value or reduce the transmission ratio of the current and voltage transformer.

A.3 Structure of the parameter data record 129 for limit monitoring

Structure of data record 129

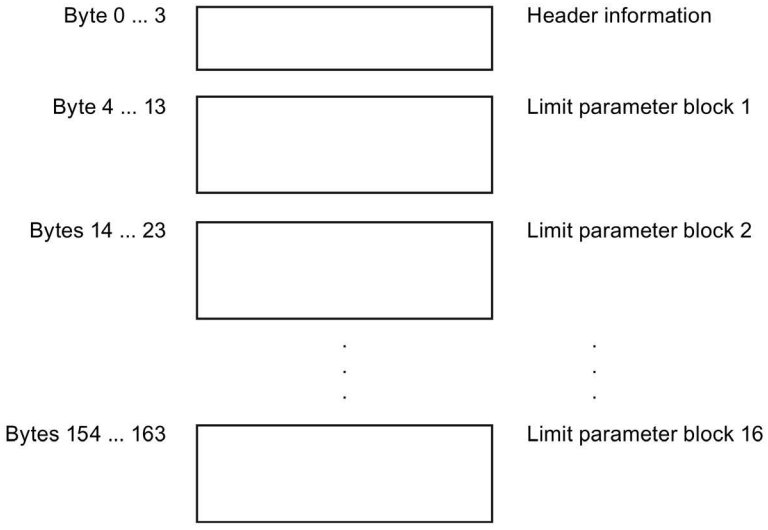


Image A-7 Structure of data record 129

Header information

The figure below shows the structure of the header information.

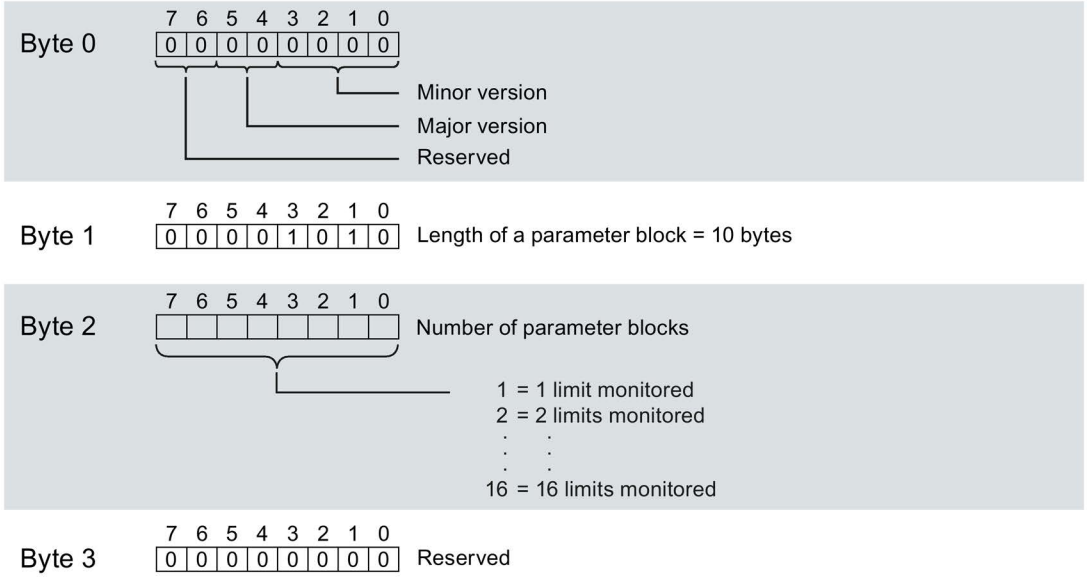
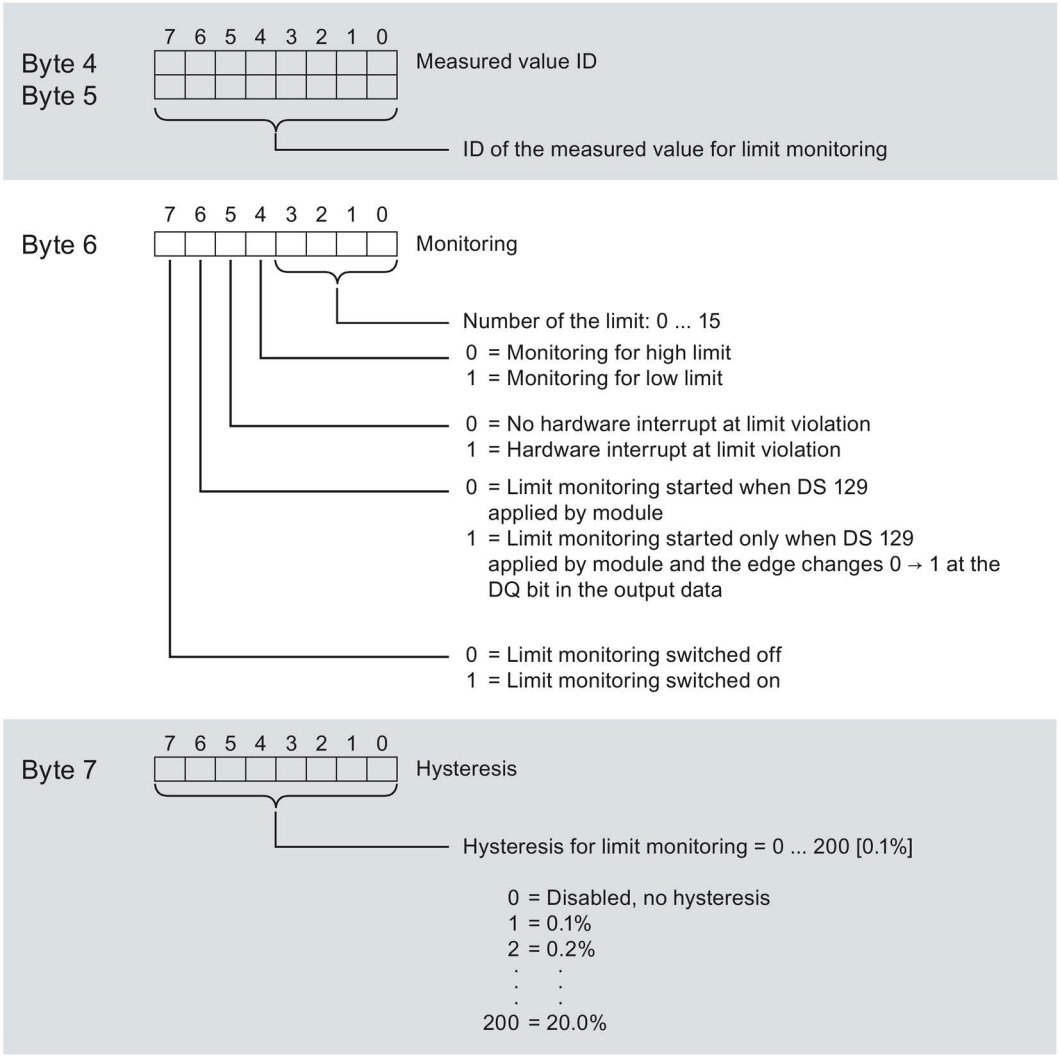


Image A-8 Header information DS 129

Limit parameter block

The following diagram shows the structure of the parameter blocks for limit monitoring.



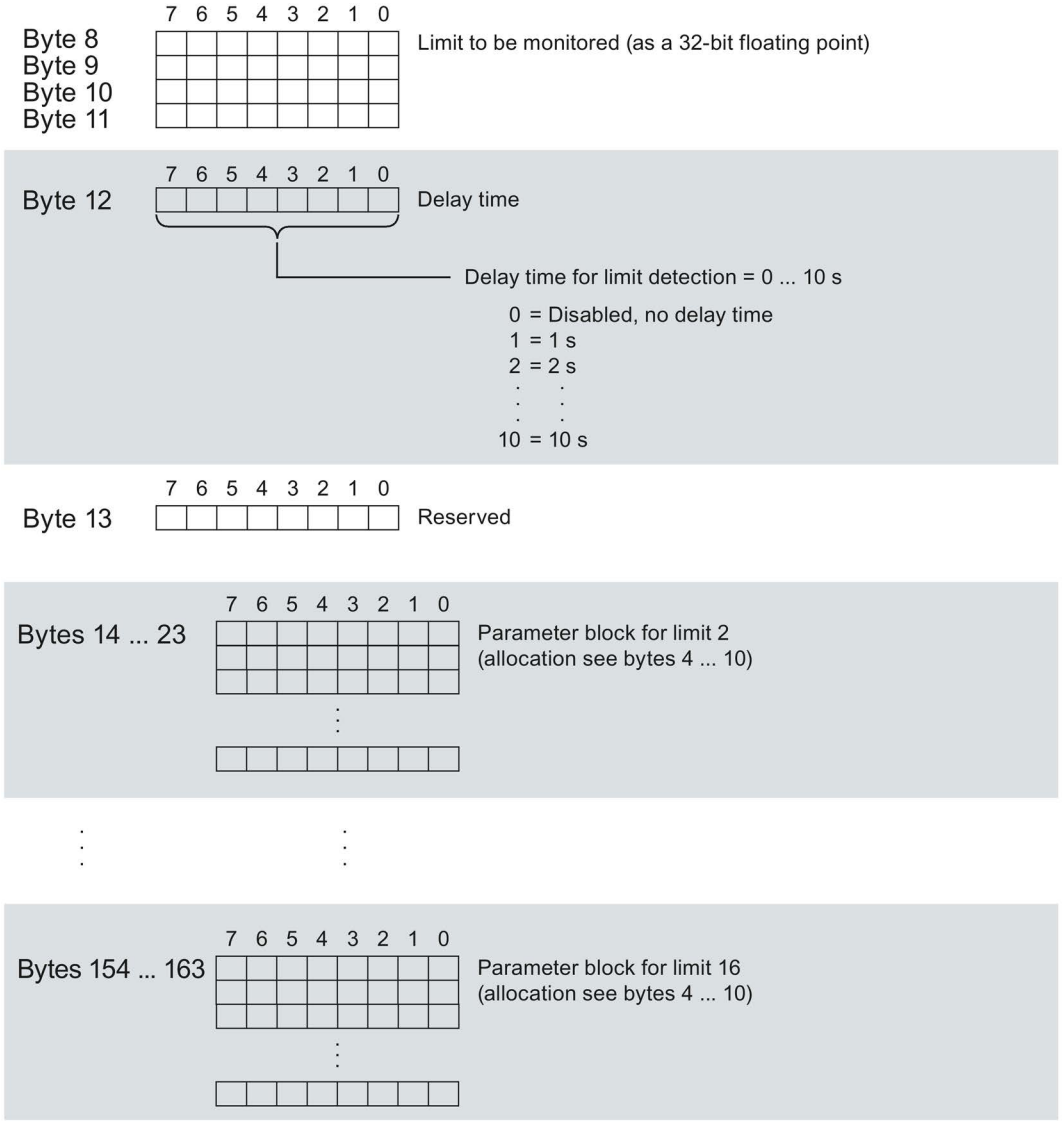


Image A-9 Limit parameter data block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 129.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 10, 11, 14, 22, 30...34, 42, 50...54, 70...74 and set the reserved bits back to 0.
DF	80	E1	31	Parameter for length of the parameter block invalid.	Check Byte 1. Length = 10 bytes
DF	80	E1	32	Parameters for number of parameter blocks invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	Parameter for measured value ID invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	34	Parameters for monitoring the limits	Check Bit 0...3 in Byte 6. Enter valid values.
DF	80	E1	35	Number for limits in monitoring parameter assigned several times	Check Bit 0...3 in Byte 6. Do not use limit number several times.
DF	80	E1	36	Parameters for hysteresis invalid	Check Byte 7. Enter valid values.
DF	80	E1	37	Parameter for limit to be monitored invalid.	Check Byte 8...11. Enter valid values.
DF	80	E1	38	Delay time in Hysteresis parameter invalid.	Check Byte 12. Enter valid values.

A.4 Structure of the parameter data record 130 for user-data mapping

Structure of data record 130

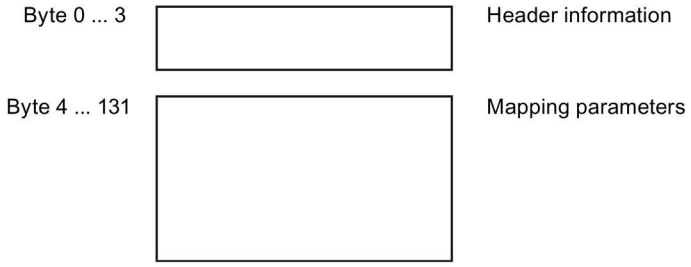


Image A-10 Structure of data record 130

Header information

The figure below shows the structure of the header information.

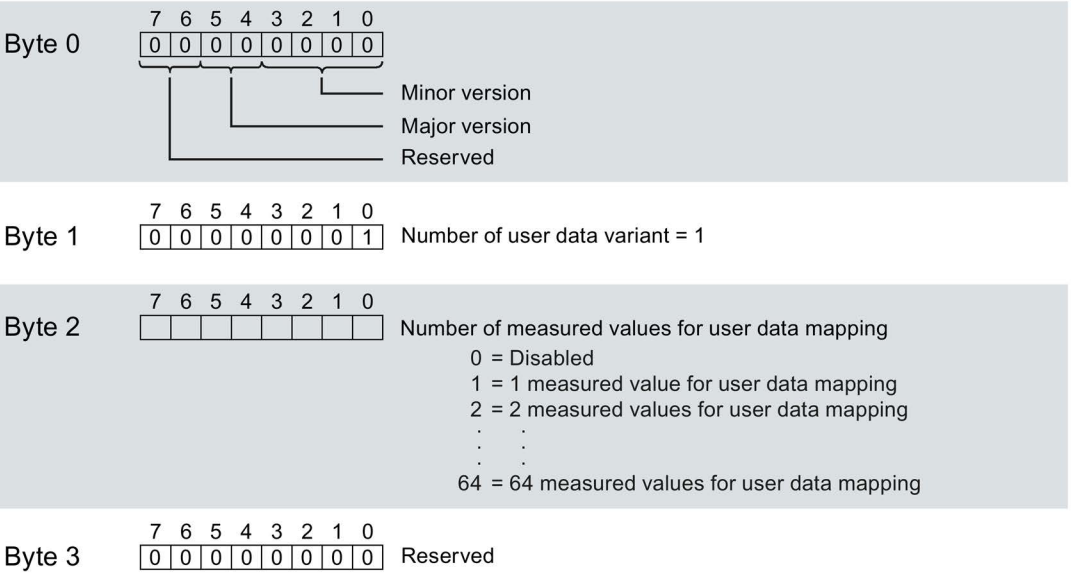


Image A-11 Header information DS 130

Parameter block for user data mapping

The following diagram shows the structure of the parameter blocks for user data mapping.

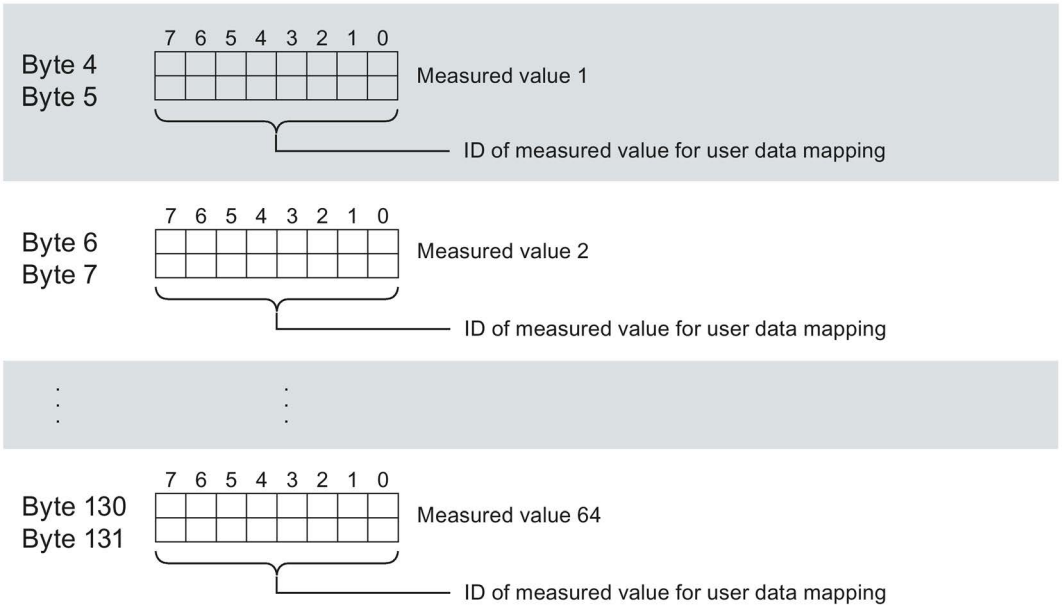


Image A-12 Parameter block for user data mapping

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 10, 11, 14, 22, 30...34, 42, 50...54, 70...74 and set the reserved bits back to 0.
DF	80	E1	21	Parameter for user data variant not possible.	Check Byte 9. Select a different user data variant or change the configuration.
DF	80	E1	30	Invalid data record number.	Check the data record number. Enter a valid data record number.
DF	80	E1	31	Parameter for length of the parameter block invalid.	Check Byte 1. Length = 10 bytes
DF	80	E1	32	Parameters for number of parameter blocks invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	Parameter for measured value ID invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	3B	Parameter for user data variant impermissible.	Check Byte 1. Number for user-specific user data variant has to be 01_H.

Measured variables

B

Measured variables for data records and user data

The following table provides an overview of all measured variables that are used in the data records and user data.

Note that the format and unit differ in the evaluation of records and user data.

Table B- 1 Measured variables for data records and user data

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
1	Voltage UL1-N [1]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓
2	Voltage UL2-N [1]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓
3	Voltage UL3-N [1]	REAL	V	0.0 ... 1000000.0		✓		✓	✓
4	Voltage UL1-L2 [2]	REAL	V	0.0 ... 1000000.0				✓	✓
5	Voltage UL2-L3 [2]	REAL	V	0.0 ... 1000000.0				✓	✓
6	Voltage UL3-L1 [2]	REAL	V	0.0 ... 1000000.0				✓	✓
7	Current L1 [1]	REAL	A	0.0 … 100000.0	✓	✓	✓	✓	✓
8	Current L2 [1]	REAL	A	0.0 … 100000.0		✓	✓	✓	✓
9	Current L3 [1]	REAL	A	0.0 … 100000.0		✓		✓	✓
10	Apparent power L1 [3]	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓	✓	✓	✓
11	Apparent power L2 [3]	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$		✓	✓	✓	✓
12	Apparent power L3 [3]	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$		✓		✓	✓
13	Active power L1 [3]	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓	✓	✓	✓
14	Active power L2 [3]	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$		✓			
15	Active power L3 [3]	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$		✓		✓	✓
16	Reactive power L1 [3]	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	✓	✓	✓	✓	✓
17	Reactive power L2 [3]	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$		✓	✓	✓	✓
18	Reactive power L3 [3]	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$		✓		✓	✓
19	Power factor L1 [3]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓
20	Power factor L2 [3]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓
21	Power factor L3 [3]	REAL	-	0.0 ... 1.0		✓		✓	✓

Meas-ured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
30	Frequency [4]	REAL	Hz	45.0 ... 65.0	✓	✓	✓	✓	✓
34	Total apparent power L1L2L3 [5]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
35	Total active power L1L2L3 [5]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
36	Total reactive power L1L2L3 [5]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
37	Total power factor L1L2L3 [6 7]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓
38	Amplitude balance for voltage [2]	REAL	%	0 ... 100				✓	✓
39	Amplitude symmetry for current [2]	REAL	%	0 ... 200				✓	✓
40	Max. voltage UL1-N [6]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓
41	Max. voltage UL2-N [6]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓
42	Max. voltage UL3-N [6]	REAL	V	0.0 ... 1000000.0		✓		✓	✓
43	Max. voltage UL1-UL2 [6]	REAL	V	0.0 ... 1000000.0				✓	✓
44	Max. voltage UL2-UL3 [6]	REAL	V	0.0 ... 1000000.0				✓	✓
45	Max. voltage UL3-UL1 [6]	REAL	V	0.0 ... 1000000.0				✓	✓
46	Max. current L1 [6]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓
47	Max. current L2 [6]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓
48	Max. current L3 [6]	REAL	A	0.0 ... 100000.0		✓		✓	✓
49	Max. apparent power L1 [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
50	Max. apparent power L2 [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9		✓	✓	✓	✓
51	Max. apparent power L3 [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9		✓		✓	✓
52	Max. active power L1 [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
53	Max. active power L2 [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9		✓	✓	✓	✓
54	Max. active power L3 [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9		✓		✓	✓
55	Max. reactive power L1 [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
56	Max. reactive power L2 [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9		✓	✓	✓	✓
57	Max. reactive power L3 [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9		✓		✓	✓
58	Max. power factor L1 [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓
59	Max. power factor L2 [6]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓
60	Max. power factor L3 [6]	REAL	-	0.0 ... 1.0		✓		✓	✓
61	Max. frequency [6]	REAL	Hz	45.0 ... 65.0	✓	✓	✓	✓	✓

Meas-ured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
65	Max. total apparent power [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
66	Max. total active power [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
67	Max. total reactive power [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
68	Max. total power factor [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓
70	Min. voltage UL1-N [6]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓
71	Min. voltage UL2-N [6]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓
72	Min. voltage UL3-N [6]	REAL	V	0.0 ... 1000000.0		✓		✓	✓
73	Min. voltage UL1-UL2 [6]	REAL	V	0.0 ... 1000000.0				✓	✓
74	Min. voltage UL2-UL3 [6]	REAL	V	0.0 ... 1000000.0				✓	✓
75	Min. voltage UL3-UL1 [6]	REAL	V	0.0 ... 1000000.0				✓	✓
76	Min. current L1 [6]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓
77	Min. current L2 [6]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓
78	Min. current L3 [6]	REAL	A	0.0 ... 100000.0		✓		✓	✓
79	Min. apparent power L1 [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
80	Min. apparent power L2 [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9		✓	✓	✓	✓
81	Min. apparent power L3 [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9		✓		✓	✓
82	Min. active power L1 [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
83	Min. active power L2 [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9		✓	✓	✓	✓
84	Min. active power L3 [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9		✓		✓	✓
85	Min. reactive power L1 [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
86	Min. reactive power L2 [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9		✓	✓	✓	✓
87	Min. reactive power L3 [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9		✓		✓	✓
88	Min. power factor L1 [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓
89	Min. power factor L2 [6]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓
90	Min. power factor L3 [6]	REAL	-	0.0 ... 1.0		✓		✓	✓
91	Min. frequency [6]	REAL	Hz	45.0 ... 65.0	✓	✓	✓	✓	✓
95	Min. total apparent p ower [6]	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
96	Min. total active power [6]	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓
97	Min. total reactive power [6]	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
98	Min. total power factor [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓
200	Total active energy inflow L1L2L3 [6]	REAL	Wh	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
201	Total active energy outflow L1L2L3 [6]	REAL	Wh	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
202	Total reactive energy inflow L1L2L3 [6]	REAL	varh	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
203	Total reactive energy outflow L1L2L3 [6]	REAL	varh	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
204	Total apparent energy L1L2L3 [6]	REAL	VAh	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
205	Total active energy L1L2L3 [6]	REAL	Wh	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
206	Total reactive energy L1L2L3 [6]	REAL	varh	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
210	Total active energy inflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
211	Total active energy outflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
212	Total reactive energy inflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
213	Total reactive energy outflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
214	Total apparent energy L1L2L3 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
215	Total active energy L1L2L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
216	Total reactive energy L1L2L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
220	Total active energy inflow L1L2L3 [6]	UDINT	Wh	0 ... 4294967295	✓	✓	✓	✓	✓
221	Total active energy outflow L1L2L3 [6]	UDINT	varh	0 ... 4294967295	✓	✓	✓	✓	✓
222	Total reactive energy inflow L1L2L3 [6]	UDINT	varh	0 ... 4294967295	✓	✓	✓	✓	✓
223	Total reactive energy outflow L1L2L3 [6]	UDINT	VAh	0 ... 4294967295	✓	✓	✓	✓	✓
224	Total apparent energy L1L2L3 [6]	UDINT	Wh	0 ... 4294967295	✓	✓	✓	✓	✓
225	Total active energy L1L2L3 [6]	UDINT	Wh	0 ... 4294967295	✓	✓	✓	✓	✓
226	Total reactive energy L1L2L3 [6]	UDINT	varh	0 ... 4294967295	✓	✓	✓	✓	✓
61149	Neutral conductor current [1]	REAL	A	0.0 ... 100000.0				✓	
61178	Phase angle L1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
61180	Active energy inflow L1 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
61181	Active energy outflow L1 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
61182	Reactive energy inflow L1 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
61183	Reactive energy outflow L1 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
61184	Apparent energy L1 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
61185	Active energy L1 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
61186	Reactive energy L1 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}	✓	✓	✓	✓	✓
61190	Overflow counter active energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓
61191	Overflow counter active energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓
61192	Overflow counter reactive energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓
61193	Overflow counter reactive energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓
61194	Overflow counter apparent energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓
61198	Phase angle L2 [3]	REAL	°	0.0 ... 360.0		✓	✓	✓	✓
61200	Active energy inflow L2 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓	✓	✓	✓
61201	Active energy outflow L2 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓	✓	✓	✓
61202	Reactive energy inflow L2 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓	✓	✓	✓
61203	Reactive energy outflow L2 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓	✓	✓	✓
61204	Apparent energy L2 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}		✓	✓	✓	✓
61205	Active energy L2 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓	✓	✓	✓
61206	Reactive energy L2 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓	✓	✓	✓
61210	Overflow counter active energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓
61211	Overflow counter active energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓
61212	Overflow counter reactive energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓
61213	Overflow counter reactive energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓
61214	Overflow counter apparent energy L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓
61218	Phase angle L3 [3]	REAL		0.0 ... 360.0		✓		✓	✓
61220	Active energy inflow L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓		✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
61221	Active energy outflow L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓		✓	✓
61222	Reactive energy inflow L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓		✓	✓
61223	Reactive energy outflow L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓		✓	✓
61224	Apparent energy L3 [6]	LREAL	VAh	0.0 ... 1.8 x 10^{308}		✓		✓	✓
61225	Active energy L3 [6]	LREAL	Wh	0.0 ... 1.8 x 10^{308}		✓		✓	✓
61226	Reactive energy 7L3 [6]	LREAL	varh	0.0 ... 1.8 x 10^{308}		✓		✓	✓
61230	Overflow counter active energy inflow L3 [6]	UINT	-	0 ... 65535		✓		✓	✓
61231	Overflow counter active energy outflow L3 [6]	UINT	-	0 ... 65535		✓		✓	✓
61232	Overflow counter reactive energy inflow L3 [6]	UINT	-	0 ... 65535		✓		✓	✓
61233	Overflow counter reactive energy outflow L3 [6]	UINT	-	0 ... 65535		✓		✓	✓
61234	Overflow counter apparent energy L3 [6]	UINT	-	0 ... 65535		✓		✓	✓
62110	Active energy inflow L1 [6]	UDINT	Wh	0 ... 4294967295	✓	✓	✓	✓	✓
62111	Active energy outflow L1 [6]	UDINT	Wh	0 ... 4294967295	✓	✓	✓	✓	✓
62112	Reactive energy inflow L1 [6]	UDINT	Varh	0 ... 4294967295	✓	✓	✓	✓	✓
62113	Reactive energy outflow L1 [6]	UDINT	Varh	0 ... 4294967295	✓	✓	✓	✓	✓
62114	Apparent energy L1 [6]	UDINT	Wh	0 ... 4294967295	✓	✓	✓	✓	✓
62115	Active energy L1 total (inflow - outflow) [6]	UDINT	Wh	0 ... 4294967295	✓	✓	✓	✓	✓
62116	Reactive energy L1 total (inflow - outflow) [6]	UDINT	Varh	0 ... 4294967295	✓	✓	✓	✓	✓
62210	Active energy inflow L2 [6]	UDINT	Wh	0 ... 4294967295		✓	✓	✓	✓
62211	Active energy outflow L2 [6]	UDINT	Wh	0 ... 4294967295		✓	✓	✓	✓
62212	Reactive energy inflow L2 [6]	UDINT	Varh	0 ... 4294967295		✓	✓	✓	✓
62213	Reactive energy outflow L2 [6]	UDINT	Varh	0 ... 4294967295		✓	✓	✓	✓
62214	Apparent energy L2 [6]	UDINT	VAh	0 ... 4294967295		✓		✓	✓
62215	Active energy L2 total (inflow - outflow) [6]	UDINT	Wh	0 ... 4294967295		✓	✓	✓	✓
62216	Reactive energy L2 total (inflow - outflow) [6]	UDINT	Varh	0 ... 4294967295		✓	✓	✓	✓
62310	Active energy inflow L3 [6]	UDINT	Wh	0 ... 4294967295		✓		✓	✓

Meas-ured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
62311	Active energy outflow L3 [6]	UDINT	Wh	0 ... 4294967295		✓		✓	✓
62312	Reactive energy inflow L3 [6]	UDINT	Varh	0 ... 4294967295		✓		✓	✓
62313	Reactive energy outflow L3 [6]	UDINT	Varh	0 ... 4294967295		✓		✓	✓
62314	Apparent energy L3 [6]	UDINT	VAh	0 ... 4294967295		✓		✓	✓
62315	Active energy L3 total (inflow - outflow) [6]	UDINT	Wh	0 ... 4294967295		✓		✓	✓
62316	Reactive energy L3 total (inflow - outflow) [6]	UDINT	Varh	0 ... 4294967295		✓		✓	✓
65500	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	✓	✓	✓	✓	✓
65501	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 xx 00		✓	✓	✓	✓
65502	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq xx 00 00		✓		✓	✓
65503	Qualifier L1L2L3	WORD	Bit field	0b 00 00 00 00 0b qq xx xx xx	✓	✓	✓	✓	✓
65504	Total operating hours counter L1L2L3 [5 8 9]	REAL	h	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
65505	Operating hours counter L1 [5]	REAL	h	0.0 ... 3.4 x 10^{38}	✓	✓	✓	✓	✓
65506	Operating hours counter L2 [5]	REAL	h	0.0 ... 3.4 x 10^{38}		✓	✓	✓	✓
65507	Operating hours counter L3 [5]	REAL	h	0.0 ... 3.4 x 10^{38}		✓		✓	✓
65508	Status of energy counter overflows	WORD	Bit field	0x xxxx xxxx	✓	✓	✓	✓	✓
65509	Status of limits	WORD	Bit field	0x xxxx xxxx	✓	✓	✓	✓	✓
65510	Counter limit violation GW1 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65511	Counter limit violation GW2 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65512	Counter limit violation GW3 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65513	Counter limit violation GW4 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65514	Counter limit violation GW5 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65515	Counter limit violation GW6 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65516	Counter limit violation GW7 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
65517	Counter limit violation GW8 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65518	Counter limit violation GW9 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65519	Counter limit violation GW10 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65520	Counter limit violation GW11 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65521	Counter limit violation GW12 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65522	Counter limit violation GW13 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65523	Counter limit violation GW14 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65524	Counter limit violation GW15 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
65525	Counter limit violation GW16 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓
66001	Voltage UL1-N [1]	UINT	0.01 V	0 ... 65535	✓	✓	✓	✓	✓
66002	Voltage UL2-N [1]	UINT	0.01 V	0 ... 65535		✓	✓	✓	✓
66003	Voltage UL3-N [1]	UINT	0.01 V	0 ... 65535		✓		✓	✓
66004	Voltage UL1-L2 [2]	UINT	0.01 V	0 ... 65535				✓	✓
66005	Voltage UL2-L3 [2]	UINT	0.01 V	0 ... 65535				✓	✓
66006	Voltage UL3-L1 [2]	UINT	0.01 V	0 ... 65535				✓	✓
66007	Current L1 [1]	UINT	1 mA	0 ... 65535	✓	✓	✓	✓	✓
66008	Current L2 [1]	UINT	1 mA	0 ... 65535		✓	✓	✓	✓
66009	Current L3 [1]	UINT	1 mA	0 ... 65535		✓		✓	✓
66010	Apparent power L1 [3]	INT	1 VA	-27648 ... 27648	✓	✓	✓	✓	✓
66011	Apparent power L2 [3]	INT	1 VA	-27648 ... 27648		✓	✓	✓	✓
66012	Apparent power L3 [3]	INT	1 VA	-27648 ... 27648		✓		✓	✓
66013	Active power L1 [3]	INT	1 W	-27648 ... 27648	✓	✓	✓	✓	✓
66014	Active power L2 [3]	INT	1 W	-27648 ... 27648		✓	✓	✓	✓
66015	Active power L3 [3]	INT	1 W	-27648 ... 27648		✓		✓	✓
66016	Reactive power L1 [3]	INT	1 var	-27648 ... 27648	✓	✓	✓	✓	✓
66017	Reactive power L2 [3]	INT	1 var	-27648 ... 27648		✓	✓	✓	✓
66018	Reactive power L3 [3]	INT	1 var	-27648 ... 27648		✓		✓	✓
66019	Power factor L1 [3]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓
66020	Power factor L2 [3]	USINT	0.01	0 ... 100		✓	✓	✓	✓
66021	Power factor L3 [3]	USINT	0.01	0 ... 100		✓		✓	✓
66030	Frequency [4]	USINT	1 Hz	45 ... 65	✓	✓	✓	✓	✓
66034	Total apparent power L1L2L3 [5]	INT	1 VA	-27648 ... 27648	✓	✓	✓	✓	✓

Meas-ured value ID	Measured variables	Data type	Unit	Value range	Connection type				
					1P2W	3x1P2W	2P3W	3P4W	3P4W1
66035	Total active power L1L2L3 [5]	INT	1 W	-27648 ... 27648	✓	✓	✓	✓	✓
66036	Total reactive power L1L2L3 [5]	INT	1 var	-27648 ... 27648	✓	✓	✓	✓	✓
66037	Total power factor L1L2L3 [6]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓
66038	Frequency [4]	UINT	0.01 Hz	4500 ... 6500	✓	✓	✓	✓	✓

1 Effective value

2 IEC 61557-12

3 Arithmetical mean value over 200 ms as floating mean

4 Arithmetical mean value over 10 s as floating mean

5 Simple summation

6 Calculation from the start/restart (inflow and outflow values are positive numbers)

7 Determined from ratio of active and apparent power

8 For mapping both states as UINT (high: Energy counter overflow, low limit)

9 Corresponds to the maximum of the phase-specific operating hours counters

Format

Table B- 2 Format and its length in bytes

Format in STEP 7 (TIA Portal)	Format to IEEE	Length in bytes	Comment
BYTE	BYTE	1 byte	Bit field with 8 bit
WORD	WORD	2 bytes	Bit field with 16 bit
USINT	INT8 (unsigned)	1 byte	Fixed-point number 8 bits without sign
INT	INT16 (signed)	2 bytes	Fixed-point number 16 bits with sign
UINT	INT16 (unsigned)	2 bytes	Fixed-point number 16 bits without sign
UDINT	INT32 (unsigned)	4 bytes	Fixed-point number 32 bits without sign
REAL	Float32	4 bytes	Floating-point number 32 bits with sign
LREAL	Float64	8 bytes	Floating-point number 64 bits with sign

Module versions

C

C.1 Module version "2 I / 2 Q"

User data of the module

The module has 2 bytes of input user data and 2 bytes of output user data for status and control information. At this module version measured variables can be read solely via measured value data records (no measured variables can be evaluated via user data).

Structure of input user data

The structure of the input user data is fixed.

Table C- 1 Structure of input user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Constant = 0x80
1	Module	Quality information	Quality bits to describe the quality of the basic measured values

Allocation of the input user data

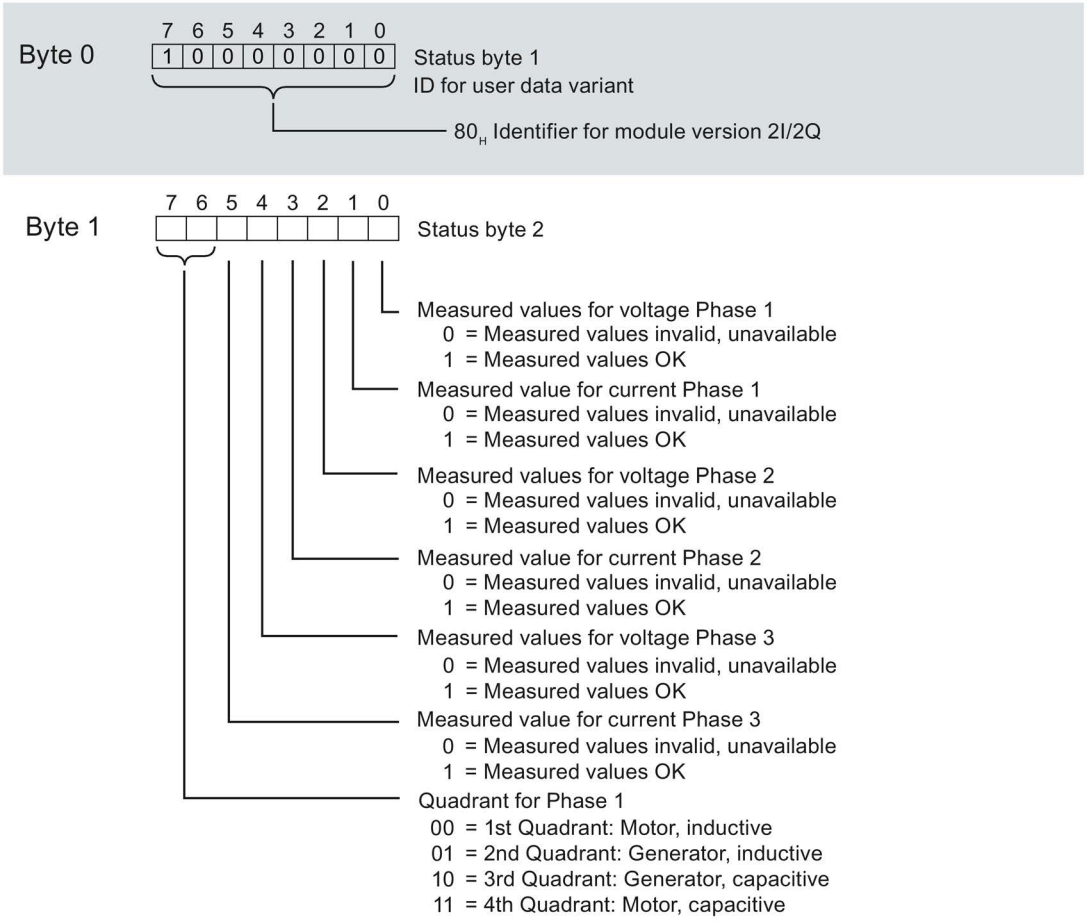


Image C-1 Allocation of the status bytes in the input user data (2 bytes)

Structure of output user data

The structure of the output user data is fixed.

Table C- 2 Structure of output user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	Reserved	Reserved
1	Module	Control outputs	Reset of values and counters, gate

Assignment of the output user data

Via the output user data you control for all phases

- Resetting for all minimum values, maximum values, limits, operating hours counter and energy counters.
- The counter gates for operating hours counter and energy counters.

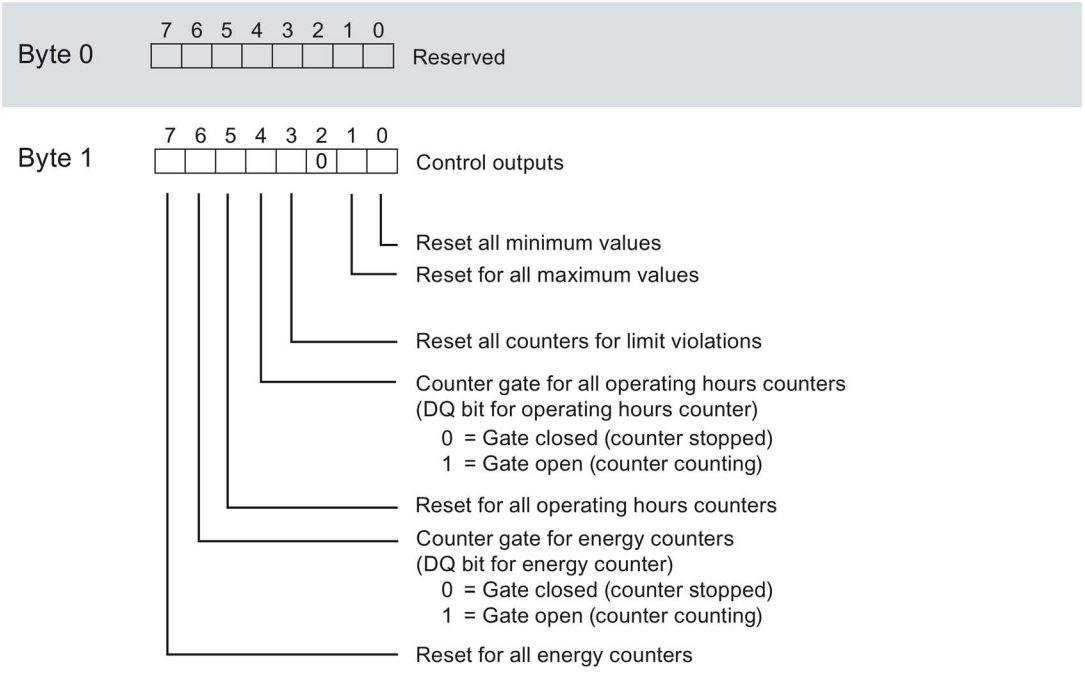


Image C-2 Allocation of the control byte in the output user data (1 byte)

Note

For module version 2 I / 2 Q, a reset of the selected variables always acts on **all** measured values/counter levels of the three phases.

- Reset energy counter: Acts on all active, reactive and apparent energies of all phases
- Reset operating hours counter: Acts on the counters of Phases 1 to 3
- Reset minimum / maximum values: Acts on the minimum and maximum value calculations of Phases 1-3
- Reset all counters for limit violations: Acts on all 16 limit values.

C.2 Module version "32 I / 12 Q"

User data of the module

The module occupies 32 bytes of input user data and 12 bytes of output user data. Of these the module uses 2 bytes input data for status information and 12 bytes output data for control information. Measured variables can be read cyclically via user data (Bytes 2 to 31) or acyclically via measured value data records

Structure of input user data

You can set the contents of the input user data dynamically. You can choose between different user data variants.

Table C- 3 Structure of input user data (12 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 31	Module or phase	Data	2 or 4 bytes of measured values or calculated values according to user data variant

Allocation of the input user data

You can change the measured variables during operation. You can choose between different user data variants.

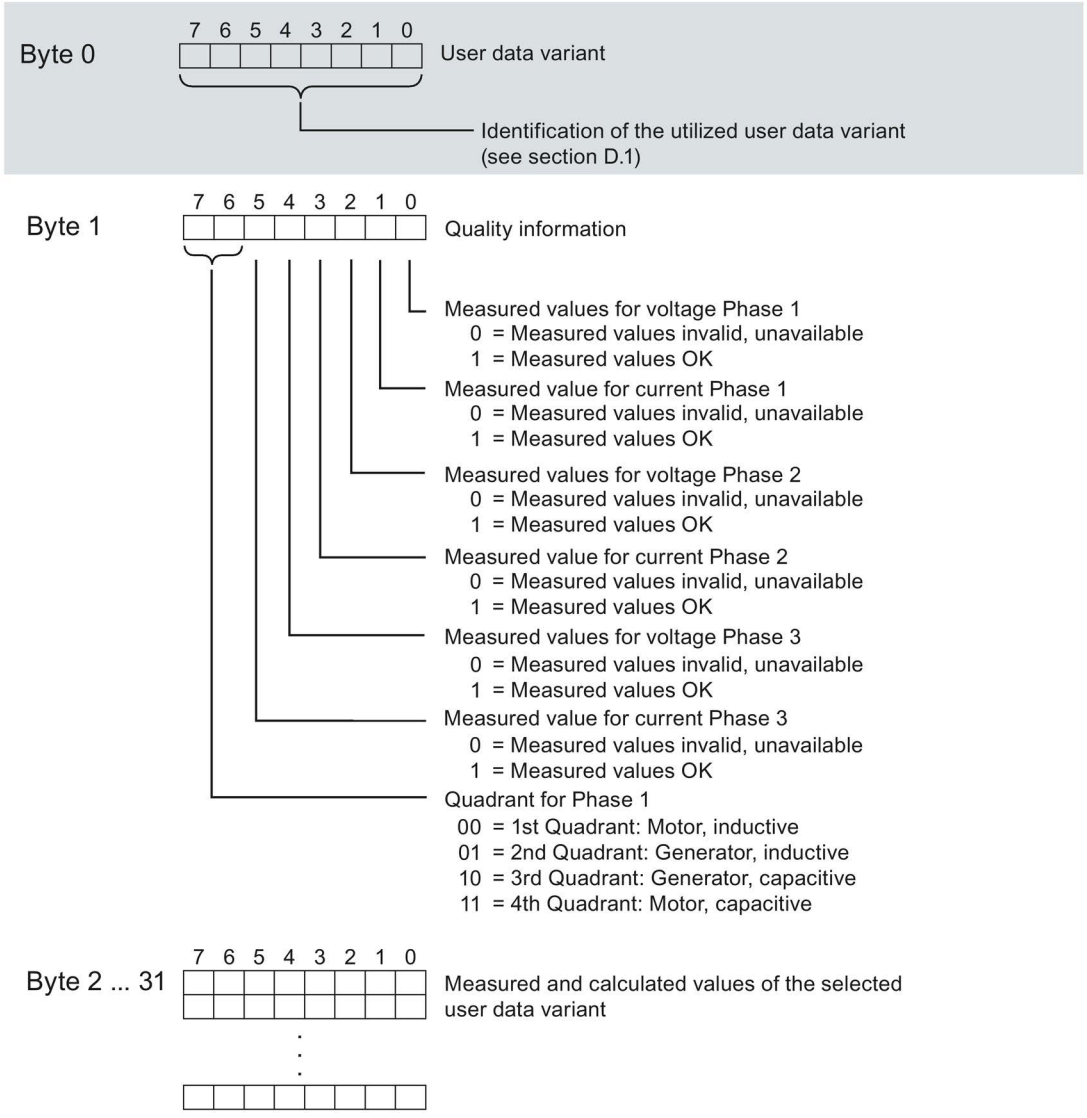


Image C-3 Assignment of the input user data (32 bytes)

Structure of output user data

The structure of the output user data is fixed and is the same at all the selectable user data variants.

Via the output user data you control globally or phase-specifically

- Resetting for minimum values, maximum values, limits, operating hours counter and energy counters.
- The counter gates for operating hours counter and energy counters.

Table C- 4 Structure of output user data (12 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Control byte for switching the user data variant
1	Module	Control byte 1	Global resetting of values and counters, gate
2	Module	Control byte 2	Selection of the energy counter to be reset
3	Module	Control byte 3	Control of the limit monitoring of limit values 9 to 16
4	Module	Control byte 4	Control of the limit monitoring of limit values 1 to 8
5	Module	Reserved	-
6	Phase L1	Control byte 6	Phase-specific resetting of values and counters, gate for Phase 1
7	Phase L1	Control byte 7	
8	Phase L2	Control byte 8	Phase-specific resetting of values and counters, gate for Phase 2
9	Phase L2	Control byte 9	
10	Phase L3	Control byte 10	Phase-specific resetting of values and counters, gate for Phase 3
11	Phase L3	Control byte 11	

Control bytes for user data variant

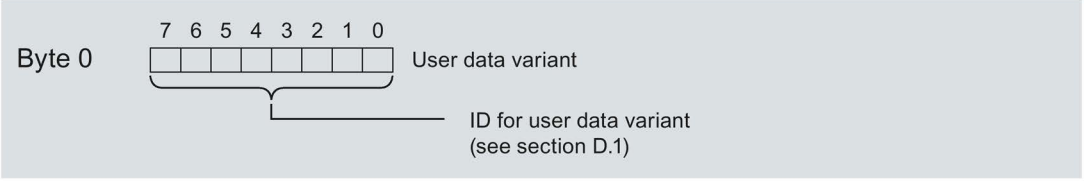


Image C-4 Allocation of the control bytes for user data variant (Byte 0)

Control bytes for all three phases

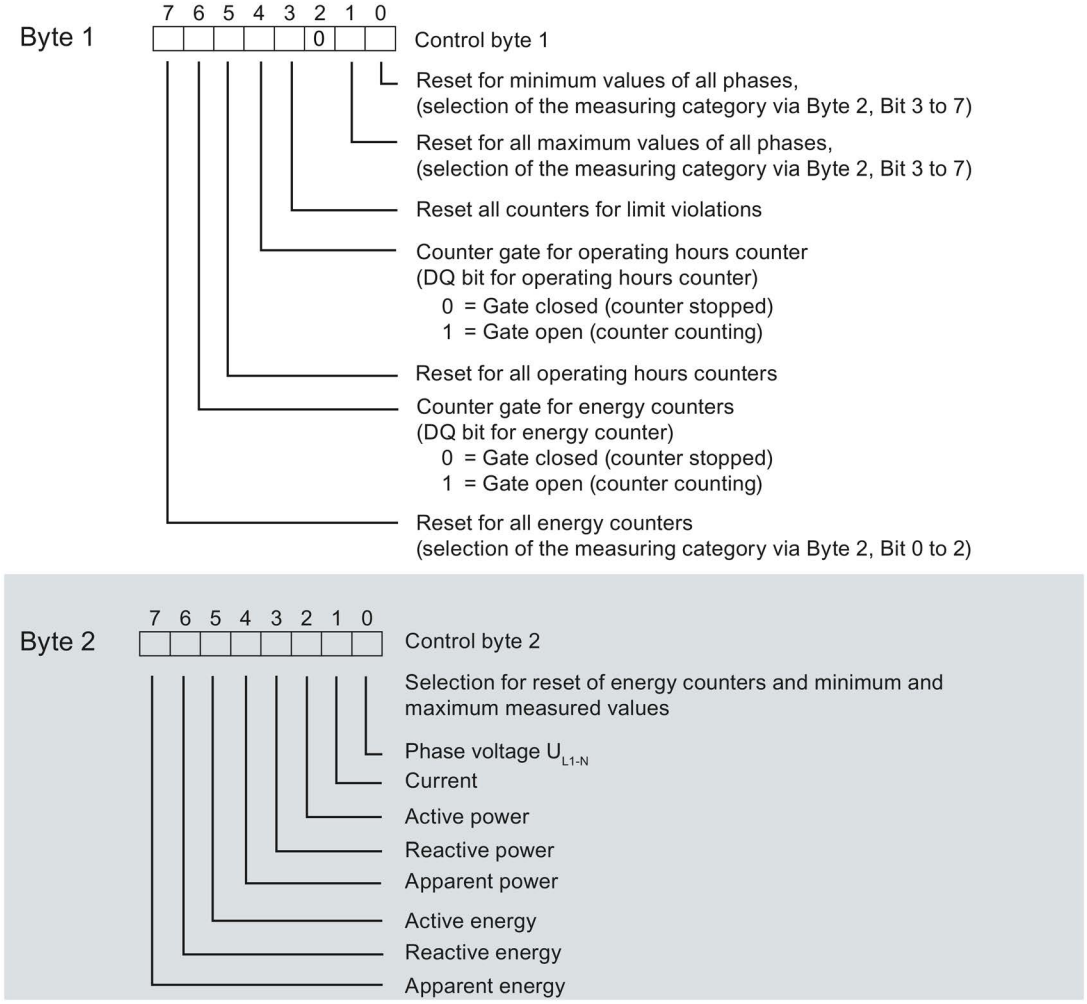


Image C-5 Allocation of the control bytes for all three phases (bytes 1 and 2)

Control bytes for limit monitoring

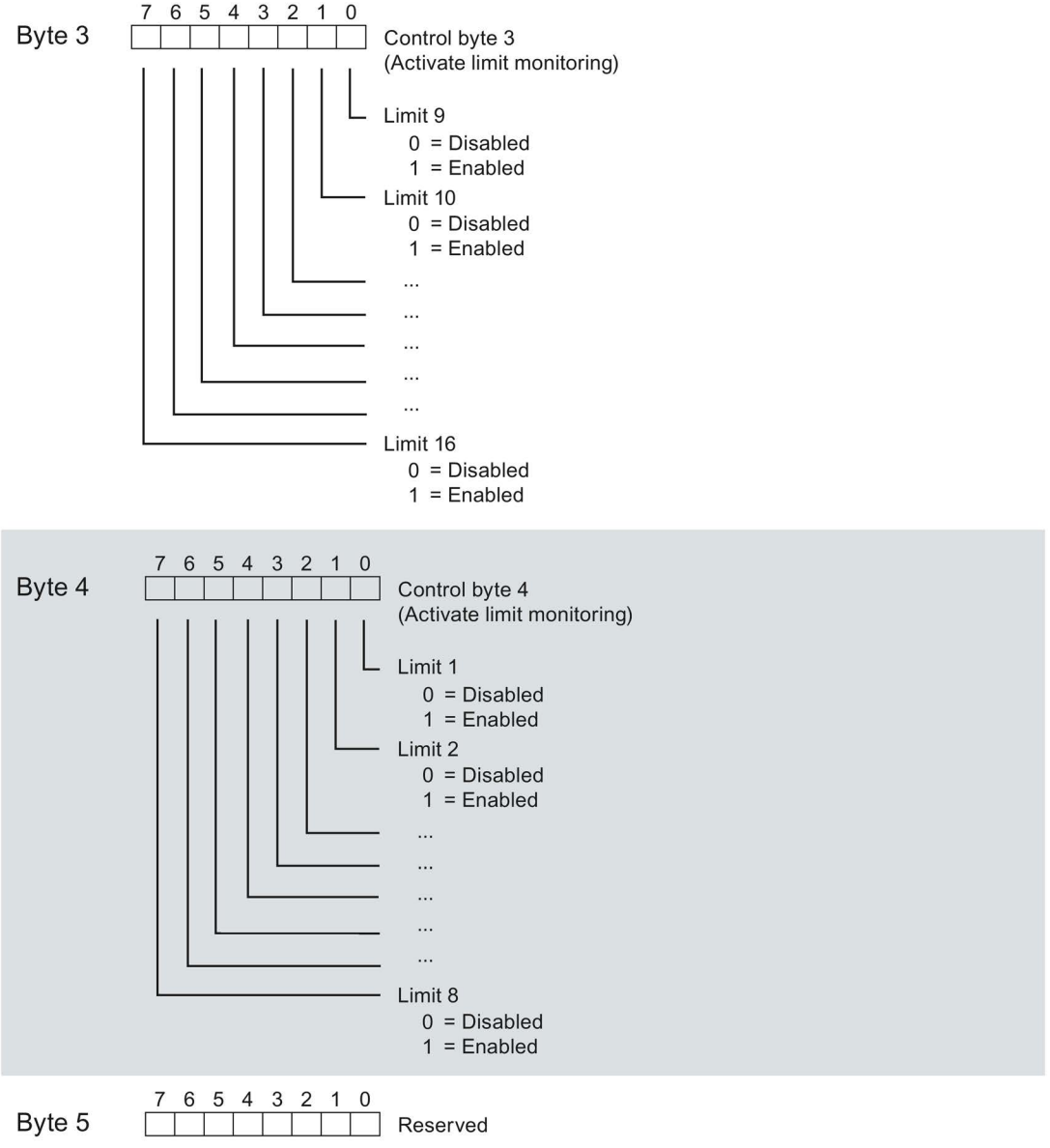


Image C-6 Allocation of the control bytes for limit monitoring (bytes 3 to 5)

Control bytes for each individual phase

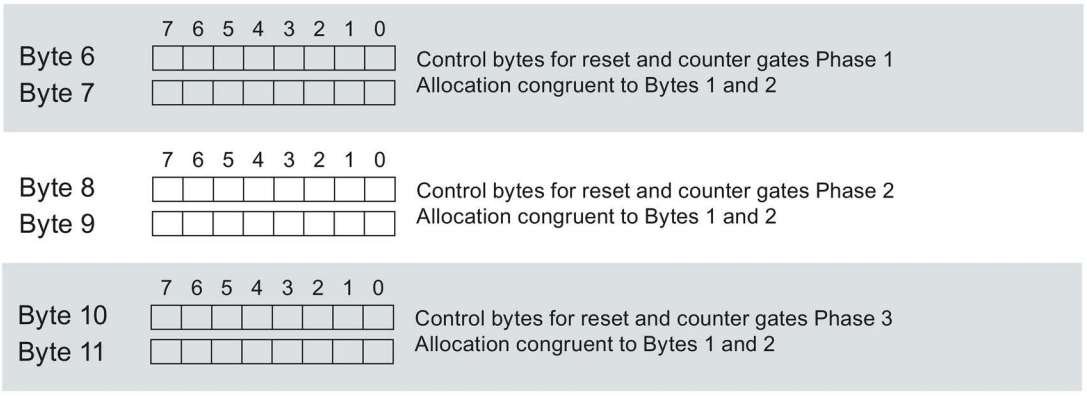


Image C-7 Allocation of the control bytes for each individual phase (bytes 6 to 11)

C.3 "User-specific" module version

User data of the module

The module occupies between 16 and 256 bytes of input user data and 12 bytes of output user data. Of these the module uses 2 bytes input data for status information and 12 bytes output data for control information. Measured variables can be read cyclically via user data (as of Byte 2) or acyclically via measured value data records

Structure of input user data

You configure the structure of the input user data starting at Byte 2 at this module version itself. An input user data length of 32 bytes also allows you to set the input user data dynamically. You can choose between different user data variants.

Table C- 5 Structure of input user data (16 to 256 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 255	Module or phase	Data	Measured values or calculated values in accordance with their configuration: • At configuration in STEP 7 the size of the input user data is calculated automatically. • At configuration via the GSD file the size of the input user data amounts to 32, 64, 128 or 256 bytes. The memory area has to be sufficiently large for the measured variables defined in parameter data record 130.

Allocation of the input user data

You can change the measured variables during operation. You can choose between different user data variants.

The allocation of the status information in Byte 0 and 1 corresponds to the module version 32 I / 12 Q, see appendix Module version "32 I / 12 Q" (Page 125).

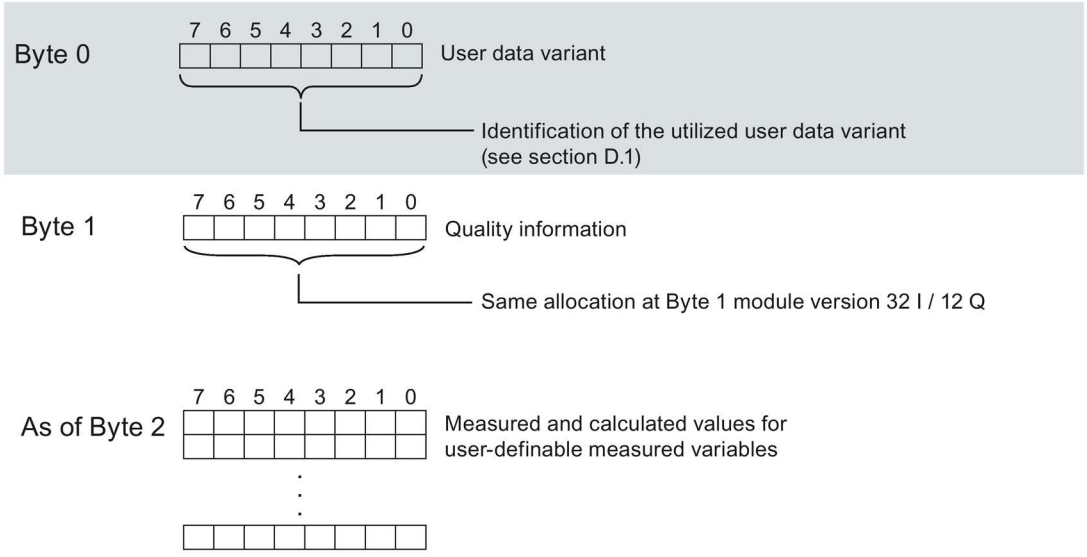


Image C-8 Allocation of the input user data ("User-specific" module version"

Note

Behavior at switchover in case of the input user data being too small

If the configured size of the variable input user data is smaller than the sized of the fixed user data variant, the response depends on the type of switchover:

- Re-configuration via parameter data record 128 / 130: Output of a parameter assignment error (33). No switchover.
- Switchover using output byte 0 of a user data variant: No switchover and no error message.

Structure of output user data

The structure of the 12 output user data is fixed and is identical to the output user data (control bytes) of the Module version "32 I / 12 Q" (Page 125).

C.4 Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3"

User data of the module

The four versions according to EE@Industry use between 4 and 104 bytes of input user data and 12 bytes of output user data. A dynamic switchover of the input user data is not possible.

Structure of input user data

The structure of the input user data for the module versions according to the EE@Industry standard is fixed and depends on the selected measurement data profile.

Table C- 6 Measurement data profile E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Current L1	REAL	1 A	0.0 … 100000.0	7
4...7	Current L2	REAL	1 A	0.0 … 100000.0	8
8...11	Current L3	REAL	1 A	0.0 … 100000.0	9

Table C- 7 Measurement data profile E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Total active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+3.0 \times 10^9$	35

Table C- 8 Measurement data profile E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Total active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+3.0 \times 10^9$	35
4...7	Total active energy L1L2L3 inflow	REAL	1 Wh	0 ... 1.8×10^{38}	210
8...11	Total active energy L1L2L3 outflow	REAL	1 Wh	0 ... 1.8×10^{38}	211

Table C- 9 Measurement data profile E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1	REAL	1 W	-3.0×10^9 ... $+3.0 \times 10^9$	13
4...7	Active power L2	REAL	1 W	-3.0×10^9 ... $+3.0 \times 10^9$	14
8...11	Active power L3	REAL	1 W	-3.0×10^9 ... $+3.0 \times 10^9$	15
12...15	Reactive power L1	REAL	1 var	-3.0×10^9 ... $+3.0 \times 10^9$	16
16...19	Reactive power L2	REAL	1 var	-3.0×10^9 ... $+3.0 \times 10^9$	17
20...23	Reactive power L3	REAL	1 var	-3.0×10^9 ... $+3.0 \times 10^9$	18
24...31	Total active energy L1L2L3 inflow	LREAL	1 Wh	0 ... 1.8×10^{308}	210
32...39	Total active energy L1L2L3 outflow	LREAL	1 Wh	0 ... 1.8×10^{308}	211
40...47	Total reactive energy L1L2L3 inflow	LREAL	1 varh	0 ... 1.8×10^{308}	212
48...55	Total reactive energy L1L2L3 outflow	LREAL	1 varh	0 ... 1.8×10^{308}	213
56...59	Voltage UL1-N	REAL	1 V	0.0 … 1000000.0	1
60...63	Voltage UL2-N	REAL	1 V	0.0 … 1000000.0	2
64...67	Voltage UL3-N	REAL	1 V	0.0 … 1000000.0	3
68...71	Voltage UL1-UL2	REAL	1 V	0.0 … 1000000.0	4
72...75	Voltage UL2-UL3	REAL	1 V	0.0 … 1000000.0	5
76...79	Voltage UL3-UL1	REAL	1 V	0.0 … 1000000.0	6
80...83	Current L1	REAL	1 A	0.0 … 100000.0	7
84...87	Current L2	REAL	1 A	0.0 … 100000.0	8
88...91	Current L3	REAL	1 A	0.0 … 100000.0	9
92...95	Power factor L1	REAL	-	0.0 … 1.0	19
96...99	Power factor L2	REAL	-	0.0 … 1.0	20
100...103	Power factor L3	REAL	-	0.0 … 1.0	21

Structure of output user data

The structure of the 12 byte output user data is fixed and is identical to the output user data (control bytes) of the Module version "32 I / 12 Q" (Page 125).

User data variants

D

D.1 User data variants with 32 bytes input data / 12 bytes output data

User data

30 bytes are available for transferring the measured values in a cycle at the module version 32 I / 12 Q. Therefore this module version supports dynamic switching between 22 preconfigured user data variants that contain a specific selection of measured values.

For more detailed information, refer to "Selecting the module versions (Page 26)".

Table D- 1 Overview of the user data variants

User data	User data variant
Total power L1L2L3	254 (FE_H) - default setting
Active power L1L2L3	253 (FD_H)
Reactive power L1L2L3	252 (FC_H)
Apparent power L1L2L3	251 (FB_H)
Basic measured values L1L2L3	250 (FA_H)
Total energy L1L2L3	249 ($F9_H$)
Energy L1	248 ($F8_H$)
Energy L2	247 ($F7_H$)
Energy L3	246 ($F6_H$)
Basic variables three-phase measurement L1L2L3	245 ($F5_H$)
Quality values three-phase measurement	240 ($F0_H$)
Energy measurement (periodic) overflow counter	239 (EF_H)
EE@Industry measurement data profile E3	227 ($E3_H$)
EE@Industry measurement data profile E2	226 ($E2_H$)
EE@Industry measurement data profile E1	225 ($E1_H$)
EE@Industry measurement data profile E0	224 ($E0_H$)
Basic variables phase-specific measurement L1	159 ($9F_H$)
Basic variables phase-specific measurement L1a	158 ($9E_H$)
Basic variables phase-specific measurement L2	157 ($9D_H$)
Basic variables phase-specific measurement L2a	156 ($9C_H$)
Basic variables phase-specific measurement L3	155 ($9B_H$)
Basic variables phase-specific measurement L3a	154 ($9A_H$)
User-defined user data structure	1 (01_H)

Total power L1L2L3 (ID 254 or FE_H)

Table D- 2 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Total active power L1L2L3	INT	1 W	-27648 … 27648	66035
10 ... 11	Total reactive power L1L2L3	INT	1 var	-27648 … 27648	66036
12 ... 13	Total apparent power L1L2L3	INT	1 VA	-27648 … 27648	66034
14 ... 17	Total active energy L1L2L3	UDINT	1 Wh	0 …4294967295	225
18 ... 21	Total reactive energy L1L2L3	UDINT	1 varh	0 …4294967295	226
22	Reserved	BYTE	-	0	-
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling total active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling total reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling total apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Active power L1L2L3 (ID 253 or FD_H)

Table D- 3 Active power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	253 (FD_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Active power L1	INT	1 W	-27648 … 27648	66013
10 ... 11	Active power L2	INT	1 W	-27648 … 27648	66014
12 ... 13	Active power L3	INT	1 W	-27648 … 27648	66015
14 ... 15	Total active power L1L2L3	INT	1 W	-27648 … 27648	66035
16 ... 19	Total active energy L1L2L3	UDINT	1 Wh	0 …4294967295	225
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1	USINT	-	0 ... 255	-
28	Scaling active power L2	USINT	-	0 ... 255	-
29	Scaling active power L3	USINT	-	0 ... 255	-
30	Scaling active power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-

Reactive power L1L2L3 (ID 252 or FC_H)

Table D- 4 Reactive power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	252 (FC_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Reactive power L1	INT	1 var	-27648 … 27648	66016
10 ... 11	Reactive power L2	INT	1 var	-27648 … 27648	66017
12 ... 13	Reactive power L3	INT	1 var	-27648 … 27648	66018
14 ... 15	Total reactive power L1L2L3	INT	1 var	-27648 … 27648	66036
16 ... 19	Total reactive energy L1L2L3	UDINT	1 varh	0 ... 4294967295	226
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling reactive power L1	USINT	-	0 ... 255	-
28	Scaling reactive power L2	USINT	-	0 ... 255	-
29	Scaling reactive power L3	USINT	-	0 ... 255	-
30	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Apparent power L1L2L3 (ID 251 or FB_H)

Table D- 5 Apparent power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	251 (FB_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Apparent power L1	INT	1 VA	-27648 … 27648	66010
10 ... 11	Apparent power L2	INT	1 VA	-27648 … 27648	66011
12 ... 13	Apparent power L3	INT	1 VA	-27648 … 27648	66012
14 ... 15	Total apparent power L1L2L3	INT	1 VA	-27648 … 27648	66034
16 ... 19	Total apparent energy L1L2L3	UDINT	1 VAh	0 ... 4294967295	224
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling apparent power L2	USINT	-	0 ... 255	-
29	Scaling apparent power L3	USINT	-	0 ... 255	-
30	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total apparent energy L1L2L3	USINT	-	0 ... 255	-

Basic measured values L1L2L3 (ID 250 or FA_H)

Table D- 6 Basic measured values L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	250 (FA_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Voltage UL1-N	UINT	0.01 V	0 … 65535	66001
10 ... 11	Voltage UL2-N	UINT	0.01 V	0 … 65535	66002
12 ... 13	Voltage UL3-N	UINT	0.01 V	0 … 65535	66003
14 ... 15	Voltage UL1-UL2	UINT	0.01 V	0 … 65535	66004
16 ... 17	Voltage UL2-UL3	UINT	0.01 V	0 … 65535	66005
18 ... 19	Voltage UL3-UL1	UINT	0.01 V	0 … 65535	66006
20	Power factor L1	USINT	0.01	0 … 100	66019
21	Power factor L2	USINT	0.01	0 … 100	66020
22	Power factor L3	USINT	0.01	0 … 100	66021
23	Total power factor L1L2L3	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling voltage UL1-N (UL1-UL2)	USINT	-	0 ... 255	-
28	Scaling voltage UL2-N (UL2-UL3)	USINT	-	0 ... 255	-
29	Scaling voltage UL3-N (UL3-UL1)	USINT	-	0 ... 255	-
30 ... 31	Frequency	UINT	0.01 Hz	4500 ... 6500	66038

Total energy L1L2L3 (ID 249 or $F9_H$)

Table D- 7 Total energy L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	249 ($F9_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Reserved	BYTE	-	-	-
3	Reserved	BYTE	-	-	-
4 ... 7	Total active energy inflow L1L2L3	UDINT	1 Wh	0 … 4294967295	220
8 ... 11	Total active energy outflow L1L2L3	UDINT	1 Wh	0 … 4294967295	221
11 ... 15	Total reactive energy inflow L1L2L3	UDINT	1 varh	0 … 4294967295	222
16 ... 19	Total reactive energy outflow L1L2L3	UDINT	1 varh	0 … 4294967295	223
20 ... 23	Total apparent energy L1L2L3	UDINT	1 VAh	0 … 4294967295	224
24	Reserved	BYTE	-	-	-
25	Scaling active energy, inflow	USINT	-	0 ... 255	-
26	Scaling active energy, outflow	USINT	-	0 ... 255	-
27	Scaling reactive energy, inflow	USINT	-	0 ... 255	-
28	Scaling reactive energy, outflow	USINT	-	0 ... 255	-
29	Scaling apparent energy	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	-	-
31	Total power factor L1L2L3	USINT	0.01	0 … 100	66037

Energy L1 (ID 248 or $F8_H$)

Table D- 8 Energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	248 ($F8_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 7	Active energy inflow L1	UDINT	1 Wh	0 … 4294967295	62110
8 ... 11	Active energy outflow L1	UDINT	1 Wh	0 … 4294967295	62111
11 ... 15	Reactive energy inflow L1	UDINT	1 varh	0 … 4294967295	62112
16 ... 19	Reactive energy outflow L1	UDINT	1 varh	0 … 4294967295	62113
20 ... 23	Apparent energy L1	UDINT	1 VAh	0 … 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active energy inflow L1	USINT	-	0 ... 255	-
26	Scaling active energy outflow L1	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L1	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L1	USINT	-	0 ... 255	-
29	Scaling apparent energy L1	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	-	-
31	Power factor L1	USINT	0.01	0 … 100	66019

Energy L2 (ID 247 or $F7_H$)

Table D- 9 Energy L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	247 ($F7_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 … 65535	66008
4 ... 7	Active energy inflow L2	UDINT	1 Wh	0 … 4294967295	62210
8 ... 11	Active energy outflow L2	UDINT	1 Wh	0 … 4294967295	62211
11 ... 15	Reactive energy inflow L2	UDINT	1 varh	0 … 4294967295	62212
16 ... 19	Reactive energy outflow L2	UDINT	1 varh	0 … 4294967295	62213
20 ... 23	Apparent energy L2	UDINT	1 VAh	0 … 4294967295	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active energy inflow L2	USINT	-	0 ... 255	-
26	Scaling active energy outflow L2	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L2	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L2	USINT	-	0 ... 255	-
29	Scaling apparent energy L2	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	-	-
31	Power factor L2	USINT	0.01	0 … 100	66020

Energy L3 (ID 246 or $F6_H$)

Table D- 10 Energy L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	246 ($F6_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 … 65535	66009
4 ... 7	Active energy inflow L3	UDINT	1 Wh	0 … 4294967295	62310
8 ... 11	Active energy L3, outflow	UDINT	1 Wh	0 … 4294967295	62311
11 ... 15	Reactive energy inflow L3	UDINT	1 varh	0 … 4294967295	62312
16 ... 19	Reactive energy outflow L3	UDINT	1 varh	0 … 4294967295	62313
20 ... 23	Apparent energy L3	UDINT	1 VAh	0 … 4294967295	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active energy inflow L3	USINT	-	0 ... 255	-
26	Scaling active energy outflow L3	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L3	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L3	USINT	-	0 ... 255	-
29	Scaling apparent energy L3	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	-	-
31	Power factor L3	USINT	0.01	0 … 100	66021

Basic variables three-phase measurements (ID 245 or $F5_H$)

Table D- 11 Basic variables three-phase measurements

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	245 ($F5_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Total active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	35
6 ... 9	Total active energy outflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	211
10 ... 13	Total active energy inflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	210
14 ... 17	Current L1	REAL	1 A	0.0 … 100000.0	7
18 ... 21	Current L2	REAL	1 A	0.0 … 100000.0	8
22 ... 25	Current L3	REAL	1 A	0.0 … 100000.0	9
26 ... 27	Voltage UL1-N	UINT	0.01 V	0 … 65535	66001
28 ... 29	Voltage UL2-N	UINT	0.01 V	0 … 65535	66002
30 ... 31	Voltage UL3-N	UINT	0.01 V	0 … 65535	66003

Basic variables quality values three-phase measurement (ID 240 or $F0_H$)

Table D- 12 Basic variables quality values three-phase measurement

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	240 (F0H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Status of the limit monitoring GW 1 ... 16 (*)	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
4 ... 5	Status of the energy counter overflows (**)	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
6 ... 7	Quality information = 00 DD QQ_3 QQ_2 QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
8 ... 9	Reserved	WORD	-	-	-
10 ... 11	Reserved	WORD	-	-	-
12 ... 13	Reserved	WORD	-	-	-
14 ... 15	Reserved	WORD	-	-	-
16 ... 17	Reserved	WORD	-	-	-
18 ... 19	Reserved	WORD	-	-	-
20 ... 21	Reserved	WORD	-	-	-
22 ... 23	Reserved	WORD	-	-	-
24 ... 25	Reserved	WORD	-	-	-
26 ... 27	Reserved	WORD	-	-	-
28 ... 29	Reserved	WORD	-	-	-
30 ... 31	Reserved	WORD	-	-	-

(*) Limit violation in:
Bit 0 = limit 1 to bit 15 = limit 16

(**) Energy counter count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Basic variables energy counter measurement (periodic) overflow counter (ID 239 or EF_H)

Table D- 13 Basic variables energy counter measurement (periodic) overflow counter

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	239 (EFH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Overflow counter for active energy inflow L1	UINT	-	0 … 65535	65120
4 ... 5	Overflow counter for active energy outflow L1	UINT	-	0 … 65535	65121
6 ... 7	Overflow counter for reactive energy inflow L1	UINT	-	0 … 65535	65122
8 ... 9	Overflow counter for reactive energy outflow L1	UINT	-	0 … 65535	65123
10 ... 11	Overflow counter for apparent energy L1	UINT	-	0 … 65535	65124
12 ... 13	Overflow counter for active energy inflow L2	UINT	-	0 … 65535	62220
14 ... 15	Overflow counter for active energy outflow L2	UINT	-	0 … 65535	62221
16 ... 17	Overflow counter for reactive energy inflow L2	UINT	-	0 … 65535	62222
18 ... 19	Overflow counter for reactive energy outflow L2	UINT	-	0 … 65535	62223
20 ... 21	Overflow counter for apparent energy L2	UINT	-	0 … 65535	62224
22 ... 23	Overflow counter for active energy inflow L3	UINT	-	0 … 65535	62320
24 ... 25	Overflow counter for active energy outflow L3	UINT	-	0 … 65535	62321
26 ... 27	Overflow counter for reactive energy inflow L3	UINT	-	0 … 65535	62322
28 ... 29	Overflow counter for reactive energy outflow L3	UINT	-	0 … 65535	62323
30 ... 31	Overflow counter for apparent energy L3	UINT	-	0 … 65535	62324

Basic variables measurement data profile (ID 227 or $E3_H$)

Table D- 14 Basic variables measurement data profile Energy E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	227 ($E3_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	13
6 ... 9	Active power L2	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	14
10 ... 13	Active power L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	15
14 ... 17	Reactive power L1	REAL	1 var	-3.0×10^9 ... $+ 3.0 \times 10^9$	16
18 ... 21	Reactive power L2	REAL	1 var	-3.0×10^9 ... $+ 3.0 \times 10^9$	17
22 ... 25	Reactive power L3	REAL	1 var	-3.0×10^9 ... $+ 3.0 \times 10^9$	18
26 ... 33	Total active energy L1L2L3 inflow	LREAL	1 Wh	0.0 ... 1.8×10^{308}	220
34 ... 41	Total active energy L1L2L3 outflow	LREAL	1 Wh	0.0 ... 1.8×10^{308}	221
42 ... 49	Total reactive energy L1L2L3 inflow	LREAL	1 varh	0.0 ... 1.8×10^{308}	222
50 ... 57	Total reactive energy L1L2L3 outflow	LREAL	1 varh	0.0 ... 1.8×10^{308}	223
58 ... 61	Voltage UL1-N	REAL	1 V	0.0 … 1000000.0	1
62 ... 65	Voltage UL2-N	REAL	1 V	0.0 … 1000000.0	2
66 ... 69	Voltage UL3-N	REAL	1 V	0.0 … 1000000.0	3
70 ... 73	Voltage UL1-UL2	REAL	1 V	0.0 … 1000000.0	4
74 ... 77	Voltage UL2-UL3	REAL	1 V	0.0 … 1000000.0	5
78 ... 81	Voltage UL3-UL1	REAL	1 V	0.0 … 1000000.0	6
82 ... 85	Current L1	REAL	1 A	0.0 … 100000.0	7
86 ... 89	Current L2	REAL	1 A	0.0 … 100000.0	8
90 ... 93	Current L3	REAL	1 A	0.0 … 100000.0	9
94 ... 97	Power factor L1	REAL	-	0.0 … 1.0	19
98 ... 101	Power factor L2	REAL	-	0.0 … 1.0	20
102 ... 105	Power factor L3	REAL	-	0.0 … 1.0	21

Basic variables measurement data profile (ID 226 or $E2_H$)

Table D- 15 Basic variables measurement data profile Energy E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	226 ($E2_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Total active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	35
6 ... 9	Total active energy inflow L1L2L3	REAL	1 W	3.0×10^9	220
10 ...13	Total active energy outflow L1L2L3	REAL	1 W	3.0×10^9	221

Basic variables measurement data profile (ID 225 or $E1_H$)

Table D- 16 Basic variables measurement data profile Energy E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	225 ($E1_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Total active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	35

Basic variables measurement data profile (ID 224 or $E0_H$)

Table D- 17 Basic variables measurement data profile Energy E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	224 ($E0_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Current L1	REAL	1 A	0.0 … 100000.0	7
6 ... 9	Current L2	REAL	1 A	0.0 … 100000.0	8
10 ...13	Current L3	REAL	1 A	0.0 … 100000.0	9

Basic variables phase-specific measurement (ID 159 or $9F_H$)

Table D- 18 Basic variables phase-specific measurement L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	159 (9FH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Voltage UL1-N	UINT	0.01 V	0 … 65535	66001
6 ... 7	Active power L1	INT	1 W	-27648 … 27648	66013
8 ... 9	Reactive power L1	INT	1 var	-27648 … 27648	66016
10 ... 11	Apparent power L1	INT	1 VA	-27648 … 27648	66010
12 ... 15	Active energy L1 total (inflow - outflow)	UDINT	1 Wh	0 … 4294967295	62115
16 ... 19	Reactive energy L1 total (inflow - outflow)	UDINT	1 varh	0 … 4294967295	62116
20 ... 23	Apparent energy L1	UDINT	1 VAh	0 … 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling active energy L1 total (inflow - outflow)	USINT	-	0 ... 255	-
29	Scaling reactive energy L1 total (inflow - outflow)	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Power factor L1	USINT	0.01	0 … 100	66019

Basic variables phase-specific measurement (ID 158 or $9E_H$)

Table D- 19 Basic variables phase-specific measurement L1a

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	158 (9EH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Voltage UL1-N	UINT	0.01 V	0 … 65535	66001
6 ... 7	Active power L1	INT	1 W	-27648 … 27648	66013
8 ... 9	Reactive power L1	INT	1 var	-27648 … 27648	66016
10 ... 11	Apparent power L1	INT	1 VA	-27648 … 27648	66010
12 ... 15	Active energy L1 total (inflow - outflow)	UDINT	1 Wh	0 … 4294967295	62115
16 ... 19	Reactive energy L1 total (inflow - outflow)	UDINT	1 varh	0 … 4294967295	62116
20 ... 23	Apparent energy L1	UDINT	1 VAh	0 … 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling active energy L1 total (inflow - outflow)	USINT	-	0 ... 255	-
29	Scaling reactive energy L1 total (inflow - outflow)	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Scaling voltage UL1-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 157 or 9D$_H$)

Table D- 20 Basic variables phase-specific measurement L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	157 (9D$_H$)	-
1	Quality information = QQ$_1$ I$_3$ U$_3$ I$_2$ U$_2$ I$_1$ U$_1$	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 … 65535	66008
4 ... 5	Voltage UL2-N	UINT	0.01 V	0 … 65535	66002
6 ... 7	Active power L2	INT	1 W	-27648 … 27648	66014
8 ... 9	Reactive power L2	INT	1 var	-27648 … 27648	66017
10 ... 11	Apparent power L2	INT	1 VA	-27648 … 27648	66011
12 ... 15	Active energy L2 total (inflow - outflow)	UDINT	1 Wh	0 … 4294967295	62215
16 ... 19	Reactive energy L2 total (inflow - outflow)	UDINT	1 varh	0 … 4294967295	62216
20 ... 23	Apparent energy L2	UDINT	1 VAh	0 … 4294967295	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Scaling active energy L2 total (inflow - outflow)	USINT	-	0 ... 255	-
29	Scaling reactive energy L2 total (inflow - outflow)	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Power factor L2	USINT	0.01	0 … 100	66020

Basic variables phase-specific measurement (ID 156 or $9C_H$)

Table D- 21 Basic variables phase-specific measurement L2a

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	156 (9CH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 … 65535	66008
4 ... 5	Voltage UL2-N	UINT	0.01 V	0 … 65535	66002
6 ... 7	Active power L2	INT	1 W	-27648 … 27648	66014
8 ... 9	Reactive power L2	INT	1 var	-27648 … 27648	66017
10 ... 11	Apparent power L2	INT	1 VA	-27648 … 27648	66011
12 ... 15	Active energy L2 total (inflow - outflow)	UDINT	1 Wh	0 … 4294967295	62215
16 ... 19	Reactive energy L2 total (inflow - outflow)	UDINT	1 varh	0 … 4294967295	62216
20 ... 23	Apparent energy L2	UDINT	1 VAh	0 … 4294967295	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Scaling active energy L2 total (inflow - outflow)	USINT	-	0 ... 255	-
29	Scaling reactive energy L2 total (inflow - outflow)	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Scaling voltage UL2-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 155 or $9B_H$)

Table D- 22 Basic variables phase-specific measurement L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	155 ($9B_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 … 65535	66009
4 ... 5	Voltage UL3-N	UINT	0.01 V	0 … 65535	66003
6 ... 7	Active power L3	INT	1 W	-27648 … 27648	66015
8 ... 9	Reactive power L3	INT	1 var	-27648 … 27648	66018
10 ... 11	Apparent power L3	INT	1 VA	-27648 … 27648	66012
12 ... 15	Active energy L3 total (inflow - outflow)	UDINT	1 Wh	0 … 4294967295	62315
16 ... 19	Reactive energy L3 total (inflow - outflow)	UDINT	1 varh	0 … 4294967295	62316
20 ... 23	Apparent energy L3	UDINT	1 VAh	0 … 4294967295	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Scaling active energy L3 total (inflow - outflow)	USINT	-	0 ... 255	-
29	Scaling reactive energy L3 total (inflow - outflow)	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Power factor L3	USINT	0.01	0 … 100	66021

Basic variables phase-specific measurement (ID 154 or $9A_H$)

Table D- 23 Basic variables phase-specific measurement L3a

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	154 ($9A_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 … 65535	66009
4 ... 5	Voltage UL3-N	UINT	0.01 V	0 … 65535	66003
6 ... 7	Active power L3	INT	1 W	-27648 … 27648	66015
8 ... 9	Reactive power L3	INT	1 var	-27648 … 27648	66018
10 ... 11	Apparent power L3	INT	1 VA	-27648 … 27648	66012
12 ... 15	Active energy L3 total (inflow - outflow)	UDINT	1 Wh	0 … 4294967295	62315
16 ... 19	Reactive energy L3 total (inflow - outflow)	UDINT	1 varh	0 … 4294967295	62316
20 ... 23	Apparent energy L3	UDINT	1 VAh	0 … 4294967295	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Scaling active energy L3 total (inflow - outflow)	USINT	-	0 ... 255	-
29	Scaling reactive energy L3 total (inflow - outflow)	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Scaling voltage UL3-N	USINT	-	0 ... 255	-

Measured value data records

E

E.1 Overview of all measured value data records

Energy Meter 480VAC ST writes the measured values in several data records that you can read acyclically using the RDREC instruction in the user program.

The following tables show the structure of the individual data records:

- Data record DS 142 for basic measured values (read only).
- Data record DS 143 for energy counters (read and write).
- Data record DS 144 for maximum values (read only).
- Data record DS 145 for minimum values (read only).
- Data record DS 147 for phase-specific measured values L1 (read only).
- Data record DS 148 for phase-specific measured values L2 (read only).
- Data record DS 149 for phase-specific measured values L3 (read only).
- Data record DS 150 for advanced measurement and status values (read only).

E.2 Measured value data record for base measurements (DS 142)

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Please note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in appendix B (Measured variables (Page 113)).

Table E- 1 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2...5	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage UL2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage UL3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage UL1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage UL2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage UL3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 … 100000.0	7
30...33	Current L2	REAL	A	0.0 … 100000.0	8
34...37	Current L3	REAL	A	0.0 … 100000.0	9
38...41	Power factor L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor L2	REAL	-	0.0 ... 1.0	20
46...49	Power factor L3	REAL	-	0.0 ... 1.0	21
50...53	Total power factor L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency	REAL	1 Hz	45.0 ... 65.0	30
58...61	Amplitude unbalance for voltage	REAL	%	0 ... 100	38
62...65	Amplitude unbalance for current	REAL	%	0 ... 200	39
66...69	Apparent power L1	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	12
78...81	Total apparent power L1L2L3	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	34
82...85	Reactive power L1	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	16
86...89	Reactive power L2	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	17
90...93	Reactive power L3	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	18
94...97	Total reactive power L1L2L3	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	36
98...101	Active power L1	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	15

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
110...113	Total active power L1L2L3	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	35
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Total apparent energy L1L2L3	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3	REAL	varh	0.0 ... 3.4×10^{38}	206
134...137	Total active energy L1L2L3	REAL	Wh	0.0 ... 3.4×10^{38}	205
138...141	Total reactive energy inflow L1L2L3	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Total reactive energy outflow L1L2L3	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Total active energy inflow L1L2L3	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Total active energy outflow L1L2L3	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Total apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214
162...169	Total reactive energy L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	216
170...177	Total active energy L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	215
178...185	Total reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Total reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Total active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Total active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral conductor current	REAL	A	0.0 ... 100000.0	61149

Note

- The cumulative value of the energy counters in 3-phase operation is obtained from the sums of the individual values of the phases.
- Inflow and outflow energy meters are always positive values.
- The operating hours counter for the entire module is calculated from the sum of the operating hours of the individual phases.

Neutral conductor current

If you operate the AI Energy Meter 480VAC ST with connection type 3P4W, the neutral conductor current is also determined under the following conditions:

- Transmission factors of all phase currents (primary and secondary currents) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current parameter.

  The neutral is subject to a "Low limit for measuring current" like all other current measurements. The lowest value of all three configured low limits is used as the minimum value.

If one of the conditions is not met, 0 is entered as the value for the neutral conductor current. You can read the determined neutral conductor current using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter 480VAC ST. Use SFB "RDREC" to read out the data record from the module. Dieser Systemfunktionsbaustein ist in der STEP 7 Bibliothek hinterlegt.

Measured values in STEP 7 as of V5.5

Measured values are represented as negative values in STEP 7 as of V5.5 if the value range of the integer format (32767 dec) is exceeded. This is not an error in the measured value. Solution: Select hexadecimal representation.

Conversion of 64-bit floating-point numbers

If you cannot process 64-bit floating-point numbers in your automation system, we recommend conversion to 32-bit floating-point numbers. Note the conversion can cause loss of accuracy. For a description of the conversion of the 64-bit floating-point numbers (data type LREAL) into 32-bit floating-point numbers (data type REAL) please refer to the Internet (http://support.automation.siemens.com/WW/view/en/56600676).

E.3 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy counter to user-specific value (e.g. "0")
- Reading the current values of the energy counters
- Reading the overflow counters
- Reading the operating hours

Energy meter data record 143

Table E- 2 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Status / control byte 1 - L1	BYTE	Bit string	-	-
3	Status / control byte 2 - L1	BYTE	Bit string		
4	Status / control byte 1 - L2	BYTE	Bit string		
5	Status / control byte 2 - L2	BYTE	Bit string		
6	Status / control byte 1 - L3	BYTE	Bit string		
7	Status / control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: 0.0...1.8 x 10^{308} During writing For continuous counting: 0.0...3.4 x 10^{12} During writing For periodic counting: 0...configured full-scale value (10^3 ...10^{15})	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204
88...95	Active energy inflow (initial value) L3	LREAL	Wh		61220
96...103	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...111	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...119	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...127	Apparent energy (initial value) L3	LREAL	VAh		61224

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
128...129	Overflow counter active energy inflow L1	UINT	-	During reading: 0...65535 During writing for continuous counting: 0 During writing for periodic counting: 0...65500	61190
130..131	Overflow counter active energy outflow L1	UINT	-		61191
132...133	Overflow counter reactive energy inflow L1	UINT	-		61192
134...135	Overflow counter reactive energy outflow L1	UINT	-		61193
136...137	Overflow counter apparent energy L1	UINT	-		61194
138...139	Overflow counter active energy inflow L2	UINT	-		61210
140...141	Overflow counter active energy outflow L2	UINT	-		61211
142...143	Overflow counter reactive energy inflow L2	UINT	-		61212
144...145	Overflow counter reactive energy outflow L2	UINT	-		61213
146...147	Overflow counter apparent energy L2	UINT	-		61214
148...149	Overflow counter active energy inflow L3	UINT	-		61230
150...151	Overflow counter active energy outflow L3	UINT	-		61231
152...153	Overflow counter reactive energy inflow L3	UINT	-		61232
154...155	Overflow counter reactive energy outflow L3	UINT	-		61233
156...157	Overflow counter apparent energy L3	UINT	-		61234
158...161	Operating hours counter L1 (initial value)	REAL	h	During reading: 0...3.4×10^{38} During writing: 0...10^9	65505
162...165	Operating hours counter L2 (initial value)	REAL	h		65506
166...169	Operating hours counter L3 (initial value)	REAL	h		65507

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

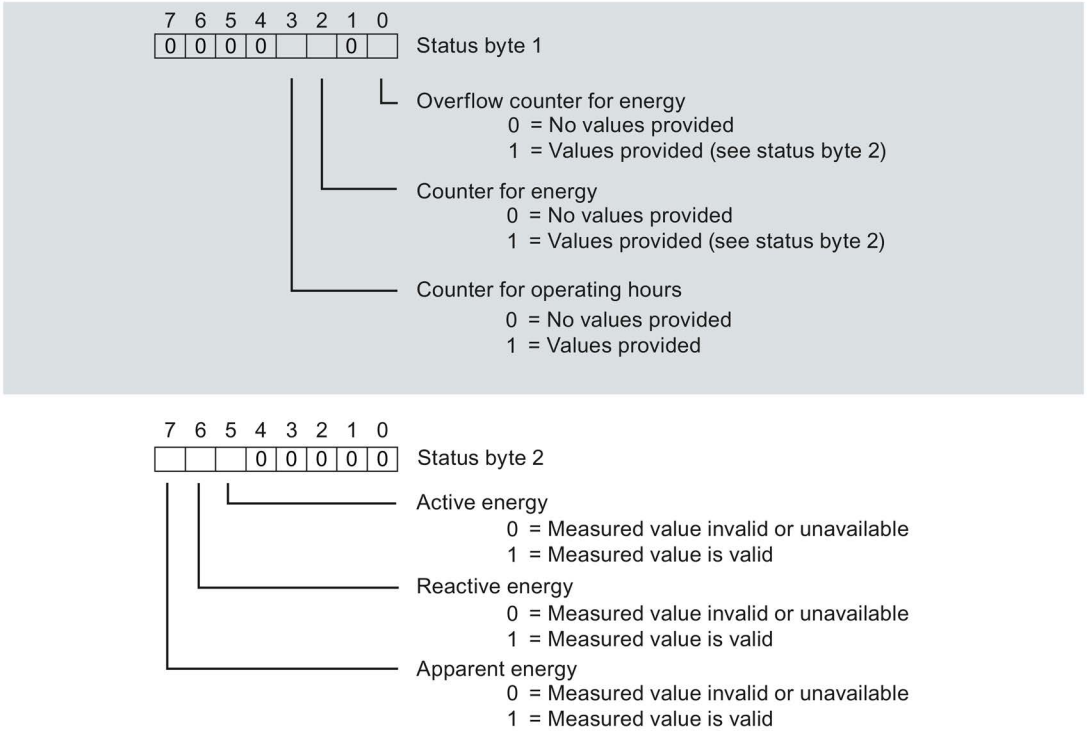


Image E-1 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters, overflow counters and operating hours counter. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to reset and the time at which counters are reset.
- In Control byte 2 you determine which energy counters and which overflow counters you want to reset.

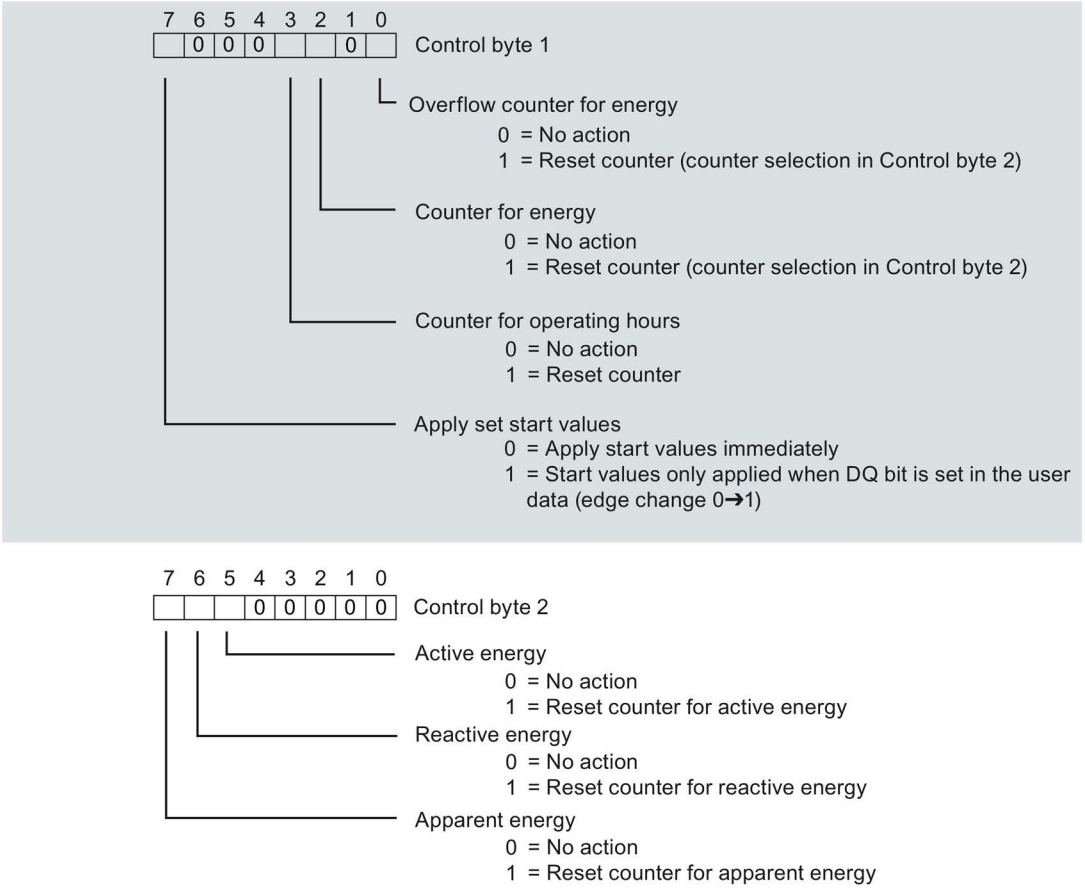


Image E-2 Control information DS 143 (write access)

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

E.4 Measured value data record for maximum values (DS 144)

Measured variables of the module

The largest values ever measured or calculated from the time AI Energy Meter 480VAC ST was started are stored in this data record.

Byte	Measured variable	Format	Unit	Default	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
0	Version	BYTE	-	0	-	✓	✓	✓	✓	✓
1	Reserved	BYTE	-	0	-	✓	✓	✓	✓	✓
2...5	Max. voltage UL1-N	REAL	V	0	40	✓	✓	✓	✓	✓
6...9	Max. voltage UL2-N	REAL	V	0	41		✓	✓	✓	✓
10...13	Max. voltage UL3-N	REAL	V	0	42		✓		✓	✓
14...17	Max. voltage UL1-L2	REAL	V	0	43				✓	✓
18...21	Max. voltage UL2-L3	REAL	V	0	44				✓	✓
22...25	Max. voltage UL3-L1	REAL	V	0	45				✓	✓
26...29	Max. current L1 [1]	REAL	A	0	46	✓	✓	✓	✓	✓
30...33	Max. current L2 [1]	REAL	A	0.	47		✓	✓	✓	✓
34...37	Max. current L3 [1]	REAL	A	0	48		✓		✓	✓
38...41	Max. apparent power L1	REAL	VA	0	49	✓	✓	✓	✓	✓
42...45	Max. apparent power L2	REAL	VA	0	50		✓	✓	✓	✓
46...49	Max. apparent power L3	REAL	VA	0	51		✓		✓	✓
50...53	Max. active power L1	REAL	W	-3.0×10^9	52	✓	✓	✓	✓	✓
54...57	Max. active power L2	REAL	W	-3.0×10^9	53		✓	✓	✓	✓
58...61	Max. active power L3	REAL	W	-3.0×10^9	54		✓		✓	✓
62...65	Max. reactive power L1	REAL	var	-3.0×10^9	55	✓	✓	✓	✓	✓
66...69	Max. reactive power L2	REAL	var	-3.0×10^9	56		✓	✓	✓	✓
70...73	Max. reactive power L3	REAL	var	-3.0×10^9	57		✓		✓	✓
74...77	Max. power factor L1	REAL	-	0	58	✓	✓	✓	✓	✓
78...81	Max. power factor L2	REAL	-	0	59		✓	✓	✓	✓
82...85	Max. power factor L3	REAL	-	0	60		✓		✓	✓
86...89	Max. frequency	REAL	Hz	45	61	✓	✓	✓	✓	✓

Byte	Measured variable	Format	Unit	Default	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
90...93	Max. total apparent power	REAL	VA	0	65	✓	✓	✓	✓	✓
94...97	Max. total active power	REAL	W	-3.0 x 10^9	66	✓	✓	✓	✓	✓
98...101	Max. total reactive power	REAL	var	-3.0 x 10^9	67	✓	✓	✓	✓	✓
102	Max. total power factor	REAL	-	0	68	✓	✓	✓	✓	✓

[1] The values reference the amount of the current measured value

E.5 Measured value data record for minimum values (DS 145)

Measured variables of the module

The smallest values ever measured or calculated from the time AI Energy Meter 480VAC ST was started are stored in this data record.

Byte	Measured variable	Format	Unit	Default	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
0	Version	BYTE	-	0	-	✓	✓	✓	✓	✓
1	Reserved	BYTE	-	0	-	✓	✓	✓	✓	✓
2...5	Min. voltage UL1-N	REAL	V	1000000	70	✓	✓	✓	✓	✓
6...9	Min. voltage UL2-N	REAL	V	1000000	71		✓	✓	✓	✓
10...13	Min. voltage UL3-N	REAL	V	1000000	72		✓		✓	✓
14...17	Min. voltage UL1-L2	REAL	V	1800000	73				✓	✓
18...21	Min. voltage UL2-L3	REAL	V	1800000	74				✓	✓
22...25	Min. voltage UL3-L1	REAL	V	1800000	75				✓	✓
26...29	Min. current L1 [1]	REAL	A	100000	76	✓	✓	✓	✓	✓
30...33	Min. current L2 [1]	REAL	A	100000	77		✓	✓	✓	✓
34...37	Min. current L3 [1]	REAL	A	100000	78		✓		✓	✓
38...41	Min. apparent power L1	REAL	VA	+3.0 x 10^9	79	✓	✓	✓	✓	✓
42...45	Min. apparent power L2	REAL	VA	+3.0 x 10^9	80		✓	✓	✓	✓
46...49	Min. apparent power L3	REAL	VA	+3.0 x 10^9	81		✓		✓	✓
50...53	Min. active power L1	REAL	W	+3.0 x 10^9	82	✓	✓	✓	✓	✓
54...57	Min. active power L2	REAL	W	+3.0 x 10^9	83		✓	✓	✓	✓
58...61	Min. active power L3	REAL	W	+3.0 x 10^9	84		✓		✓	✓
62...65	Min. reactive power L1	REAL	var	+3.0 x 10^9	85	✓	✓	✓	✓	✓

Byte	Measured variable	Format	Unit	Default	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
66...69	Min. reactive power L2	REAL	var	+3.0 x 10^9	86		✓	✓	✓	✓
70...73	Min. reactive power L3	REAL	var	+3.0 x 10^9	87		✓		✓	✓
74...77	Min. power factor L1	REAL	-	1	88	✓	✓	✓	✓	✓
78...81	Min. power factor L2	REAL	-	1	89		✓	✓	✓	✓
82...85	Min. power factor L3	REAL	-	1	90		✓		✓	✓
86...89	Min. frequency	REAL	Hz	65	91	✓	✓	✓	✓	✓
90...93	Min. total apparent power	REAL	VA	+3.0 x 10^9	95	✓	✓	✓	✓	✓
94...97	Min. total active power	REAL	W	+3.0 x 10^9	96	✓	✓	✓	✓	✓
98...101	Min. total reactive power	REAL	var	+3.0 x 10^9	97	✓	✓	✓	✓	✓
102	Min. total power factor	REAL	-	1	98	✓	✓	✓	✓	✓

[1] The values reference the amount of the current measured value

E.6 Measured value data record for phase-based measured values L1 (DS 147)

Measured variables of the module (DS 147)

Byte	Measured variable	Format	Unit	Value range	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
0	Version	BYTE	-	1	-	✓	✓	✓	✓	✓
1	Reserved	BYTE	-	0	-	✓	✓	✓	✓	✓
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500	✓	✓	✓	✓	✓
4...7	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	1	✓	✓	✓	✓	✓
8...11	Current L1	REAL	A	0.0 … 100000.0	7	✓	✓	✓	✓	✓
12...15	Apparent power L1	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	10	✓	✓	✓	✓	✓
16...19	Active power L1	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	13	✓	✓	✓	✓	✓
20...23	Reactive power L1	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	16	✓	✓	✓	✓	✓
24...27	Power factor L1	REAL	-	0.0 ... 1.0	19	✓	✓	✓	✓	✓

Byte	Measured variable	Format	Unit	Value range	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178	✓	✓	✓	✓	✓
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8 x 10^{308}	61184	✓	✓	✓	✓	✓
40...47	Active energy (total) L1	LREAL	Wh	0.0 ... 1.8 x 10^{308}	61185	✓	✓	✓	✓	✓
48...55	Reactive energy (total) L1	LREAL	varh	0.0 ... 1.8 x 10^{308}	61186	✓	✓	✓	✓	✓
56...59	Max. voltage UL1-N	REAL	V	0.0 ... 1000000.0	40	✓	✓	✓	✓	✓
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46	✓	✓	✓	✓	✓
64...67	Max. apparent power L1	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	49	✓	✓	✓	✓	✓
68...71	Max. active power L1	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	52	✓	✓	✓	✓	✓
72...75	Max. reactive power L1	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	55	✓	✓	✓	✓	✓
76...79	Max. power factor L1	REAL	-	0.0 ... 1.0	58	✓	✓	✓	✓	✓
80...83	Min. voltage UL1-N	REAL	V	0.0 ... 1000000.0	70	✓	✓	✓	✓	✓
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76	✓				
88...91	Min. apparent power L1	REAL	VA	-3.0 x 10^9 … +3.0 x 10^9	79	✓	✓	✓	✓	✓
92...95	Min. active power L1	REAL	W	-3.0 x 10^9 … +3.0 x 10^9	83	✓	✓	✓	✓	✓
96...99	Min. reactive power L1	REAL	var	-3.0 x 10^9 … +3.0 x 10^9	85	✓	✓	✓	✓	✓
100...103	Min. power factor L1	REAL	-	0.0 ... 1.0	88	✓	✓	✓	✓	✓

E.7 Measured value data record for phase-based measured values L2 (DS 148)

Measured variables of the module (DS 148)

Byte	Measured variable	Format	Unit	Value range	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
0	Version	BYTE	-	1	-	✓	✓	✓	✓	✓
1	Reserved	BYTE	-	0	-	✓	✓	✓	✓	✓

Byte	Measured variable	Format	Unit	Value range	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501		✓	✓	✓	✓
4...7	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	2		✓	✓	✓	✓
8...11	Current L2	REAL	A	0.0 … 100000.0	8		✓	✓	✓	✓
12...15	Apparent power L2	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	11		✓	✓	✓	✓
16...19	Active power L2	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	14		✓	✓	✓	✓
20...23	Reactive power L2	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	17		✓	✓	✓	✓
24...27	Power factor L2	REAL	-	0.0 ... 1.0	20		✓	✓	✓	✓
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198		✓	✓	✓	✓
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204		✓	✓	✓	✓
40...47	Active energy (total) L2	LREAL	Wh	0.0 ... 1.8×10^{308}	61205		✓	✓	✓	✓
48...55	Reactive energy (total) L2	LREAL	varh	0.0 ... 1.8×10^{308}	61206		✓	✓	✓	✓
56...59	Max. voltage UL1-N	REAL	V	0.0 ... 1000000.0	41		✓	✓	✓	✓
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47		✓	✓	✓	✓
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	50		✓	✓	✓	✓
68...71	Max. active power L2	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	53		✓	✓	✓	✓
72...75	Max. reactive power L2	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	56		✓	✓	✓	✓
76...79	Max. power factor L2	REAL	-	0.0 ... 1.0	59		✓	✓	✓	✓
80...83	Min. voltage UL1-N	REAL	V	0.0 ... 1000000.0	71		✓	✓	✓	✓
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77					
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	80		✓	✓	✓	✓
92...95	Min. active power L2	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	84		✓	✓	✓	✓
96...99	Min. reactive power L2	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	86		✓	✓	✓	✓
100...103	Min. power factor L2	REAL	-	0.0 ... 1.0	89		✓	✓	✓	✓

E.8 Measured value data record for phase-based measured values L3 (DS 149)

Measured variables of the module (DS 149)

Byte	Measured variable	Format	Unit	Value range	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
0	Version	BYTE	-	1	-	✓	✓	✓	✓	✓
1	Reserved	BYTE	-	0	-	✓	✓	✓	✓	✓
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502		✓		✓	✓
4...7	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	3		✓		✓	✓
8...11	Current L3	REAL	A	0.0 … 100000.0	9		✓		✓	✓
12...15	Apparent power L3	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	12		✓		✓	✓
16...19	Active power L3	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	15		✓		✓	✓
20...23	Reactive power L3	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	18		✓		✓	✓
24...27	Power factor L3	REAL	-	0.0 ... 1.0	21		✓		✓	✓
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218		✓		✓	✓
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8×10^{308}	61224		✓		✓	✓
40...47	Active energy (total) L3	LREAL	Wh	0.0 ... 1.8×10^{308}	61225		✓		✓	✓
48...55	Reactive energy (total) L3	LREAL	varh	0.0 ... 1.8×10^{308}	61226		✓		✓	✓
56...59	Max. voltage UL1-N	REAL	V	0.0 ... 1000000.0	42		✓		✓	✓
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48		✓		✓	✓
64...67	Max. apparent power L3	REAL	VA	-3.0×10^9 … $+ 3.0 \times 10^9$	51		✓		✓	✓
68...71	Max. active power L3	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	53		✓		✓	✓
72...75	Max. reactive power L3	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	57		✓		✓	✓
76...79	Max. power factor L3	REAL	-	0.0 ... 1.0	60		✓		✓	✓

Byte	Measured variable	Format	Unit	Value range	Measured value ID	Connection type				
						1P2W	3x1P2W	2P3W	3P4W	3P4W1
80...83	Min. voltage UL1-N	REAL	V	0.0 ... 1000000.0	72		✓		✓	✓
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78					
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 … $+3.0 \times 10^9$	81		✓		✓	✓
92...95	Min. active power L3	REAL	W	-3.0×10^9 … $+3.0 \times 10^9$	85		✓		✓	✓
96...99	Min. reactive power L3	REAL	var	-3.0×10^9 … $+3.0 \times 10^9$	87		✓		✓	✓
100...103	Min. power factor L3	REAL	-	0.0 ... 1.0	90		✓		✓	✓

E.9 Measured value data record for advanced measurement and status values (DS 150)

Measured variables of the module

Data record 150

Byte	Measured variable	Format	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2...5	Operating hours counter L1L2L3	REAL	h	0.0 ... 3.4×10^{38}	65504
6...9	Operating hours counter L1	REAL	h	0.0 ... 3.4×10^{38}	65505
10...13	Operating hours counter L2	REAL	h	0.0 ... 3.4×10^{38}	65506
14...17	Operating hours counter L3	REAL	h	0.0 ... 3.4×10^{38}	65507
18...19	Status limit violation GW 1...16	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
20...21	Status of energy counter overflows [1]	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
22...25	Counter limit violation GW 1	UDINT	-	0 ... 4294967296	65510
26...29	Counter limit violation GW 2	UDINT	-	0 ... 4294967296	65511
30...33	Counter limit violation GW 3	UDINT	-	0 ... 4294967296	65512
34...37	Counter limit violation GW 4	UDINT	-	0 ... 4294967296	65513
38...41	Counter limit violation GW 5	UDINT	-	0 ... 4294967296	65514
42...45	Counter limit violation GW 6	UDINT	-	0 ... 4294967296	65515
46...49	Counter limit violation GW 7	UDINT	-	0 ... 4294967296	65516
50...53	Counter limit violation GW 8	UDINT	-	0 ... 4294967296	65517
54...57	Counter limit violation GW 9	UDINT	-	0 ... 4294967296	65518
58...61	Counter limit violation GW 10	UDINT	-	0 ... 4294967296	65519

Byte	Measured variable	Format	Unit	Value range	Measured value ID
62...65	Counter limit violation GW 11	UDINT	-	0 ... 4294967296	65520
66...69	Counter limit violation GW 12	UDINT	-	0 ... 4294967296	65521
70...73	Counter limit violation GW 13	UDINT	-	0 ... 4294967296	65522
74...77	Counter limit violation GW 14	UDINT	-	0 ... 4294967296	65523
78...81	Counter limit violation GW 15	UDINT	-	0 ... 4294967296	65524
82..85	Counter limit violation GW 16	UDINT	-	0 ... 4294967296	65525
86..87	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503

[1] Energy counters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Tips and tricks

F

F.1 Tips and tricks

Processing and visualizing energy data

On the basis of an application example we show you how the measured values of the AI Energy Meter can be processed further and visualized.

You can find this application example on the Internet (http://support.automation.siemens.com/WW/view/en/86299299)

IT network

You must create an artificial N-conductor (for example, by means of a 1:1 voltage transformer) in IT networks due to the missing neutral conductor. You can then use the module.

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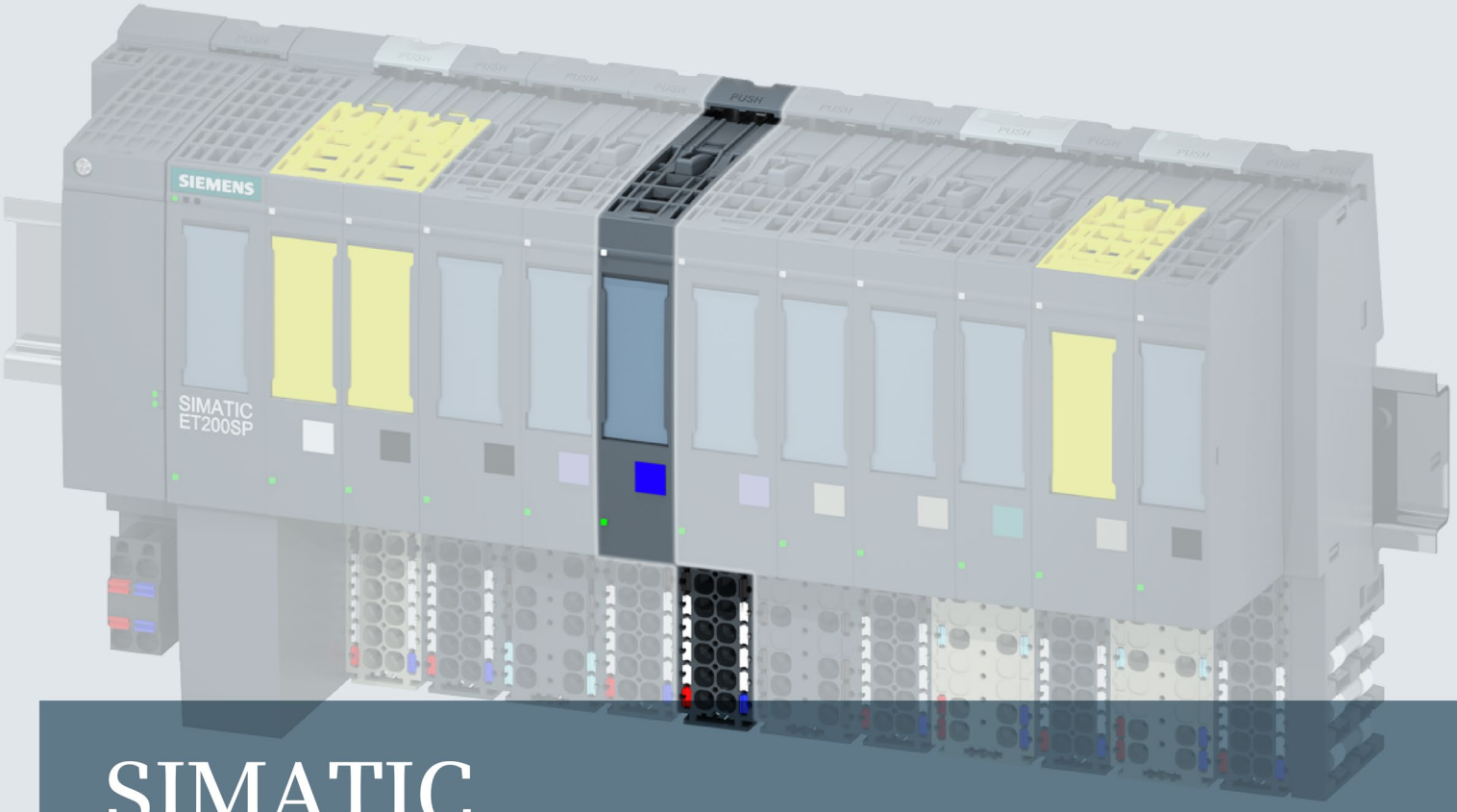

SIMATIC

ET 200SP

Analog output module AQ 2xU ST (6ES7135-6FB00-0BA1)

Manual

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Answers for industry.

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Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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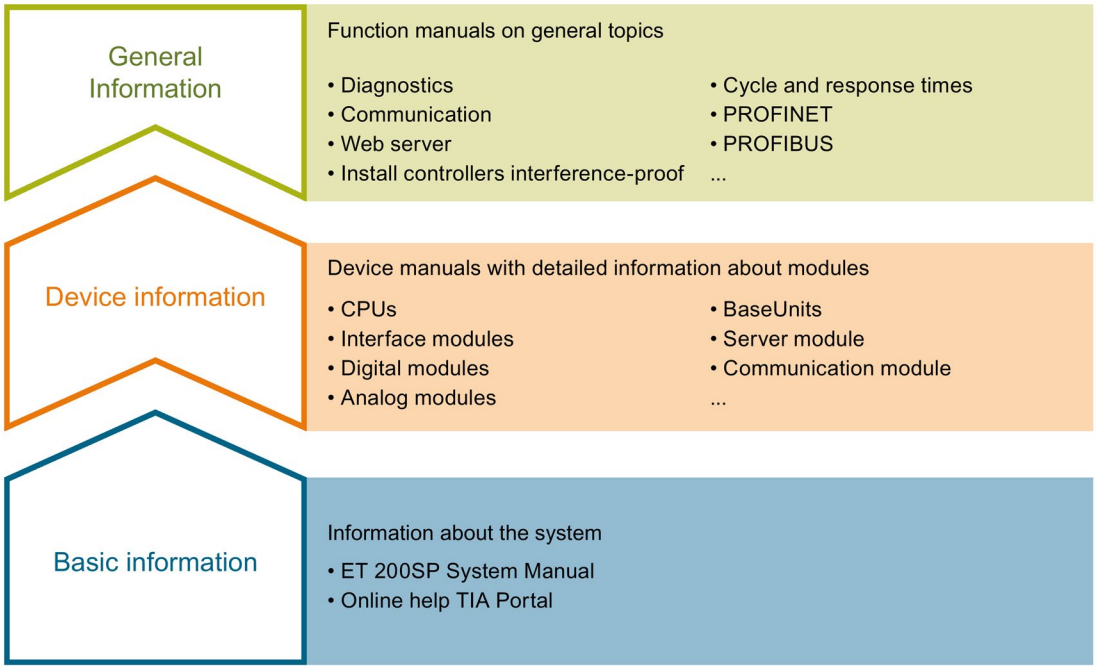
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

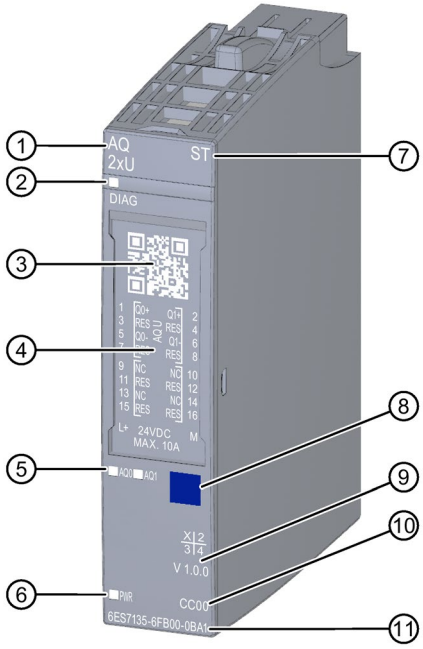
2

2.1 Properties

Article number

6ES7135-6FB00-0BA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module AQ 2×U ST

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
  - for voltage output
- Output range for voltage output:
  - ±10 V, resolution 16 bits including sign
  - ±5 V, resolution 15 bits including sign
  - 0 to 10 V, resolution 15 bits
  - 1 to 5 V, resolution 13 bits
- Electrically isolated from supply voltage L+
- Configurable diagnostics (per module)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the AQ 2xU ST module with the terminal assignments for a 2-wire connection.

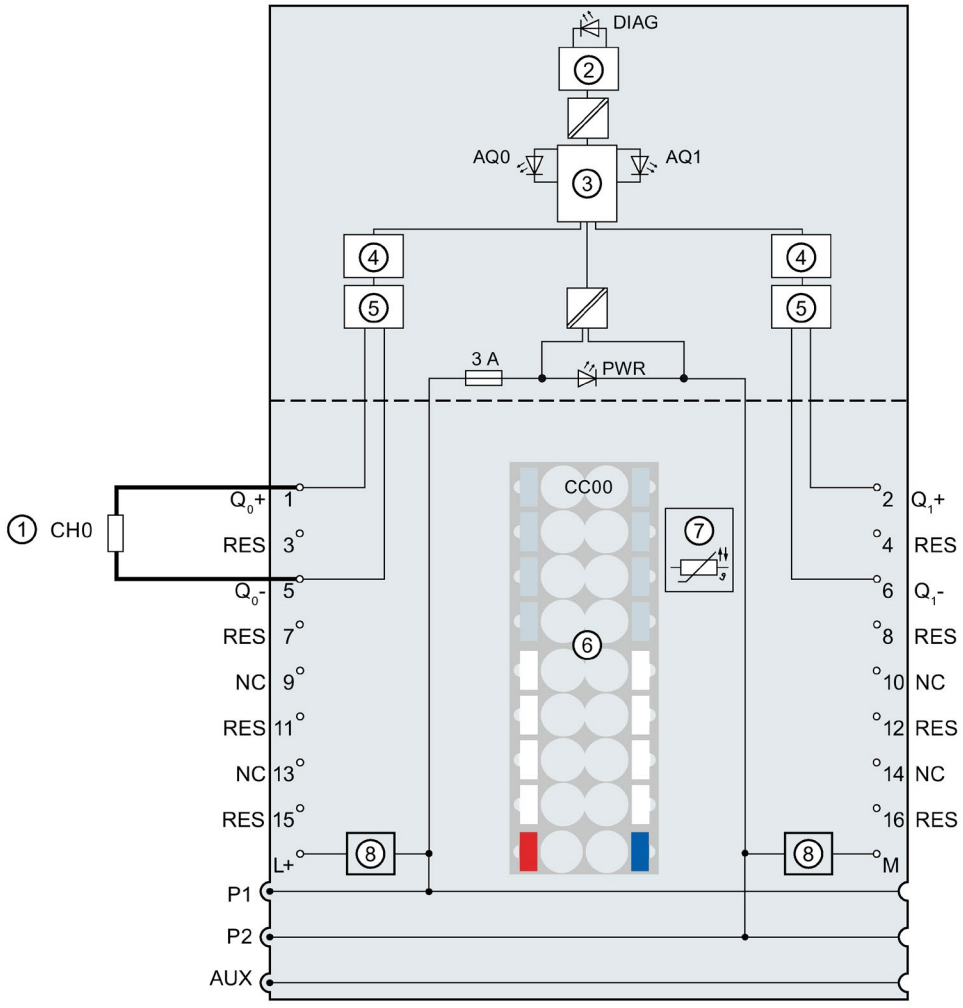
You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: Voltage output 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xU ST on the BaseUnit BU type A0/A1.



①	2-wire connection for voltage output	Q_n+	Analog output voltage positive, channel n
②	Backplane bus interface	Q_n-	Analog output voltage negative, channel n
③	Microcontroller	NC	Not connected
④	Digital-to-analog converter (DAC)	RES	Reserve, must remain unused for future function extensions
⑤	Output conditioner	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Color-coded label with color code CC00 (optional)	M	Ground
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)	DIAG	Diagnostics LED (green, red)
		AQ0, AQ1	Channel status LED (green)
		PWR	Power LED (green)

Image 3-1 Wiring and block diagram for voltage output 2-wire connection

Parameters/address space

4

4.1 Output ranges

The analog output module AQ 2×U ST has the following output ranges:

Table 4- 1 Output ranges

Output type	Output ranges	Resolution
Voltage	± 10 V	16 bits incl. sign
	± 5 V	15 bits including sign
	0 to 10 V	15 bits
	1 to 5 V	13 bits

The tables of the output ranges, overflow, overrange, etc. can be found in section Representation of analog values (Page 28).

4.2 Parameters

Parameters of the AQ 2xU ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 24).
The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Short-circuit to ground[1]	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Module	Module [2]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Module	

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Output type/range	• Deactivated • Voltage +/- 10 V • Voltage +/- 5 V • Voltage 0..10 V • Voltage 1..5 V	Voltage +/- 10 V	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Module
Substitute value	For permissible substitute values for the various output ranges, see appendix Parameter assignment and structure of the parameter data record (Page 24), Substitute values → Codes for substitute values table	0	Yes	Channel	Channel
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 No diagnostics detection between -0.5 V and +0.5 V (no short-circuit detection)

2 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

Note

Unused channels

A deactivated channel always returns the value "no voltage".

4.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value exceeds the overrange, falls below the minimum output value or reaches underflow.

Output type / output range

See section Output ranges (Page 13)

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 and 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no errors on the module.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AQ 2×U ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

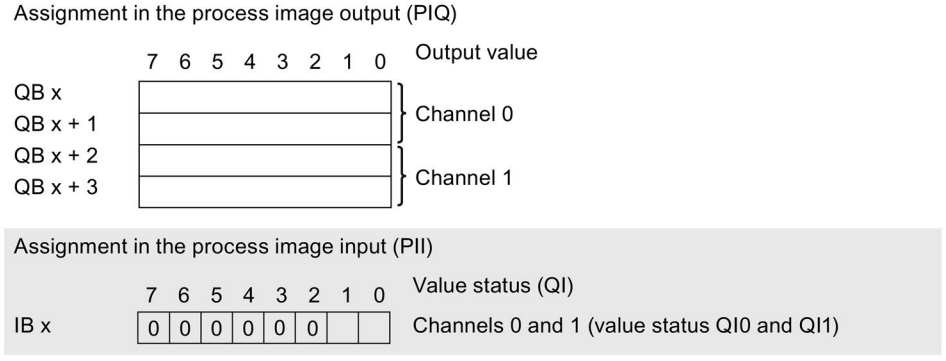


Image 4-1 Address space of the AQ 2×U ST with value status

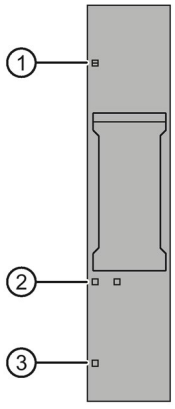
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the AQ 2xU ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 19).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel disabled
On	Channel activated

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The AQ 2×U ST analog output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (voltage)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	Short-circuit of the actuator supply	Correct the process wiring
High limit violated	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Low limit violated	8_H	The output value specified by the user program is below the underrange.	Correct the output value
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AQ 2×U ST

	6ES7135-6FB00-0BA1
General information	
Product type designation	ET 200SP, AQ 2xU Standard
Firmware version	V1.0
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable output range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 / -
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
Oversampling	No
MSO	No
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Calibration in RUN possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	80 mA
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
Address space per module, max.	4 bytes; + 1 byte for QI information

	6ES7135-6FB00-0BA1
Analog outputs	
Number of analog outputs	2
Voltage output, short-circuit current, max.	45 mA
Cycle time (all channels), min.	1 ms
Analog output with oversampling	No
Output ranges, voltage	
0 to 10 V	Yes; 15 bits
1 V to 5 V	Yes; 13 bits
-5 V to +5 V	Yes; 15 bits including sign
-10 V to +10 V	Yes; 16 bits incl. sign
Connection of actuators	
for voltage output two-wire connection	Yes
for voltage output four-wire connection	No
Load resistance (in nominal range of the output)	
For voltage outputs, min.	2 kΩ
For voltage outputs, capacitive load, max.	1 µF
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Shielded, max.	200 m
Analog value generation for the outputs	
Oscillation time	
For resistive load	0.1 ms
For capacitive load	1 ms
Errors/accuracies	
Linearity error (in relation to output range), (+/-)	0.03%
Temperature error (in relation to output range), (+/-)	0.005%/K
Crosstalk between outputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	0.05%
Operational limit in the entire temperature range	
Voltage in relation to output range, (+/-)	0.5%
Current in relation to output range, (+/-)	0.5%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	0.3%
Current in relation to output range, (+/-)	0.3%
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes

	6ES7135-6FB00-0BA1
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Short-circuit	Yes
Group error	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Environmental conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the output type and output range for PROFINET.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow		
Deactivated		*	*	*	*	*	*
Voltage	±10 V	x	x	x	x	x	x
	±5 V	x	x	x	x	x	x
	0 V to 10 V	x	x	x	x	x	x
	1 V to 5 V	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the output type and output range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow		
Deactivated		*	*	*	*	*	*
Voltage	±10 V	x	x	x	x	x	x
	±5 V	x	x	x	x	x	x
	0 V to 10 V	x	x	x	x	x	x
	1 V to 5 V	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

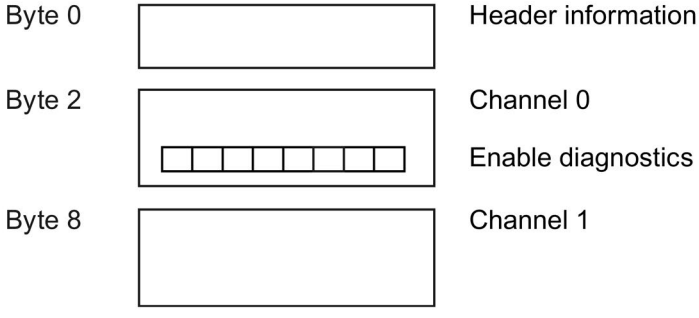


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

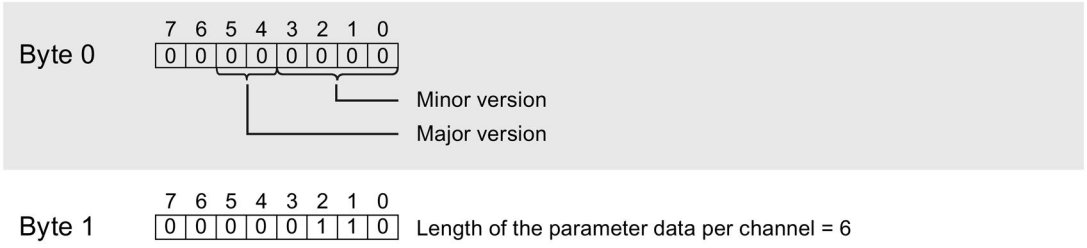
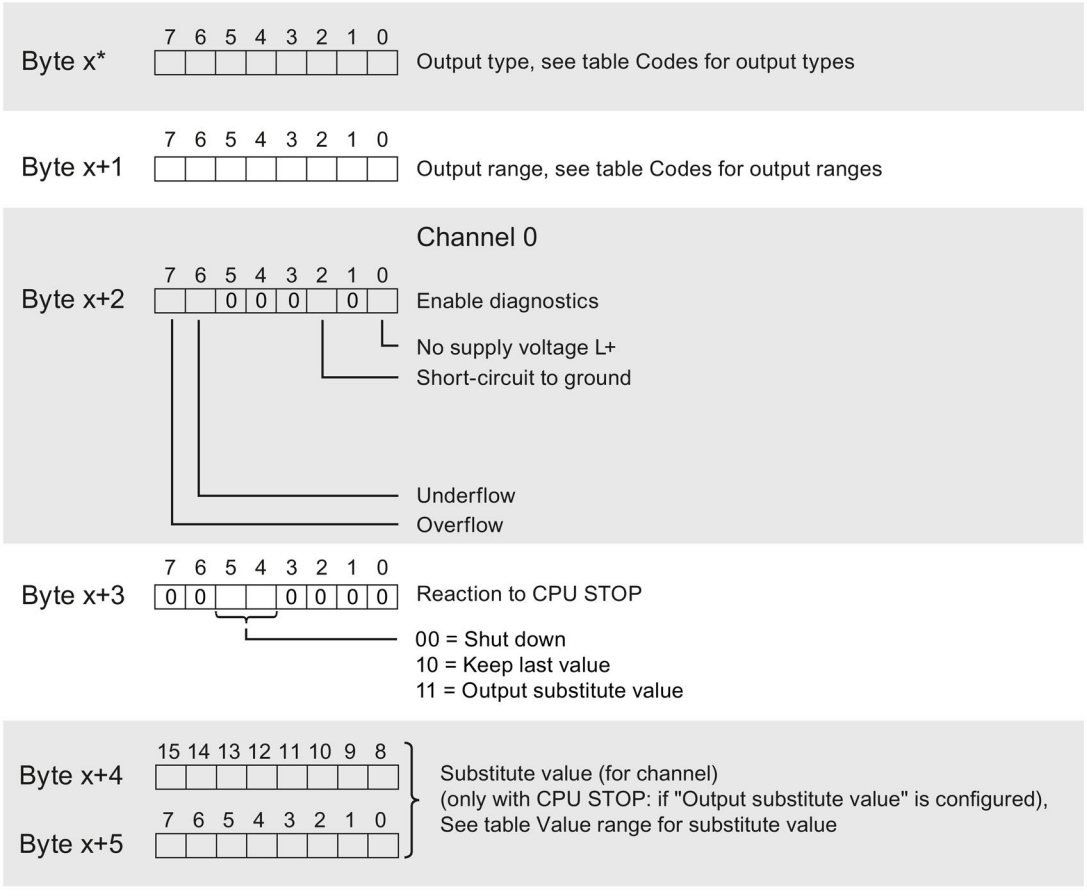


Image A-2 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 6); channel number = 0 and 1

Image A-3 Structure of bytes x to x+5 for channels 0 and 1

Codes for output types

The following table contains the codes for the output types of the analog output module. You enter this coding in byte x (see previous figure).

Table A- 1 Codes for output types

Output type	Code
Deactivated	0000 0000
Voltage	0000 0001

Codes for output ranges

The following table contains the codes for the output ranges of the analog output module. You enter these codes in byte x+1 of data record 128 (see previous figure).

Table A- 2 Codes for output ranges

Output range	Code
Voltage	
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011

Value range for substitute value

The following table contains the value ranges for the substitute values. You must enter the corresponding codes in bytes x+4 and x+5 (see previous figure).

Output range	Permissible value range
Voltage	
±10 V	-32512 to 32511
±5 V	-32512 to 32511
0 to 10 V	0 to 32511
1 to 5 V	-6912 to 32511

Error transmitting the data record

The module always checks all values of the transmitted data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values

This appendix describes the analog values for all output ranges supported by the AQ 2xU ST analog module.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. Analog values are output as fixed point numbers in two's complement.

In the following table, you will find the representation of the binary analog values and the associated decimal or hexadecimal units of the analog values.

The resolutions 13, 14, 15 and 16 bits including sign are shown. Each analog value is entered left aligned into the ACCU. The bits marked with "x" are set to "0".

Table B- 1 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table B- 2 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table B- 3 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.3 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table B- 4 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	Hex.	±10 V	±5 V	
118.5149%	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Nominal range
75%	20736	5100	7.5 V	3.75 V	
0.003617%	1	1	361.7 µV	180.8 µV	
0%	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75%	-20736	AF00	-7.5 V	-3.75 V	
-100%	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange
-117.593%	-32512	8100	-11.76 V	-5.88 V	
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519%	-32768	8000			

* Outputs positive maximum value or negative minimum value

Table B- 5 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	Hex.	0 to 10 V	
118.519%	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table B- 6 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	Hex.	1 to 5 V	
118.519%	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V + 144.7 µV	
0%	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25%	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

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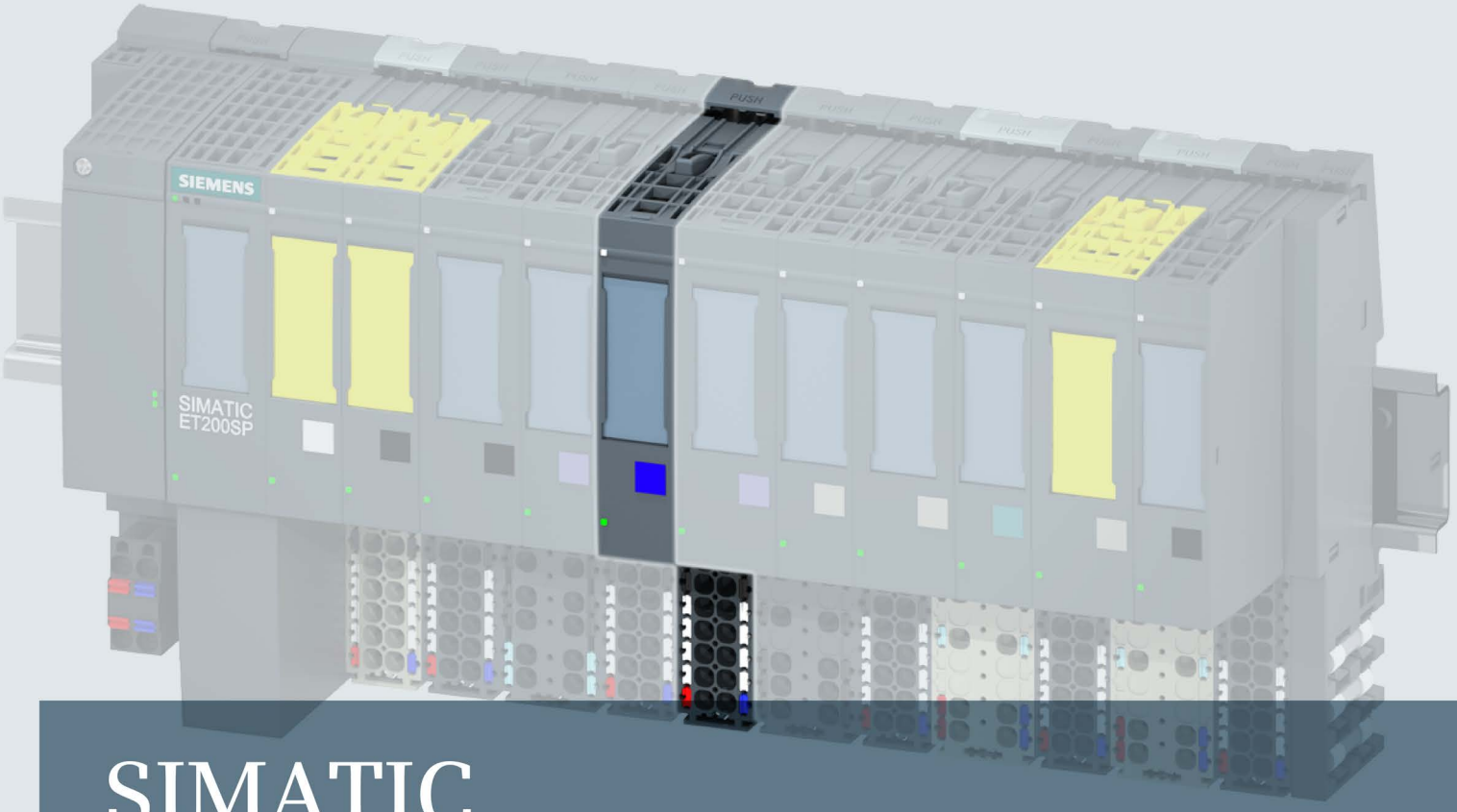

SIMATIC

ET 200SP

Analog output module AQ 2xI ST (6ES7135-6GB00-0BA1)

Manual

Edition 12/2015

Answers for industry.

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ET 200SP
Analog output module AQ 2xI ST (6ES7135-6GB00-0BA1)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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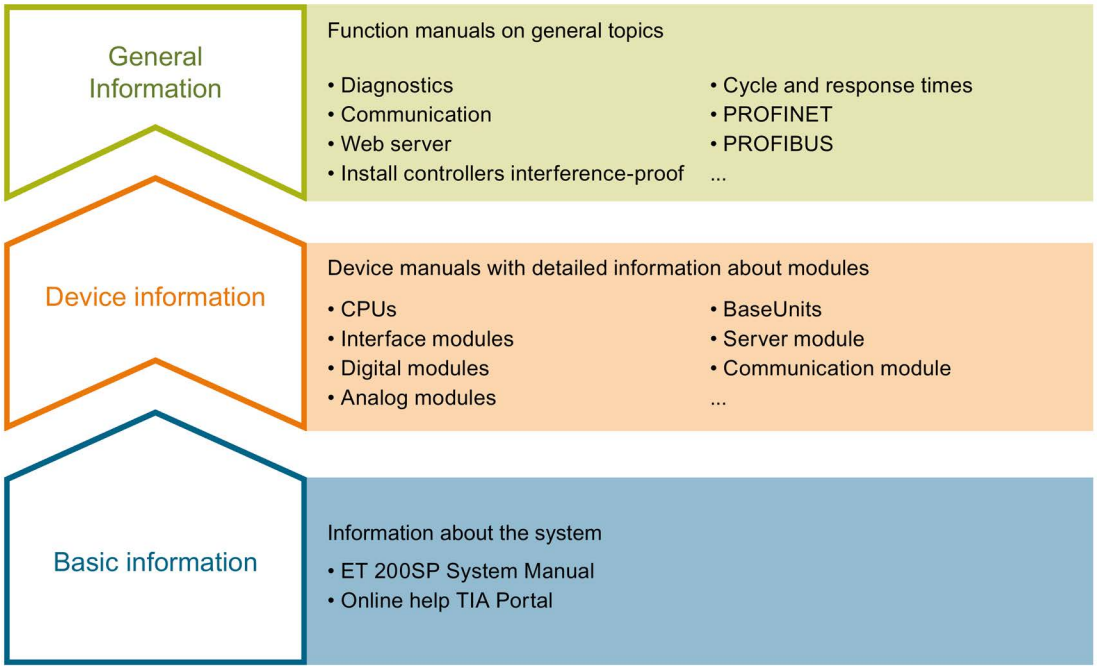
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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In doing so you can select:

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- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

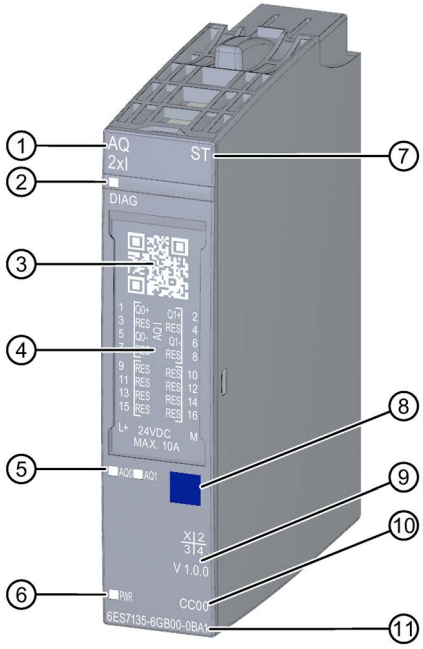
2

2.1 Properties

Article number

6ES7135-GB00-0BA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Image 2-1 View of the module AQ 2xI ST

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
  - for current output
- Output range for current output:
  - ±20 mA, resolution 16 bits including sign
  - 0 mA to 20 mA, resolution 15 bits
  - 4 to 20 mA, resolution 14 bits
- Electrically isolated from supply voltage L+
- Configurable diagnostics (per module)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the AQ 2xI ST with the terminal assignments.

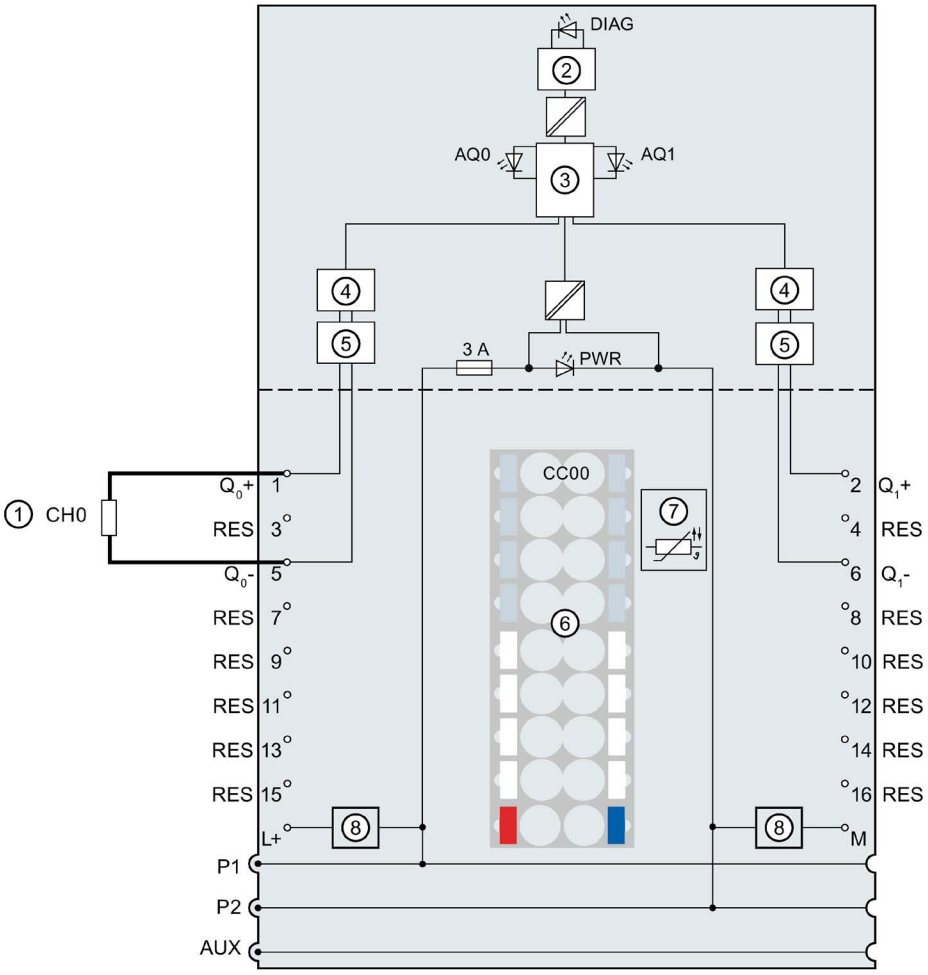
You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: Current output 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xI ST on the BaseUnit BU type A0/A1.



①	2-wire connection for current output	Q_n+	Analog output current positive, channel n
②	Backplane bus interface	Q_n-	Analog output current negative, channel n
③	Microcontroller	RES	Reserve, must remain unused for future function extensions
④	Digital-to-analog converter (DAC)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Output conditioner	M	Ground
⑥	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)	AQ0, AQ1	Channel status LED (green)
		PWR	Power LED (green)

Image 3-1 Wiring and block diagram for current output 2-wire connection

Parameters/address space

4

4.1 Output ranges

The analog output module AQ 2×I ST has the following output ranges:

Table 4- 1 Output ranges

Output type	Output ranges	Resolution
Current	± 20 mA	16 bits incl. sign
	0 mA to 20 mA	15 bits
	4 mA to 20 mA	14 bits

The tables of the output ranges, overflow, overrange, etc. can be found in section Representation of analog values (Page 30).

4.2 Parameters

Parameters of the AQ 2xI ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 26).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow [1]	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow [1]	• Disable • Enable	Disable	Yes	Module	
Diagnostics: Wire break [2]	• Disable • Enable	Disable	Yes	Module	Module
Output type/range	• Deactivated • Current +/- 20 mA • Current 0 - 20 mA • Current 4 - 20 mA	Current 4 - 20 mA	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Module

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Substitute value	For permissible substitute values for the various output ranges, see appendix Parameter assignment and structure of the parameter data record (Page 26), Substitute values → Codes for substitute values table	0	Yes	Channel	Channel
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

[2] No diagnostics detection between -3 and +3 mA (no wire break detection)

Note

Unused channels

A disabled channel always returns the value "no current or voltage".

4.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value exceeds the overrange, falls below the minimum output value or reaches underflow.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Output type / output range

See section Output ranges (Page 13).

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 and 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no errors on the module.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AQ 2×I ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

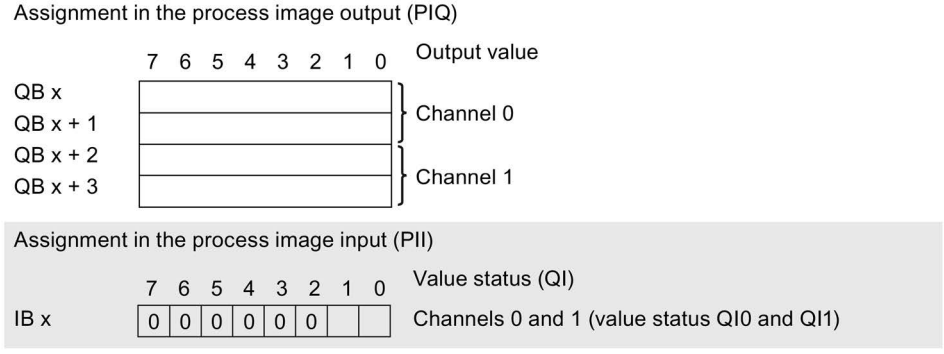


Image 4-1 Address space of the AQ 2×I ST with value status

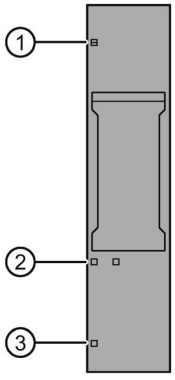
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the AQ 2xI ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 21).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel disabled
On	Channel activated

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The AQ 2×I ST analog output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Line break (current)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable the channel ("output type" parameter) • Connect the channel
High limit violated	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Low limit violated	8_H	The output value specified by the user program is below the underrange.	Correct the output value
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AQ 2×I ST

	6ES7135-6GB00-0BA1
General information	
Product type designation	ET 200SP, AQ 2xI Standard
Firmware version	V1.0
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Scalable output range	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 / -
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
Oversampling	No
MSO	No
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Calibration in RUN possible	No
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	110 mA
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	4 bytes; + 1 byte for QI information

	6ES7135-6GB00-0BA1
Analog outputs	
Number of analog outputs	2
Cycle time (all channels), min.	1 ms
Analog output with oversampling	No
Output ranges, current	
0 mA to 20 mA	Yes; 15 bits
-20 mA to +20 mA	Yes; 16 bits incl. sign
4 mA to 20 mA	Yes; 14 bits
Connection of actuators	
for current output two-wire connection	Yes
Load resistance (in nominal range of the output)	
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Shielded, max.	1000 m
Analog value generation for the outputs	
Oscillation time	
For resistive load	0.1 ms; typ. value
For inductive load	0.5 ms
Errors/accuracies	
Linearity error (in relation to output range), (+/-)	0.03%
Temperature error (in relation to output range), (+/-)	0.005%/K
Crosstalk between outputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	0.05%
Operational limit in the entire temperature range	
Voltage in relation to output range, (+/-)	0.5%
Current in relation to output range, (+/-)	0.5%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	0.3%
Current in relation to output range, (+/-)	0.3%
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No

	6ES7135-6GB00-0BA1
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of the supply voltage	Yes
Wire break	Yes
Group error	Yes
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	No
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and backplane bus	Yes
Between the channels and voltage supply of the electronics	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Environmental conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the output type and output range for PROFINET.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Overflow	Underflow	Wire break		
Deactivated		*	*	*	*	*	*
Current	±20 mA	x	x	x	x	x	x
	0 mA to 20 mA	x	x	x	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the output type and output range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Overflow	Underflow	Wire break		
Deactivated		*	*	*	*	*	*
Current	±20 mA	x	x	x	x	x	x
	0 mA to 20 mA	x	x	x	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can change the parameters of the module in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 includes the diagnostics enable for the entire module.

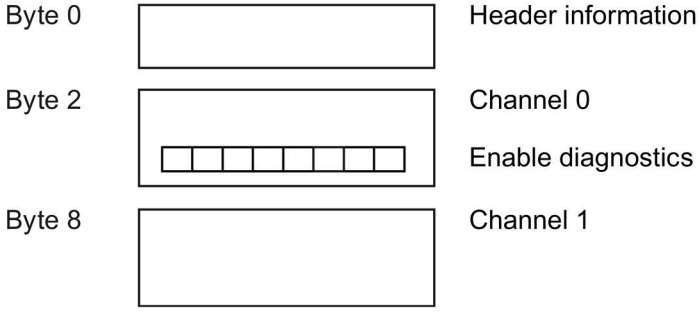


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

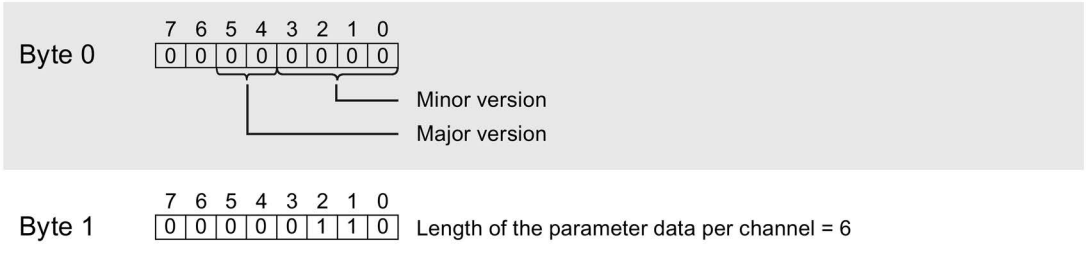
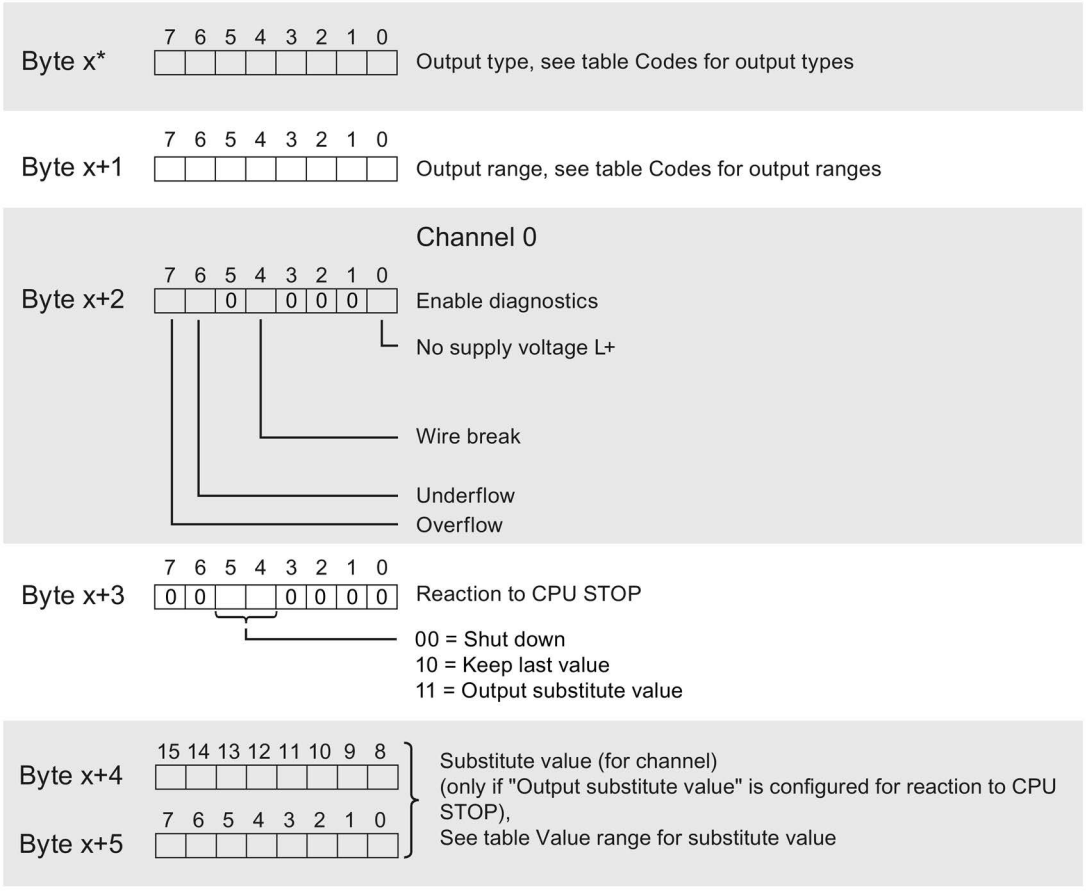


Image A-2 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 6); channel number = 0 and 1

Image A-3 Structure of bytes x to x+5 for channels 0 and 1

Codes for output types

The following table contains the codes for the output types of the analog output module. You enter this coding in byte x (see previous figure).

Table A- 1 Codes for output types

Output type	Code
Deactivated	0000 0000
Current	0000 0011

Codes for output ranges

The following table contains the codes for the output ranges of the analog output module. You enter these codes in byte x+1 of data record 128 (see previous figure).

Table A- 2 Codes for output ranges

Output range	Code
Current	
±20 mA	0000 0000
0 mA to 20 mA	0000 0001
4 mA to 20 mA	0000 0010

Value range for substitute value

The following table contains the value ranges for the substitute values. You must enter the corresponding codes in bytes x+4 and x+5 (see previous figure).

Output range	Permissible value range
Current	
±20 mA	-29031 to 29030
0 mA to 20 mA	0 to 29030
4 to 20 mA	-692 to 29376

Error transmitting the data record

The module always checks all values of the transmitted data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values

This appendix describes the analog values for all output ranges supported by the AQ 2xI ST analog module.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. Analog values are output as fixed point numbers in two's complement.

In the following table, you will find the representation of the binary analog values and the associated decimal or hexadecimal units of the analog values.

The resolutions 15 and 16 bits including sign are shown. Each analog value is entered left aligned into the ACCU. The bits marked with "x" are set to "0".

Table B- 1 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table B- 2 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table B- 3 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table B- 4 Current output range ±20 mA

Values			Current output range	Range
	Dec.	Hex.	±20 mA	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF	-20 mA + 723.4 nA	Underrange
-105%	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table B- 5 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table B- 6 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	19008	4A40	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5%	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

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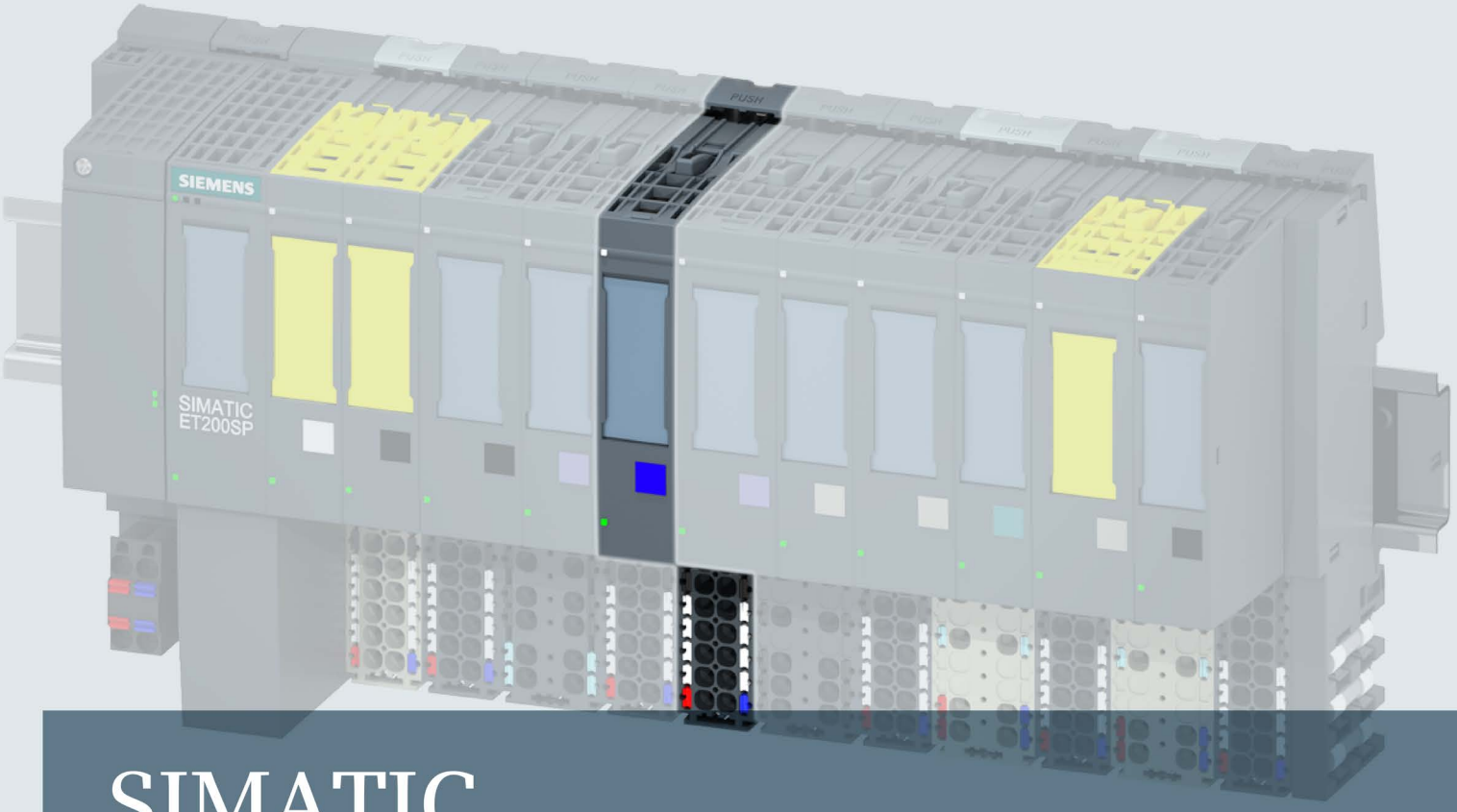

SIMATIC

ET 200SP

Analog output module AQ 4xU/I ST (6ES7135-6HD00-0BA1)

Manual

Edition 03/2016

siemens.com

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ET 200SP
Analog Output Module AQ 4xU/I ST (6ES7135-6HD00-0BA1)

Manual

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03/2016

A5E03573365-AD

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Changes described in this manual, compared to the edition 07/2014:

- 3-wire connection for voltage output
- Derating trend for current output for modules as of hardware version FS 06.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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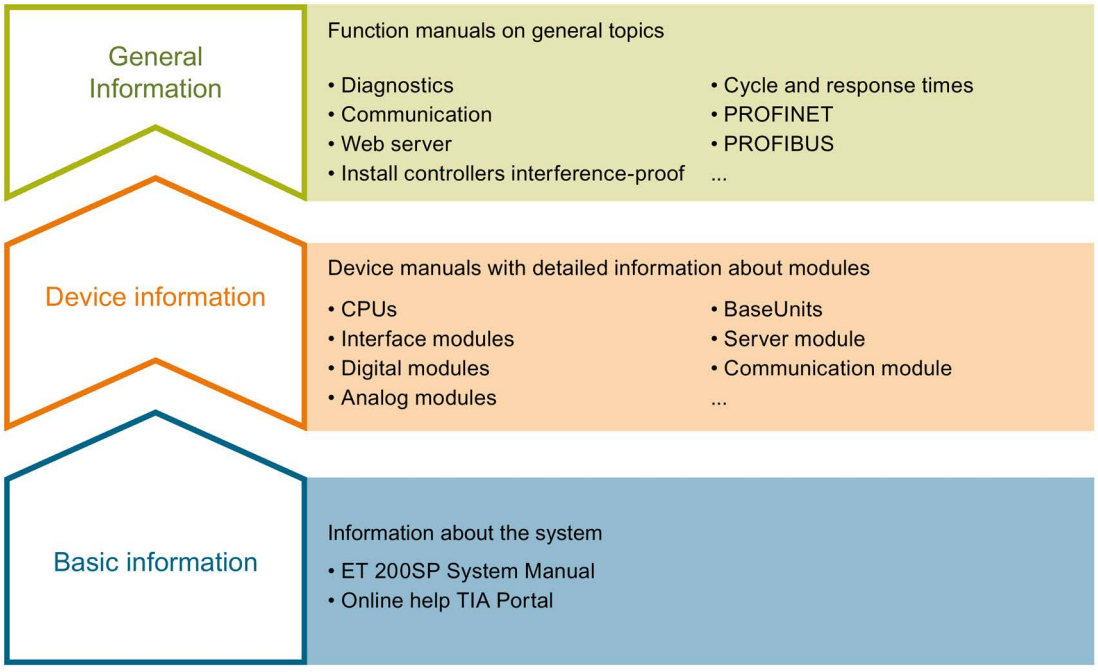
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 Properties

Article number

6ES7135-6HD00-0BA1

View of the module

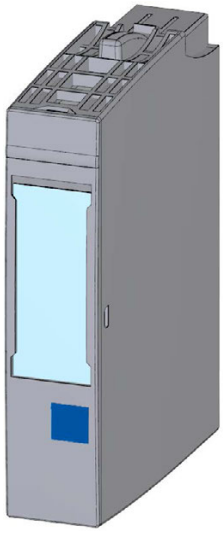


Image 2-1 View of the module AQ 4×U/I ST

Properties

The module has the following technical properties:

- Analog output module with 4 outputs
  - For current output and
  - voltage output
- Output range for current output:
  - ±20 mA, resolution 16 bits including sign
  - 0 to 20 mA, resolution 15 bits
  - 4 to 20 mA, resolution 14 bits
- Output range for voltage output:
  - ±10 V, resolution 16 bits including sign
  - ±5 V, resolution 15 bits including sign
  - 0 to 10 V, resolution 15 bits
  - 1 to 5 V, resolution 13 bits
- Electrically isolated from supply voltage L+
- Configurable diagnostics per module

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

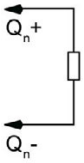
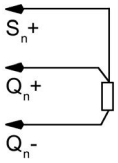
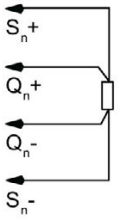
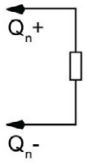
Wiring up

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment

Terminal assignment for AQ 4×U/I ST (6ES7135-6HD00-0BA1)						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Explanation**	**BaseUnit**[1]	**Color identification label**
1	Q_0+	**2**	Q_1+	• Q_n+: Analog output voltage/current (positive), channel n • Q_n-: Analog output voltage/current (negative), channel n • S_n+: Sensor line positive, channel n • S_n-: Sensor line negative, channel n	A0 A1	---
3	Q_2+	**4**	Q_3+			
5	Q_0-	**6**	Q_1-			
7	Q_2-	**8**	Q_3-			
9	S_0+	**10**	S_1+			
11	S_2+	**12**	S_3+			
13	S_0-	**14**	S_1-			
15	S_2-	**16**	S_3-			
L+	24 VDC	**M**	M			
Voltage 2-wire connection 		Voltage 3-wire connection 		Voltage 4-wire connection 		Current 

[1] Usable BaseUnit types, can be identified by the last two digits of the article number.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Also keep this in mind during the configuration.

You will find additional information on the BaseUnit types in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Schematic circuit diagram

Schematic circuit diagram

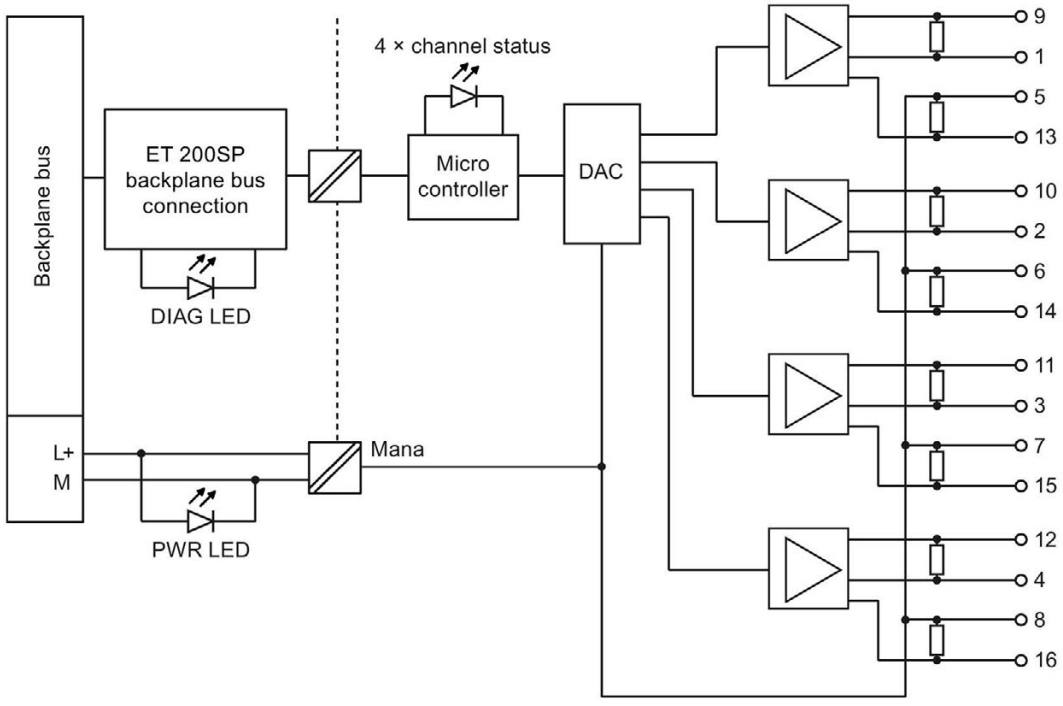


Image 3-1 Schematic circuit diagram for AQ 4×U/I ST

Parameters/address space

4

4.1 Output ranges

The analog output module AQ 4×U/I ST has the following measuring ranges:

Table 4- 1 Output ranges

Output type	Output ranges	Resolution
Current	± 20 mA	16 bits including sign
	0 to 20 mA	15 bits
	4 to 20 mA	14 bits
Voltage	±10 V	16 bits including sign
	±5 V	15 bits including sign
	0 to 10 V	15 bits
	1 to 5 V	13 bits

The tables of the output ranges, overflow, overrange, etc. can be found in section Representation of analog values (Page 34).

4.2 Parameters

Parameters of the AQ 4xU/I ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 31).

The following parameter settings are possible:

Table 4- 2 Settable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics: Short-circuit[1]	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Overflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Underflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics wire break[2]	• Disable • Enable	Disable	yes	Module	Module
Output type/range	• deactivated • Voltage +/- 10 V • Voltage +/- 5 V • Voltage 0..10 V • Voltage 1..5 V • Current +/- 20 mA • Current 0 - 20 mA • Current 4 - 20 mA	Current 4 - 20 mA	yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	yes	Channel	Module

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Substitute value	For permissible substitute values for the various output ranges, see appendix Parameter data record (Page 30), Substitute values → Codes for substitute value table	0	yes	Channel	Channel
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	no	Module	Module

1 no diagnostics detection between -0.5 V and +0.5 V (no short-circuit detection)

2 no diagnostics detection between -3 mA and +3 mA (no wire break detection)

Note

Unused channels

"Disable" the unused channels in the parameter assignment. This improves the temperature characteristics of the module, see Derating, section Technical specifications (Page 25).

A disabled channel always returns the value "no current or voltage".

4.3 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the output value exceeds the overrange, falls below the minimum output value or reaches underflow.

Diagnostics wire break

Enabling of the diagnostics if the line to the actuator is broken.

Output type / output range

See section Output ranges (Page 16)

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

Specifies that a BaseUnit with voltage supply feed-in is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no faults/errors on the module.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AQ 4×U/I ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

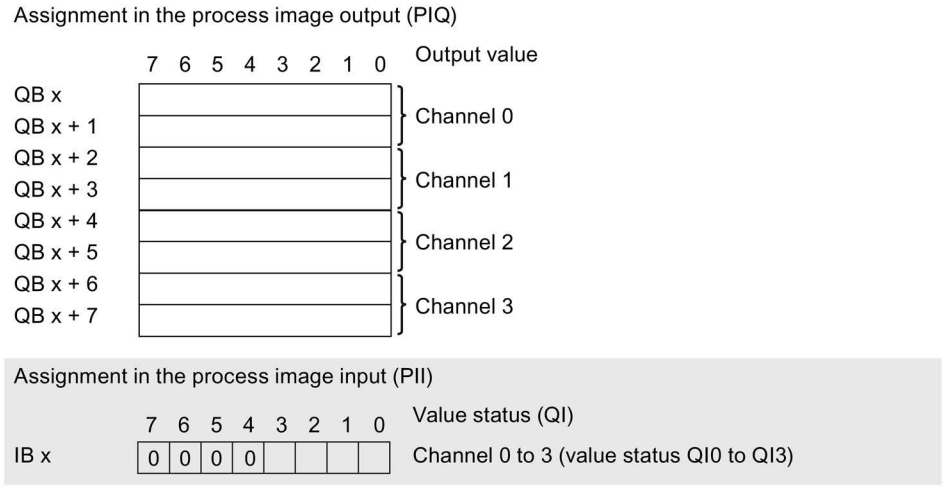


Image 4-1 Address space of the AQ 4×U/I ST with value status

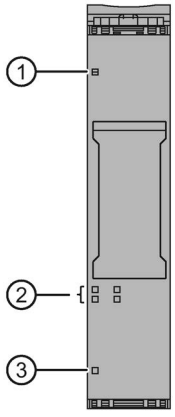
Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the AQ 4xU/I ST.



① DIAG (green/red)
② Channel status (green)
③ PWR (green)

Image 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 24).

DIAG LED

Table 5- 1 DIAG LED fault/error display

DIAG LED	Meaning
▫ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ on	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 5- 2 Status display of the channel status LED

Channel status LED	Meaning
▫ off	Channel disabled
■ on	Channel enabled

PWR LED

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
▫ off	No supply voltage L+
■ on	Supply voltage L+ present

5.2 Interrupts

The analog output module AQ 4×U/I ST supports diagnostic interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit (voltage)
- Overtemperature
- Line break (current)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware being updated. The module is currently not performing any outputs.	–
		The channel is currently being calibrated.	
Short-circuit	1_H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	4_H	Thermal overload of the I/O module	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high.	Use a different actuator type or wire differently, e.g. use cables with a larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable the channel ("output type" parameter) • Connect the channel
High limit violated	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Low limit violated	8_H	The output value specified by the user program is below the underrange.	Correct the output value
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of AQ 4×U/I ST

	6ES7135-6HD00-0BA1
Product type designation	AQ 4xU/I ST
General information	
Firmware version	V1.1
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V11 SP2 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	150 mA
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	8 bytes; + 1 byte for QI information

	6ES7135-6HD00-0BA1
Analog outputs	
Number of analog outputs	4
Voltage output, short-circuit current, max.	45 mA
Cycle time (all channels), min.	5 ms
Output ranges, voltage	
0 to 10 V	Yes; 15 bits
1 to 5 V	Yes; 13 bits
-5 to +5 V	Yes; 15 bits including sign
-10 to +10 V	Yes; 16 bits including sign
Output ranges, current	
0 to 20 mA	Yes; 15 bits
-20 to +20 mA	Yes; 16 bits including sign
4 to 20 mA	Yes; 14 bits
Connection of actuators	
for voltage output two-wire connection	Yes
for voltage output three-wire connection	Yes
for voltage output four-wire connection	Yes
for current output two-wire connection	Yes
Load resistance (in nominal range of the output)	
For voltage outputs, min.	2 kΩ
For voltage outputs, capacitive load, max.	1 µF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Cable length shielded, max.	1000 m; 200 m for voltage output
Analog value formation	
Oscillation time	
For resistive load	0.1 ms
For capacitive load	1 ms
For inductive load	0.5 ms
Errors/accuracies	
Linearity error (in relation to output range), (+/-)	±0.03 %
Temperature error (in relation to output range), (+/-)	0.005 %/K
Crosstalk between outputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	±0.05 %
Operational limit in the entire temperature range	
Voltage in relation to output range, (+/-)	±0.5 %
Current in relation to output range, (+/-)	±0.5 %

	6ES7135-6HD00-0BA1
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	±0.3 %
Current in relation to output range, (+/-)	±0.3 %
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes
Short-circuit	Yes
Overflow/underflow	Yes
Diagnostics display LED	
Monitoring of the supply voltage (PWR LED)	Yes; green LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic isolation)
Insulation	
Insulation tested with	707 VDC (type test)
Environmental conditions	
Operating temperature	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Derating trend for permitted load during power output and horizontal mounting position:

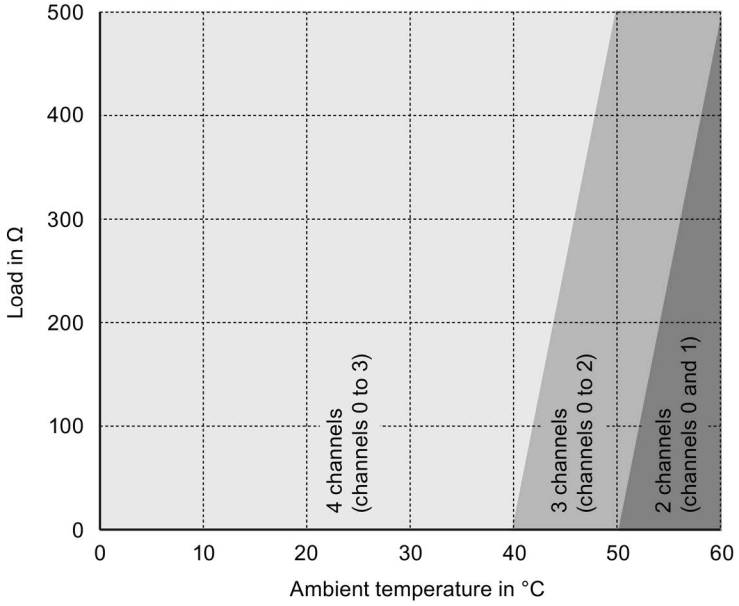


Image 6-1 Derating trend current output (horizontal)

Derating trend for permitted load during power output and vertical mounting position:

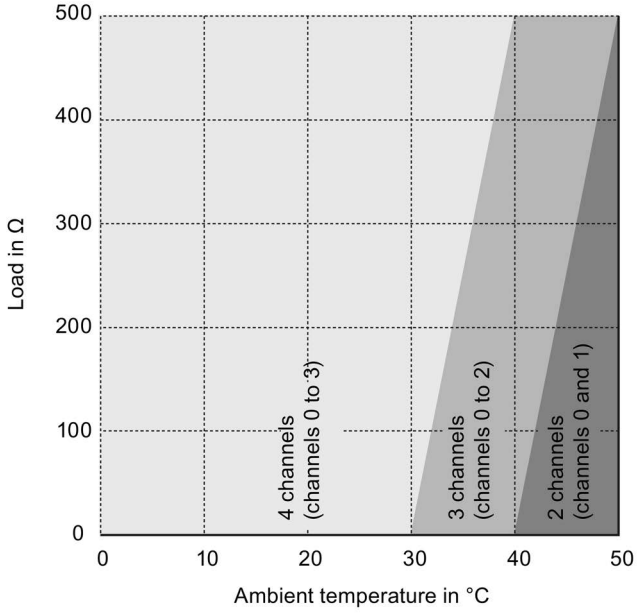


Image 6-2 Derating trend current output (vertical)

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the output type and output range for PROFINET.

Output type	Output range	Diagnostics					Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to M	Overflow	Underflow	Wire break		
deactivated		*	*	*	*	*	*	*
Voltage	±5 V	x	x	x	x	-	x	x
	±10 V	x	x	x	x	-	x	x
	1..5 V	x	x	x	x	-	x	x
	0..10 V	x	x	x	x	-	x	x
Current	±20 mA	x	-	x	x	x	x	x
	0..20 mA	x	-	x	x	x	x	x
	4..20 mA	x	-	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the output type and output range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to M	Overflow/ Underflow	Wire break		
deactivated		*	*	*	*	*	*
Voltage	±5 V	x	x	x	-	x	x
	±10 V	x	x	x	-	x	x
	1..5 V	x	x	x	-	x	x
	0..10 V	x	x	x	-	x	x
Current	±20 mA	x	-	x	x	x	x
	0..20 mA	x	-	x	x	x	x
	4..20 mA	x	-	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

Note

Channel 0 contains the diagnostics for the entire module.

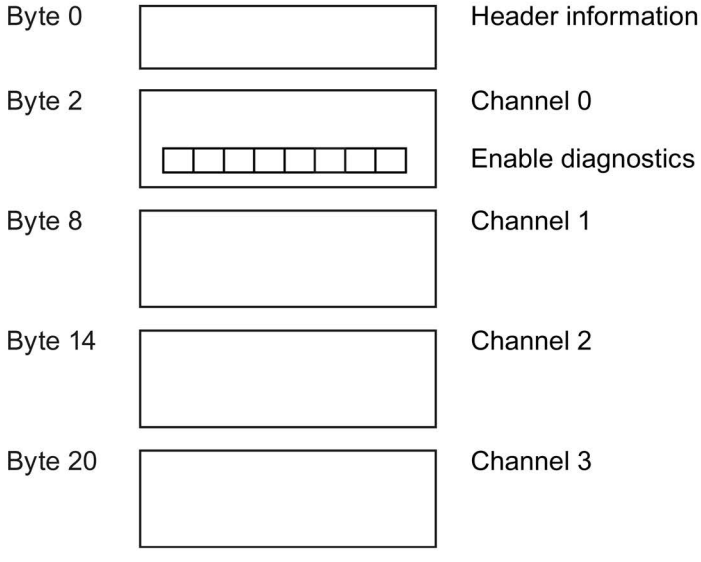


Image A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

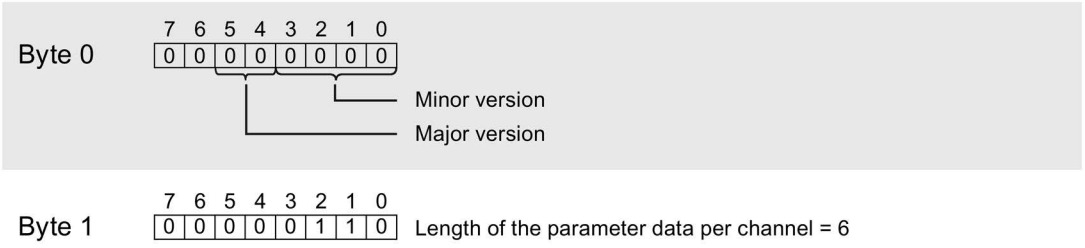
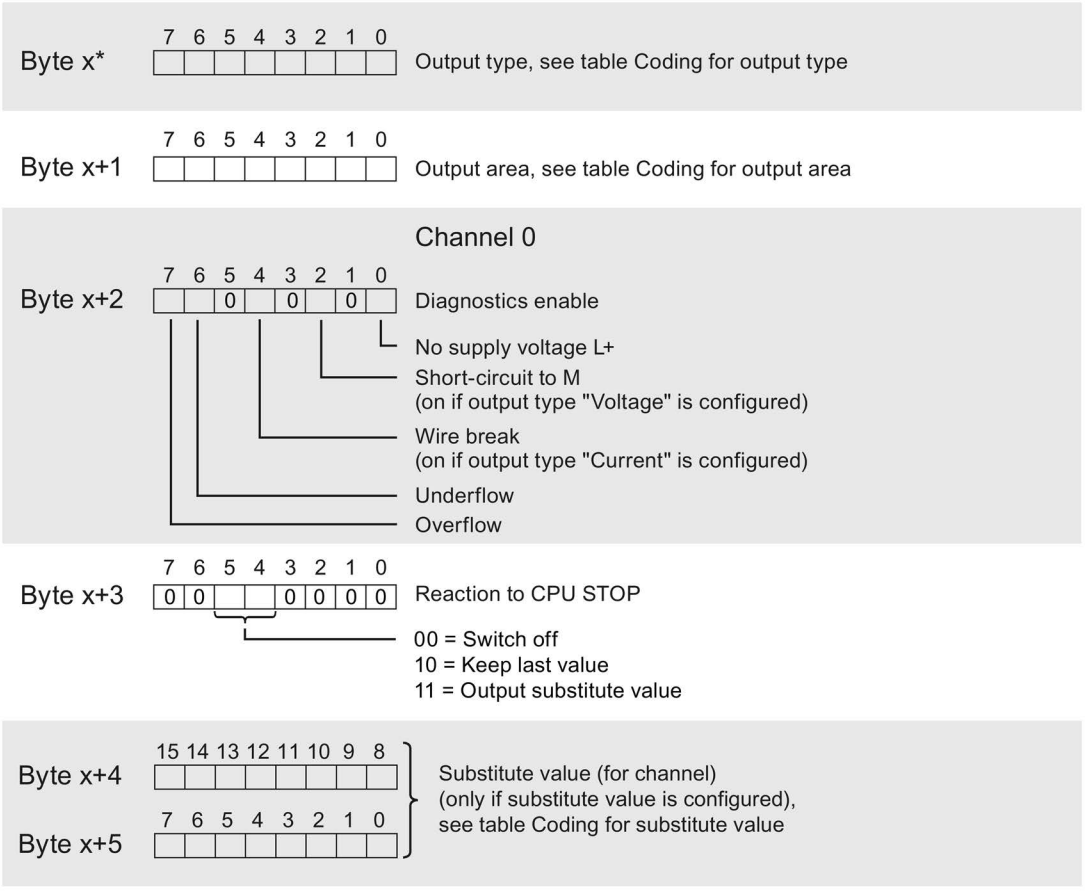


Image A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".



* x = 2 + (channel number × 6); channel number = 0 to 3

Image A-3 Structure byte x up to x+5 for the channel 0 to 3

Codes for output type

The following table contains the codes for the output types of the analog output module. You enter this coding in byte x (see previous figure).

Table A- 1 Codes for output type

Output type	Coding
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0011

Codes for output range

The following table contains the codes for the output ranges of the analog output module. You enter these codes in byte x+1 of data record 128 (see previous figure).

Table A- 2 Codes for output range

Output range	Coding
Voltage	
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011
Current	
±20 mA	0000 0000
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010

Codes for substitute value

The following table contains the codes for the substitute values. You enter these codes in bytes x+4 and x+5 (see previous figure).

Output range	Permissible substitute value
Voltage	
±10 V	-32512 to 32511
±5 V	-32512 to 32511
0 to 10 V	0 to 32511
1 to 5 V	-6912 to 32511
Current	
±20 mA	-29031 to 29030
0 to 20 mA	0 to 29030
4 to 20 mA	-692 to 29376

Representation of analog values

B

This appendix describes the analog values for all output ranges that you can use with the analog module AQ 4xU/I ST.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. Analog values are output as fixed point numbers in two's complement.

In the following table, you will find the representation of the binary analog values and the associated decimal or hexadecimal units of the analog values.

The resolutions 14, 15 and 16 bits including sign are shown. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table B- 1 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table B- 2 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table B- 3 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table B- 4 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	Hex.	±10 V	±5 V	
118.5149 %	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589 %	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100 %	27648	6C00	10 V	5 V	Nominal range
75 %	20736	5100	7.5 V	3.75 V	
0.003617 %	1	1	361.7 µV	180.8 µV	
0 %	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75 %	-20736	AF00	-7.5 V	-3.75 V	
-100 %	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange
-117.593 %	-32512	8100	-11.76 V	-5.88 V	
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519 %	-32768	8000			

* outputs positive maximum value or negative minimum value

Table B- 5 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	Hex.	0 to 10 V	
118.519 %	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589 %	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100 %	27648	6C00	10 V	Nominal range
75 %	20736	5100	7.5 V	
0.003617 %	1	1	361.7 µV	
0 %	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

Table B- 6 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	Hex.	1 to 5 V	
118.519 %	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589 %	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100 %	27648	6C00	5 V	Nominal range
75 %	20736	5100	4 V	
0.003617 %	1	1	1 V + 144.7 µV	
0 %	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25 %	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table B- 7 Current output range ±20 mA

Values			Current output range	Range
	Dec.	Hex.	±20 mA	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29031	7167		
105 %	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100 %	27648	6C00	20 mA	Nominal range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75 %	-20736	AF00	-15 mA	
-100 %	-27648	9400	-20 mA	
	-27649	93FF	-20 mA + 723.4 nA	Underrange
-105 %	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

Table B- 8 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29031	7167		
105 %	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100 %	27648	6C00	20 mA	Nominal range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

Table B- 9 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25 %	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100 %	27648	6C00	20 mA	Nominal range
75 %	19008	4A40	16 mA	
0.003617 %	1	1	4 mA + 578.7 nA	
0 %	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5 %	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

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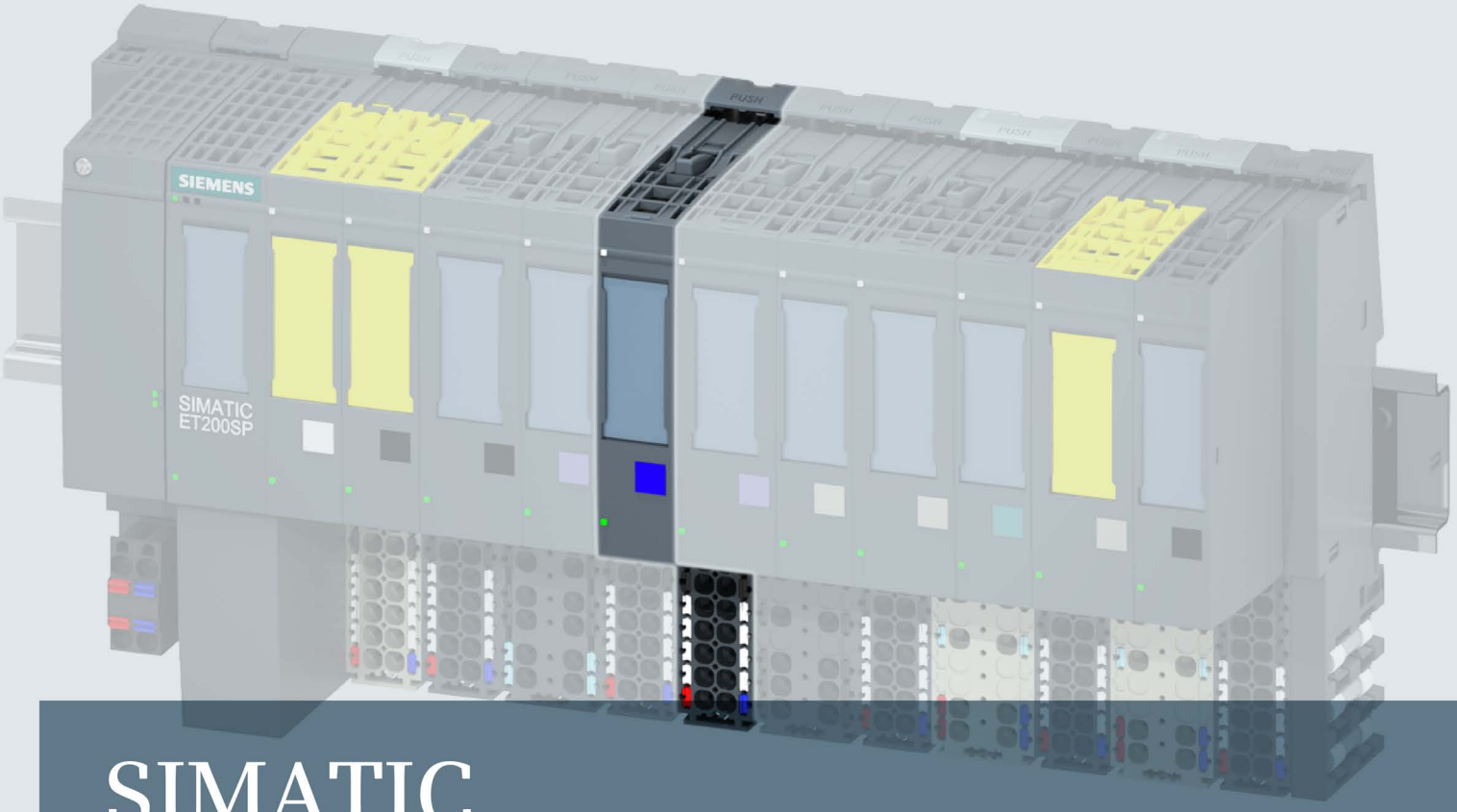

SIMATIC

ET 200SP

Analog output module AQ 2xU/I HS (6ES7135-6HB00-0DA1)

Manual

Edition 09/2016

siemens.com

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ET 200SP
Analog output module AQ 2xU/I HS (6ES7135-6HB00-0DA1)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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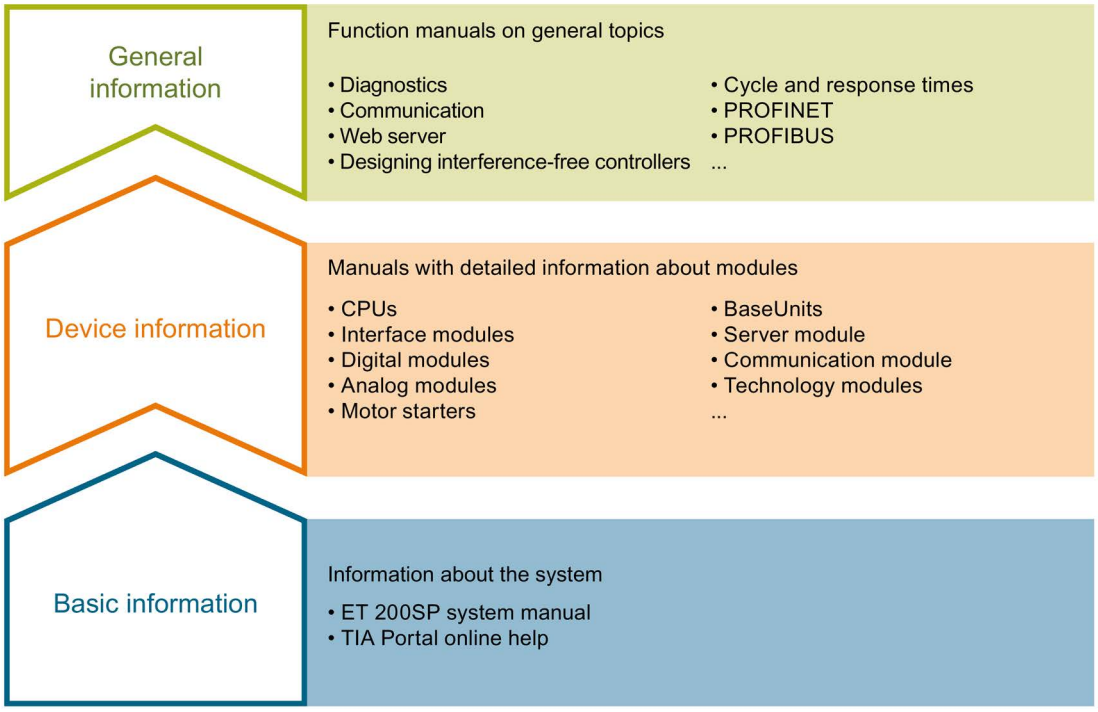
Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

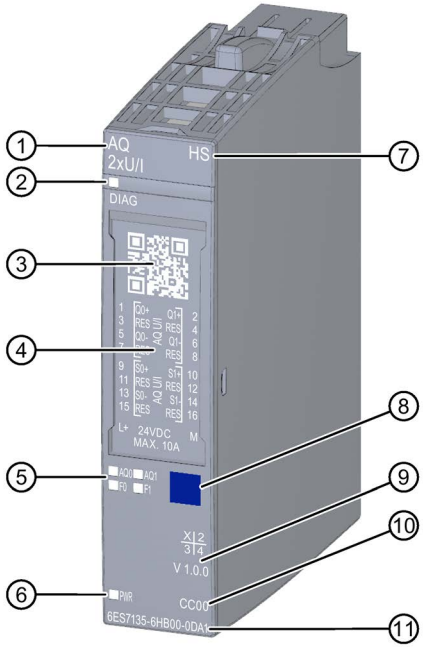
2

2.1 Properties

Article number

6ES7135-6HB00-0DA1

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-1 View of the AQ 2×U/I HS module

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
  - For current output and
  - Voltage output
- Output ranges for current output:
  - ±20 mA, resolution 16 bit including sign
  - 0 to 20 mA, resolution 15 bit
  - 4 to 20 mA, resolution 14 bit
- Output ranges for voltage output:
  - ±10 V, resolution 16 bit including sign
  - ±5 V, resolution 15 bit incl. sign
  - 0 to 10 V, resolution 15 bit
  - 1 to 5 V, resolution 13 bit
- Electrically isolated from supply voltage L+
- Configurable diagnostics (per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy

Table 2- 1 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Basic version	1	V1.0.0
Isochronous mode with send clock up to 250 µs	2	V1.1.0
Value status	2	V1.1.0
Oversampling channel 0	2	V1.1.0
Oversampling channel 0 and 1	2	V2.0.0
Isochronous mode with send clock up to 125 µs	2	V2.0.1

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Connecting

3

3.1 Wiring and block diagram

This section includes the block diagram of the module with the AQ 2xU/I HS pin assignments for a 2-wire, 3-wire and 4-wire connection for voltage output.

The 3-wire and 4-wire connection are used for the compensation of the voltage drop on the connection cables.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Note

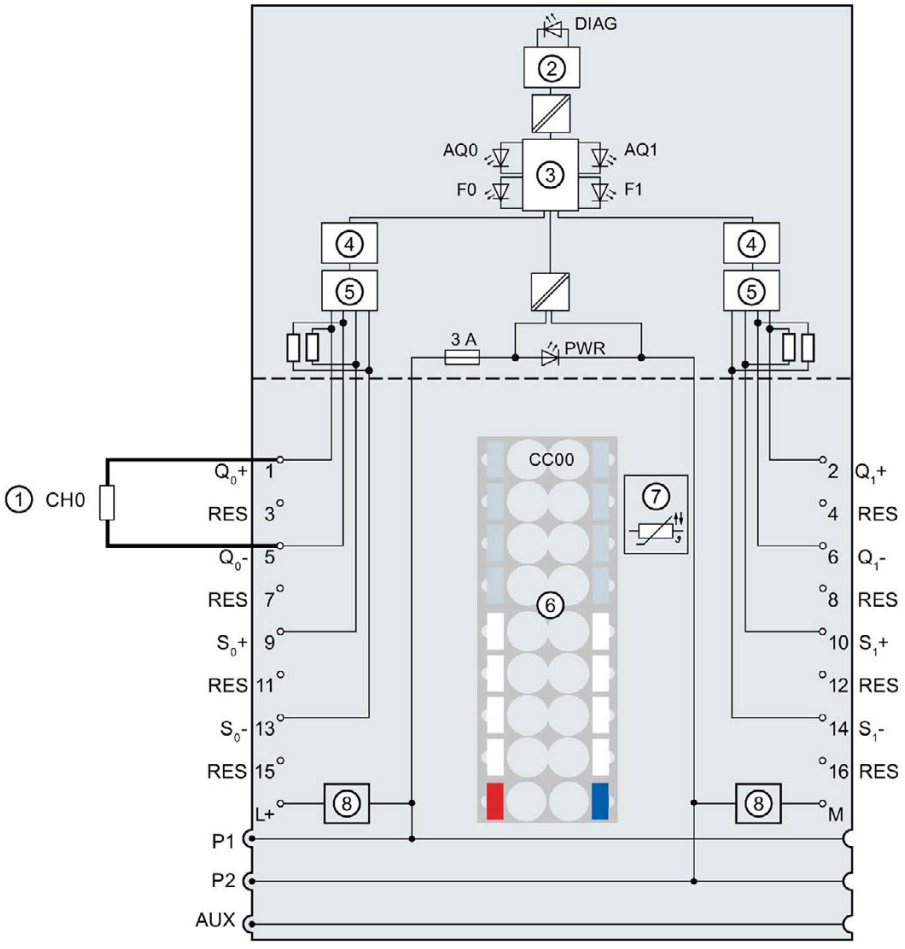
You may use and combine the different wiring options for all channels.

Note

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connection: Current output 2-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xU/I HS on the BaseUnit BU type A0/A1.

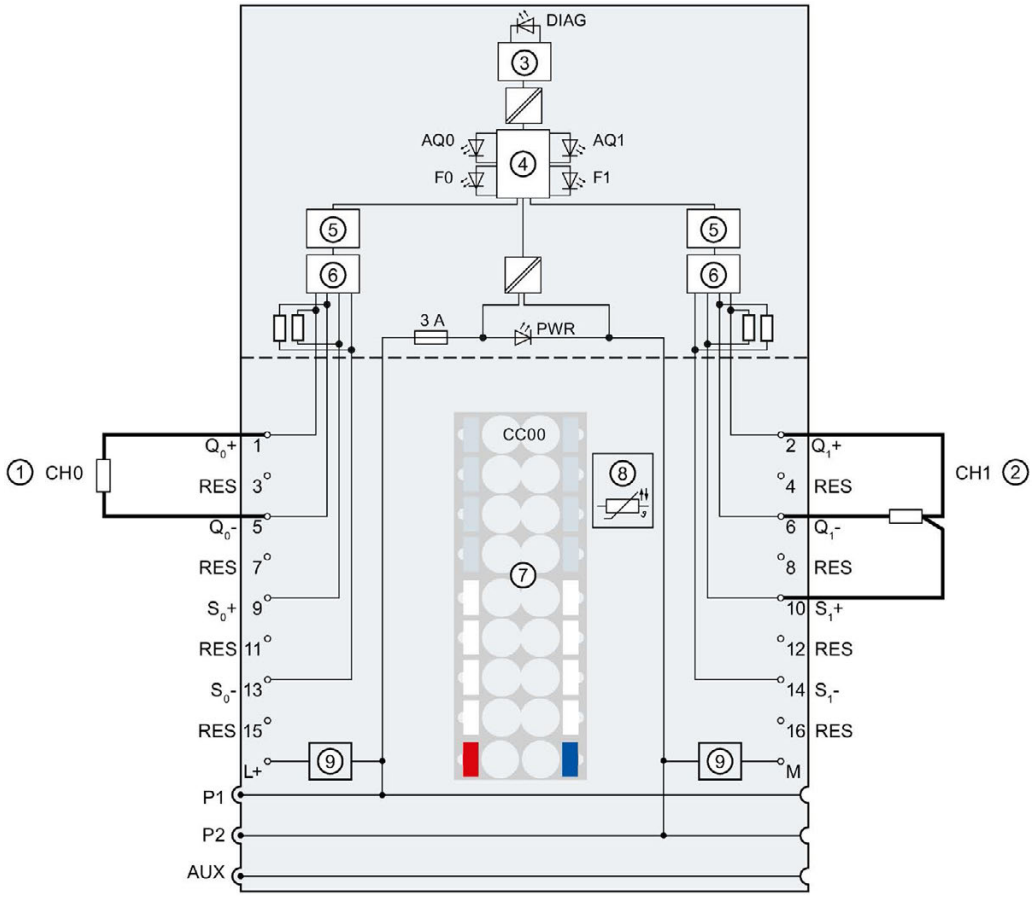


①	2-wire connection for current output	S_n+	Sensor cable positive, channel n
②	Backplane bus interface	S_n-	Sensor cable negative, channel n
③	Microcontroller	RES	Reserve, must remain unused for future function extensions
④	Digital-to-analog converter (DAC)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Output conditioner	M	Ground
⑥	Color identification label CCxx (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)	AQ0, AQ1	Channel status LED (green)
Q_n+	Analog output voltage/current positive, channel n	F0, F1	Channel fault LED (red)
Q_n-	Analog output voltage/current negative, channel n	PWR	Power LED (green)

Figure 3-1 Wiring and block diagram for current output 2-wire connection

Connection: Voltage output 2-wire and 3-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xU/I HSon the BaseUnit BU type A0/A1.

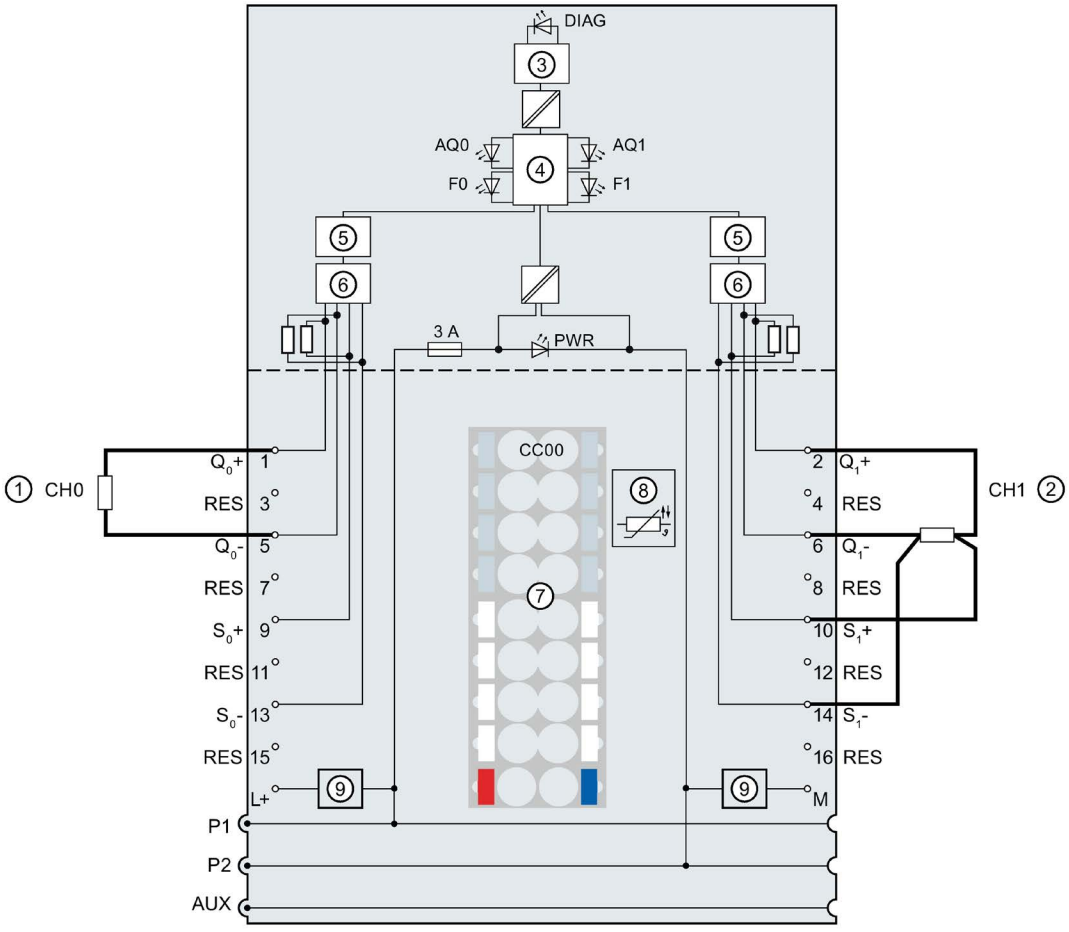


①	2-wire connection for voltage output	S_n+	Sensor cable positive, channel n
②	3-wire connection for voltage output	S_n-	Sensor cable negative, channel n
③	Output conditioner	RES	Reserve, must remain unused for future function extensions
④	Digital-to-analog converter (DAC)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Microcontroller	M	Ground
⑥	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Color identification label CCxx (optional)	DIAG	Diagnostics LED (green, red)
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	AQ0, AQ1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
Q_n+	Analog output voltage/current positive, channel n	PWR	Power LED (green)
Q_n-	Analog output voltage/current negative, channel n		

Figure 3-2 Wiring and block diagram for voltage output 2-wire and 3-wire connection

Connection: Voltage output 2-wire and 4-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xU/I HS on the BaseUnit BU type A0/A1.



①	2-wire connection for voltage output	S_n+	Sensor cable positive, channel n
②	4-wire connection for voltage output	S_n-	Sensor cable negative, channel n
③	Output conditioner	RES	Reserve, must remain unused for future function extensions
④	Digital-to-analog converter (DAC)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Microcontroller	M	Ground
⑥	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Color identification label CCxx (optional)	DIAG	Diagnostics LED (green, red)
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	AQ0, AQ1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
Q_n+	Analog output voltage/current positive, channel n	PWR	Power LED (green)
Q_n-	Analog output voltage/current negative, channel n		

Figure 3-3 Wiring and block diagram for voltage output 2-wire and 4-wire connection

Parameters/address space

4

4.1 Output types and output ranges

The analog output module AQ 2×U/I HS has the following output ranges:

Table 4- 1 Output ranges

Output type	Output range	Resolution
Current	±20 mA	16 bit incl. sign
	0 to 20 mA	15 bit
	4 to 20 mA	14 bit
Voltage	± 10 V	16 bit incl. sign
	± 5 V	15 bit incl. sign
	0 to 10 V	15 bit
	1 to 5 V	13 bit

You will find the tables of output ranges and overflow, overrange, etc. in the section Representation of analog values (Page 43) and the "Analog value processing" function manual.

4.2 Parameters

Parameters of the AQ 2×U/I HS

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP oder an einem ET 200SP Open Controller CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of parameter data record (Page 38).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Sampling rate	1 value/cycle	1 value/cycle	No	Module	Module
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground [1]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Channel [3]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break[2]	• Disable • Enable	Disable	Yes	Channel	Channel
Output type/range	• Deactivated • Voltage +/- 10 V • Voltage +/- 5 V • Voltage 0 to 10 V • Voltage 1 to 5 V • Current +/- 20 mA • Current 0 to 20 mA • Current 4 to 20 mA	Current 4 to 20 mA	Yes	Channel	Channel

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Reaction to CPU STOP	• Shut down • Keep last value • Output substitute value	Shut down	Yes	Channel	Module [3]
Substitute value	For permissible substitute values for the various output ranges, see Parameter assignment and structure of the parameter data record (Page 38) appendix, Substitute values → Codes for substitute values table	0	Yes	Channel	Channel
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] No diagnostics detection between -0.5 V and +0.5 V (no short-circuit detection)

[2] No diagnostics detection between -3 mA and +3 mA (no wire break detection)

[3] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 7 bytes.

Note

Unused channels

A deactivated channel always returns the value "no current or voltage".

4.3 Description of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics alarm for missing or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value falls below the underrange or reaches the minimum output value or underflow.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Output type/output range

See the section Output types and output ranges (Page 18).

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute values are values issued by the outputs (the output) in the event of a CPU STOP.

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

4.4 Oversampling

Function

Oversampling is the output of data in constant bus cycle segments (sub-cycles), whereby n sub-cycles correspond to one PROFINET bus cycle. A data packet is transmitted from the controller to the module, which outputs the packet in n constant bus sub-cycles.

Oversampling is useful whenever you require output of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With oversampling, a PROFINET bus cycle is divided into constant bus sub-cycles:

- Each sub-cycle returns an output value.
- The minimum PROFINET bus cycle for oversampling is 250 µs.
- You can configure oversampling for:
  - Channel 0 (1-channel operation)
  - Channel 0/1 (2-channel operation)
- The number of sub-cycles can be set as follows:
  - From 2 to 16 for one channel
  - From 2 to 8 for two channels

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameter:

- Sampling rate

Note

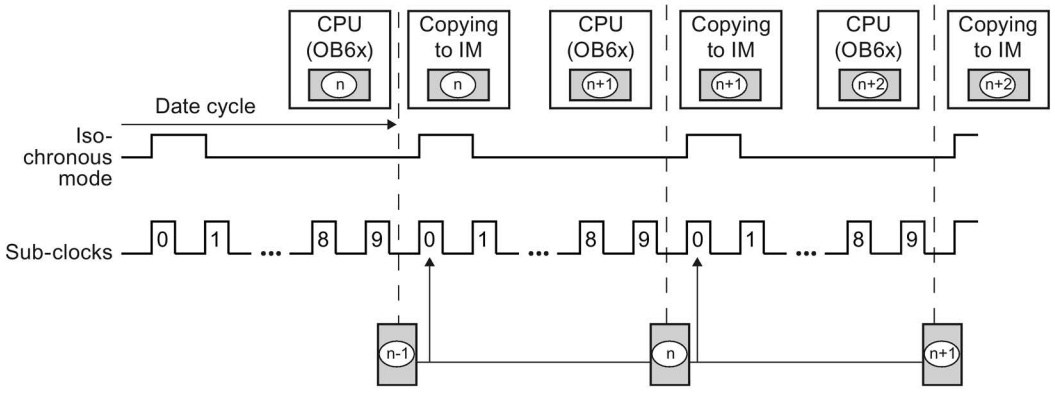
Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

Overview of the operating modes

Function	Normal operation	Oversampling in normal operation	
		1-channel operation	2-channel operation
Isochronous mode	Yes, optional	Yes, required	
• Shortest send clock	125 µs	250 µs	
Oversampling	No	Yes	Yes
• Number of over-sampling levels (output rate)	-	2 to 16	2 to 8
• Shortest sub-cycle (= shortest sampling time)	-	35 µs	45 µs
±10 V	x	x	
0 to 10 V	x	x	
±5 V	x	x	
1 to 5 V	x	x	
±20 mA	x	x	
0 to 20 mA	x	x	
4 to 20 mA	x	x	
Overflow	x	x	
Underflow	x	x	
Wire break for current	x	x	
Short-circuit for voltage	x	x	
Load voltage diagnostics	x	x	
Value status (QI)	x	-	
Reaction to CPU STOP	x	x	
Data length	4 bytes	32 bytes	

Chronological sequence

The figure shows the chronological sequence for oversampling. The output data present in the CPU is output in the data cycle after the next one, distributed across the sub-cycles which are generated on the actual module.



① n = output values from bus cycle n

Figure 4-1 Oversampling

4.5 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bit 0 and 1 in this byte are assigned to the module. They provide information about the validity of the analog value.

Bit =1: No fault is present on the channel.

Bit =0: The wiring, the value created on the channel, or similar is incorrect.

Address space

The following figure shows the assignment of the address space for the AQ 2xU/I HS with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

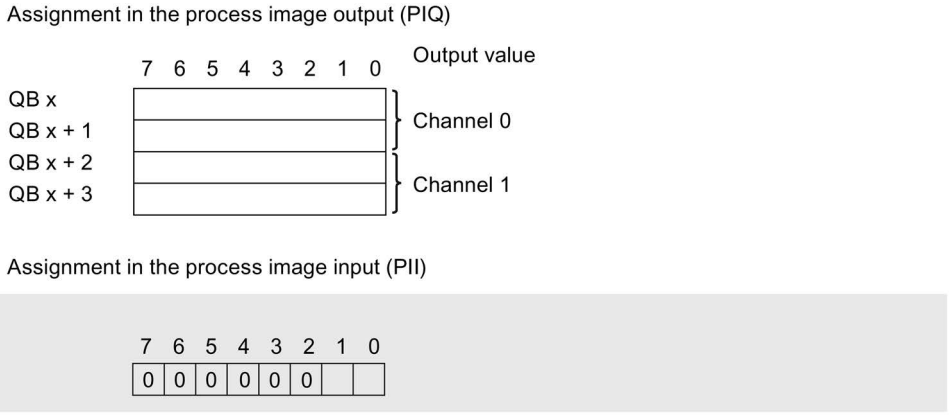


Figure 4-2 Address space of the AQ 2xU/I HS with value status

Address space of the AQ 2xU/I HS for oversampling with one channel

The following figure shows the assignment of the address space for oversampling with one channel. Writing always starts from QB x. Only a maximum of 16 sub-cycles are possible.

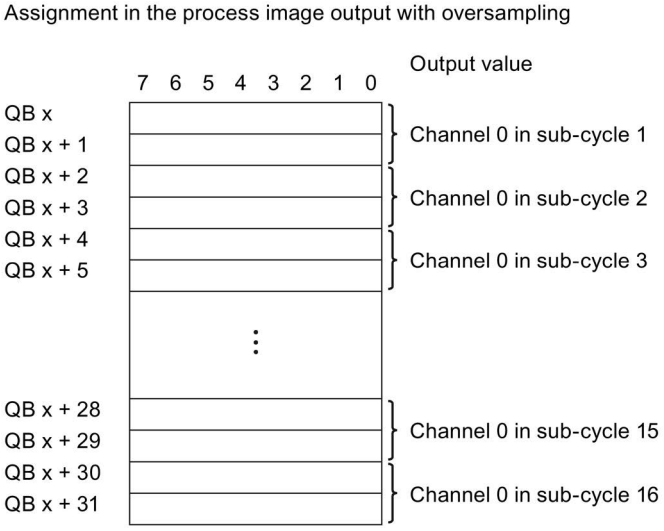


Figure 4-3 Address space of the AQ 2xU/I HS for oversampling with one channel

Address space of the AQ 2xU/I HS for oversampling with two channels

The following figure shows the assignment of the address space for oversampling with two channels. Writing always starts from QB x. Only a maximum of 8 sub-cycles are possible.

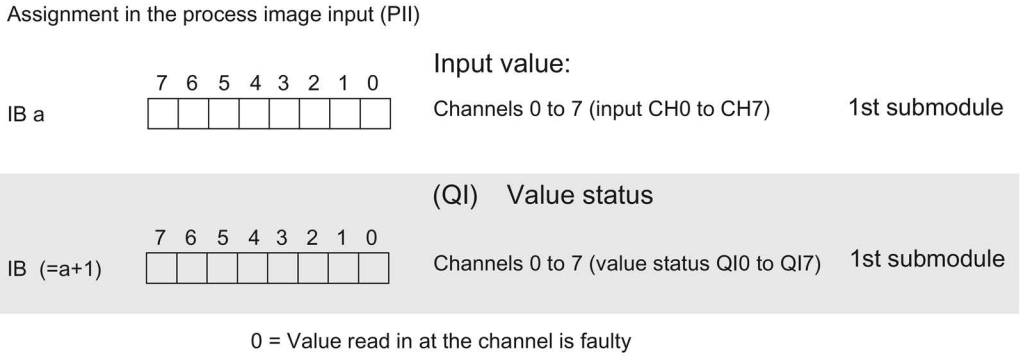


Figure 4-4 Address space of the AQ 2xU/I HS for oversampling with two channels

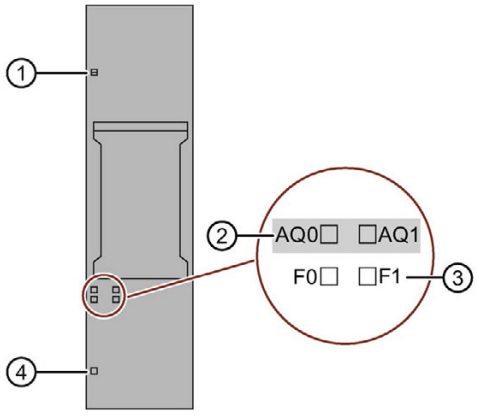
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED display

The figure below shows the LED displays of the AQ 2×U/I HS.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 5-1 LED displays

Meaning of the LEDs

The following table contains the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 30).

DIAG LED

Table 5- 1 Error display of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status/channel fault LED

Table 5- 2 Status/error display of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Channel deactivated or no load voltage L+
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

PWR LED

Table 5- 3 Status display of the PWR LED

PWR	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The analog output module AQ 2×U/I HS supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- Short-circuit
- Overtemperature
- Wire break
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- No load voltage
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program

Table 5- 4 Error types

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (current)	1_H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	4_H	Thermal overload of the I/O module	Reduce the ambient temperature, pay attention to derating
Wire break (current)	6_H	Impedance of actuator circuit too high	Use a different actuator type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Deactivate the channel ("Output type" parameter) • Deactivate diagnostics • Connect the channel
High limit violated	7_H	The output value defined by the user program is above the overrange.	Correct the output value
Low limit violated	8_H	The output value defined by the user program is below the underrange.	Correct the output value
Error	9_H	Internal module error occurred	Replace the module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AQ 2×U/I HS

	6ES7135-6HB00-0DA1
Product type designation	ET 200SP, AQ 2xU/I High Speed
General information	
Firmware version	V2.0.1
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
Oversampling	Yes; 2 channels per module
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Input current	
Current consumption (rated value)	45 mA; no load
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
Address space per module, max.	4 byte; + 1 byte for QI information (32 bytes in oversampling mode)

	6ES7135-6HB00-0DA1
Analog outputs	
Number of analog outputs	2
Voltage output, short-circuit protection	Yes
Voltage output, short-circuit current, max.	45 mA
Cycle time (all channels), min.	125 µs
Analog output with oversampling	Yes
• Values per cycle, max.	16
• Resolution, min.	45 µs; (2 channels), 35 µs (1 channel)
Output ranges, voltage	
0 to 10 V	Yes; 15 bit
1 V to 5 V	Yes; 13 bit
-5 V to +5 V	Yes; 15 bit incl. sign
-10 V to +10 V	Yes; 16 bit incl. sign
Output ranges, current	
0 to 20 mA	Yes; 15 bit
-20 mA to +20 mA	Yes; 16 bit incl. sign
4 mA to 20 mA	Yes; 14 bit
Wiring the actuators	
for voltage output two-wire connection	Yes
for voltage output four-wire connection	Yes
for current output two-wire connection	Yes
Load resistance (in rated range of the output)	
For voltage outputs, min.	2 kΩ
For voltage outputs, capacitive load, max.	1 µF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Shielded, max.	1000 m; 200 m for voltage output
Formation of analog values for the outputs	
Settling time	
For resistive load	0.05 ms
For capacitive load	0.05 ms; max. 47 nF and 20 m cable length
For inductive load	0.05 ms

	6ES7135-6HB00-0DA1
Errors/accuracies	
Output ripple (in relation to output range, bandwidth 0 kHz to 50 kHz), (+/-)	0.02%
Linearity error (in relation to output range), (+/-)	0.03%
Temperature error (in relation to output range), (+/-)	0.003%/K
Crosstalk between outputs, max.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	0.03%
Operational limit in the entire temperature range	
Voltage in relation to output range, (+/-)	0.2%
Current in relation to output range, (+/-)	0.2%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	0.1%
Current in relation to output range, (+/-)	0.1%
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	70 µs
Bus cycle time (TDP), min.	125 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; channel-based, only for output type current
Short-circuit	Yes; channel-based, only for output type voltage
Overflow/underflow	Yes
Diagnostics display LED	
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Insulation	
Insulation tested with	707 V DC (type test)

	6ES7135-6HB00-0DA1
Ambient conditions	
Ambient temperature during operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Derating trends with horizontal installation:

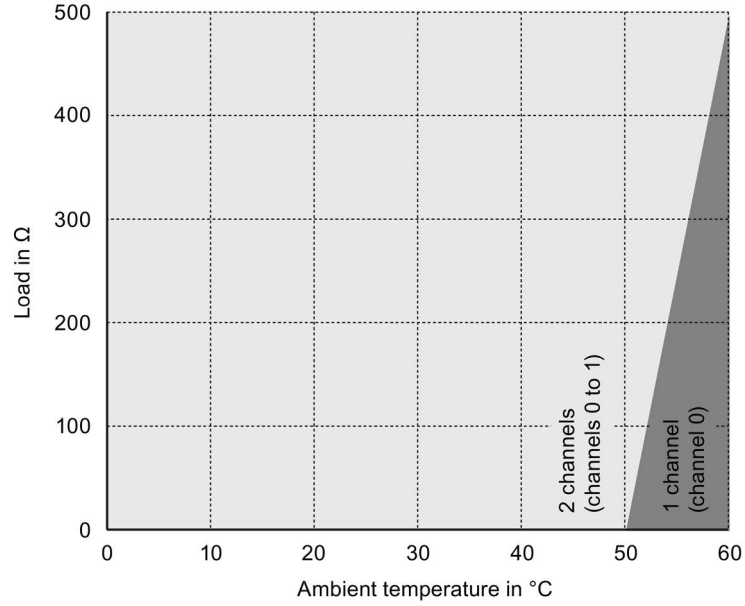


Figure 6-1 Derating trend current output (horizontal)

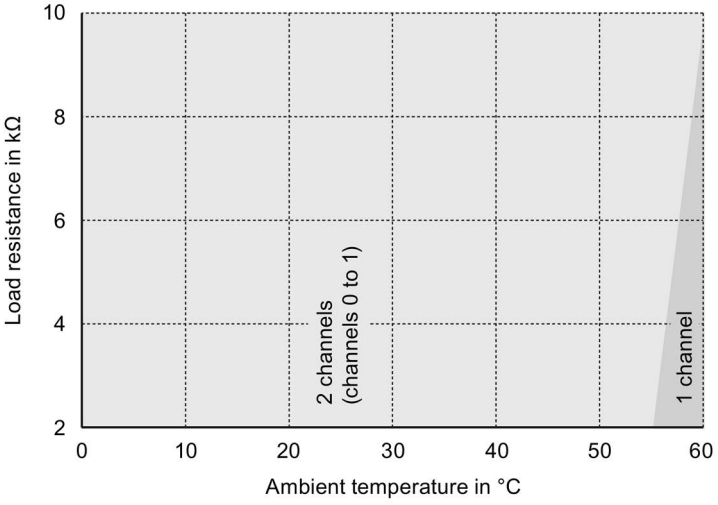


Figure 6-2 Derating trend voltage output (horizontal)

Derating trends with vertical installation:

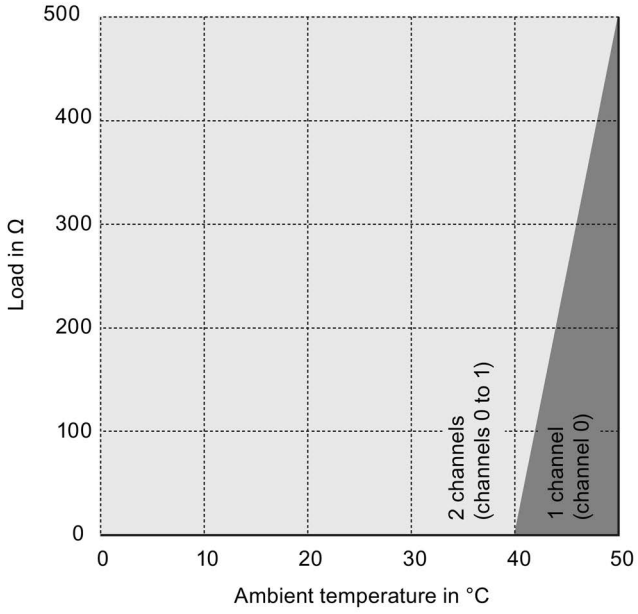


Figure 6-3 Derating trend current output (vertical)

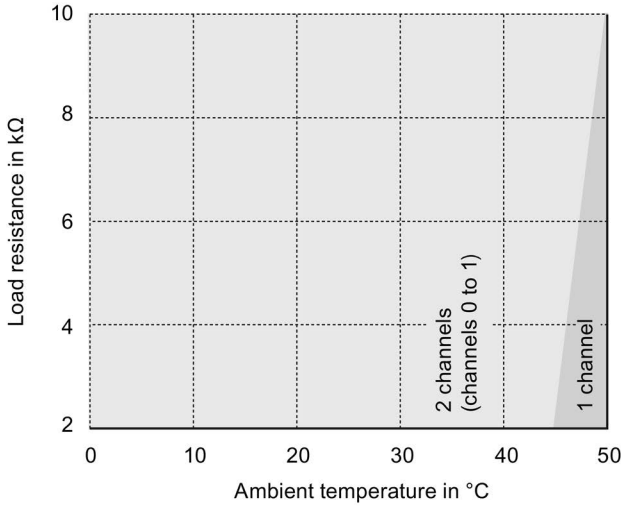


Figure 6-4 Derating trend voltage trend (vertical)

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Output type	Output range	Diagnostics					Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow	Wire break		
Deactivated		*	*	*	*	*	*	*
Voltage	±5 V	x	x	x	x	-	x	x
	±10 V	x	x	x	x	-	x	x
	1 to 5 V	x	x	x	x	-	x	x
	0 to 10 V	x	x	x	x	-	x	x
Current	±20 mA	x	-	x	x	x	x	x
	0 to 20 mA	x	-	x	x	x	x	x
	4 to 20 mA	x	-	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow/ Underflow	Wire break		
Deactivated		*	*	*	*	*	*
Voltage	±5 V	x	x	x	-	x	x
	±10 V	x	x	x	-	x	x
	1 to 5 V	x	x	x	-	x	x
	0 to 10 V	x	x	x	-	x	x
Current	±20 mA	x	-	x	x	x	x
	0 to 20 mA	x	-	x	x	x	x
	4 to 20 mA	x	-	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current ranges of selected channels can be changed in RUN without having an effect on the other channels).

Note

Following a firmware update, you need to re-configure the I/O module before you can use the new functions.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

Note

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment results in a brief exit from clocked measuring mode and renewed synchronization with the fieldbus cycle. The slowest channel provides the "internal" measuring cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

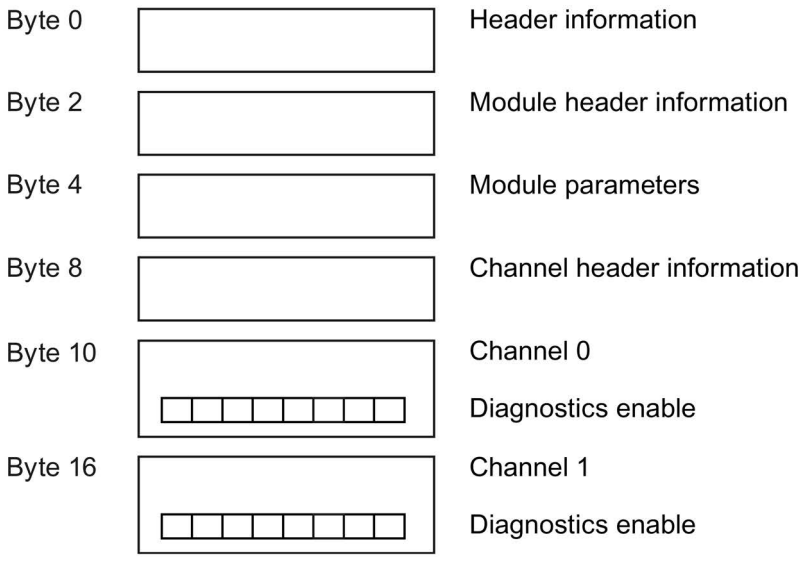


Figure A-1 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

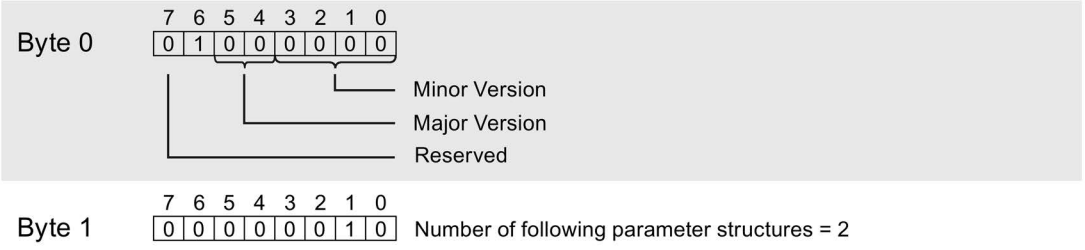


Figure A-2 Header information

Module header information

The figure below shows the structure of the module header information.

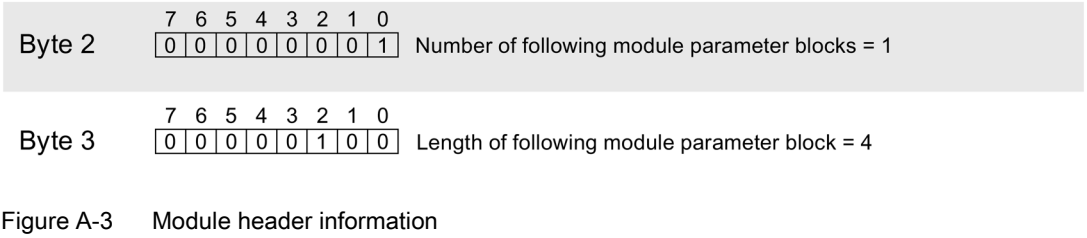


Figure A-3 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 and 1.

Enable a parameter by setting the corresponding bit to "1".

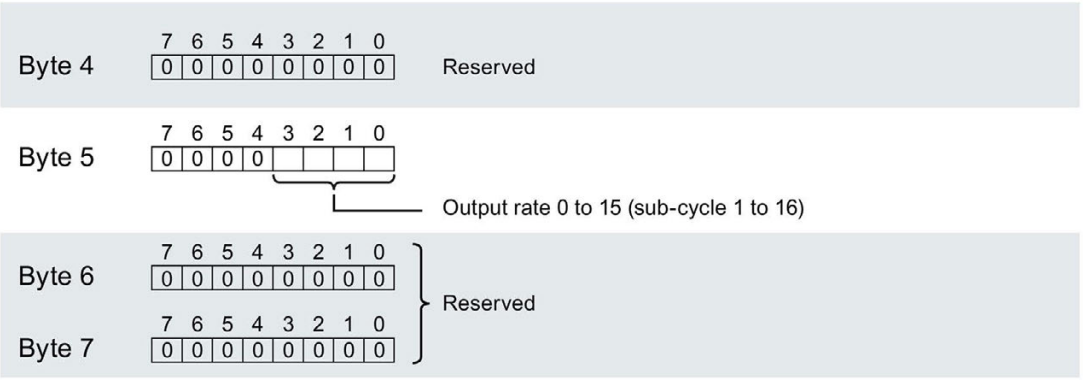


Figure A-4 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

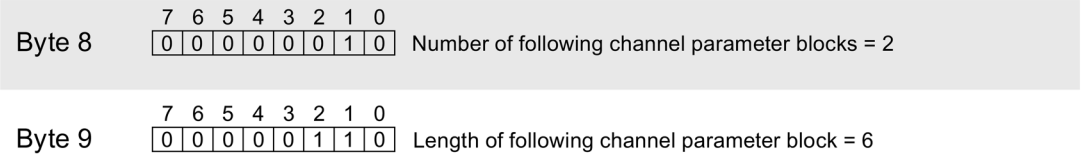
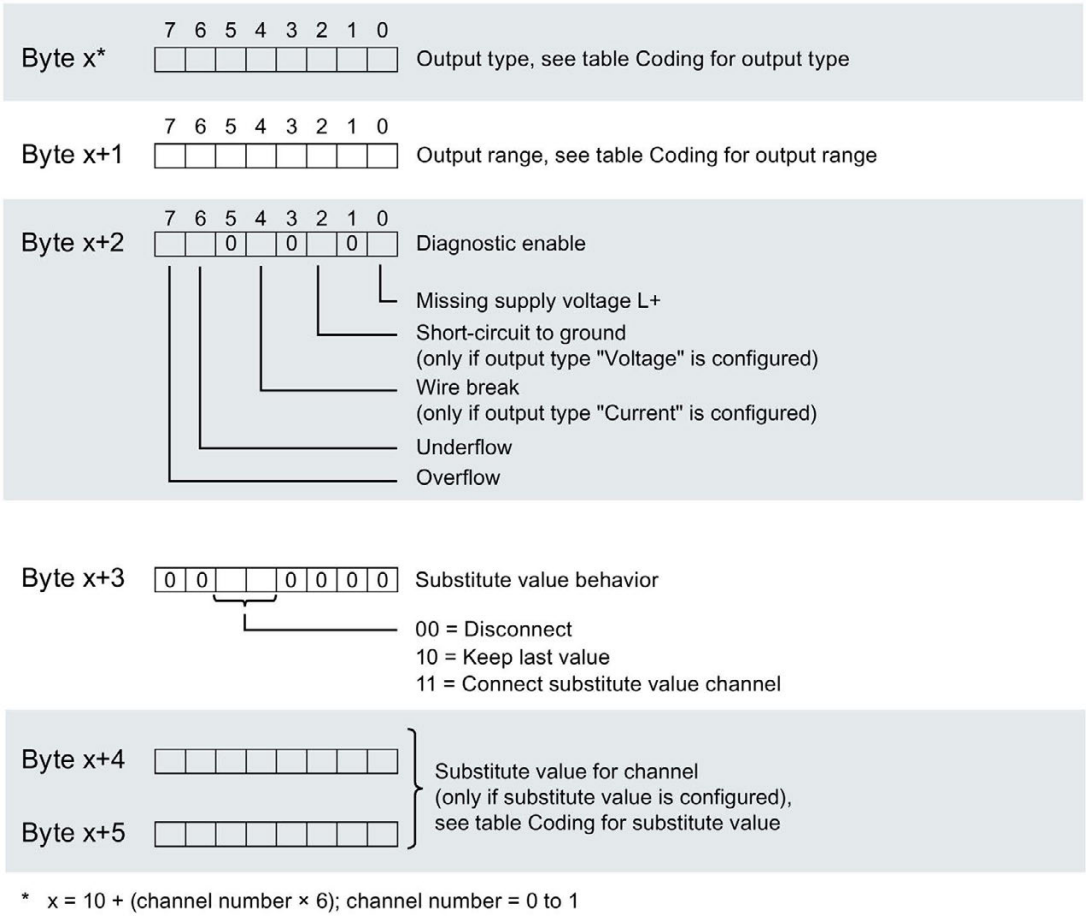


Figure A-5 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".



* x = 10 + (channel number × 6); channel number = 0 to 1

Figure A-6 Structure of byte x to x+5 for channels 0 and 1

Codes for output types

The table below contains the codes for the output types of the analog output module. You must enter these codes in bytes x of the channel parameter block of data record 128 (see previous figure).

Table A- 1 Codes for output types

Output type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0011

Codes for output ranges

The table below contains the codes for the output ranges of the analog output module. You must enter these codes in bytes x+1 of the channel parameter block of data record 128 (see previous figure).

Table A- 2 Codes for output ranges

Output range	Code
Voltage	
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011
Current	
±20 mA	0000 0000
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010

Codes for substitute values

The table below contains the codes for the substitute values. You must enter these codes in bytes x+4 and x+5 (see previous figure).

Table A- 3 Codes for substitute values

Output range for	Permitted substitute value
Voltage	
±10 V	-32512 ... +32511
±5 V	-32512 ... +32511
0 to 10 V	0 ... +32511
1 to 5 V	-6912 ... +32511
Current	
±20 mA	-29031 ... +29030
0 to 20 mA	0 ... +29030
4 to 20 mA	-692 ... +29030

Representation of analog values

B

This appendix describes the analog values for all output ranges supported by the AQ 2xU/I HS analog output module.

Measured value resolution

The digitized analog value is the same for input and output values at the same nominal range. The analog values are represented as a fixed point number in the two's complement.

The following table shows the representation of the binary analog values and the associated decimal and hexadecimal units of the analog values.

The resolutions 13, 14, 15, and 16 bit including sign are displayed. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table B- 1 Possible resolutions of the analog values

Resolution in bit	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table B- 2 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table B- 3 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table B- 4 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	Hex.	±10 V	±5 V	
118.515%	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Nominal range
75%	20736	5100	7.5 V	3.75 V	
0.003617%	1	1	361.7 µV	180.8 µV	
0%	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75%	-20736	AF00	-7.5 V	-3.75 V	
-100%	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange
-117.593%	-32512	8100	-11.76 V	-5.88 V	
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519%	-32768	8000			

* Outputs positive maximum value or negative minimum value

Table B- 5 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	Hex.	0 to 10 V	
118.515%	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table B- 6 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	Hex.	1 to 5 V	
118.515%	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V + 144.7 µV	
0%	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25%	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table B- 7 Current output range ±20 mA

Values			Current output range	Range
	Dec.	Hex.	±20 mA	
118.515%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF	-20 mA - 723.4nA	Underrange
-105%	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table B- 8 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.515%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table B- 9 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.515%	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	19008	4A40	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5%	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

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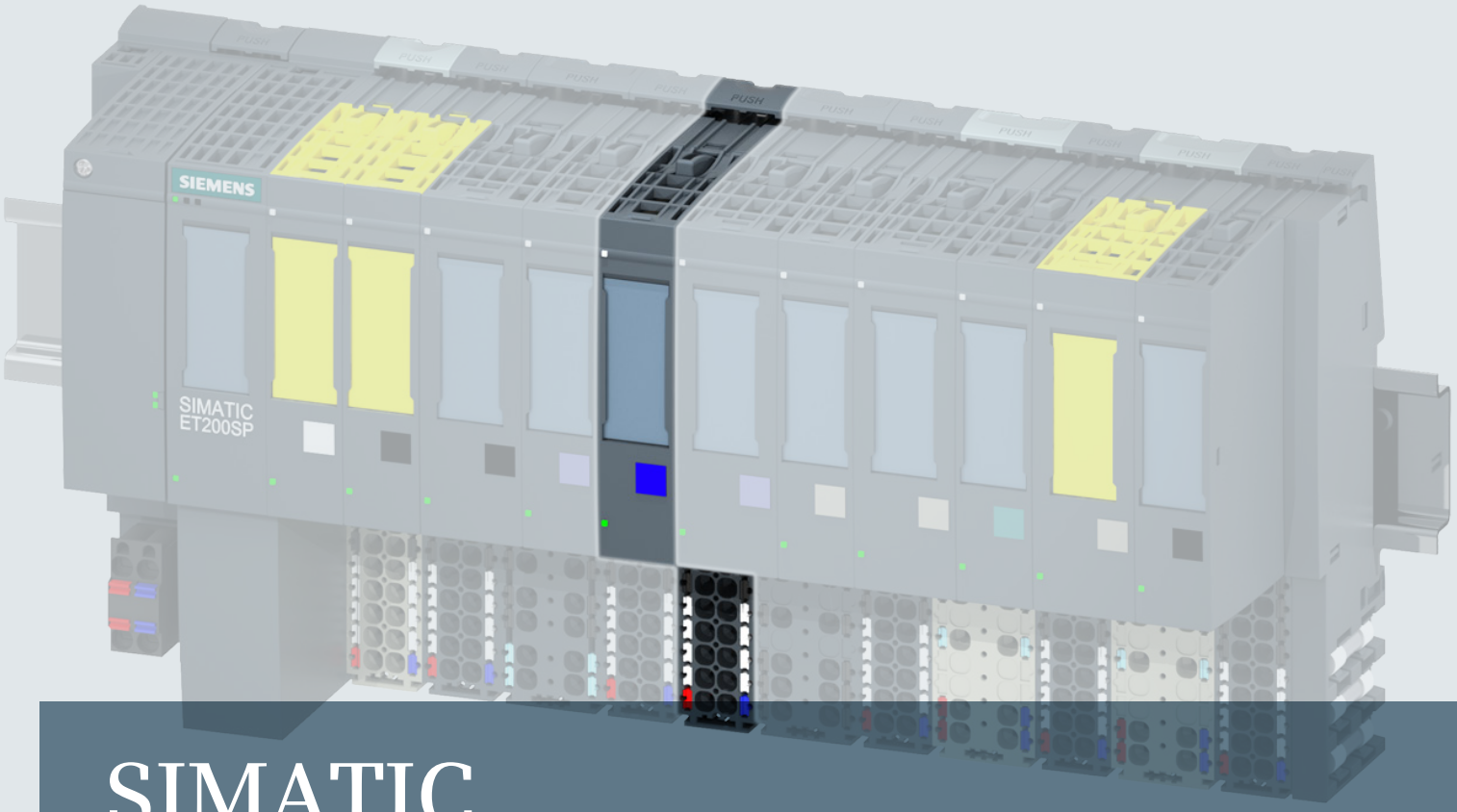

SIMATIC

ET 200SP

Analog output module AQ 2xU/I HF (6ES7135-6HB00-0CA1)

Manual

Edition 02/2014

Answers for industry.

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ET 200SP
Analog output module
AQ 2xU/I HF
(6ES7135-6HB00-0CA1)

Manual

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02/2014

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⚠WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Guide to documentation

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of a system manual, function manuals and product manuals.

The STEP 7 information system (online help) also supports you during the configuration and programming of your automation system.

Overview of documentation for analog output module AQ 2×U/I HF

The following table shows additional documentation that you need when using the AQ 2×U/I HF analog output module.

Table 1- 1 Documentation for the analog output module AQ 2×U/I HF

Topic	Documentation	Key contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
Analog value processing	Function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Key contents
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Amendments and special features of the ET 200SP distributed I/O system	Product information on documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or product manuals.

SIMATIC manuals

All current manuals for SIMATIC products are available to download free of charge on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Article number

6ES7135-6HB00-0CA1

View of the module

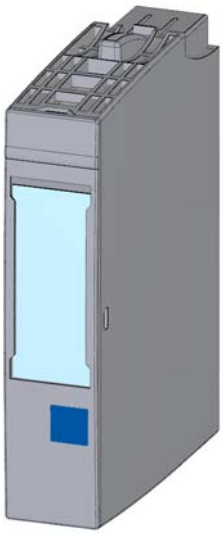


Figure 2-1 View of the module AQ 2×U/I HF

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
- Resolution: Up to 16 bits including sign
- Voltage output can be set for each channel
- Current output can be set for each channel
- Configurable diagnostics for each channel

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy
- Calibration in runtime
- Isochronous mode (PROFINET IO only)
- Value status (PROFINET IO only)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

See also

For more information on accessories, refer to the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Wiring

3

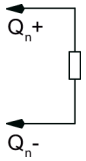
3.1 Pin assignment

General pin assignment

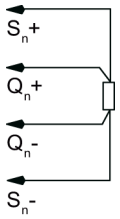
Table 3- 1 Pin assignment for AQ 2×U/I HF

Pin assignment for AQ 2×U/I HF (6ES7135-6HB00-0CA1)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Notes**	**BaseUnits**[1]	**Color identification label**
1	Q_0+	**2**	Q_1+	• Q_n+: Analog output voltage/current (positive), channel n • Q_n-: Analog output voltage/current negative, channel n • S_n+: Sensor line positive, channel n • S_n-: Sensor line negative, channel n • RES: Reserved; not connected	A0, A1	–
3	RES	**4**	RES			
5	Q_0-	**6**	Q_1-			
7	RES	**8**	RES			
9	S_0+	**10**	S_1+			
11	RES	**12**	RES			
13	S_0-	**14**	S_1-			
15	RES	**16**	RES			
L+	24 VDC	**M**	M			

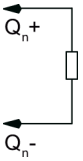
Voltage 2-wire connection



Voltage 4-wire



Current



[1] Usable BaseUnit types, can be identified by the last two digits of the article number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Keep this in mind also during the configuration.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

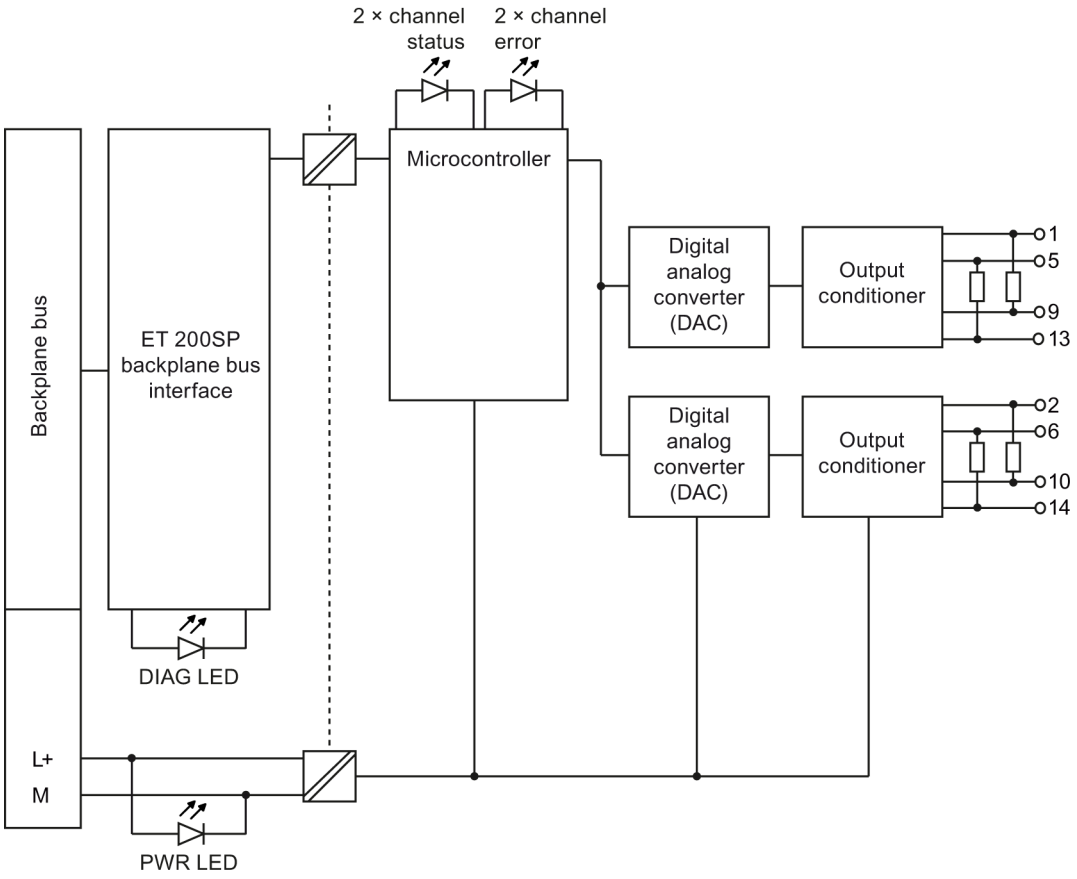


Figure 3-1 Block diagram of AQ 2xU/I HF

Parameters/address space

4

4.1 Output type and output ranges

The following table shows the output type and the respective output ranges.

Table 4- 1 Output ranges

Output type	Output ranges	Resolution
Current	± 20 mA	16 bit including sign
	0 to 20 mA	15 bit
	4 to 20 mA	14 bit
Voltage	± 10 V	16 bit including sign
	± 5 V	15 bit including sign
	0 to 10 V	15 bit
	1 to 5 V	13 bit

You can find the tables of output ranges and overflow, overload, etc. in the section Representation of analog values (Page 30) and in the function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094).

4.2 Parameters

Parameters of the AQ 2xU/I HF

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of parameter data record (Page 25).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground [1]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow [3]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Underflow [3]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Wire break [2]	• Disable • Enable	Disable	Yes	Channel	Channel
Output type/range	• Deactivated • Voltage ±10 V • Voltage ±5 V • Voltage 0..10 V • Voltage 1..5 V • Current ±20 mA • Current 0 - 20 mA • Current 4 - 20 mA	Current 4 - 20 mA	Yes	Channel	Channel

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Reaction to CPU STOP [3]	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Module
Substitute value	For permissible substitute values for the various measuring ranges, see device manual AQ 2xU/I HF, Substitute values → Codes for substitute value table	0	Yes	Channel	Channel
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

1 No diagnostics detection between -0.5 and +0.5 V (no short-circuit detection)

2 No diagnostics detection between -3 and +3 mA (no wire break detection)

3 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 8 bytes.

Note

Unused channels

"Deactivate" the unused outputs in the parameter assignment.

A deactivated output always returns the value "no current or voltage".

4.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value falls below the underrange or reaches the minimum output value or underflow.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

Specifies that a BaseUnit with incoming voltage supply is located on this slot (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Address space

Address space of the analog output module AQ 2×U/I HF

The following figure shows the assignment of the address space for the AQ 2xU/I HF with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

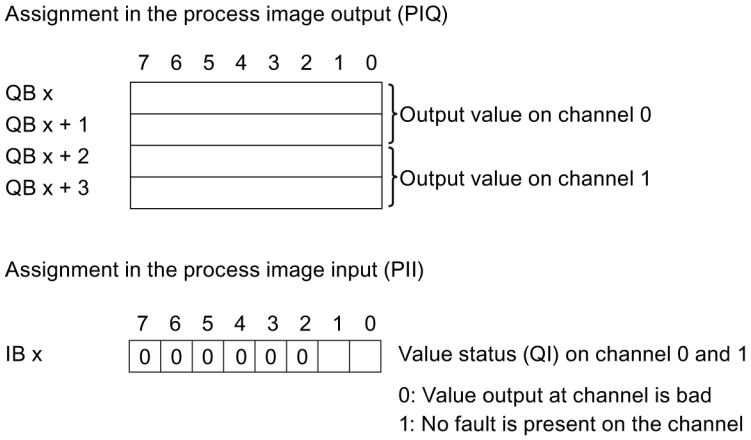


Figure 4-1 Address space of the analog output module AQ 2×U/I HF

Configuration options of the AQ 2xU/I HF

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: The wiring, the value created on the channel, or similar is incorrect.

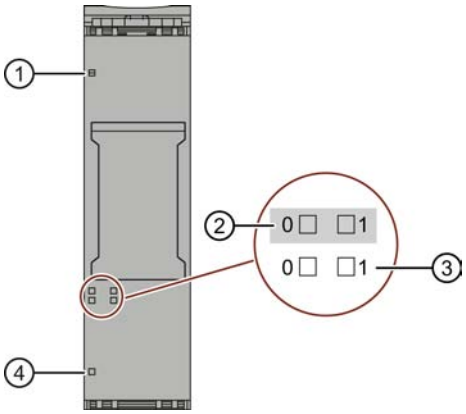
Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays of the AQ 2xU/I HF.



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Figure 5-1 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 19).

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Table 5- 2 Status display of Channel status/channel error LED

Channel status	Channel error	Meaning
Off	Off	Channel deactivated or load voltage L+ missing
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ present

5.2 Interrupts

The analog output module AQ 2×U/I HF supports diagnostic error interrupts.

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit
- Overtemperature
- Wire break
- Violation of high limit
- Violation of low limit
- Error
- Parameter assignment error
- Load voltage missing

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 5- 4 Diagnostics alarms, their meaning and remedies

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware update is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	–
		The channel is currently being calibrated.	
Short-circuit	1_H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	4_H	Thermal overload of the I/O module	Correct the process wiring
Wire break	6_H	Actuator circuit resistance too high	Use a different actuator type or change the wiring, for example, use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Deactivate the channel ("Measurement type" parameter) • Connect the channel
Violation of high limit	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Violation of low limit	8_H	The output value specified by the user program falls below the underrange.	Correct the output value
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel: Module plugged in does not match the configuration. Incorrect parameter assignment.	• Correct the configuration (comparison of preset and actual setup). • Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Load voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

Technical specifications of AQ 2×U/I HF

	6ES7135-6HB00-0CA1
Product type designation	AQ 2xU/I HF
General information	
Firmware version	V1.0
Usable BaseUnits	BU type A0, A1
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Input current	
Current consumption (rated value)	45 mA; no load
Current consumption, max.	90 mA; 2 channels current output 20 mA
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
Address space per module, max.	4 bytes; + 1 byte for QI information

	6ES7135-6HB00-0CA1
Analog outputs	
Number of analog outputs	2
Voltage output, short-circuit protection	Yes
Voltage output, short circuit current, max.	45 mA
Cycle time (all channels), min.	750 µs
Output ranges, voltage	
0 to 10 V	Yes; 15 bits
1 to 5 V	Yes; 13 bits
-5 to +5 V	Yes; 15 bits incl. sign
-10 to +10 V	Yes; 16 bits incl. sign
Output ranges, current	
0 to 20 mA	Yes; 15 bits
-20 to +20 mA	Yes; 16 bits incl. sign
4 to 20 mA	Yes; 14 bits
Connecting the actuators	
For voltage output 2-wire connection	Yes
For voltage output 4-wire connection	Yes
For current output 2-wire connection	Yes
Load resistance (in nominal range of the output)	
For voltage outputs, min.	2 kΩ
For voltage outputs, capacitive load, max.	1 µF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Cable length shielded, max.	200 m; 1000 m for current output
Analog value generation	
Settling time	
For resistive load	0.05 ms
For capacitive load	0.05 ms; max. 47 nF and 20 m cable length
For inductive load	0.05 ms
Errors/accuracies	
Output ripple (in relation to output range, bandwidth 0 to 50 kHz), (+/-)	± 0.02%
Linearity error (in relation to output range), (+/-)	± 0.03%
Temperature error (in relation to output range)	± 0.003%
Crosstalk between outputs, max.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	± 0.03%

	6ES7135-6HB00-0CA1
Operational limit in entire temperature range	
Voltage in relation to output range, (+/-)	± 0.2%
Current in relation to output range, (+/-)	± 0.2%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	± 0.1%
Current in relation to output range, (+/-)	± 0.1%
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	500 µs
Bus cycle time (TDP), min.	750 µs
Jitter, max.	5 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostic error interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; channel-based, only for output type current
Short-circuit	Yes; channel-based, only for output type voltage
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic insulation)
Insulation	
Insulation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics				
		Underflow	Overflow	Wire break	Short-circuit to ground	Missing supply voltage L+
Deactivated	*	*	*	*	*	*
Voltage	±10 V	x	x	–	x	x
	±5 V	x	x	–	x	x
	0 to 10 V	x	x	–	x	x
	1 to 5 V	x	x	–	x	x
Current	±20 mA	x	x	x	–	x
	0 to 20 mA	x	x	x	–	x
	4 to 20 mA	x	x	x	–	x

x = property is allowed, – = property is **not allowed**, * = property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		Underflow / overflow	Wire break	Load voltage L+	Short-circuit to ground
Deactivated	*	*	*	*	*
Voltage	±10 V	x	–	x	x
	±5 V	x	–	x	x
	0 to 10 V	x	–	x	x
	1 to 5 V	x	–	x	x
Current	±20 mA	x	x	x	–
Current (2-wire connection)	0 to 20 mA	x	x	x	–
	4 to 20 mA	x	x	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

A.2 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

The module parameter settings can be changed in RUN (for example, the voltage or current values of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

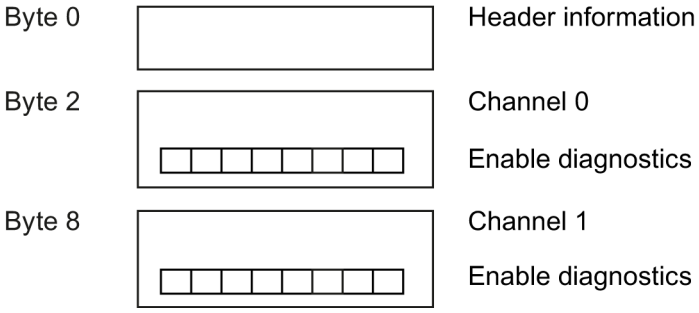


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

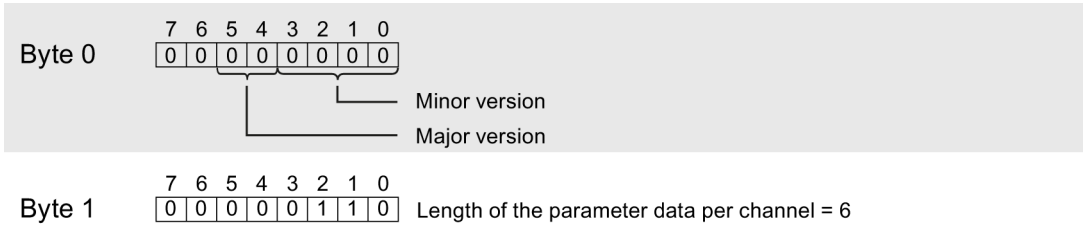


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 1.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 6); channel number = 0 to 1

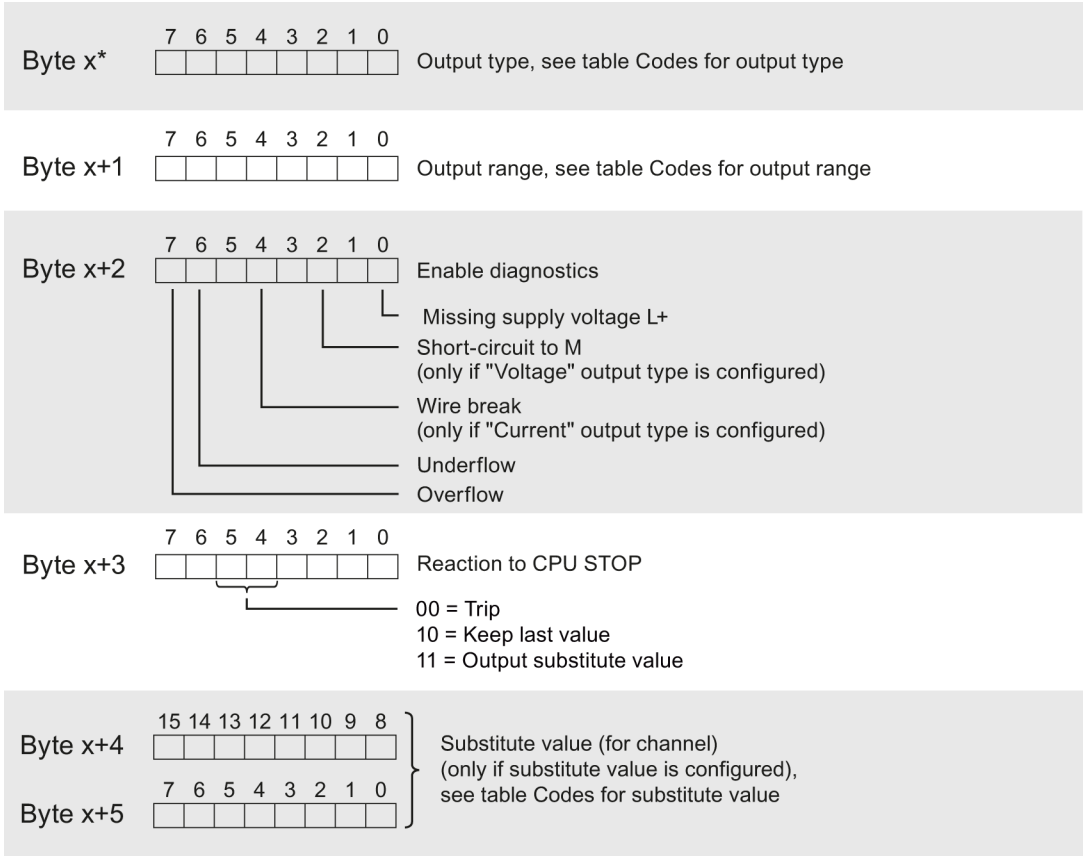


Figure A-3 Structure of byte x to x+5 for channel 0 and 1

Codes for output type

The following table contains the codes for the output types of the analog output module. You must enter these codes in byte x (see previous figure).

Table A- 1 Codes for output type

Output range for voltage	Code
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0011

Codes for output range

The following table contains the codes for the output ranges of the analog output module. You must enter these codes in byte x+1 (see previous figure).

Table A- 2 Codes for output range

Output range for voltage	Code
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011
Output range for current	**Code**
±20 mA	0000 0000
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010

Codes for substitute value

The following table contains the codes for the substitute values. You must enter these codes in bytes x+4 and x+5 (see previous figure).

Table A- 3 Codes for substitute value

Output range for voltage and current	Valid substitute value
±10 V	-32512 to 32511
±5 V	-32512 to 32511
0 to 10 V	0 to 32511
1 to 5 V	-6912 to 32511
±20 mA	-29031 to 29030
0 to 20 mA	0 to 29030
4 to 20 mA	-692 to 29376

Representation of analog values

B

This appendix describes the analog values for all output ranges supported by the AQ 2xU/I HF analog module.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. The analog values are represented as a fixed point number in the two's complement.

The resolutions 13, 14, 15, and 16 bit including sign are displayed. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table B- 1 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table B- 2 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥ 32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table B- 3 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥ 32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table B- 4 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	Hex.	±10 V	±5 V	
118.515%	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Nominal range
75%	20736	5100	7.5 V	3.75 V	
0.003617%	1	1	361.7 µV	180.8 µV	
0%	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75%	-20736	AF00	-7.5 V	-3.75 V	
-100%	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange
-117.593%	-32512	8100	-11.76 V	-5.88 V	
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519%	-32768	8000			

* outputs positive maximum value or negative minimum value

Table B- 5 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	Hex.	0 to 10 V	
118.519%	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

Table B- 6 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	Hex.	1 to 5 V	
118.519%	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V + 144.7 µV	
0%	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25%	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table B- 7 Current output range ±20 mA

Values			Current output range	Range
	Dec.	Hex.	±20 mA	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF	-20 mA + 723.4 nA	Underrange
-105%	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

Table B- 8 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

Table B- 9 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	19008	4A40	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5%	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

SIEMENS

SIMATIC

ET 200SP

Motor Starter (3RK1308-0**00-0CP0)

Manual

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SIEMENS

Industrial Controls

SIMATIC ET 200SP Motor starter (3RK1308-0**00-0CP0)

Manual

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12/2016

A5E34821005002A/RS-AB/002

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 12/2016 Subject to change

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Preface

Purpose of the documentation

This manual describes the non-fail-safe and the fail-safe ET 200SP motor starters with firmware version V1.1.0 or higher.

This manual supplements the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) System Manual. Functions affecting the system in general are described in this System Manual. There, you will also find information on installation, connection and the installation conditions of the ET 200SP motor starter.

The information provided in this manual, the system manual and the function manuals enables you to commission the ET 200SP distributed I/O system.

Basic knowledge required

A general knowledge of the following areas is needed in order to understand this manual:

- Industrial controls
- Digital circuit logic
- Automation technology
- Safety functions
- PROFINET and PROFIBUS bus topology
- TIA Portal

Definition

In this manual, "SIMATIC ET 200SP motor starter" is used as a synonym for all non-fail-safe and fail-safe variants of the SIMATIC ET 200SP motor starter.

See also

SIOS (https://support.industry.siemens.com/cs/us/en/)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit:
http://www.siemens.com/industrialsecurity

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under:
http://www.siemens.com/industrialsecurity

Responsibility for system configuration and functionality

The products described here have been developed to carry out safety-related functions as part of a complete plant or machine. In general, a complete safety system consists of sensors, evaluation units, signaling devices and methods for safe tripping. It is the responsibility of the manufacturer to ensure that the system or machine is functioning properly as a whole.

Siemens AG, its subsidiaries, and associated companies (hereinafter referred to as "Siemens") are not in a position to guarantee every characteristic of a complete plant or machine not designed by Siemens.

Nor can Siemens assume liability for recommendations that appear or are implied in the following description. No new guarantee, warranty, or liability claims beyond the scope of the Siemens general terms of supply are to be derived or inferred from the following description.

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Product-specific safety instructions

1

1.1 General safety notes

DANGER

Hazardous voltage.
Will cause death or serious injury.

Turn off and lock out all power supplying this device before working on this device.

NOTICE

Damage caused by electrostatic charge

If the ET 200SP motor starter is live and you touch the exposed pins, damage can occur on the motor starter due to electrostatic charging.

When handling and installing the ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

It is only permitted to connect ET 200SP motor starters after disconnection of the electronic power supply (PELV and SELV) and of the line power supply (500 V AC).

1.2 Safety information for hazardous areas

WARNING

Explosion hazard in Class I and Class II Hazardous Locations.
Can cause death or serious injury.

The components of the ET 200SP motor starters are not suitable for Class I and Class II Hazardous Locations.

1.3 Safety instructions for safety-related applications

WARNING

Hazardous voltage.
Will cause death or serious injury.

To avoid an electric shock, observe the following safety measures when working on the plant and the device:

- Turn off and lock out all power supplying this device before working on this device.
- Make sure that the device cannot be switched back on.
- Verify that the equipment is not live.
- Ground the plant.
- Cover adjacent live parts or erect barriers around them.

WARNING

Hazardous Voltage

Work on live parts of the ET 200SP motor starter system can result in death or serious injury.

The device is only allowed to be commissioned and operated by qualified personnel. For the purpose of the safety information in this documentation, a "qualified person" is someone who is authorized to energize, ground, and tag equipment, systems, and circuits in accordance with established safety procedures.

NOTICE

Loss of the safety function

For the fail-safe ET 200SP motor starter, the key safety values apply in the case of a function test interval (state change of the outputs) ≤ 1 month.

To check functioning of the switching elements, switch the motor on or off at least once every month. For additional information on checking the switching elements, see chapter"Specifications for operating fail-safe motor starters (Page 29)".

WARNING

Loss of the safety function with incorrect wiring

If wiring is incorrect, the motor starter cannot shut down in the event of a fault and the motor will continue to run. There is a risk of severe injury or death. Material damage is also possible.

To ensure the safety function, in the case of a single-phase load route the phase and the neutral conductor through the motor starter. You will find additional information next to the connection examples in chapter "Single-phase motor (Page 143)". In the case of a three-phase load, do not connect the neutral conductor to the star point of the load.

NOTICE
Electromagnetic interference To ensure interference immunity of the motor starter, ground PELV/SELV power supply units in accordance with regulations. (Please also note the documentation for the respective power supply unit in this regard.)

1.4 Intended use

⚠ WARNING
Improper use of hardware products. **Serious damage to property, can cause death or serious injury.** This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens. Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults. EU note: Commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed complies with the stipulations of the Directive 2006/42/EC.

1.5 Current information about operational safety

Important note for maintaining operational safety of your system

Please take note of our latest information.

Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we publish a special newsletter containing information on product developments and features that are (or could be) relevant to operation of safety-related systems. By subscribing to the appropriate newsletter, you will ensure that you are always up-to-date and able to make changes to your system, when necessary:

Siemens newsletter (http://www.industry.siemens.com/newsletter)

Sign on to the following newsletter under "Products & Solutions":

- Safety Integrated Newsletter
- Totally Integrated Automation Newsletter

1.6 Declaration of conformity

The manufacturer declares that the safety components of the fail-safe ET 200SP motor starter series in the designs marketed by us comply with the applicable basic health and safety requirements of the EC Directives* stated (including amendments), and that the stated standards* were applied in their design and construction.

* You can download the complete EC Declaration of Conformity from the Internet (http://www.siemens.com/sirius/approvals) as a PDF.

Standards

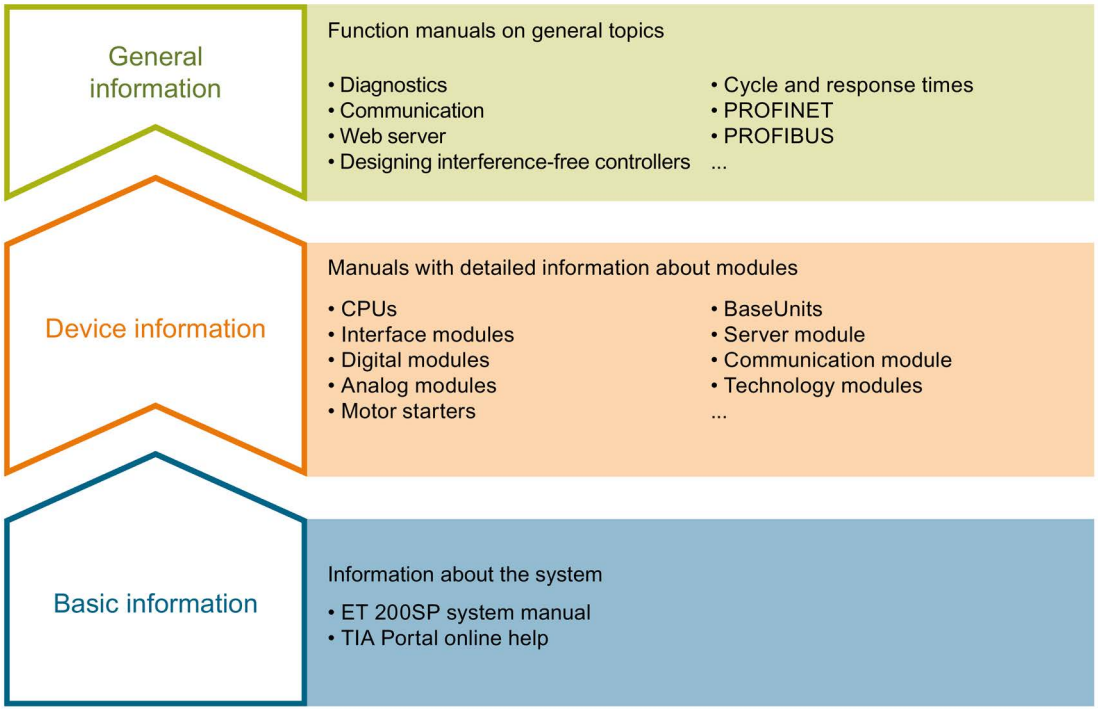
The table below shows the standards that each of the ET 200SP motor starters comply with:

Standard	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
IEC 60947-4-2:2011-05	x	x	x	x
IEC 60947-4-3:2011-07	x	-	-	-
EN 62061: 2005	-	-	x	x
EN ISO 13849-1:2015	-	-	x	x
IEC 61508-1:2010	-	-	x	x
IEC 61508-2:2010	-	-	x	x
IEC 61508-3:2010	-	-	x	x

Documentation guide

2

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet.

Product overview

3

3.1 Properties

Article numbers

Short code	Article number
Direct-on-line starter	
DS 0.3 - 1 A HF	3RK1308-0AB00-0CP0
DS 0.9 - 3 A HF	3RK1308-0AC00-0CP0
DS 2.8 - 9 A HF	3RK1308-0AD00-0CP0
DS 4.0 - 12 A HF	3RK1308-0AE00-0CP0
Reversing starter	
RS 0.3 - 1 A HF	3RK1308-0BB00-0CP0
RS 0.9 - 3 A HF	3RK1308-0BC00-0CP0
RS 2.8 - 9 A HF	3RK1308-0BD00-0CP0
RS 4.0 - 12 A HF	3RK1308-0BE00-0CP0
Fail-safe direct-on-line starters	
F-DS 0.3 - 1 A HF	3RK1308-0CB00-0CP0
F-DS 0.9 - 3 A HF	3RK1308-0CC00-0CP0
F-DS 2.8 - 9 A HF	3RK1308-0CD00-0CP0
F-DS 4.0 - 12 A HF	3RK1308-0CE00-0CP0
Fail-safe reversing starters	
F-RS 0.3 - 1 A HF	3RK1308-0DB00-0CP0
F-RS 0.9 - 3 A HF	3RK1308-0DC00-0CP0
F-RS 2.8 - 9 A HF	3RK1308-0DD00-0CP0
F-RS 4.0 - 12 A HF	3RK1308-0DE00-0CP0

Views of the SIMATIC ET 200SP motor starter

The SIMATIC ET 200SP motor starter is a 30-mm-wide compact device with hybrid technology. The SIMATIC ET 200SP motor starter has electronic overload protection for switching of three-phase asynchronous motors and single-phase AC motors up to 5.5 kW (at 500 V) during normal operating conditions. Fail-safe variants of the motor starter are also available.

The figure below shows a SIMATIC ET 200SP motor starter.

Figure 3-1 View of the SIMATIC ET 200SP motor starter with mounted 3DI/LC module (optionally available)

The figure below shows a fail-safe SIMATIC ET 200SP motor starter.

Figure 3-2 View of the fail-safe SIMATIC ET 200SP motor starter with mounted 3DI/LC module (optionally available)

Properties

The SIMATIC ET 200SP motor starter has the following technical properties.

- Switching and protection device for three-phase asynchronous motors and single-phase AC motors
- Integrated short-circuit and overload protection
- Direct-on-line or reversing start function

Fail-safe motor starters additionally support safety-related disconnection (Safe Torque Off). The fail-safe variants of the motor starter are therefore suitable for the following uses:

- Safety-related applications up to SIL 3 to EN 61508, PL e/Cat. 4 to EN ISO 13849-1
- Overload protection of motors in hazardous areas

You can find all the functions supported by the SIMATIC ET 200SP motor starter in chapter "Functions (Page 32)".

The following system functions of the ET 200SP family remain supported:

- I&M data
- Firmware update
- Maintenance

You will find the descriptions of these functions and also rules and regulations for commissioning in the System Manual of the ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Accessories

You can order the following accessories separately:

- BaseUnit with width of 30 mm (3RK1908-0AP00-0xx0)
- Labeling strips in various versions:
  - 500 units light-gray on a roll (6ES7193-6LR10-0AA0)
  - 500 units yellow on a roll (6ES7193-6LR10-0AA0)
  - 1000 units light-gray on DIN A4 sheets (6ES7193-6LA10-0AG0)
  - 1000 units yellow on DIN A4 sheets (6ES7193-6LA10-0AG0)
- 160 reference identification labels (6ES7193-6LF30-0AW0)
- 3DI/LC module (3RK1908-1AA00-0BP0)
- Fan (3RW4928-8VB00)
- Mechanical bracket for BaseUnit (3RK1908-1EA00-1BP0)
- Cover for an empty BaseUnit (3RK1908-1CA00-0BP0)
- Touch protection cover for infeed bus (3RK1908-1DA00-2BP0)

Reference

You can find information on accessories in the Appendix entitled "Accessories/spare parts" of the ET 200SP System Manual.

See also

Preface (Page 5)

3.2 Applications

You can use the SIMATIC ET 200SP motor starters wherever you want to switch and protect drives up to 5.5 kW with an ET 200SP system.

The SIMATIC ET 200SP motor starters are used for the following, for example:

- Conveyor technology
- Logistics systems
- Production machines
- Machine tools
- Gas discharge lamps

Fail-safe motor starters are designed exclusively for the switching and protection of motor loads.

3.3 Permissible ambient temperatures up to 1000 m above sea level.

General supplementary conditions

You can install the motor starter in three mounting positions. The mounting position depends on the position of the standard mounting rail. The following maximum permissible ambient temperatures apply depending on the mounting position:

- Horizontal mounting position: 60 °C
- Vertical mounting position: 50 °C
- Recumbent installation: 50 °C

Observe the following general conditions when using the motor starters:

- Parameterized rated operational current I_e
- Current of the infeed system
- Current of the power bus (24 V DC)
- Fan operation

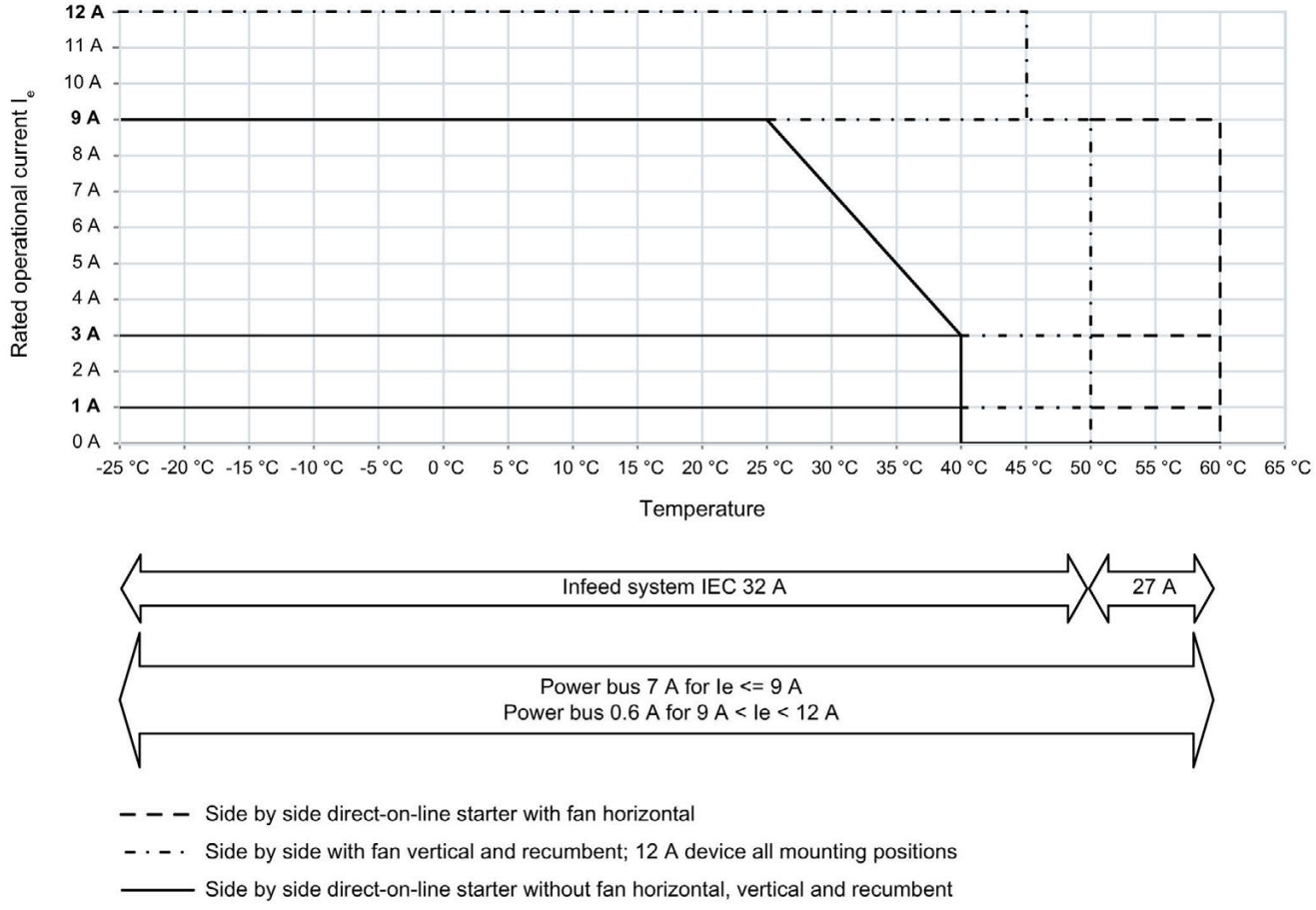
Stand-alone installation

You can operate motor starters equipped with fans with the max. parameterizable I_e within the specified temperature limits.

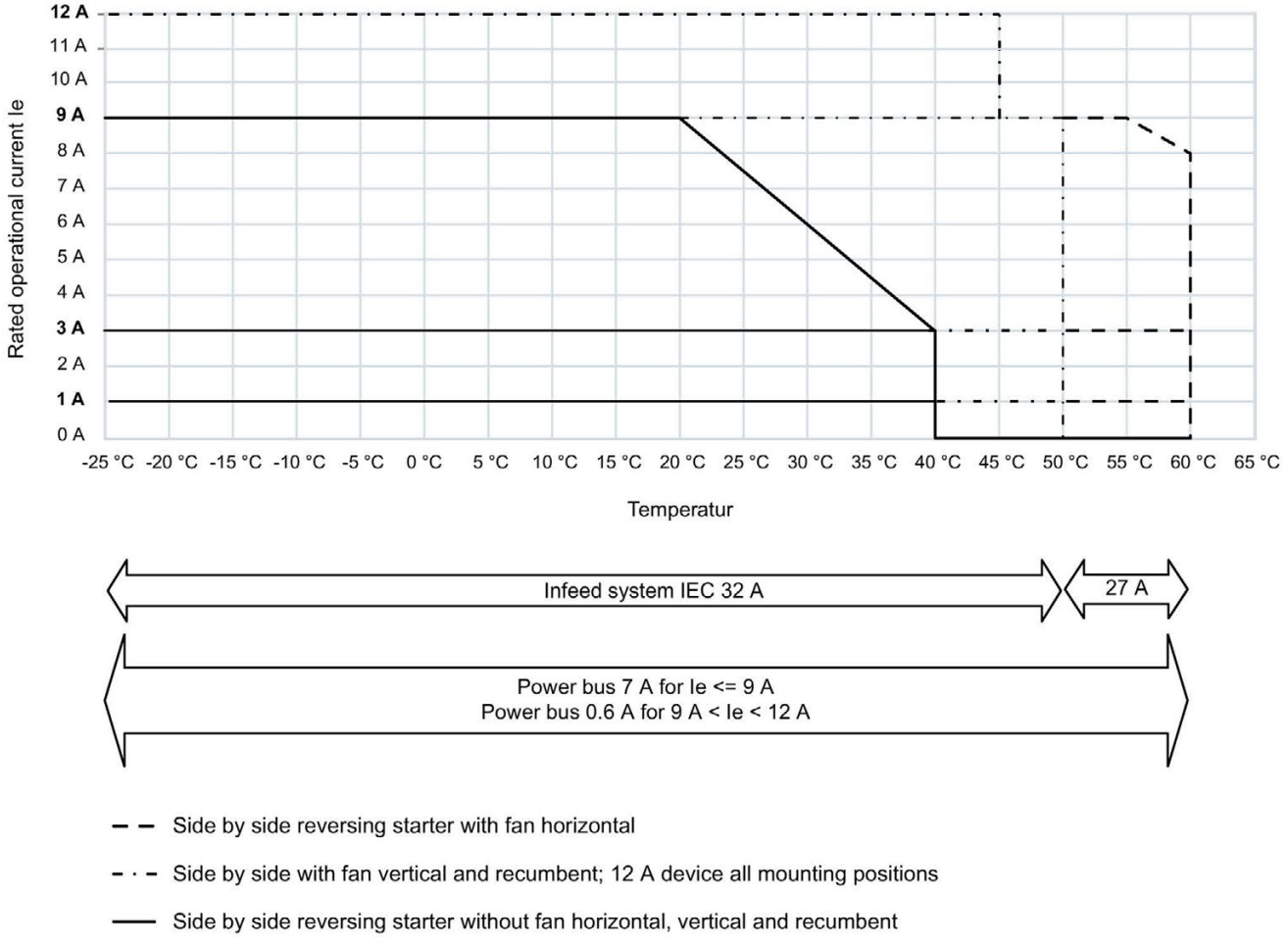
Group configuration (side-by-side)

In the case of horizontal station configuration without a fan, you can use direct-on-line starters and reversing starters (standard and fail-safe) at ambient temperatures 5 °C higher than specified in the following diagrams.

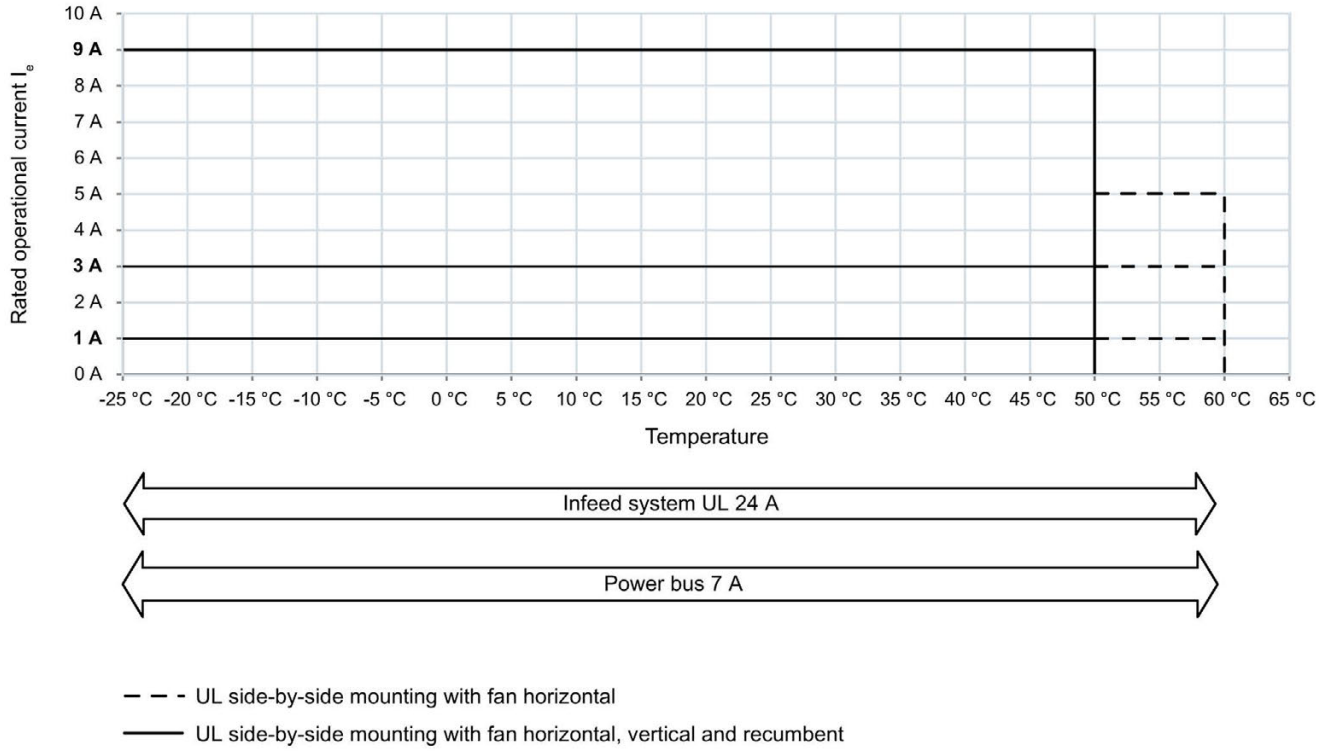
The figure below shows the derating curves for the ET 200SP direct-on-line starter with side-by-side mounting:



The figure below shows the derating curves for the ET 200SP reversing starter (standard and fail-safe) with side-by-side mounting. When the power bus current is reduced to 5 A, the reversing starter can be operated at an I_e of 9 A at an ambient temperature of 60 °C.



If you use the motor starter in accordance with UL requirements, always use a fan regardless of the ambient temperature. The figure below shows the derating curves of an ET 200SP direct-on-line and reversing starter according to UL/CSA requirements:



3.4 Permissible ambient temperatures at more than 1000 m above sea level.

Current derating as a function of the installation altitude is applicable for devices with and without fans.

Possible restrictions through current derating at installation altitudes above 1000 m can be compensated for by using a fan.

The following table shows the current derating as a function of the altitude of the installation location:

Installation altitude h in m	I_e in %
1000 m	100 % (see above)
2000 m	92 %
3000 m	85 %
4000 m	78 %

The I_e values can be interpolated on the basis of the available altitude specifications.

Note

Use of fail-safe ET 200SP motor starters is permissible only below 2000 m above sea level.

To ensure the safety functions, use fail-safe ET 200SP motor starters below 2000 m above sea level only.

3.5 Device versions

Current ranges

The table below shows the switchable motor powers depending on the primary voltage, according to DIN EN 60947-4-1: Table G.1. The stated current ranges are valid for the hybrid starters.

	0.3 … 1 A		0.9 … 3 A		2.8 … 9 A		4 ... 12 A	
	0.3 A	1 A	0.9 A	3 A	2.8 A	9 A	4 A	12 A
230 V AC	< 0.06 kW	0.18 kW	0.18 kW	0.55 kW	0.55 kW	2.20 kW	0.75 kW	3.0 kW
400 V AC	< 0.09 kW	0.25 kW	0.37 kW	1.10 kW	1.50 kW	4.00 kW	1.5 kW	5.5 kW
500 V AC	< 0.12 kW	0.37 kW	0.55 kW	1.50 kW	1.50 kW	4.00 kW	2.2 kW	5.5 kW

The assignments of the motor currents to the motor powers are recommended values. Due to the introduction of energy-efficient motors (IE3, IE4) to the market, rated currents are falling for any given power. At the same time, the start-up currents rise.

Take the current characteristics of the connected motor and motor starter into account when dimensioning. The following characteristic values are relevant:

- Ratio of rated current to motor starting current
- The maximum starting current may deviate from the values specified by the manufacturer by 20 % in accordance with DIN EN 60034-1.
- Maximum permissible current range of the motor starter
  The permissible current range can be found in the graphic in Chapter "Device protection model (Page 58)".

You will find more information on dimensioning switching devices for IE3/IE4 motors in the "Switching devices with IE3/IE4 motors" application manual (http://support.automation.siemens.com/WW/view/en/94770820).

3.6 Specifications for operating fail-safe motor starters

Checking switching elements

The switching elements (semiconductor, relay) cannot be tested during operation (motor ON) and in the switched-off state (motor OFF). Therefore, pay attention to the following:

- Run a self-test of the motor starter once every month if it has been switched off for more than a month. The self-test is started by switching the motor on and off. As an alternative, you can commission the complete system once.
- If the motor is operated continuously, disconnect it from the power supply at least once monthly by way of the motor starter.
- In the case of reversing starters, make sure that the switching elements for both directions of rotation are tested. To do this, start the motor once in the clockwise direction and once in the counter-clockwise direction.

The switching elements are checked automatically when the motor is switched off and on via the motor starter.

The switching on and off routines must be run through without errors. This means:

- Current must flow.
- The motor starter must not display any errors.
- The supply voltage must be stable.

The switching on or off routine is canceled as soon as an error is detected. The motor starter assumes the safe off state. Pay attention to the diagnostic messages in data set 72 (Page 120). Depending on the error message, you can reset the error by switching off the 24 V supply voltage and then switching it on again.

If the supply voltage is interrupted during switching on or off, this may lead to a device fault (entry 308 in data set 92 (Page 126)). The entry 20017 "Residual current detection or bypass element does not close" in data set 72 (Page 120) is also possible. You can reset these faults. If the faults recur, this indicates that the motor starter is defective in spite of the fact that the supply voltage is stable. Replace the motor starter in this case.

Replacing the fail-safe motor starter

When replacing a fail-safe motor starter, pay attention to the commissioning specifications for fail-safe systems.

Fail-safe input F-DI on the BaseUnit

In the case of safety-related applications, control the fail-safe input F-DI on the BaseUnit from a safe output.

Bright and dark tests

With bright and dark tests, safety relays such as ET 200SP F-PM-E (6ES7136-6PA00-0BC0) or SIRIUS 3SK check whether their safe outputs can still be activated and deactivated. The bright and dark tests are run cyclically. The ET 200SP motor starter is intended for operation with an F-PM-E or 3SK connected upstream and is adapted to the bright and dark test times of these devices.

You can find more information on the operating principle and parameter assignment of bright and dark tests in the respective device manual.

To avoid an unintentional response of the fail-safe motor starter during the bright and dark test, these tests must not exceed a certain time. Due to component aging, the permissible read-back time can also decrease throughout the motor starter's service life. The voltage of the power supply unit also has an influence on the permissible read-back time. Increase the power supply unit's output voltage to minimize the risk of incorrect deactivation during dark tests.

By trial and error, set the read-back time as low as possible, but so high that the output channel is not deactivated.

WARNING

Inadvertent starting of the motor if the bright test lasts too long

The motor can start if the bright test lasts more than 10 ms. There is a risk of severe injury or death. Material damage is also possible.

Make sure that the bright test lasts less than 10 ms on devices that are connected upstream of the motor starter.

Power supply

In the case of a 24 V DC power supply, observe the following safety measures:

- Ensure safe electrical separation and separate routing of cables.
- Ensure increased insulation of the extra-low voltage (SELV/PELV) from circuits with hazardous potentials in accordance with IEC 60364-4-41.
- Use a permissible SELV/PELV power supply unit, thus making sure that the voltage on the infeed bus does not exceed the permissible maximum voltage, not even if the power supply unit is defective.
- To deactivate safely via the power bus, use a suitable power supply in compliance with the requirements of the safety classification used.

In UL systems (corner-grounded delta), the starter's 24 V supply must be SELV. PELV is not permissible in UL systems.

Switching a motor holding brake is inadmissible

Do not use a motor brake in parallel with the connected motor. This applies both to connection between phases and to connection to the neutral conductor.

Checking the settings

Always check the safety-related parameters during acceptance of the system. Also always check the parameters if a parameter has been changed or if you are commissioning the system for the first time.

Operation by experienced users only

Use the fail-safe motor starter only if you are familiar with motors and safety-related applications.

ATEX certified motor overload protection

ET 200SP fail-safe motor starters are approved under device group II, Category (2) in the "GD" area. This means that the fail-safe motor starters can protect motors that are located in hazardous gas, vapor, mist and air mixtures and also combustible dust. The motor starter itself must not be situated in the hazardous area.

Due to the increased danger in hazardous areas, observe the following standards:

- EN 60079-14 / VDE 0165-1 Explosive atmospheres - Part 14: Electrical installations
- EN 60079-17 Explosive atmospheres - Part 17: Electrical installations inspection and maintenance
- EN 50495 Safety devices required for the safe functioning of equipment with respect to explosion risks

3.7 Functions

3.7.1 Overview of functions

The table below shows the functions of the various versions of ET 200SP motor starters:

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Basic function/basic parameter (Page 34)				
• Rated operational current (Page 35)	x	x	x	x
• Load type (Page 36)	x	--- (Only 3-phase possible)	x ("1-phase" not possible for ATEX applications)	---
Motor control (Page 37)				
• Solid-state switching technology (Page 37)	x	x	x	x
• Reversing starter control function (Page 40)	---	x	---	x
• Operating modes (Page 41)	x	x	x	x
Overload protection (Page 42)	x	x	x (Restrictions in ATEX operation)	x (Restrictions in ATEX operation)
Monitoring functions (Page 51)				
• Response to residual current detection (Page 52)	x	x	--- (Only "Deactivate" possible)	--- (Only "Deactivate" possible)
• Upper/lower current warning limit (Page 55)	x	x	x	x
• Upper/lower current limit (Page 55)	x	x	x	x
• Blocking protection	x	x	x	x
• Blocking time	x	x	x	x
• Blocking current (Page 56)	x	x	x	x
• Asymmetry monitoring (Page 61)	x	x	x (Restrictions in ATEX operation)	x (Restrictions in ATEX operation)
• Short-circuit protection (fuses) (Page 62)	x	x	x	x
Response to CPU/master STOP (Page 64)	x	x	x	x
Group fault diagnostics/group warning diagnostics (Page 64)	x	x	x	x
TEST/RESET button (Page 113)	x	x	x	x
Emergency start (Page 75)	x	x	x (Not with an ATEX application)	x (Not with an ATEX application)

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Trip RESET (Page 79)	x	x	x	x
Cold start (Page 79)	x	x	---	---
PROFIenergy (Page 81)	x	x	x	x
Logbook (Page 80)	x	x	x	x
Maintenance (Page 116)	x	x	x	x

The following functions are available when using the 3DI/LC module via the inputs:

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Inputs (Page 65)	x	x	x	x
Manual local (local control) (Page 71)	x	x	x	x
Trip without restart (Page 71)	x	x	x	x
Trip with restart (Page 71)	x	x	x	x
Trip emergency end position CW (Page 72)	x	x	x	x
Trip emergency end position CCW (Page 74)	x	x	x	x
Group warning (Page 74)	x	x	x	x
Emergency start (Page 75)	x	x	x (Not with an ATEX application)	x (Not with an ATEX application)
Motor CW (Page 75)	x	x	x	x
Motor CCW (Page 76)	---	x	---	x
Quick Stop (direction-independent) (Page 76)	x	x	x	x
Quick Stop clockwise (Page 78)	x	x	x	x
Quick Stop counter-clockwise (Page 78)	---	x	---	x
Trip RESET (Page 79)	x	x	x	x
Cold start (Page 79)	x	x	---	---
Operational trip end position CW (Page 80)	x	x	x	x
Operational trip end position CCW (Page 80)	x	x	x	x

The following functions are safety-related:

	Fail-safe direct-on-line starter	Fail-safe reversing starter
Safety-related tripping (Page 63) (STO = Safe Torque Off)	x	x
Ex motor (Page 63)	x	x
Rated operational current (Page 35)	x (ATEX application only)	x (ATEX application only)
Overload protection (Page 42)	x (ATEX application only)	x (ATEX application only)

Note

Restrictions in relation to monitoring and input functions

When you activate safety-related functions, parameterization of the monitoring or input functions may be restricted.

3.7.2 Intrinsic protection

The SIMATIC ET 200SP motor starter protects itself against overload. Intrinsic device protection cannot be parameterized or switched off. You can find more information on the permissible ambient temperatures in chapter "Permissible ambient temperatures up to 1000 m above sea level. (Page 23)".

If the intrinsic protection becomes active, the follow responses occur:

- The motor trips.
- Emergency starting is not possible in the case of tripping due to intrinsic device protection.
- The diagnostics message "Switching element overload" is output in data set 92 (Page 126).
- The entry "Number of switching element overload trips" in data set 95 (Page 130) is incremented by 1.

If the intrinsic device protection was active, the device's diagnostics function indicates a device fault.

NOTICE
Damage from operating capacitive loads
When using capacitive loads, the switching components in the SIMATIC ET 200SP motor starter can be damaged by excessively high making currents.
Operation in series with a frequency converter is not allowed.

3.7.3 Basic function/basic parameter

3.7.3.1 Basic functions/parameters during first commissioning

The default settings listed in the following two chapters apply to first commissioning and as defaults for the programming devices (exception: rated operational current). When a motor starter is set to the commissioning mode a further time, it uses the values that were valid when the technology supply voltage was last lost.

3.7.3.2 Rated operational current

This parameter is used to set the rated operational current that the feeder can carry without interruption. Usually, the rated operational current of the motor is specified on the rating plate of the motor. The setting range depends on the rating class of the SIMATIC ET 200SP motor starter.

Note

Rated operational current

The rated operational current is one of the key parameters.

You cannot disable motor protection completely. However, you can prevent tripping of the motor by selecting the parameter Response to overload (Page 42).

In this case, motor protection must be ensured by other measures (e.g. a thermistor in the motor).

Note

Functional switching

Observe the minimum loads in the case of SIMATIC ET 200SP motor starters.

The minimum loads are specified in the technical specifications of the relevant device. You can find more information on the minimum loads in chapter "Minimum load current (Page 39)".

Current motor current

The latest current in the motor starter is returned via the process image for analysis. In addition, you can read out the latest current with phase precision in data set 94.

The current is measured on two phases. The current for the third phase is calculated. The highest of the three values is determined. The returned 6-bit value specifies the motor current ratio I_{curr} / I_{rated} (I_{rated} = parameterized rated operational current).
The value is represented by one digit before the decimal point (DI 1.5) and five digits after the point (DI 1.0 to DI 1.4). This results in a maximum ratio for I_{curr} / I_{rated} of 1.96875 (approx. 197 %).
The resolution is 1/32 per bit (3.125 %).

DI 1.5	DI 1.4	DI 1.3	DI 1.2	DI 1.1	DI 1.0	
2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	
1	0.5	0.25	0.125	0.0625	0.03125	Sum = 1.96875
0	0	0	0	0	0	I_{curr} = 0
1	0	0	0	0	0	I_{curr} = I_{rated} x 1
1	0	1	1	0	0	I_{curr} = I_{rated} x 1.375
1	1	1	1	1	1	I_{curr} = I_{rated} x 1.96875

I_{curr} = rated operational current I_{rated} x value (DI 1.0 to DI 1.5)

I_{rated} = rated current of the motor

Default setting

- In the SIMATIC ET 200SP motor starter, the rated operational current is preset at the factory to the maximum value. In the event of renewed parameterization, the parameters last set apply.
- Due to the engineering systems, the rated operational current is preset to the minimum value for safety reasons. You must therefore parameterize this value when you configure the system. The SIMATIC ET 200SP motor starter can otherwise trip due to overload on first starting.

Settings

Table 3- 1 Settings for actual motor current

Device parameters	Default settings	Setting range
Rated operational current	• In the motor starter: Maximum value or last parameterization • In engineering systems: Minimum value	• 0.3 A … 1 A • 0.9 A … 3 A • 2.8 A … 9 A • 4 A ... 12 A Increment: 0.1 A

The setting range depends on the device type.

3.7.3.3 Load type

This is where you select whether the motor starter should protect a single-phase or a three-phase load.

Note

Reversing starter

1-phase loads are not permissible on the reversing starter. 1-phase operation is also not permissible after activation of the "EX motor" parameter in the case of fail-safe motor starters.

Settings

Table 3- 2 Settings for load type

Device parameters	Default setting	Setting range
Load type	3-phase	• 3-phase • 1-phase

3-phase operation

In 3-phase operation, you can operate a 3-phase asynchronous motor at the connections of the motor starter.

To ensure motor protection, do not connect more than one motor to one motor starter.

Do not operate several single-phase motors on one motor starter in three-phase operation.

1-phase operation

In 1-phase operation, you can operate a 1-phase asynchronous motor at the connections of the motor starter. 1-phase operation is only possible when using a direct-on-line starter. The relevant three-pole tripping characteristics apply to single-phase operation.

Feed in the line voltage on terminals L1 and L2(N) only and connect the single-phase motor to the terminals T1 and T2 only.

An ATEX approval in 1-phase operation is not possible with the motor starter.

See also

Overload protection (Page 42)

3.7.4 Motor control

3.7.4.1 Electronic switching technology (hybrid switching technology)

The SIMATIC ET 200SP motor starter combines the advantages of semiconductor technology and relay technology.

The SIMATIC ET 200SP motor starter switches the load in phases L1 and L2 via semiconductors and bypass relays. Phase L3 is always switched via a relay.

⚠ DANGER

Hazardous Voltage
Can Cause Death or Serious Injury

If the line voltage is applied at the infeed bus of the motor starter, a hazardous voltage may be active at the output of the motor starter even without a motor ON command. When working on the feeder, you must ensure disconnection from the power, e.g. by the position "Parking position/OFF".

You will find further information on the "Parking position/OFF" in the "ET 200SP distributed I/O system" (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

The SIMATIC ET 200SP motor starter combines the advantages of semiconductor technology and relay technology.

This combination is known as hybrid switching technology. Hybrid switching technology in the SIMATIC ET 200SP motor starter is characterized by the following properties:

Switching on

The inrush current in the case of motorized loads is conducted briefly via the semiconductors.

Advantage: The relay contacts are protected. Longer service life is achieved thanks to reduced wear and tear.

Current routing

The continuous current is routed via relay contacts.

Advantage: Relay contacts cause lower thermal losses than semiconductors.

Switching off

Switching off is implemented via the semiconductors.

Advantage: The contacts are not stressed with arcs when switching via the semiconductors. This results in increased service life.

Schematic circuit diagram

The following diagrams show schematic circuit diagrams of the standard and fail-safe versions of the ET 200SP motor starter:

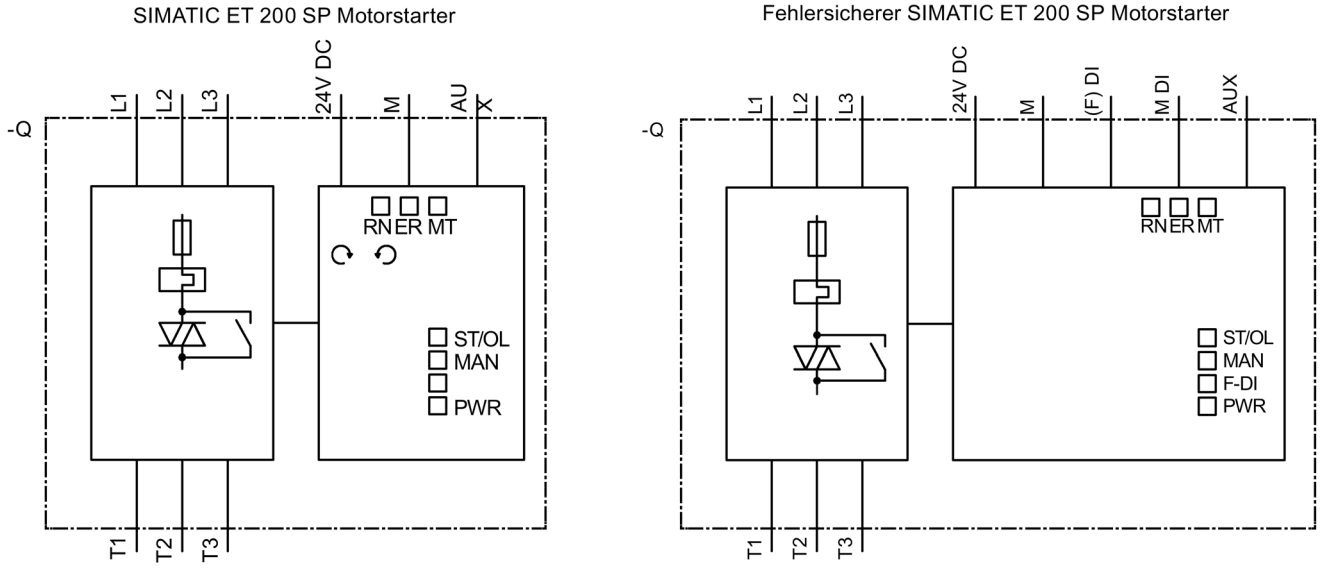


Figure 3-3 Schematic circuit diagram

The ET 200SP motor starters do not possess any galvanic isolation of the switching elements in the main circuits. The isolating function in compliance with EN 60947-1 is only warranted in the parking position.

See also

Preface (Page 5)

3.7.4.2 Minimum load current

The minimum load current is 20% of the set motor current, but at least the absolute minimum current specified in the tables below.

The minimum load current differs between the ET 200SP motor starters and the fail-safe ET 200SP motor starters:

Load current	0.3 … 1 A	0.9 … 3 A	2.8 … 9 A	4 ... 12 A
Motor/ohmic load of motor starter	0.15	0.18	0.56	0.8
Motor/ohmic load of fail-safe motor starter	0.15	0.45	1.4	2

As soon as the minimum current limit is violated, fault detection (residual current detection) picks up. In the case of fail-safe ET 200SP motor starters, the device fault "Switching element defective" (data set 92 (Page 126)) is reported. The object number 20017 is also entered in data set 72 (Page 120). The starter can resume operation by means of Power OFF/ON.

Disconnection or a warning is triggered depending on the setting of the "Response to residual current detection" parameter. Residual current detection cannot be parameterized to "Warn" in the case of fail-safe motor starters.

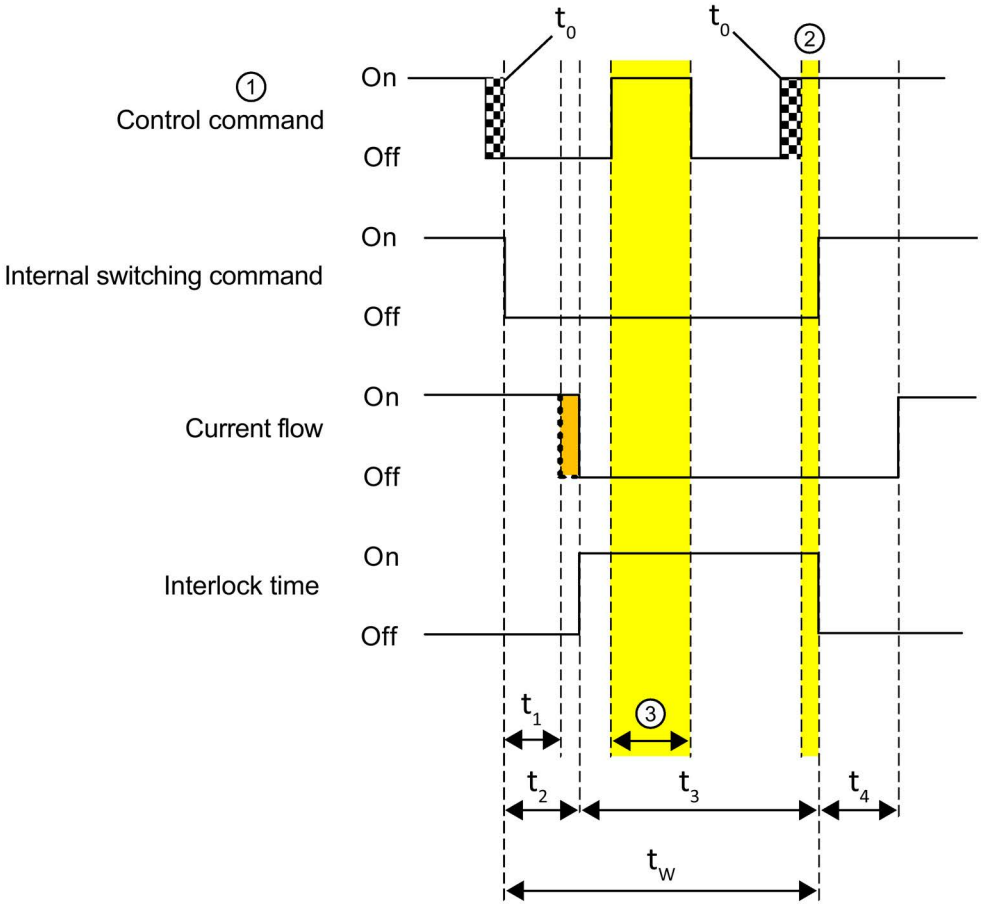
See also

Response to residual current detection (Page 52)

3.7.4.3 Control function

The motor starter controls the direction of rotation of motors with the control function. Internal logic prevents you from activating both directions of rotation simultaneously.

The graphic below shows the reaction times of the motor starter to control commands. The reaction times when restarting and changing direction of rotation are identical.



① The execution times t_0 until a device-internal control command is active are different depending on the source of the control command:

- 3DI/LC module: 10 ms debounce time => t_0 = 10 ms
- PIQ: The times are dependent on the cycle clock of the field bus and the station topology + 5 ms jitter.

② ON commands within the interlock time are delayed.

③ ON commands within the interlock time are suppressed.

t_1 Minimum OFF-delay time
- Fail-safe motor starter: Minimum 35 ms
- Standard motor starters: 20 ms

t_2 Maximum OFF-delay time
- Fail-safe motor starters: Maximum 50 ms
- Standard motor starters: Maximum 35 ms

t_3 Interlock time: 150 ms + 5 ms time slice run

t_4 ON-delay
- Fail-safe motor starters: 25 ms
- Standard motor starters: 20 ms

t_W Recovery time $t_0 + t_2 + t_3$
- Fail-safe motor starters: t_0 + 205 ms
- Standard motor starters: t0 + 190 ms

Figure 3-4 Control command reaction times

3.7.4.4 Operating modes

The following modes are available (in ascending order of priority):

- Operating mode: Automatic (lowest priority)

  The motor starter can only be controlled with the PLC via the fieldbus.

  Automatic mode is activated automatically when communication with the interface module or the higher-level CPU is established.

- Operating mode: Manual local via the 3DI/LC module (highest priority)

  The motor starter can be controlled as follows:

  – Set the "Local Control" (LC on the 3DI/LC module) input to activate manual local mode.

  – Also set a digital input on the 3DI/LC module (1, 2 or 3, depending on the parameterization) to "Motor CW" or "Motor CCW", for example.

Using the LED "MAN", the message bits in the PII (Page 107), and the diagnostics data set DS92 (Page 126), you detect which control source currently has control priority:

- Operating mode: Automatic ("MAN" LED off)
- Operating mode: Manual local ("MAN" LED on)

See also

Status and error displays (Page 109)

3.7.5 Overload protection

Description

The approximate temperature of the motor is calculated using the measured motor currents and device parameters "Rated operating current" and "Tripping class". This indicates whether the motor is overloaded or is functioning in the normal operating range.

Note

To ensure overload protection, do not connect more than one motor to one motor starter.

Response of the thermal motor model on restart

You set the response of the thermal motor model on restart with this parameter:

- Retention of the thermal motor model on restart

  If the motor starter has been disconnected from the 24 V power supply, the thermal motor model is at the same motor temperature rise state when the power supply is restored as it was before disconnection. This behavior protects the motor against overload in the case of brief failures of the 24 V power supply. With this setting, you can therefore specify that the motor starter retains the thermal motor model when the power supply is restored.

- Deletion of the thermal motor model on restart

  If the motor starter has been disconnected from the 24 V power supply for a longer period, for maintenance purposes, for example, the saved values can result in an incorrect interpretation of the motor state. With this setting, you can therefore specify that the motor starter deletes the thermal motor model when the power supply is restored.

In ATEX operation, fail-safe motor starters can only be parameterized to "Retention of the thermal motor model on restart", however.

Principle of operation

The electronics continuously calculate a model of the thermal load on the motor dependent on the operating time and the current load. The motor memory model charges when the motor is switched on. The motor memory model discharges after the motor is switched off.

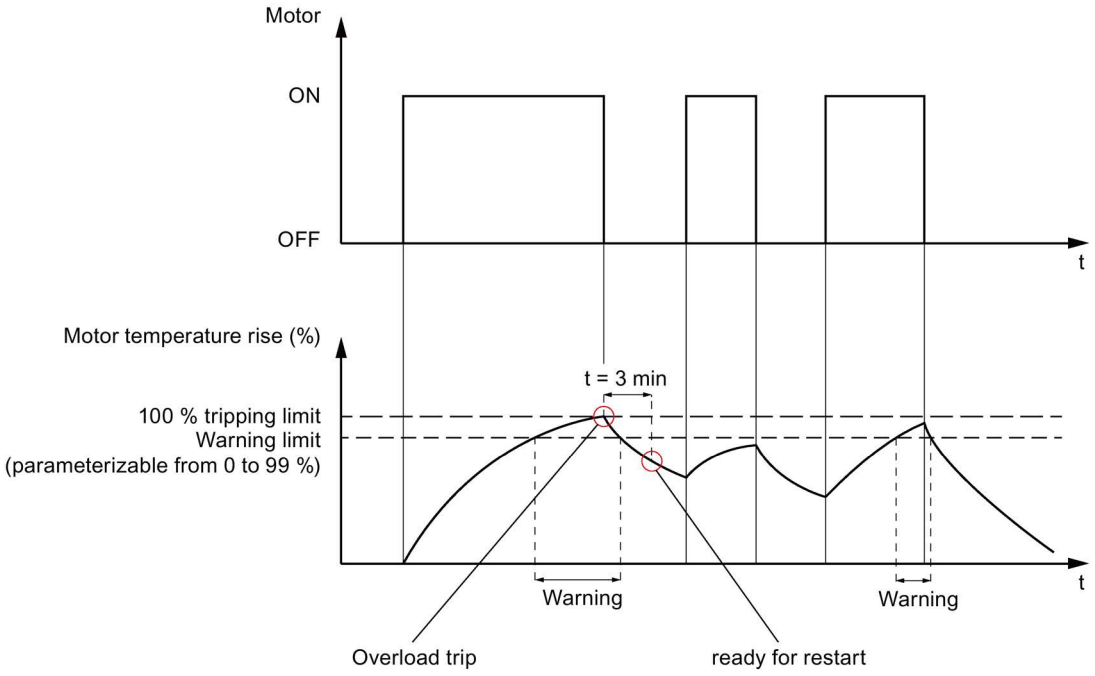


Figure 3-5 Principle of operation

Following an overload tripping operation, the motor memory model is fully discharged after approximately three minutes. You must wait for this cooling time to elapse before you can acknowledge the fault. If the control supply voltage fails, the motor starter can store the remaining cooling time if the relevant parameters have been set. When the control supply voltage is restored, the remaining cooling time elapses before the load can be switched on again.

If you initiate a restart within a very short time after switching off the motor, it may be that the motor memory model has not yet fully discharged. This can result in an extremely fast overload trip after the restart. In continuous operation (partially charged motor memory model), the tripping times are reduced depending on the pre-charge.

Warning limit motor heating

The motor starter displays a warning if the motor heating limit is overshot. You use this parameter to preset a motor heating value in percent as a warning limit.

This function is deactivated with a warning limit for motor temperature rise of 0 %.

If the warning limit for motor heating is exceeded, a group warning and the "Thermal motor model overload" maintenance alarm are output.

Response to overload - thermal motor model

You use this device parameter to specify how the motor starter is to respond to overload:

- Trip without restart
- Trip with restart

⚠ WARNING
Hazardous Voltage. **Can Cause Death, Serious Injury, or Property Damage.** When the cooling time has expired following an overload trip, and a RESET takes place, or automatic restart has been parameterized, the machine starts up immediately if a control command is active. People in the danger area may be injured. Make sure that the danger area of the machine is kept clear of people.

- Warning
  A group warning Is set.

In ATEX operation, you can only parameterize fail-safe motor starters to "Trip without restart".

Trip class

The trip class (CLASS) specifies the maximum time within which a protective device must trip from a cold state at 7.2 x the setting current (motor protection to IEC 60947-2). The tripping characteristics represent the time to trip as a function of the current multiple. The continuous black line in the following diagrams illustrates the tripping characteristic curve for three-pole symmetrical loads and for single-phase loads. The continuous red line illustrates the tripping characteristic curve for three-pole loads when one phase fails.

The following graphic shows the overload protection for CLASS 5:

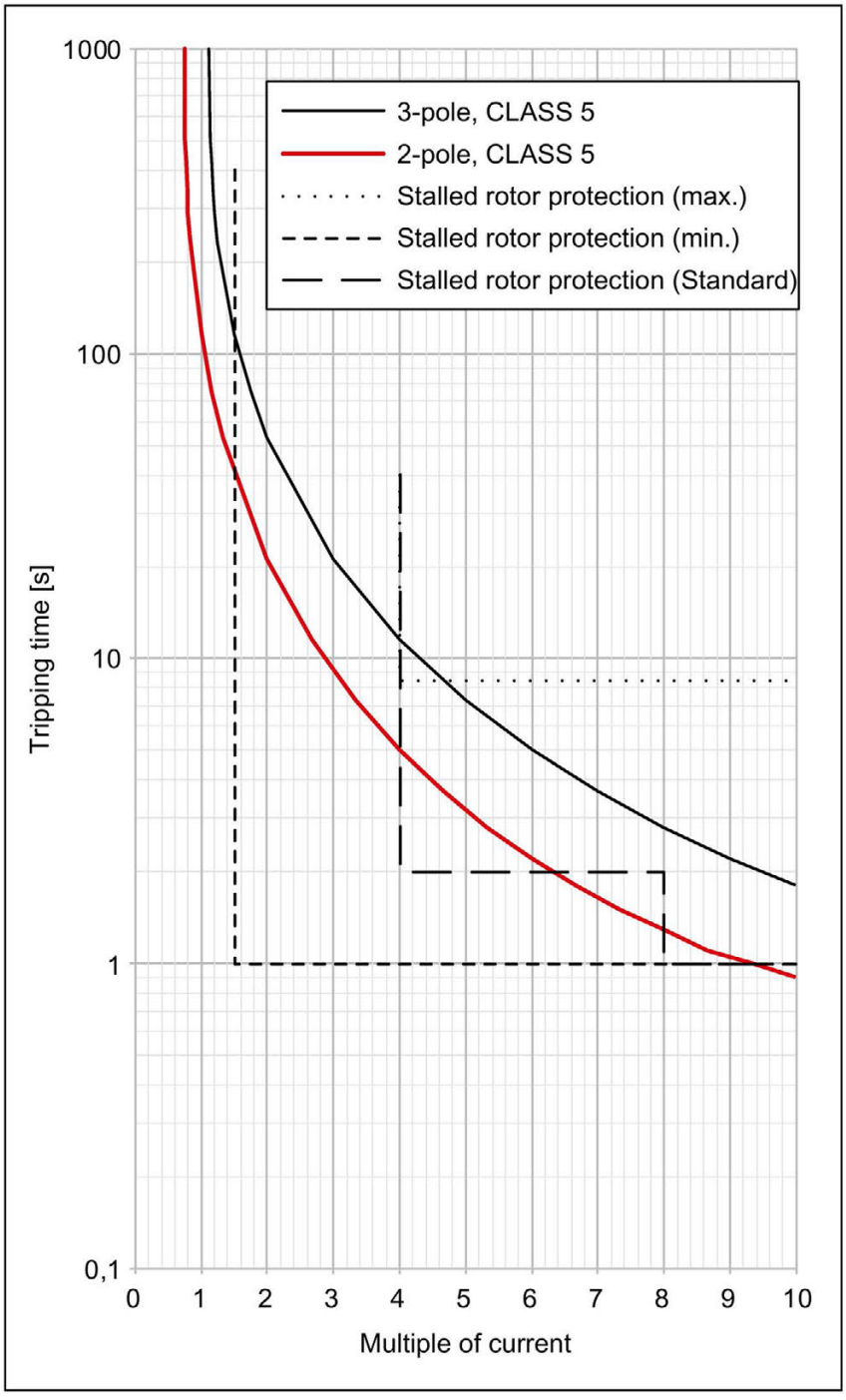


Figure 3-6 CLASS 5 overload protection

The following graphic shows the overload protection for CLASS 10:

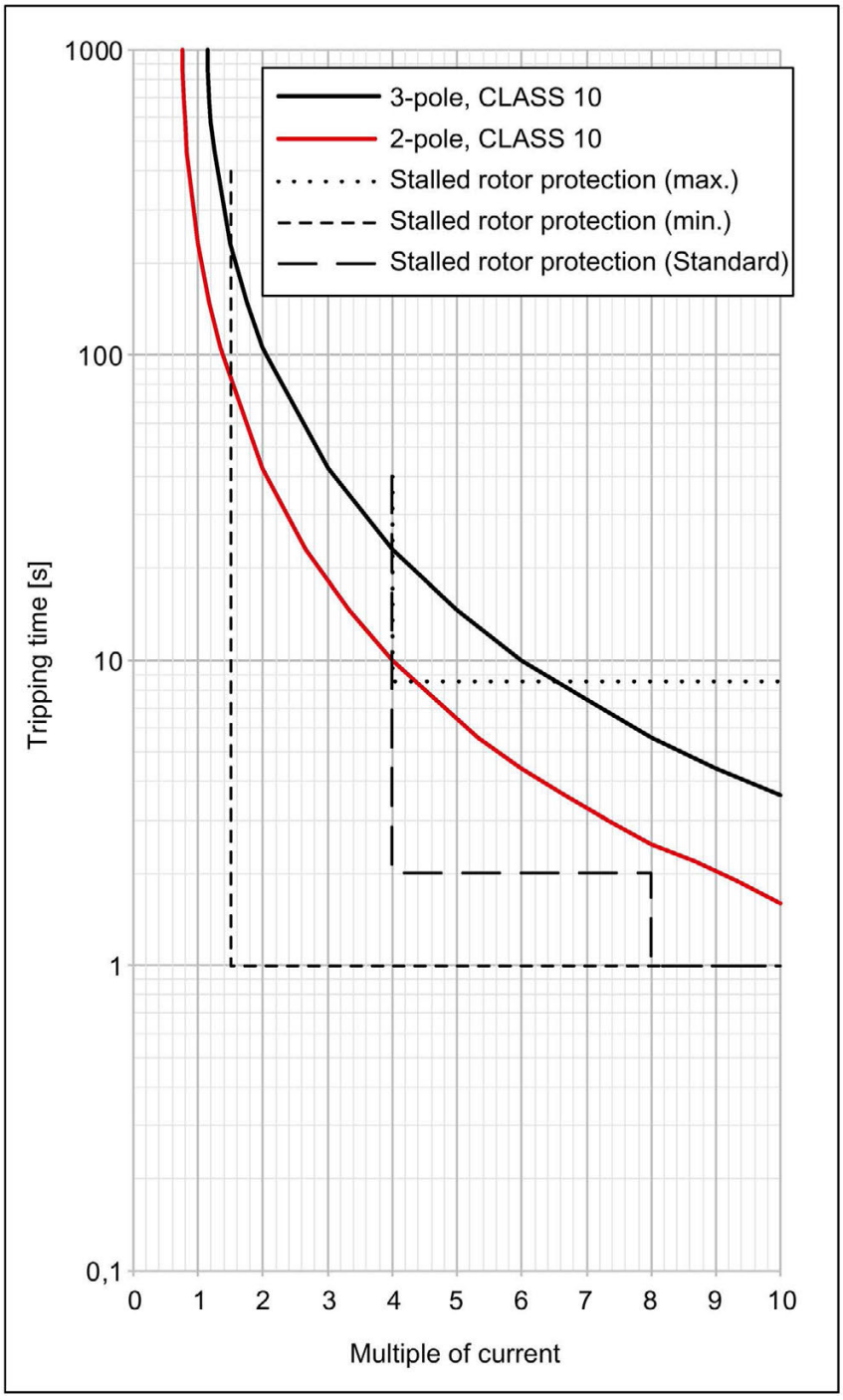


Figure 3-7 CLASS 10 overload protection

You can find out how to calculate the switching cycles in chapter "Calculating switching cycles (Page 48)"

The following trip classes can be parameterized according to IEC 60947-4-2:

- CLASS 5 (10 A)
- CLASS 10

To protect the switching elements in the main circuit against impermissible operating states, an integrated intrinsic device protection is provided in the upper load range. At overload currents greater than 65 A, shutdown becomes effective earlier than with the motor protection function (intrinsic device protection model).

The setting range of the overload protection is 1:3.

You can find more information about intrinsic device protection in chapter "Device protection model (Page 58)".

3.7.6 Calculating switching cycles

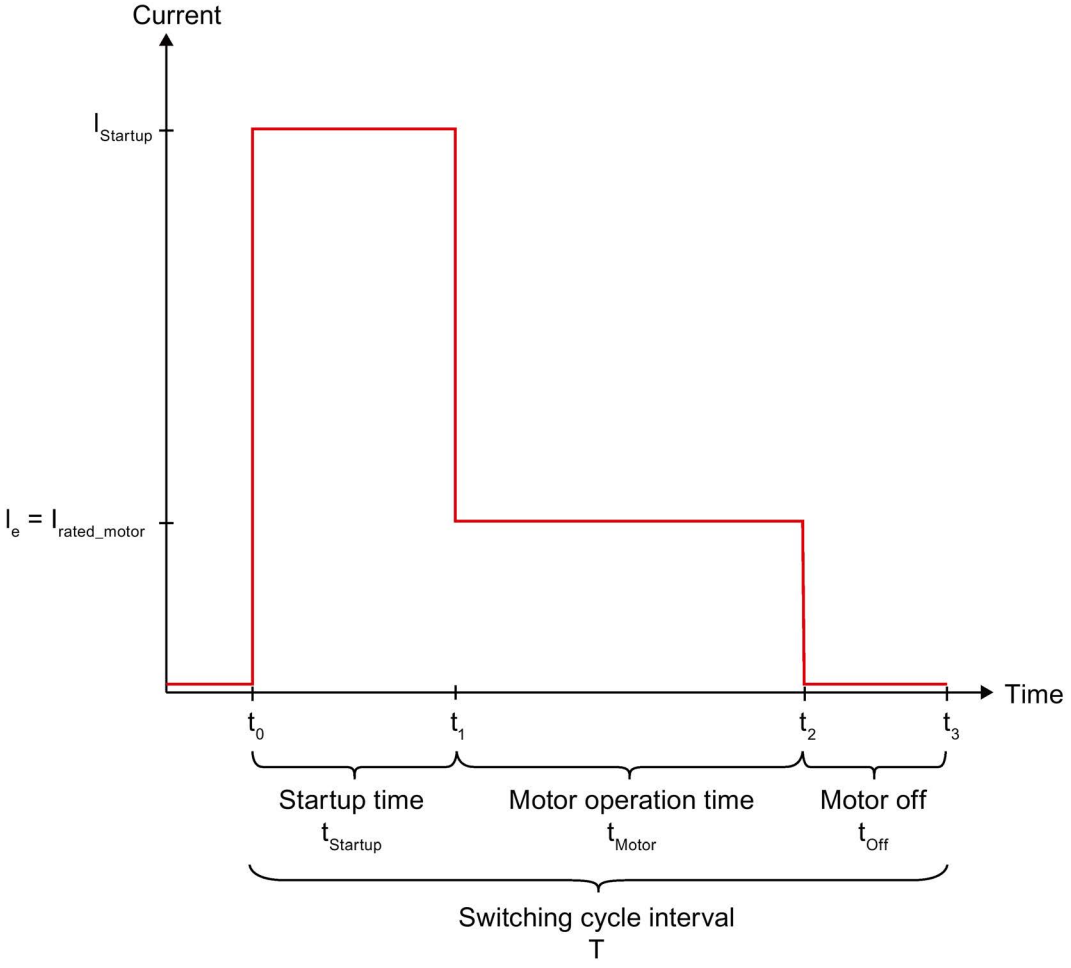
The switching cycles attainable by the ET200 SP motor starter are determined by the root-mean-square of the motor current I_{rms_motor}. The switching cycle considered is admissible if the following criterion is met:

$I_{rms_motor} <= I_e * 1.05$

I_{rms_motor} is determined on the basis of the root-mean-squares of the motor currents during the startup time and the motor operation time taking the motor OFF time into account. In the following formula, I_e corresponds to the rated current of the connected motor.

x = starting current factor $I_{Startup}/I_e$

$$I_{rms_motor} = \sqrt{\frac{1}{T}\left[(x * I_e)^2 * t_{Startup} + I_e^2 * t_{Motor}\right]}$$



Switching cycle parameters

The following table shows all the parameters that you have to consider for calculation of the permissible switching cycle:

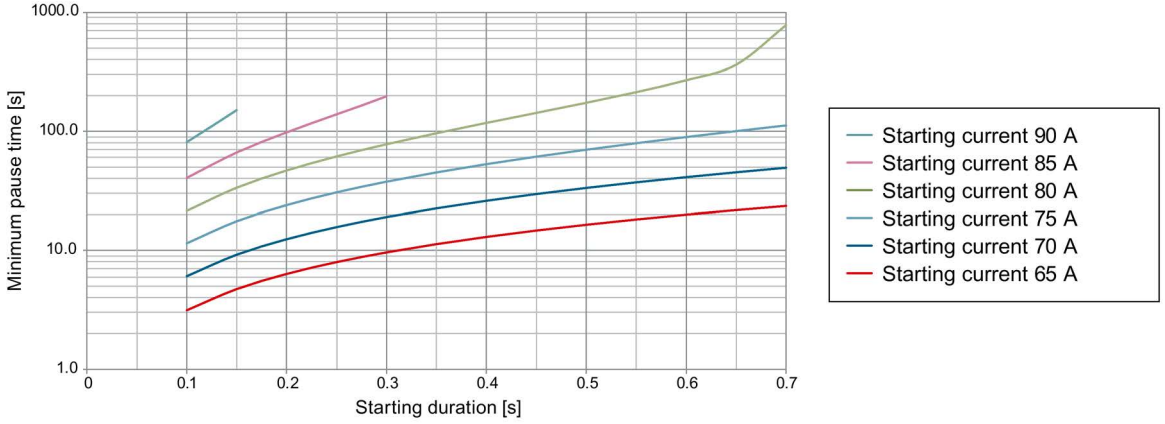
Parameters		Description	Conditions
Starting time	$t_{Startup}$ [s]	Time during which the motor accelerates up to its operating speed from standstill	The maximum is determined by the parameterized tripping class and the intrinsic device protection (see also Overload protection (Page 42)).
Starting current	$I_{Startup}$ [A]	Root-mean-square of the motor current that flows during the starting time. It is considered as a multiple x of the rated value of the motor I_{rated_motor} and/or the parameterized rated operational current I_e. $I_{Startup}$ [A] = x * I_e [A]	The maximum is the permissible current of the relevant device class. Consider additional idle times in the case of starting currents in excess of 65 A (see example graphics). (Also see: Overload protection (Page 42) and the example graphics)
Motor operation time	t_{Motor}[s]	Time in which the motor is in operation after startup.	-
Rated operational current	I_e [A]	Root-mean-square of the motor current in the operating phase after the starting time or the parameterized value I_e of the motor starter	The permissible I_e is determined by the adjustment range of the motor starter used and its ambient temperature (see also: Overload protection (Page 42)).
Motor OFF time:	t_{Off} [s]	Idle time of the motor within the switching cycle	Consider additional idle times in the case of starting currents in excess of 65 A (see example graphics).
Switching cycle interval	T [s]	Total of t_{Off}, t_{Motor} and $t_{Startup}$	The maximum time is 300 s.

You use the switching cycle interval time to determine the permissible starting frequency per hour as follows:

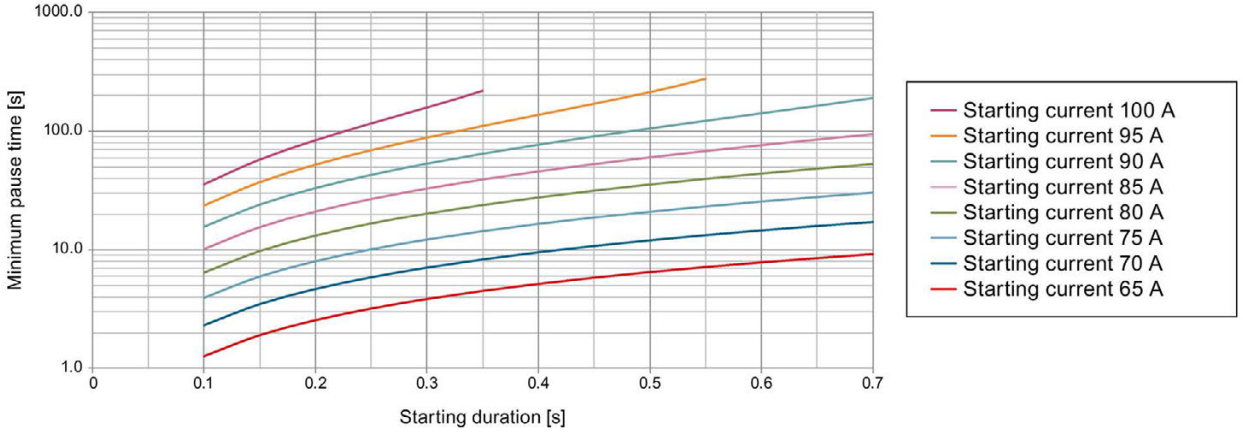
$$\text{Switching cycles [1/h]} = \frac{1}{T} * 3600$$

As from a starting current of 65 A in the case of the 9 A and 12 A motor starters, consider the device protection model for calculation of the switching cycles. The following graphics show the minimum idle time depending on the starting current:

Minimum idle time (T_{Off}) 9 A motor starter at $I_{Startup}/I_{rated_motor}$ = 8



Minimum idle time (T_{Off}) 12 A motor starter at $I_{Startup}/I_{rated_motor}$ = 8



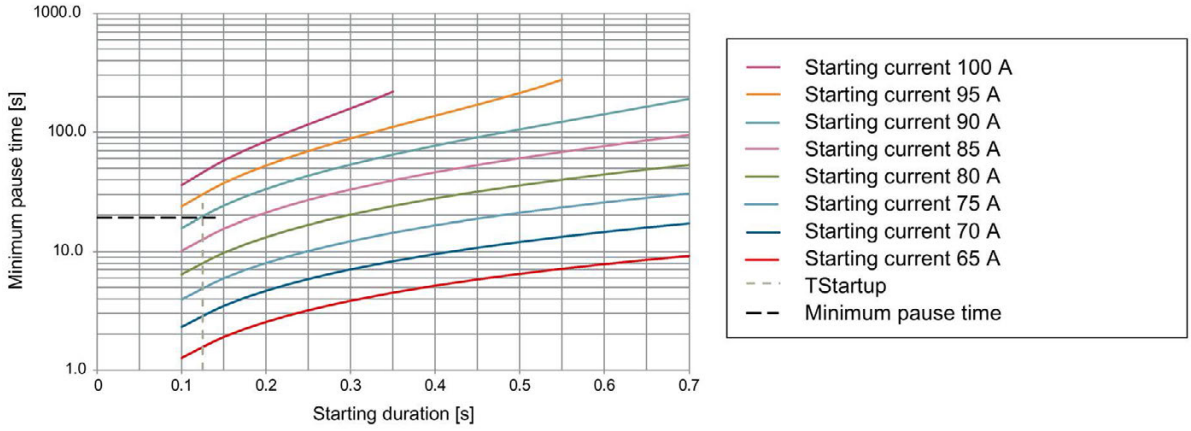
Example for the minimum idle time (T_{Off}) 12 A motor starter at $I_{Startup}/I_{rated}$ = 8

The graphic below shows the minimum idle time of a 12 A motor starter with the following parameters:

I_{rated_motor} = 10.4 A

$I_{startup/Irated_motor}$ = 8.6; thus: $I_{Startup}$ ≈ 89 A

$T_{Startup}$ = 0.125 s T_{Off} ≥ 19 s



3.7.7 Substation monitoring

You can determine various system states with the help of the motor current and the current limits.

System state	Current value	Protection by:
Motor operates more sluggishly, e. g. due to bearing damage	Current is higher than normal	Current limits
Motor operates more smoothly, e. g. because the system has run out of processing material.	Current is lower than normal	Current warning limit
Motor is blocked	Very high current flowing	Blocking protection
• Open circuit • Defective fuse • Motor idling • Power failure • No load connected	Very low current flowing Minimum load undershot	Residual current detection

3.7.7.1 Response to residual current detection

If the motor current drops to under 20 % from the set operational current or below the minimum load limit in one of the phases, residual current detection responds. You use this device parameter to specify how the motor starter is to behave in the event of residual current being detected:

- Warning (not in the case of fail-safe motor starters)
- Tripping

Note

When the motor is switched on, residual current detection is suppressed for approximately 1 s.

Residual current detection in the case of motor starters with 0.3 ... 1 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.3 to 1 A:

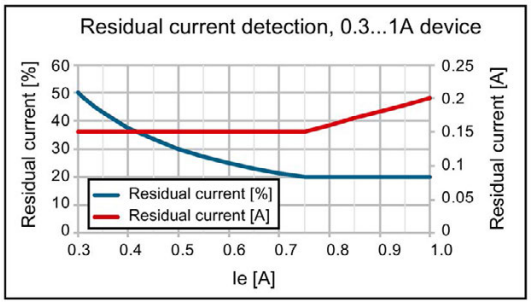


Figure 3-8 Residual current detection 0.3-1 A device

Residual current detection in the case of motor starters with 0.9 ... 3 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.9 to 3 A:

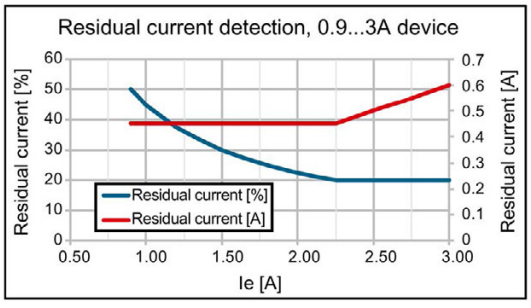


Figure 3-9 Residual current detection 0.9-3 A device

Residual current detection in the case of motor starters with 2.8 ... 9 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 2.8 to 9 A:

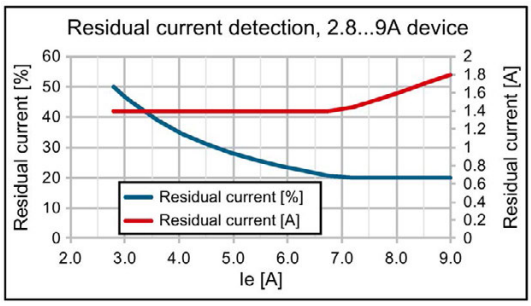


Figure 3-10 Residual current detection 2.8-9 A device

Residual current detection in the case of motor starters with 4 ... 12 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 4 to 12 A:

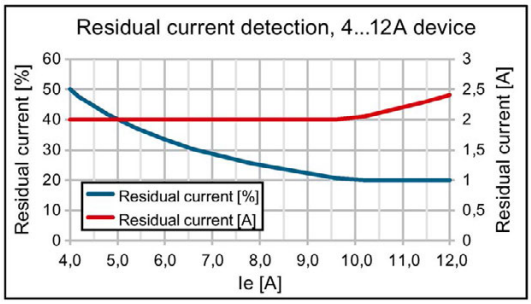


Figure 3-11 Residual current detection 4-12 A device

Residual current detection in the case of fail-safe motor starters with 0.3 ... 1 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.3 to 1 A:

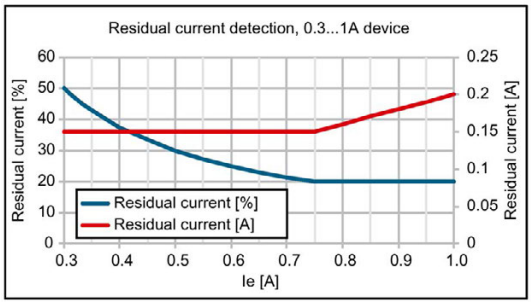


Figure 3-12 Residual current detection 0.3-1 A device

Residual current detection in the case of fail-safe motor starters with 0.9 ... 3 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.9 to 3 A:

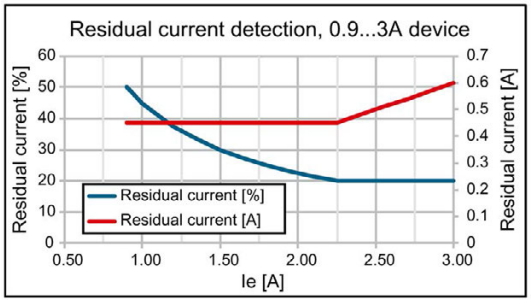


Figure 3-13 Residual current detection 0.9-3 A device

Residual current detection in the case of fail-safe motor starters with 2.8 ... 9 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 2.8 to 9 A:

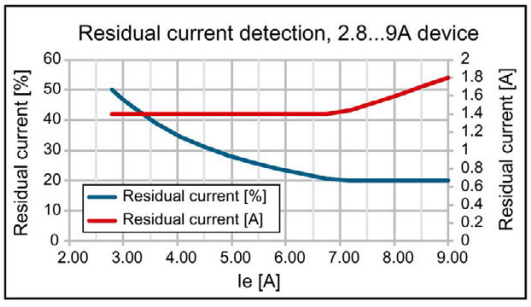


Figure 3-14 Residual current detection 2.8-9 A device

Residual current detection in the case of fail-safe motor starters with 4 ... 12 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 4 to 12 A:

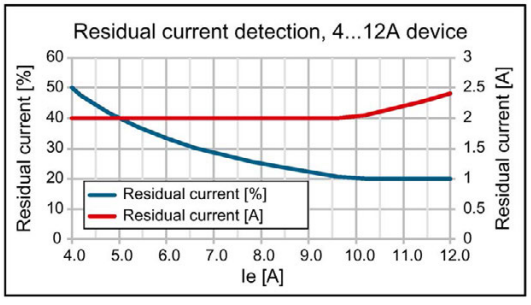


Figure 3-15 Residual current detection 4-12 A device

See also

Minimum load current (Page 39)

3.7.7.2 Upper/lower current warning limit

You can enter an upper and/or a lower current warning limit value. If the current warning values are exceeded or undershot, the motor starter responds with a warning message without tripping. The warning message is acknowledged as soon as the warning threshold is exceeded or undershot by 5 %.

Note

The current warning thresholds are activated by default. You can deactivate the current warning thresholds, however. The current warning thresholds are not activated until the CLASS time expires.

Setting ranges

The table below shows the possible setting range for the lower and upper current warning limits:

Device parameters	Default setting	Setting range
Lower current warning limit	21.875 %	• 18.75 ... 100 % of I_e • 0 % (= deactivated) Increment: 3.125 %
Upper current warning limit	112.5 %	• 50 to 400 % of I_e • 0 % (= deactivated) Increment: 3.125 %

3.7.7.3 Upper/lower current limit

You can enter an upper and/or a lower current limit. The current limits are deactivated by default. If the current limits are overshot or undershot, the motor starter responds by tripping. The "I_e upper limit value violation" or "I_e lower limit value violation" message is issued. If the current exceeds the maximum rated operational current by a factor of ten, the motor starter shuts down the motor even if the current limit values are deactivated. An entry in the logbook (data set 73 (Page 122)) is generated.

Example

The following example shows an application for the upper and lower current limit:

- The viscosity of the mixed mass is too high, that is, the upper current limit has been overshot.
- "No load because drive belt is broken", that is, the lower current limit has been violated.

Note

The parameterized current warning thresholds are not activated until the CLASS time expires.

Setting ranges

The table below shows the possible setting range for the lower and upper current warning limits:

Device parameters	Default setting	Setting range
Lower current limit	Deactivated	• 18.75 ... 100 % of I_e • 0 % (= deactivated) Increment: 3.125 %
Upper current limit	Deactivated	• 50 to 400 % of I_e • 0 % (= deactivated) Increment: 3.125 %

3.7.7.4 Blocking time and blocking current

The blocking current specifies how much current is consumed by the motor (at rated voltage) when the drive is blocked.

If the motor current exceeds the parameterized value for the blocking current, the motor starter detects a blockage. Blocking time monitoring is activated from the point where the blocking current is exceeded. If the blocking current flows for longer than the parameterized blocking time, the motor starter automatically generates a trip command.

The blocking current and blocking time can be parameterized. The run-up time corresponds to the parameterized blocking time after switching on the motor.

Blocking protection in run-up phase

If the motor current exceeds the parameterized value for the blocking current, the motor starter detects a blockage.

- Blocking time monitoring is activated from the point where the blocking current is exceeded.
- If the blocking current flows for longer than the parameterized blocking time, the motor starter automatically generates a trip command.

You can parameterize the response threshold of the blocking current and the blocking time up to tripping so that starting the motor does not lead to erroneous tripping due to motor blocking.

The figure below shows the principle of blocking protection during the run-up phase, that is, the interaction of blocking current and blocking time:

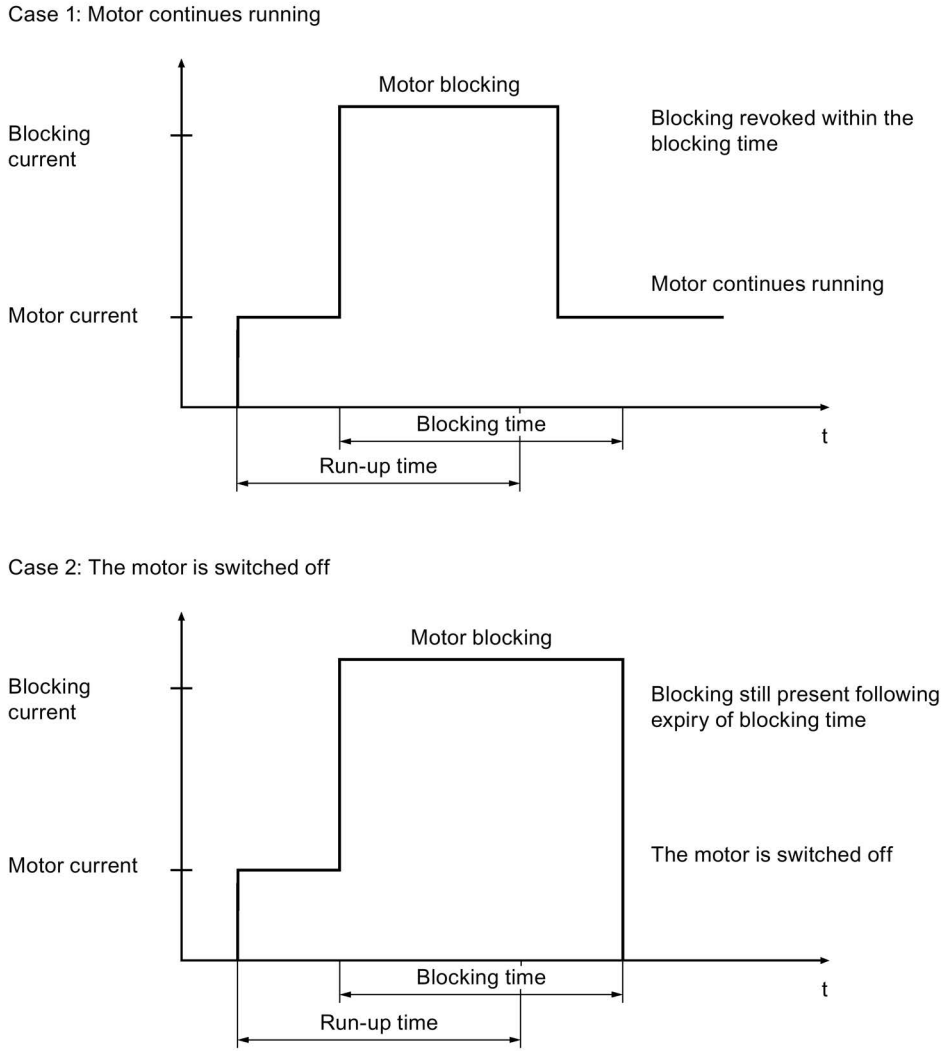


Figure 3-16 Blocking protection principle in run-up phase:

Blocking protection after run-up phase

The blocking protection after the run-up phase cannot be parameterized. After the parameterized blocking time, blocking protection behaves as follows during continuous operation:

- The blocking time is set permanently to 1 s. The blocking current is limited to a maximum of 400 %. If the blocking current during run-up is set to < 400 %, the parameterized value applies.
- When the blocking protection responds, the motor starter itself generates a trip command.
- The "Tripping due to motor blocking" and "Group fault" diagnostic messages are generated.
- The statistic "Number of motor overload trips" is incremented by 1.

If the parameter "Group fault diagnostics" is set to "Enabled", a corresponding diagnostic interrupt is set if blocking protection responds.

Setting ranges

The table below shows the possible setting range for the blocking current and the blocking time:

Device parameters	Default setting	Setting range
Blocking current	800 %	150 ... 1000 % of I_e Increment: 50 %
Blocking time	1 s	1 ... 7.5 s Increment: 0.5 s

See also

Overload protection (Page 42)

3.7.7.5 Device protection model

To protect the switching elements in the main circuit against impermissible operating states, an integrated intrinsic device protection is provided in the upper load range. The device protection model consists of the relay protection model (dotted line) and the thermal motor model (continuous line) with the highest permissible current setting. The device protection is active 20 ms after the ON command. This means that, in the case of ET 200SP motor starters, an overload trip may occur in the upper current range before the motor protection trips. The device protection is active even when the overload protection is set to "Warn" and the "Response of the thermal motor model on restart" parameter is set to "Delete".

The motor starter operates within a permissible current range. The following graphic shows the permissible current range:

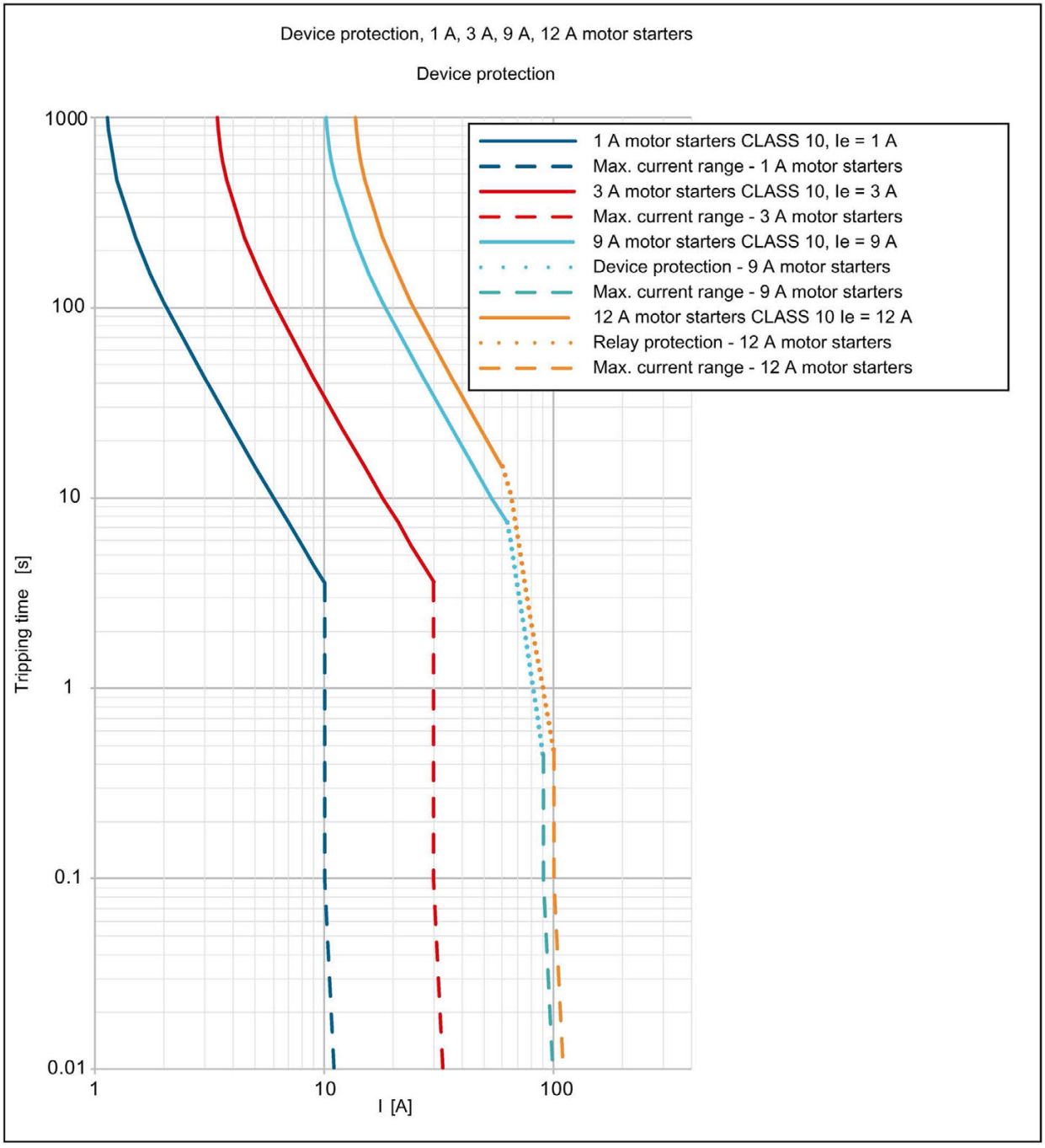


Figure 3-17 Device protection

How the motor starter's device protection works is described below.

Shutting down the motor starter within the permissible current range

The motor starter switches off in the following cases:

- The motor starter is too hot.
- The CLASS 10 tripping characteristic for the maximum current setting has been exceeded.
- The relay protection characteristic in the case of 9 A and in the case of 12 A motor starters has been exceeded.

Wait at least three minutes after shutting down the motor starter. Then trigger a trip reset. The motor starter is operable again.

Violation of the permissible current range

Switching elements may be damaged if the permissible current range (represented by the vertical line in the graphic) is exceeded. The motor starter switches off. The "Current measuring range overshot" message is issued. 9 A and 12 A motor starters switch off without the support of the semiconductors. This is referred to as "hard switching" of the semiconductors and is output as a fault diagnosis.

To prevent response of the device protection, a motor's maximum starting current must not be higher than the motor starter's max. permissible current range.

Fail-safe motor starters are defective after overshoot of the permissible current range and cannot be activated again. Reactivation of non-fail-safe motor starters is possible. The service life of the non-fail-safe motor starter is, however, limited.

See also

Overload protection (Page 42)

3.7.7.6 Temperature monitoring

The motor starter has a temperature monitoring function. If the motor starter becomes too hot, the "Switching element hot" alarm (object number 1580) is issued in data set 75 (Page 124). The motor starter switches off if the temperature continues to rise. The "Switching element overload" diagnostic message (object number 309) is issued in data set 92 (Page 126) if temperature monitoring responds.

You can trigger trip reset on the motor starter after a cooling time of at least three minutes. You can activate the motor starter again once it has sufficiently cooled down.

3.7.7.7 Asymmetry monitoring

Description

Three-phase asynchronous motors respond to slight asymmetries in the supply voltage with a higher asymmetric current consumption. As a result, the temperature in the stator and rotor windings of the drive increases. The SIMATIC ET 200SP motor starter protects the load against overload by issuing a warning or by tripping. You can parameterize whether a warning is output or tripping occurs.

Note

When the motor is switched on, asymmetry evaluation is suppressed for approx. 0.5 s.

Asymmetry limit

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Tripping

Settings

Table 3- 3 Settings for asymmetry monitoring

Device parameters	Default setting	Setting range
Response to asymmetry	Tripping	• Warn • Tripping

See also

Overload protection (Page 42)

3.7.7.8 Short-circuit protection (fuses)

Description

The SIMATIC ET 200SP motor starter is equipped with integrated fuses as short-circuit protection. Short-circuit protection is implemented both between a phase and ground (= ground fault), and between two phases.

Switching performance

The SIMATIC ET 200SP motor starter switches off short-circuits in the motor or in the cables. The SIMATIC ET 200SP motor starter complies with the requirements of type of coordination 1 (IEC 60947-4-2).

On tested assemblies, the type of coordination defines the permissible condition of devices following a short-circuit. Type of coordination 1 means that the load feeder is non-operational after a short circuit has been cleared.

Messages and actions

After the fuse responds, the "Residual current detection" message is output in the case of non-fail-safe motor starters. The "Switching element defective" message is issued in the case of fail-safe motor starters. Then replace the starter.

3.7.8 Safety-related functions

3.7.8.1 Self-test

ET 200SP fail-safe motor starters run a self-test of the switching elements every time they are switched on and off.

Ensure a stable line power supply. An unstable power supply may lead to a situation in which the motor starter incorrectly signals a fault.

3.7.8.2 Response to safety-related tripping

The STO (Safe Torque Off) function is the safety function integrated in the fail-safe motor starter. It ensures the safe disconnection of torque-generating energy on the motor. Safe Torque Off prevents unintentional start-up in compliance with EN 60204-1 Section 5.4. The drive is safely free from torque. This state is monitored in the motor starter.

Safety-related tripping is achieved for the fail-safe motor starters thanks to the special arrangement and checking of the switching elements.
Safety-related tripping is achieved by low level ("0" signal) at the fail-safe digital input F-DI of the BaseUnit. As an alternative, safety-related tripping can be achieved by removing the 24 V supply voltage from the power bus.

In the case of ET 200SP fail-safe motor starters, the OFF state is defined as the safe state (Safe Torque Off). ET 200SP fail-safe motor starters are self-monitoring. A diagnostic message can be sent to the controller in the event of tripping via F-DI.

Settings

Table 3- 4 Response to safety-related tripping

Device parameter	Default setting	Setting range
Response to safety-related tripping	No warning	• No warning • Warning

See also

F-PM-E tripping (Page 147)

Shutdown via a safety-related actuator via F-DQ (Page 148)

Safety Local (Page 149)

3.7.8.3 Ex motor application

Set the "Ex motor application" parameter if the fail-safe motor starter is to switch and protect an explosion-proof motor.

Note

ATEX Ex II (2) G D zones

You can use the fail-safe motor starter for explosion-proof motors that are situated in ATEX Ex II (2) G D zones.

An ATEX approval is not possible with the motor starter when it is used in 1-phase operation. An ATEX approval is possible by means of further measures such as thermoclick.

Settings

Table 3- 5 Settings for Ex motor application

Device parameters	Default setting	Setting range
Ex motor application	No	• No • Yes

The maintenance alarm 0x1036, "New safety-related parameters received", is issued if you have activated the "EX motor" parameter. Before the "EX motor" parameter is accepted, you must confirm it on the device with the blue button.

See also

Setting safety-related parameters (Page 98)

3.7.9 Response to CPU/master STOP

With this parameter, you set the response of the PIQ following a CPU STOP:

- Retain last value

  The last received and valid value of the process image of the outputs is retained.

- Switch substitute value 0

  The process image of the outputs is assigned the value "0". "Switch substitute value 0" is active even if the header module of the ET 200SP station is deenergized.

Note

The response to CPU/master STOP is only relevant in "Automatic" mode.

3.7.10 Group fault diagnostics/group warning diagnostics

You can use these parameters to determine whether diagnostics are enabled or disabled. If you set the group diagnostics parameter to "Disable", no diagnostic messages are output to the CPU. If you set the group warning diagnostics parameter to "Disable", no maintenance alarms are output.

You will find the requirements for use of maintenance alarms in an FAQ entry in Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109485777).

Settings

Table 3- 6 Settings for group fault/group warning diagnostics

Device parameter	Default setting	Setting range
Group fault diagnostics	Enable	• Disable • Enable
Group warning diagnostics	Disable	• Disable • Enable

3.7.11 Inputs

If you use the optional 3DI/LC module (3RK1908-1AA00-0BP0), the motor starter can execute various actions with the "Inputs" device function. The actions are parameterizable. The signals are evaluated on the 3DI/LC module for this purpose. Inputs 1 to 3 (DI 0.4 to 0.6) can be connected directly with contact elements or sensors.

The bit 2.5 in the process image of the inputs indicates whether a 3DI/LC module is inserted.

The signal states are transferred in parallel via the process image. In addition, the signal states in data set 92 (Page 126) can be read out. The input actions of the individual digital inputs affect the motor starter functions independently of one another.

The input LC (local control) switches over to manual local mode. You cannot change the parameterization of the input. This input is always implemented as an NO contact. You can detect whether or not manual local is active if bits 0.7 and 1.6 are active in the process image input.

Response to sensor supply overload

The supply voltage for the digital inputs is short-circuit proof. The current is limited to a maximum of 100 mA. If a short-circuit or overload situation occurs in the sensor supply, the switching elements (motor) are shut down and a group fault is output. Acknowledge the fault with Trip Reset.

Response to removal of the 3DI/LC module:

The bit 2.5 is reset in the process image of the inputs if the 3DI/LC module is removed during operation. You can evaluate the bit and thus indicate unintentional removal. The inputs are not open-circuit-proof.

Note

When you remove the 3DI/LC module, the motor can continue to run during manual local operation and with appropriate parameterization.

Input signal delay

The input signal delay is fixed at 10 ms.

Input n signal

You can use this device parameter to determine whether or not the input level of the inputs is to be saved.

- Retentive, i.e. latching mode (edge evaluation)

  Regardless of the input signal present, the action can only be deactivated again by a further event and remains active even after cancellation until it is overwritten by another action (e.g. process image of the outputs).

- Non-retentive, that is, jog (level evaluation)

  This input action is active as long as the input is active.

Input n level

You use this device parameter to specify the input logic:

- NC contact
- NO contact

Note

Parameterization only as NO contact.

For "Input n action": "Emergency start", "Motor CW", "Motor CCW", "Cold start" and "Trip reset", "Input n level" can only be parameterized as an NO contact.

Note

Change from NC contact to NO contact

If "Input n level" is changed from a normally closed contact to a normally open contact and the associated "Input n action" is parameterized as "Trip without restart", the "Input tripping" message bit is set and shut down accordingly in the case of an open input due to the input delay!

Note

Applied input voltage

If input voltage is applied (input active), the value "1" is transferred to the controller regardless of the "Input n level" parameter.

Input n action

Different actions can be triggered when an input signal is present. You can parameterize the following actions dependent on "Input n level", "Input n signal" and "Mode".

Note

If "Input n signal" = retentive, and "Input n action" = Motor CW/CCW, at least one input must always be parameterized with input action "Tripping ..." or "Quick Stop". If this rule is violated, the motor starter will reject the parameters with the relevant diagnostics message.

Input n action	Input n level	Input n signal	Operating mode	Description
No action	NO/NC	n. ret./ret.	All	No direct action on the motor starter. Evaluation und further processing possible using the process image.
Trip without restart	NO/NC	n. ret.	All	• Results in tripping of the motor. • Must be acknowledged once the cause of the tripping has been rectified (initial status).
Trip with restart (AUTO RESET)	NO/NC	n. ret.	All	• Results in tripping of the motor. • Acknowledged automatically after the cause of the trip has been rectified (initial status).
Trip end position CW	NO/NC	n. ret.	All	• The motor is switched off regardless of the direction of rotation. • A fault is generated and reported. • The motor can only be switched on with "Motor CCW"
Trip end position CCW	NO/NC	n. ret.	All	• The motor is switched off regardless of the direction of rotation. • A fault is generated and reported. • The motor can only be switched on with "Motor CW"
Group warning	NO/NC	n. ret./ret.	All	• The diagnosis "Group warning" is output. • The motor starter is not switched off.
Emergency start	NO	n. ret.	All	• Starts the load when an ON command is issued despite the fact that an internal trip command is present. • Intrinsic device protection of the motor starter remains active and prevents the device from being destroyed. • Only allowed as an NO contact • Not parameterizable when the "EX motor" parameter is active.

Input n action	Input n level	Input n signal	Operating mode	Description
Motor CW Motor CCW (with reversing starters only)	NO	n. ret./ret.	Manual mode local	• The motor starter must be in "manual local" mode for these actions. • Motor CW: Switching the motor on or off • Motor CCW: Switching the motor on or off • Only allowed as an NO contact • n. ret. The input action is active while the input signal is pending. • ret.: The action becomes active by means of the rising edge of the input and remains active regardless of the level. The action is reset by the input action "Quick Stop" or "group fault".
Quick Stop	NO/NC	n. ret./ret.	All	• Motor is switched off direction-independently without group fault. • "Quick Stop" takes priority over "Motor CW" and "Motor CCW"
Quick Stop clockwise	NO/NC	n. ret./ret.	All	• Motor is switched off with "Motor CW" without group fault. • "Quick Stop" takes priority over "Motor CW"
Quick Stop counter-clockwise	NO/NC	n. ret./ret.	All	• Motor is switched off with "Motor CCW" without group fault. • "Quick Stop" takes priority over "Motor CCW" • The action is only available for reversing starters.
Trip RESET	NO	n. ret.	All	• "Trip RESET" is triggered once. • "Trip RESET" is only possible as NO contact.
Cold start	NO	n. ret.	All	• Enables switch-on without main power. If the main power supply is nevertheless present (current flowing), an internal trip command is generated. • Cannot be set in the case of fail-safe motor starters
Operational trip end position CW	NO/NC	n. ret.	All	The motor is tripped regardless of the direction of rotation (CW or CCW). • The motor can only be switched on with "Motor CCW". • The parameter can only be implemented as "non-retentive". • A group fault is not generated, but a diagnostics message is set in data set 92.

Input n action	Input n level	Input n signal	Operating mode	Description
Operational trip end position CCW	NO/NC	n. ret.	All	The motor is tripped regardless of the direction of rotation (CW or CCW). • The motor can only be switched on with "Motor CW". • The parameter can only be implemented as "non-retentive". • A group fault is not generated, but a diagnostics message is set in data set 92.
NO: NO contact NC: NC contact ret.: retentive n. ret.: non-retentive (activation and deactivation of the input action follows the status of the input signal (= jog))				

Settings

Table 3- 7 Settings for inputs

Device parameters	Default setting	Setting range
Input signal delay	• 10 ms	-
Input 1 level	• NO contact	• NC contact • NO contact
Input 2 level		
Input 3 level		
Input 1 action	• Motor CW	• No action • Trip without restart • Trip with restart • Trip end position CW • Trip end position CCW • Group warning • Emergency start • Motor CW • Motor CCW • Quick Stop (direction-independent) • Quick Stop clockwise • Quick Stop counter-clockwise • Trip RESET • Cold start • Operational trip end position CW • Operational trip end position CCW
Input 2 action	• Motor CCW (RS) • No action (DS)	
Input 3 action	• Cold start	
Input 1 signal	• Non-retentive	• Retentive • Non-retentive
Input 2 signal		
Input 3 signal		

3.7.12 Manual local (local control)

Manual local control with the SIMATIC ET 200SP motor starter is only possible when the 3DI/LC module is inserted. A digital input is permanently assigned the function "Manual local" (LC connection). If the digital input is active, that is, "manual local" is requested, the SIMATIC ET 200SP motor starter changes to manual local mode even in the case of motor ON. To exit manual local mode, the manual local input must be inactive and the motor must be switched off via the DI module. That is, with active input action "Motor CCW" or "Motor CW", the SIMATIC ET 200SP motor starter remains in manual local mode and thus in the "Motor ON" state as long as the input action is not interrupted.

Note

Removal during operation

If the 3DI/LC module is removed from the SIMATIC ET 200SP motor starter during manual local mode, this results immediately in shutdown of the running motor and then to exiting of manual local mode.

If a removed 3DI/LC module is plugged onto the SIMATIC ET 200SP motor starter while "manual local" is active, a changeover is made to manual local mode.

The motor starter assumes automatic mode when manual local mode is ended, i.e. the motor starter switches to the control priority of the CPU. The motor can start immediately when CW or CCW command is pending via the process image of the outputs.

3.7.13 Trip without restart

The action "Trip without restart" results in the following behavior:

- The motor is tripped. Acknowledge disconnection via Trip Reset after remedying the cause of tripping. You can then switch on the motor again.
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.

3.7.14 Trip with restart

The action "Trip with restart" results in the following behavior:

- The motor is tripped.
- Acknowledged automatically after the cause of the trip has been rectified (input status).
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.

3.7.15 Trip emergency end position CW

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Trip end position CW responded" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor when emergency start is deactivated. The interrupt "Trip end position CW" is reported as outgoing (DS92 entry is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CW" is issued in the case of trip end position CW DI static "1", an incoming diagnostic message "trip end position CW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CW direction of rotation (emergency start deactivated).

The action "Trip end position CW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.
- Emergency trip end position CW can be overridden by emergency starting.

Example

The following example shows the "trip end position CW" with digital input 1 parameterized to "Trip end position CW":

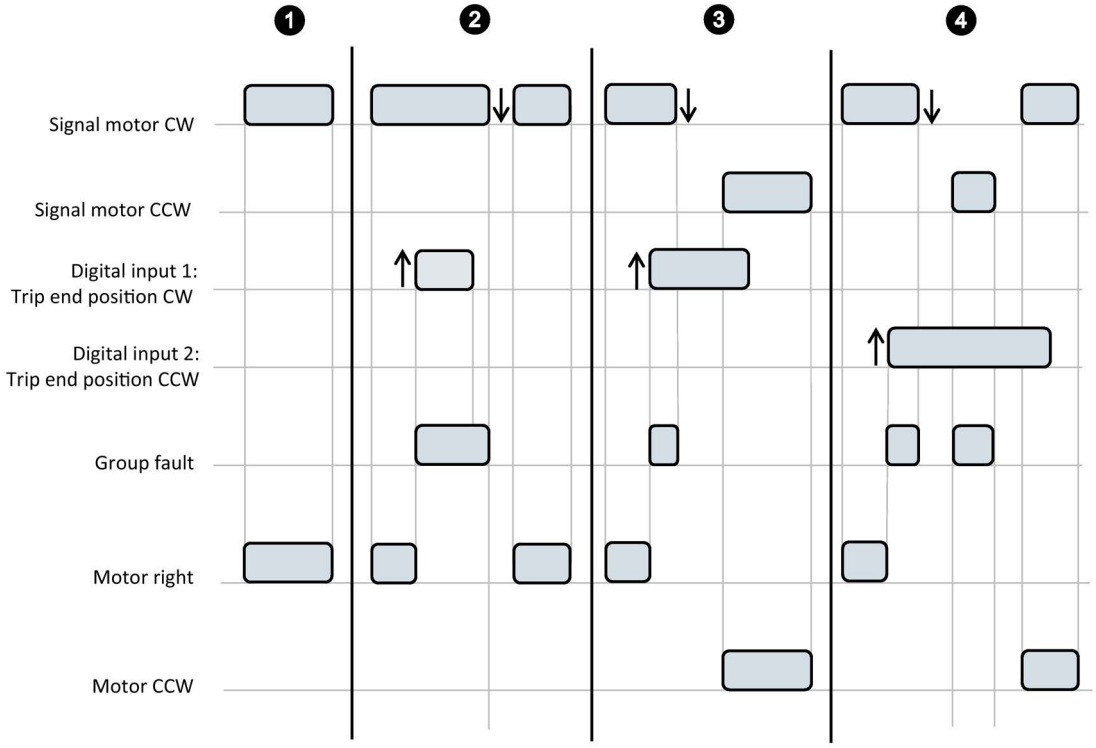


Figure 3-18 Example of trip end position CW

① You switch the motor on by means of "Motor CW". The motor is running.

② You switch the motor on by means of "Motor CW". The motor is running. The motor is switched off by setting the digital input 1 (parameterized to input action 1 = Trip end position CW). A group fault is generated at the same time by the starter. To switch the motor back on again, digital input 1 and the signal "Motor CW" must be reset again. Thereafter you can start the motor again via the signal "Motor CW". The group fault is deleted when the signal "Motor CW" is canceled.

③ You switch the motor on by means of "Motor CW". The motor is switched off by setting the digital input 1 (parameterized to input action 1 = Trip end position CW). A group fault is generated at the same time by the starter. While digital input 1 is set, you can only run the motor counter-clockwise. The group fault is deleted when the signal "Motor CW" is canceled.

④ You switch the motor on by means of "Motor CW". The motor is also switched off by setting the digital input 2 (parameterized to input action 1 = Trip end position CCW). A group fault is generated at the same time by the starter. While digital input 2 is set, you can only run the motor clockwise. To switch the motor back on again, digital input 2 and the signal "Motor CW" or "Motor CCW" must be reset again. Thereafter you can start the motor again via the signal "Motor CW". The group fault is deleted when the signal "Motor CW" is canceled.

3.7.16 Trip emergency end position CCW

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Trip end position CCW responded" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor when emergency start is deactivated. The interrupt "Trip end position CCW" is reported as outgoing (entry 92 is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CCW" is issued in the case of trip limit CCW DI static "1", an incoming diagnostic message "trip end position CCW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CCW direction of rotation (emergency start deactivated).

The action "Trip end position CCW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.
- Emergency trip end position CCW can be overridden by emergency starting.

3.7.17 Group warning

The action "Group warning" results in the following behavior:

- A "group warning" is generated.
- An entry with the object number 304 (byte 0, bit 7) is generated in data set 92 (Page 126).
- A logbook entry is created in data set 75 (Page 124).
- The motor is not tripped.
- A maintenance alarm is generated when group warning diagnostics is enabled.

3.7.18 Emergency start

Description

In the case of an emergency start, the ON command is accepted even if an OFF command is active.

Emergency starting is not possible in the following situations:

- When you are using a fail-safe motor starter in ATEX operation
- If a device fault is active
- If there is no switched/unswitched 24 V DC supply voltage, or if the supply voltage is outside the specified range.
- The blocking protection has responded
- If a process image error is active

You can activate the function "Emergency start" as follows:

- PIQ 0.4 "Emergency start"
- Via the 3LC/DI module

Messages and actions

Table 3- 8 Messages and actions emergency start

Message	Action
Emergency start active	Remains pending while emergency start is active, even if the motor is switched off.

3.7.19 Motor CW

In automatic mode, the motor is activated or deactivated in the CW direction with the aid of the process image of the outputs. If you would like to control the motor via the 3DI/LC module, activate the LC input on the 3DI/LC module (manual local mode). Bit 0.0 "Motor CW" in the process image of the outputs is ignored in manual local mode.

The parameter can only be implemented as an "NO contact".

If "Input n signal" = retentive, and "Input n action" = Motor CW/CCW, at least one input must always be parameterized with the "Tripping ... " or "Quick Stop" input action.
If this rule is violated, the motor starter will reject the parameters with the relevant diagnostics message.

3.7.20 Motor CCW

In automatic mode, the motor is activated or deactivated in the CCW direction with the aid of the process image of the outputs. If you would like to control the motor via the 3DI/LC module, activate the LC input on the 3DI/LC module (manual local mode). Bit 0.1 "Motor CCW" in the process image of the outputs is ignored in manual local mode.

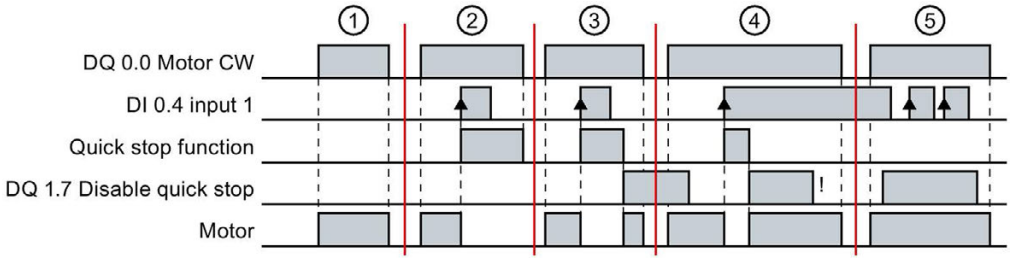
The parameter can only be implemented as an "NO contact".

If "Input n signal" = retentive, and "Input n action" = Motor CW/CCW, at least one input must always be parameterized with the "Tripping ... " or "Quick Stop" input action.
If this rule is violated, the motor starter will reject the parameters with the relevant diagnostics message.

3.7.21 Quick Stop direction-independent

- Motor is tripped without group fault.
- "Quick Stop" takes priority over "Motor CW" and "Motor CCW"
- The input action responds to the active edge of the input signal, which means that deactivation is possible when the static input signal "Quick stop" is present.
- The input trigger is reset through cancelation of the "Motor CW" and "Motor CCW" control commands, or by means of "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.
- The motor is tripped regardless of the direction of rotation.

Example 1: Input 1 signal = retentive/edge-triggered



① The motor is switched on by "Motor CW".

② Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1 (parameterized to input action 1 = Quick Stop). By revoking the "Motor CW" command, the Quick Stop function is reset.

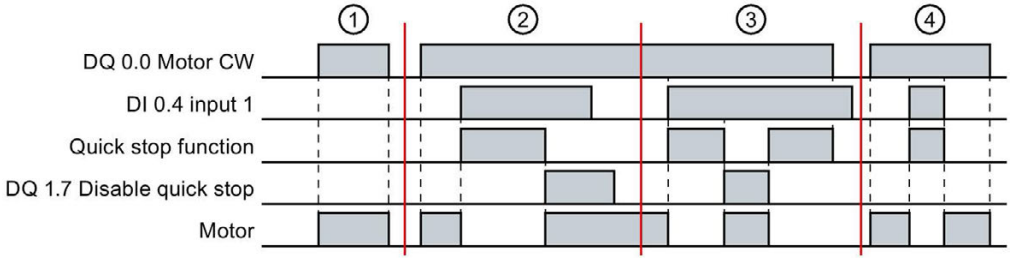
③ Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1. By setting Disable quick stop, the Quick Stop function is reset and the motor runs "CW" again until the "Motor CW" command is revoked.

④ Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1. By setting Disable quick stop, the Quick Stop function is reset and the motor runs "CW" again. Although the static digital input signal 1 (DI2) is still present, the motor continues to run and is only reset by revoking the "Motor CW" command.

Reason: The input action is edge-triggered.

⑤ Motor is switched on by "Motor CW" and continues to run uninterrupted since Disable quick stop continuously overwrites the edges of the signal of digital input 1 (DI2).

Example 2: Input 1 signal = non-retentive



① The motor is switched on and off by "Motor CW".

② The motor is switched on by "Motor CW", then switched off by the level at digital input 1 (parameterized with input action 1 = Quick Stop). The Quick Stop function is reset by Disable quick stop. The motor is switched on again since "Motor CW" is still active.

③ The motor is switched off by the level at digital input 1. The "Quick Stop" function is reset by setting "Disable quick stop". As the level "Motor CW" is still active, the motor runs "CW" again until the "Disable quick stop" command is revoked.

④ Motor is switched on by "Motor CW", then switched off by the level at digital input 1. While the "Quick Stop" function is active, the motor remains switched off and starts up again when "Quick Stop" is revoked until "Motor CW" is switched off.

3.7.22 Quick Stop clockwise

The action "Quick Stop CW" results in the following behavior:

- The motor is switched off with pending signal "Motor CW" without group fault
- The motor is not switched off with pending signal "Motor CCW"
- "Quick Stop CW" takes priority over "Motor CW"
- The input action responds to the active edge of the input signal, which means deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset through cancelation of the control commands "Motor CW" or "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.

3.7.23 Quick Stop counter-clockwise

The action "Quick Stop CCW" results in the following behavior:

- The motor is switched off with pending signal "Motor CCW" without group fault
- The motor is not switched off with pending signal "Motor CW"
- "Quick Stop CCW" takes priority over "Motor CCW"
- The input action responds to the active edge of the input signal, Deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset through cancelation of the commands "Motor CCW" or "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.

Note

No quick stop CW in the case of direct-on-line starters

You cannot use quick stop CCW in combination with direct-on-line starters.

3.7.24 Trip RESET

"Trip RESET" acknowledges all the errors/faults that are currently active and that can be acknowledged. An error/fault can be acknowledged if its cause has been rectified or if it is no longer present.

Trip RESET is triggered by:

- When loading a valid parameterization
- Remote RESET via PLC (PIQ bit 0.3 Trip RESET)
- Remote RESET via input actions (if parameterized)
- TEST/RESET button on the SIMATIC ET 200SP motor starter
- Power-On-RESET (switching off and on again of one or both 24 V supply voltages on the device or the backplane bus)

Note

TRIP RESET as input n signal

The "Trip Reset" action is only possible as an "input n signal" (non-retentive).

3.7.25 Cold start

Description

The "cold start" function enables control of a motor without error messages. The function is available only in the case of the non-fail-safe motor starter. The motor starter responds here as if the main power supply were connected to the system. Thus, in the commissioning phase, for example, the relevant control commands are accepted from the controller and the relevant messages are sent.

Note

If the main power supply is nevertheless present (current flowing), an internal trip command is generated.

Note

The "cold start" action is only permissible as an "input n level" (NO contact) and only as an "input n signal" (non-retentive).

You can activate the "cold start" function as follows:

- PIQ 0.7 "Cold start"
- Via the 3LC/DI module

3.7.26 Operational trip end position CW

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CW DI is detected. This motor tripping triggered by the operational trip end position is revoked by the motor control command "Motor OFF". If the motor control command "Motor CW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This motor tripping triggered by the operational trip end position prevents renewed switch-on of the motor in the CW direction of rotation.

The action "Operational trip end position CW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "non-retentive".
- A group fault is not generated, but a diagnostics message is set in data set 92.
- Operational trip end position CW cannot be overridden by emergency start.

3.7.27 Operational trip end position CCW

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CCW DI is detected. This motor tripping triggered by the operational trip end position is revoked by the motor control command "Motor OFF". If the motor control command "Motor CCW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This motor tripping triggered by the operational trip end position prevents renewed switch-on of the motor in the CCW direction of rotation.

The action "Operational trip end position CCW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "non-retentive".
- A group fault is not generated, but a diagnostics message is set in data set 92.
- Operational trip end position CCW cannot be overridden by emergency start.

3.7.28 Logbook

Description

The logbooks contain a chronological list of device faults, trips and events that are assigned a time stamp, thus creating a log. The log is stored internally so that the causes can be evaluated at a later stage.

Logbooks

Three logbooks that can be read as a data set are available:

- DS72: Logbook - device faults (Page 120)
- DS73: Logbook - trips (Page 122)
- DS75: Logbook - events (Page 124)

The operating hours of the device in seconds are used as a time stamp. You can find the object numbers of the relevant messages in the relevant data sets. The last 21 entries are stored in the logbooks. You can read out the entries with the relevant data sets. The logbook is designed as a circular buffer. After 21 entries, the oldest entry is overwritten. The latest entry is at the first location.

Logbook - Read device errors

The logbook "Read device errors" contains all device errors/faults. The object numbers of the actual fault causes are entered, e.g. object number 476, "Current measurement defective".

Logbook - Read trips

The logbook "Read trips" contains all group faults. The object numbers of the actual fault causes are entered, e.g. "Switching element defective".

Logbook - Read events

The logbook "Read events" contains all warnings as well as certain actions. Incoming events are reported as incoming. In addition, some events are also reported as outgoing. Incoming entries are marked "+". Outgoing events are marked "-".

3.7.29 PROFIenergy

3.7.29.1 What is PROFIenergy?

PROFIenergy supports the following two functions:

- Energy saving function

  Supports targeted shutdown of loads during idle times.

- Measured value function

  Energy management is an instrument which is ideally suited to reducing energy consumption and thereby energy costs within a company both systematically and on a long term basis. The aim of energy management is to optimize the use of energy in a company - from the purchasing of energy through to the consumption of energy - economically and ecologically. The measured value function provides the measured values required for optimization.

3.7.29.2 PROFIenergy in the motor starter

The SIMATIC ET 200SP motor starter supports the "Energy saving function" and "Measured value function" for the motor current. These are identified as commands, since they trigger reactions in the SIMATIC ET 200SP motor starter.

In addition, the SIMATIC ET 200SP motor starter also provides so-called services that provide information on the status of the motor starter as defined in PROFIenergy. These can then be evaluated and further processed in the user program.

Using PROFIenergy with the SIMATIC ET 200SP motor starters

SIEMENS provides two function blocks for using PROFIenergy:

- PE_START_END (FB815) supports the switch to an energy-saving mode.
- PE_CMD (FB816) supports the reading out of measured values and the switch to an energy-saving mode

You will find further information in the document entitled "Common Application Profile PROFIenergy, Technical Specification for PROFINET Version V1.1 Edition 2, Dec. 2013, Order Number 3802" published by PROFIBUS Nutzerorganisation e.V. (PNO).

Note

PROFIenergy is not possible with PROFIBUS interface modules.

Note

The PROFIenergy function is available with firmware version V3.3 of the interface modules.

Commands

The following tables show the supported commands:

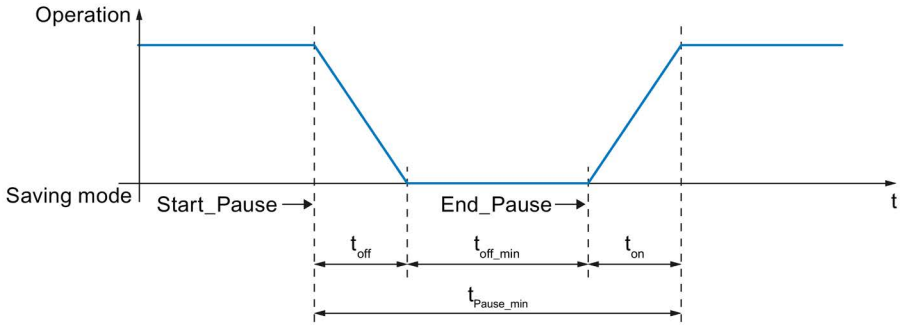
Control commands	
Start_Pause	The starter switches to energy-saving mode.
Start_Pause_with_time_response	The starter switches to energy-saving mode and signals its minimum idle times.
End_Pause	The starter switches back to operating mode.

Status commands	
PE_Identify	Provides a list of supported PROFIenergy commands/functions.
PEM_Status	Returns the current mode.
PEM_Status_with_time_response	Returns the extended status of the current mode.

Status commands	
Query_Modes	
List_Energy_Saving_Modes	Provides a list of supported energy-saving modes.
Get_Mode	Provides the parameter values with which the energy-saving function works.
Query_Version	Shows the implemented PROFIenergy profile.
Query_Measurement	
Get_Measurement_List	Provides a list of supported measured values.
Get_Measurement_List_with_object_number	Provides a list of supported measured values and the associated object number.
Get_Measurement_Values	Provides the requested measured values.
Get_Measurement_Values_with_object_number	Provides the requested measured values together with the object number.

The SIMATIC ET 200SP motor starter operates with the following ProfiEnergy modes (PE modes):

PE_Mode_ID = 255	Ready to operate
PE_Mode_ID = 01	Energy-saving mode



t_{off}	Time_to_Pause	Time the starter requires in order to change to energy saving mode. With the SIMATIC ET 200SP motor starter, this time is always 100 ms.
t_{off_min}	Time_min_length_of_stay	Minimum time that the device spends or should spend in saving mode. With the SIMATIC ET 200SP motor starter: 150 ms
t_{on}	Time_to_operate	Time that will elapse before the starter changes back to the operating state. With the SIMATIC ET 200SP motor starter: 100 ms (due to startup sequence)
t_{Pause_min}	Time_min_Pause	Time that is compared with t_{Pause} (is transferred together with the "Start_Pause" command to the motor starter); if $t_{Pause} \geq t_{Pause_min}$, the device switches to saving mode.

"Measured value function" command

Measured values for energy need to be supplied for efficient energy management.
The PROFIenergy specification offers various measured values from which to choose, each of which is assigned a measured value ID. The SIMATIC ET 200SP motor starter supports the instantaneous values of the phase current and the mean value of the phase currents as measured values.

The measured values are uniquely identified by IDs. The following measured value IDs 7, 8, 9, and 33 are supported:

- ID = 7: Current rms value of the phase current a (L1)
- ID = 8: Current rms value of the phase current b (L2)
- ID = 9: Current rms value of the phase current c (L3)
- ID = 33: Mean value of the three phase currents (a+b+c)/3

The current values are transferred with the following tolerances:

- Domain = 0x03 → IEC 61557-12
- Class = 0x0B → 5 %

The result is that the measured values are transferred with an accuracy of 5 % relative to the maximum configurable rated operational current I_e.

Reaction of the starter when energy-saving mode is activated

Shutdown of the motor by suppression of the PIQ bits (Motor CW, Motor CCW). The other PIQ bits (e.g. Trip RESET) remain active.

Interactions with the various operating modes

- PROFIenergy is operative only in Automatic mode
- Manual local mode is not influenced by PROFIenergy; → it is still possible to switch to manual mode and thereby to control the motor manually.
- Both cyclic and acyclic data transmission (PIQ, PII, data sets, diagnostics, alarms, etc.) to and from the motor starter are still possible.

Prerequisites for the starter to switch to energy-saving mode (min. idle time, etc.)

The changeover to "Pause" energy-saving mode only becomes effective when the idle time sent is greater than the device-specific minimum idle time. This means that a switch is only performed when the pause is longer than the motor starter requires to switch off and again switch on the main energy for the load.

The switch to energy-saving mode is recorded in the "Events" logbook.
Entry: "Energy saving mode active"

See also

Application example (https://support.industry.siemens.com/cs/ww/en/view/109478388)

PROFINET system description
(http://support.automation.siemens.com/WW/view/en/19292127)

3.7.30 Firmware update

Introduction

During operation it may be necessary to update the firmware (e.g. to extend the available functions). You update the firmware of the motor starter with the help of firmware files.

Requirements

- You have downloaded the file(s) for the firmware update from the Product Support (https://support.industry.siemens.com/) web page.

  On this web page, select:

  – Automation Technology > Automation Systems > SIMATIC Industrial Automation Systems > I/O Systems > ET 200 systems for the cabinet > ET 200SP.

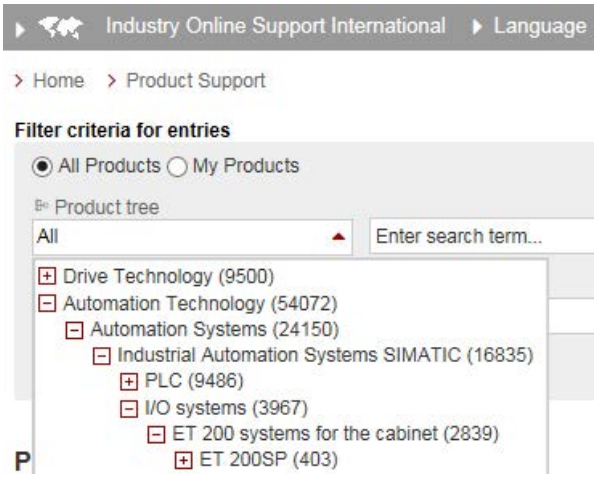


Figure 3-19 ET 200SP in the product tree

From there, navigate to the specific type of module that you want to update. To continue, click on the "Software downloads" link under "Support". Save the desired firmware update files.

Figure 3-20 Selecting the software downloads

- Before installing the firmware update, make sure that the modules are not being used.
- In the case of fail-safe motor starters, the firmware update is permissible only if the motor starter is the only module on a rack. Also make sure that the motor starter is exclusively connected to the device on which the firmware is being updated (e.g. PG/PC or the CPU).

NOTICE
Loss of the safety function after an incorrect firmware update The safety functions can be lost if you inadvertently install a firmware update on a motor starter for which the update was not intended. Make sure that the PG/PC or the CPU is exclusively connected to the motor starter on which the firmware is being updated.

Note

Securing the supply voltage

On starting, and during the firmware update, the 24 V DC supply voltage must be applied at the header module and the motor starter.

Note

Interrupted firmware update

If a firmware update has been interrupted, remove and reconnect the affected module before a renewed firmware update.

Options for the firmware update

The following options are available for updating firmware:

- Online via PROFINET IO/PROFIBUS DP (with STEP 7)
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules)
- With the TIA Portal:
  - Non-fail-safe ET 200SP motor starter, SIMATIC STEP 7 V13 SP1 or higher with installed HSP
  - Fail-safe ET 200SP motor starter, SIMATIC STEP 7 V14 or higher with installed HSP
- Via a SIMATIC memory card
- With SIMATIC STEP 7 Version V5.5 SP4 or higher

Installation of the firmware update

⚠ WARNING

Risk of impermissible system states

The CPU switches to STOP mode or the interface module to "station failure" as a result of the firmware update being installed. STOP or station failure due to a firmware update can cause an unpredictable motor starter state. After completion of the update, the current PIO and the input actions take effect again.

Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to property damage.

Before installing the firmware update, ensure that the motor starter, the CPU and the interface module are not executing an active process.

Procedure using STEP 7

Proceed as follows to perform an online firmware update with STEP 7:

1. Select the module in the device view.
2. Select the "Online & diagnostics" command from the shortcut menu.
3. Select the "Firmware update" group in the "Functions" folder.
4. Click the "Browse" button to select the path to the firmware update files in the "Firmware update" area.
5. Select the suitable firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module.

Note

If a firmware update is interrupted, you need to remove and insert the module before starting the firmware update again.

Procedure using a SIMATIC memory card

Proceed as follows to perform a firmware update via the SIMATIC memory card:

1. Insert a SIMATIC memory card into the SD card reader of your programming device / computer.
2. To save the update file on the SIMATIC memory card, mark the SIMATIC memory card in the project navigator under "Card reader/USB memory".
3. Select the "Card Reader/USB memory > Create firmware update memory card" command in the "Project" menu.
4. Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether you want to delete the content of the SIMATIC memory card or whether you want to add the firmware update files to the SIMATIC memory card.
5. Insert the SIMATIC memory card containing the firmware update files in the CPU.

Procedure using the Web server

The procedure is described in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual.

Behavior during the firmware update

Note the following behavior during the firmware update of the motor starter:

- The LEDs flash as described in chapter "Status and error displays (Page 109)".
- The motor starter powers up again after completion of the firmware update. Diagnoses are reset. The firmware update does not affect the TMM and the cooling time.
- The sensor supply of the DI module remains active.

Behavior after the firmware update

After the firmware update, check the firmware version of the updated module. A successfully loaded firmware update is activated immediately.

If a fail-safe motor starter is in "Manual local" mode during the firmware update, the motor starter switches to commissioning mode after the successful firmware update operation. You must first confirm ATEX parameters before you can perform manual local control.

Reference

You can find more information on the procedure in the STEP 7 online help.

See also

Commissioning mode (Page 92)

Configuring ATEX operation (Page 100)

Parameters/address space

4

4.1 Parameter assignment

When configuring a SIMATIC ET 200SP motor starter, the full parameterization scope is set and automatically transferred to the motor starter. When parameterizing in the user program, the parameters are transferred to the module via the data sets with the statement "WRREC". If the CPU initiates a new parameter assignment, e.g. if communication breaks down, the parameterization is overwritten by the system parameterization via the user program.

The modules of the ET 200SP distributed I/O system support the full parameterization scope of the SIMATIC ET 200SP motor starters.

Note

List of supported ET 200SP header modules

You will find a list of the compatible ET 200SP header modules in the Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109485777).

Note

Reduction to default parameters

In the following cases, the full scope of parameterization is reduced by the configuring software to the standard parameters (DS201) for system reasons:

- Activated DPV0 alarm mode (in the case of PROFIBUS IMs)
- Activated option handling (in the case of PROFIBUS IMs)
- When configuring using a GSD (for parameters, see data set 201 (Page 131))

Note

Trip RESET

When you send valid parameters to the motor starter, a trip RESET is triggered. Acknowledgeable active faults are deleted.

Parameters for SIMATIC ET 200SP motor starters

The effective range of the adjustable parameters depends on the type of configuration. The following configurations are possible:

- Centralized operation with an ET 200SP CPU and the ET 200SP Open Controller
- Distributed operation on the PROFINET IO in an ET 200SP system
- Distributed operation on the PROFIBUS IO in an ET 200SP system

When you assign parameters in the user program, transfer the parameters to the module via the data sets with the "WRREC" statement.

The parameters that can be set can be found in the Appendix in data set 201 (Page 131) and data set 202 (Page 133).

You will find an explanation of the parameters in Explanation of the parameters (Page 95).

4.2 Commissioning mode

Commissioning mode is available for fail-safe ET 200SP motor starters.

When setting up a system, you can test the wiring without the functioning PROFINET or PROFIBUS connection. Perform the test in commissioning mode.

The motor starter switches to commissioning mode in the following cases:

- After the power supply has been activated, the motor starter does not receive any parameterization via the backplane bus.
- The DI module's "Local Control" switch is activated.

  As soon as Local Control is active, the parameterization saved last is used when the power supply is activated. Control via the DI module is possible after confirmation via the TEST/RESET button.

To switch to commissioning mode in the case of fail-safe motor starters, confirm the change with the blue button. During ATEX operation, additionally confirm the current parameters, as described in chapter "Configuring ATEX operation (Page 100)".

If the motor starter receives valid parameterization via the backplane bus in commissioning mode, the parameterization is placed in intermediate storage. The parameterization becomes active when "Local Control" is terminated (motor OFF). The commissioning mode is exited.

See also

Setting safety-related parameters (Page 98)

4.3 Parameterization using a GSD file

For the SIMATIC ET 200SP motor starter, there are two different GSD files, one for operation with PROFINET, and one for operation with PROFIBUS. The GSD and GSDML files can be used with STEP 7 V5.5 SP4 and higher, and TIA Portal V13 SP1 and higher.

If you configure the SIMATIC ET 200SP motor starter in the PROFIBUS environment with GSD, and the standard values in data set 202 have to be changed, then you create data set 202 via the user program on initial commissioning of the starter. Transfer the data set to the PLC.

Parameterization with the PROFINET GSDML file

With the GSDML file for PROFINET, the SIMATIC ET 200SP motor starter can be fully configured with all parameters.

Parameterization with the PROFIBUS GSD file

Two parameter data sets (DS201 and DS202) are used for configuring the SIMATIC ET 200SP motor starter. Only data set DS 201 is ever transferred as the startup data set when using a PROFIBUS GSD.

4.4 Slot rules

You can find further information on the structure of a system with an ET 200SP motor starter in the the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

4.5 Data plausibility check

Checking incoming parameters in "Automatic" mode

The motor starter checks all incoming parameters for validity and plausibility, provided manual local mode is not active. The valid parameters are stored in data set 203 and 204.

In the case of incorrect parameters during startup (after power ON):

- The "Group fault" and "Invalid parameter value" diagnoses are set in data set 92 (Page 126).
- The motor remains shut down.
- An "Invalid parameter value" logbook entry (object number 365) is created in data set 73 (Page 122).
- The currently valid parameter values are retained and can be read via data set 203 (Page 134). Incorrect parameters can be read back and verified in data set 201 (Page 131).

In the case of incorrect parameters from the user program and when the motor is switched off:

- The "Group warning" and "Invalid parameter value" diagnoses are set and the number of the invalid parameter is entered in data set 92 (Page 126).
- A logbook entry is created in data set 75 (Page 124).
- The currently valid parameter values are retained and can be read via data set 203 (Page 134). Incorrect parameters can be read back and verified in data set 201.

For parameters when the motor is running:

- The parameters are not accepted by the starter.
- The "Parameters cannot be changed in ON state" maintenance alarm is set if the maintenance alarm is enabled in the current parameterization.
- The "Group warning" and "Invalid parameter value" entries are set in data set 92 (Page 126) and the number of the invalid parameter is entered.
- The motor is not switched off.
- A logbook entry is created in data set 75 (Page 124).
- The currently valid parameter values are retained and can be read via data set 203 (Page 134). Incorrect parameters can be read back and verified in data set 201 (Page 131).

Checking incoming parameters in "Manual local" mode

The incoming parameters are checked as follows in "Manual local" mode:

- When the motor is switched off:

  The motor starter saves the parameter and accepts it only when the motor starter has switched over to "Automatic" mode again. Only after changing to "Automatic" are the parameters checked.

- When the motor is running:
  - The parameters are not accepted by the motor starter, even if the motor starter changes later to "Automatic" mode.
  - The "Parameters cannot be changed in ON state" diagnosis is set in data set 75 (Page 124).
  - The diagnosis "Group warning" is set.
  - The motor is not switched off.
  - A logbook entry is created
  - The currently valid parameter values are retained.

4.6 Declaration of parameters

Load type

Here, you can specify whether the motor starter must protect a 1-phase load (direct-on-line starters only) or a 3-phase load.

You will find more information in Chapter "Load type (Page 36)".

Trip class

The trip class (CLASS) specifies the maximum time within which a protective device must trip from a cold state at 7.2 x the setting current (motor protection to IEC 60947).

You will find more information in Chapter "Overload protection (Page 42).

Thermal motor model (response to overload)

You use this device parameter to determine how the motor starter is to respond to overload.

You will find more information in Chapter "Overload protection (Page 42).

Response to CPU/master STOP

Determines the module's response to CPU STOP.

You will find more information in Chapter "Response to CPU STOP (Page 64)".

Response to residual current detection

You use this device parameter to specify how the motor starter is to respond to residual current detection.

You will find more information in Chapter "Response to residual current detection (Page 52)".

Response to asymmetry

You use this device parameter to determine how the motor starter is to behave in the event of asymmetry.

You will find more information in Chapter "Asymmetry monitoring (Page 61)".

Group fault diagnostics

You use this parameter to determine whether diagnostics via PROFINET or PROFIBUS DP (fault type) are enabled or disabled.

You will find more information in Chapter "Group fault diagnostics/group warning diagnostics (Page 64).

Group warning diagnostics

You use this device parameter to determine whether or not a maintenance alarm is forwarded to the higher-level CPU.

You will find more information in Chapter "Group fault diagnostics/group warning diagnostics (Page 64).

Input n signal

You use this device parameter to determine whether or not the input level of the digital inputs is to be saved.

You will find more information in Chapter "Inputs (Page 65)".

Input n level

You use this device parameter to specify the input logic.

You will find more information in Chapter "Inputs (Page 65)".

Input n action

Different actions can be triggered when an input signal is present.

You can find out which actions you can parameterize depending on "Input n level", "Input n signal" and "Mode" in Chapter Inputs (Page 65).

Rated operational current I_e

This is where you can enter the rated operational current that the branch (switchgear and motor) can carry without interruption. The setting range depends on the relevant device's rating class.

You will find more information in Chapter "Rated operational current (Page 35)".

Upper/lower current warning limit

You can enter a lower and/or an upper current warning limit value.

Note

The current limits are not activated for startup override until the CLASS time expires, e.g. after 10 seconds for CLASS 10.

You will find more information in Chapter "Upper/lower current warning limit (Page 55)".

Upper/lower current limit

You can enter a lower and/or an upper current limit value.

Note

The current limits are not activated for startup override until the CLASS time expires, e.g. after 10 seconds for CLASS 10.

You will find more information in Chapter "Upper/lower current limit (Page 55)".

Blocking current

If the blocking current is overshot, the motor starter detects stalling.

You will find more information in Chapter "Blocking current (Page 56)".

Blocking time

The blocking time is the time a motor block can be permitted without tripping the motor. If the blocking time expires and the system is still stalled, the motor starter switches off.

You will find more information in Chapter "Blocking time and blocking current (Page 56)".

Warning limit motor heating

The motor starter displays a warning if the motor heating limit is overshot. You use this parameter to preset a motor heating value in percent as a warning limit. At a warning limit of 0 %, the function is deactivated.

You will find more information in Chapter "Overload protection (Page 42)".

See also

Parameterization using a GSD file (Page 93)

4.7 Assigning fail-safe motor starter parameters

4.7.1 Explanation of safety-related parameters

Ex motor

The motor starter can switch and protect loads in an EX protection zone.

Response to safety-related tripping

The motor starter can send a warning to the CPU if tripping has been triggered through the fail-safe input.

See also

Response to safety-related tripping (Page 63)

Ex motor application (Page 63)

4.7.2 Setting safety-related parameters

Fail-safe motor starters possess the following safety-related parameters:

- Ex motor
- Rated operational current
- Trip class

Response to modified safety-related parameters

If modified safety-related parameters are received during run-up, the parameters are displayed. Confirm the modified parameters by pressing the Reset button twice before continuing work.

If modified safety-related parameters are received after run-up has been completed, the motor starter responds as follows depending on its status:

- Motor OFF in automatic mode

  The motor starter accepts the new parameters. The parameters are indicated by the LEDs' flashing sequence. To activate the parameters, confirm them with the blue button. The motor cannot be switched on before the parameters are activated.

- Motor ON in automatic mode and in manual local mode

  The motor starter rejects the parameters. The "Parameter changes not allowed in motor ON state" message is issued. As communication is not secure, the motor starter does not respond to the modified parameters. Depending on the parameterization, entries in data set "DS92" or diagnostic interrupts are generated. The entries in data set "DS92" are deleted as soon as the modified parameters are active.

- Manual local mode

  The motor starter accepts the new parameters and saves them. As soon as manual local mode is ended, the parameters are activated and indicated by means of the LEDs' flashing sequence. Confirm the parameters with the blue button. The motor cannot be switched on before the parameters are activated.

The motor starter remains in the safe state (STO) until you have confirmed the parameters. Before you have confirmed the parameters, they can already be read out in data set "DS203". Data set "DS201" is accepted. A group warning in data set 92 (Page 126) and in the process image of the inputs is triggered. Moreover, a maintenance alarm, "New safety-related parameters received" (0x1036), can be generated.

Response to invalid parameterization

If inconsistent or invalid parameterization is detected, the applicable parameters are discarded. Entries in data set "DS92" or diagnostic interrupts are generated. To narrow down the invalid parameterization, compare the parameter values from the data sets "DS201" and "DS203" or "DS202" and "DS204".

Reading back the data sets "DS201" and "DS202" returns the last correctly transferred data set, even if it is rejected later due to inadmissible content.

Data sets with incorrect lengths are rejected and discarded. The starter continues to operate with the last valid parameter.

4.7.3 Configuring ATEX operation

ET 200SP fail-safe motor starters protect motors in an ATEX environment. The following parameters are considered to be safety-related in ATEX operation:

- Rated operating current (I_e)
- Trip class

You set the parameters via the data sets or using the engineering software.

Before the new safety-related parameters are accepted, however, check and confirm the new parameters. The parameter settings are indicated by means of a flashing sequence of the LEDs on the fail-safe motor starter. As soon as you have ensured with the aid of the LEDs that all parameters are correctly set, confirm the new parameters on the device by means of the blue button. The parameters are not accepted until you have confirmed and the motor starter is "Ready for motor ON". Changes to parameters that are not safety-related do not require confirmation.

LED flashing sequence

The following graphic shows the order in which the LEDs flash:

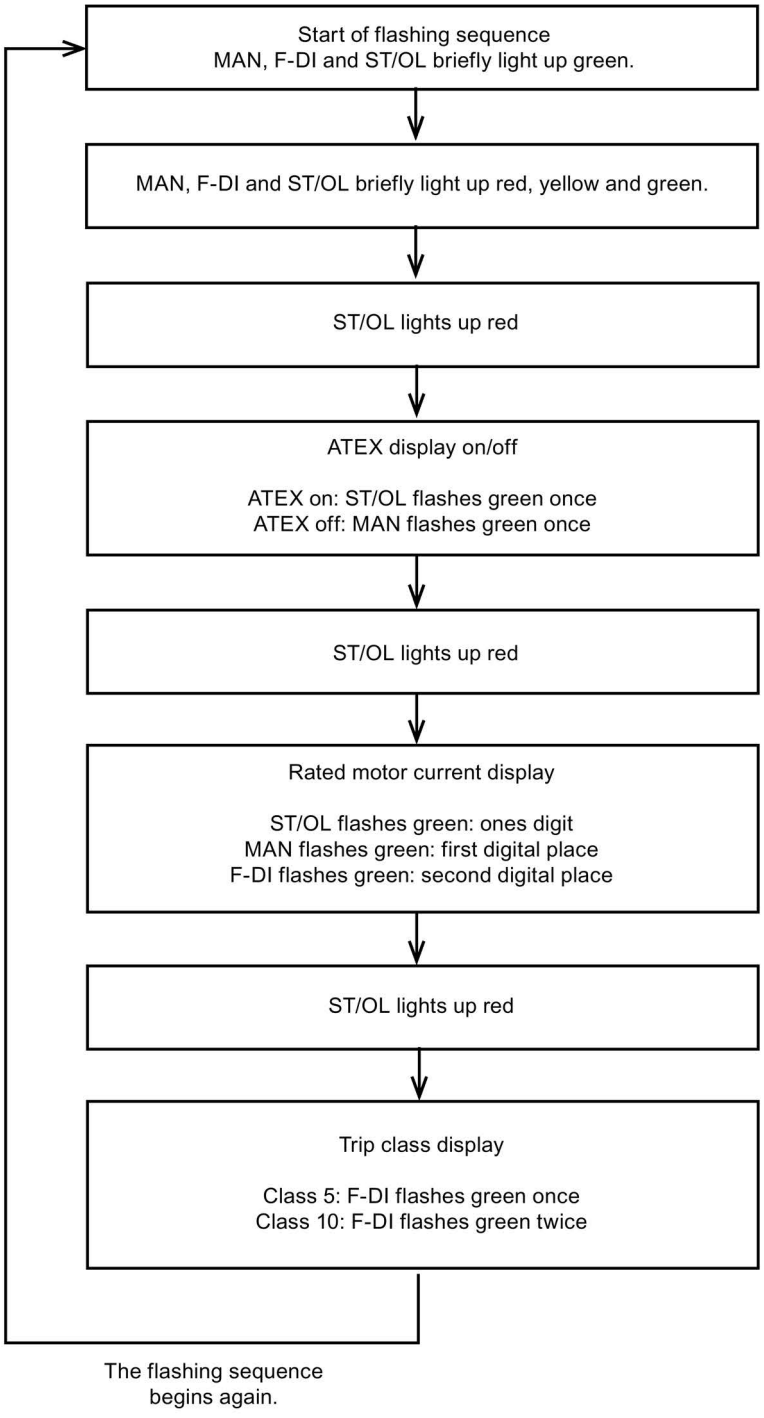


Figure 4-1 Flashing sequence during ATEX operation

The start of the flashing sequence is indicated by the "MAN", "F-DI" and "ST/OL" LEDs, which light up briefly in green all at the same time. The multi-colored LEDs then light up in red and yellow. Lighting up also serves to verify that all LEDs are functioning correctly.

To signal display of the next parameter, the "ST/OL" LED briefly lights up in red between every flashing signal for a set parameter.

The flashing sequence ends as soon as you press the blue button twice and confirm the set parameters.

Note

Receiving several parameter assignments

If safety-related parameters are received during a flashing sequence, conform the first parameters (or reject them) first. Only then are the parameters that have been sent last indicated. The motor cannot be started until the parameters last sent are valid and you have confirmed them.

Rejecting ATEX parameterization

Proceed as follows if you want to reject the set parameterization:

1. Press the blue button for longer than five seconds.

   A group fault is output and the "Invalid parameter value" diagnostic message in data set 92 is set. A logbook entry is also created in data set 73. The diagnostic interrupt 0x1095 is also triggered if group fault diagnostics is enabled. In this state you cannot trigger any of the other functions.

2. Send the correct parameterization via the data set "DS201".
3. Confirm the correct parameterization.

Displaying ATEX parameters

To display the safety-related parameter settings during normal operation, press the TEST/RESET button for at least five seconds.

See also

DS92 Read device diagnostics (Page 126)

4.7.4 Examples of LED flashing sequences

Below you see a few examples of the LED flashing sequence.

Example of I_e = 5 A and CLASS 10

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 5 A and CLASS 10:

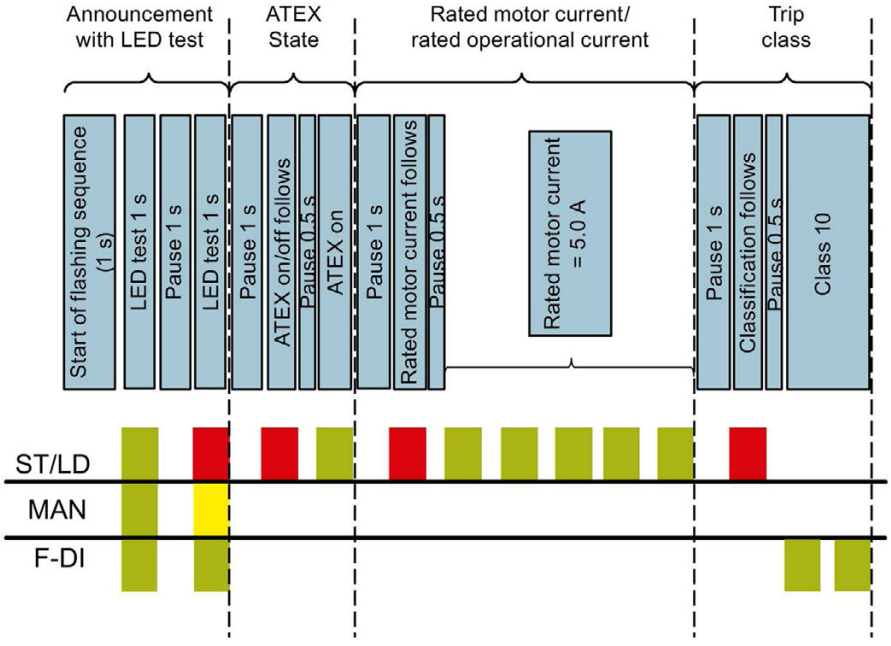


Figure 4-2 Display example I_e = 5.0 A CLASS 10

Example of I_e = 0.34 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 0.34 A and CLASS 5:

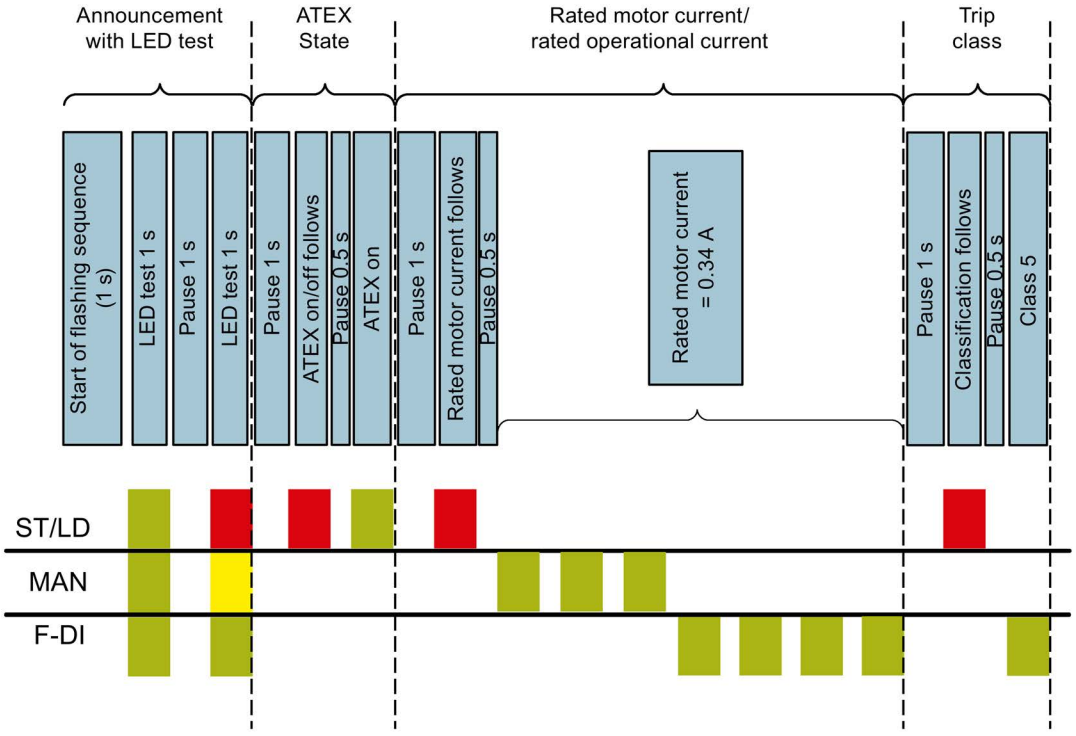


Figure 4-3 Display example I_e = 0.34 A CLASS 5

Example of I_e = 11.4 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 11.4 A and CLASS 5:

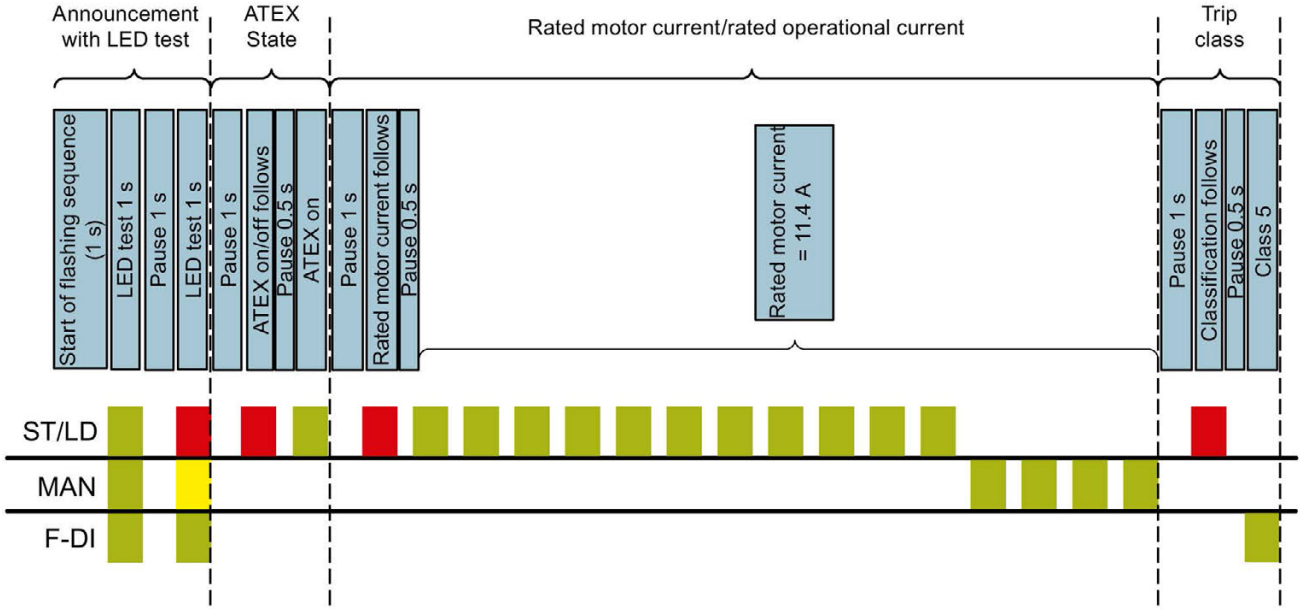


Figure 4-4 Display example 11.4 A CLASS 5

Example of I_e = 3.75 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 3.75 A and CLASS 5:

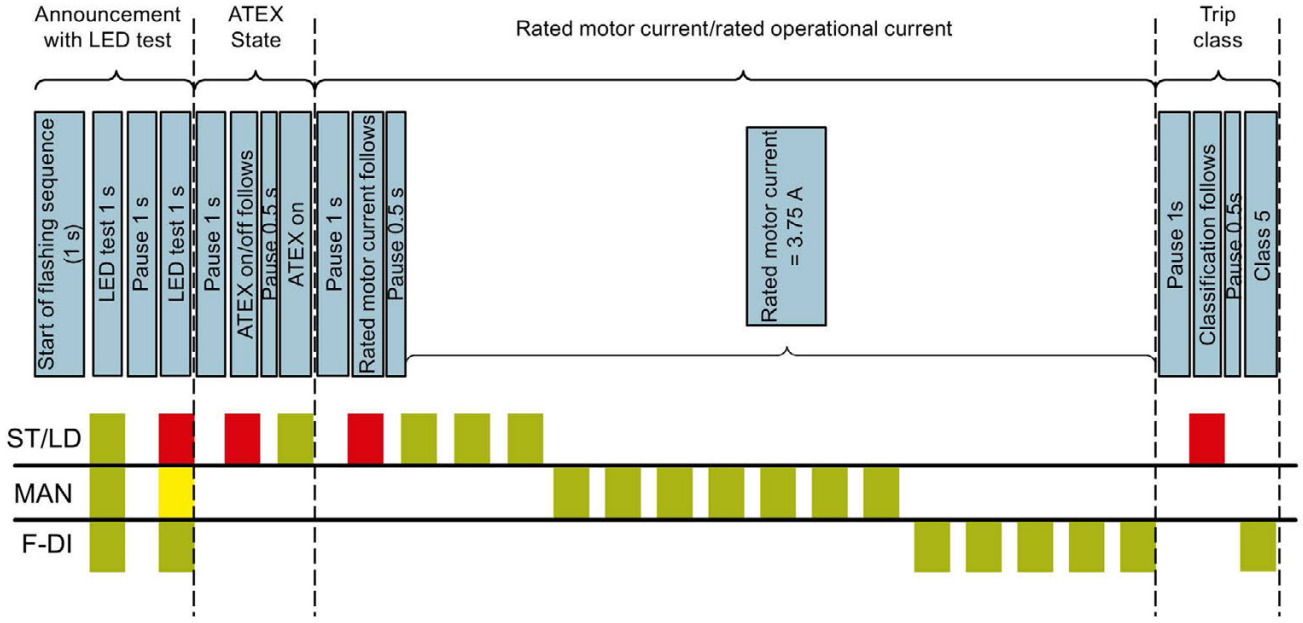


Figure 4-5 Display example I_e = 3.75 A CLASS 5

ATEX off display

The following figure shows the LED flashing sequence when ATEX operation for a fail-safe motor starter is deactivated:

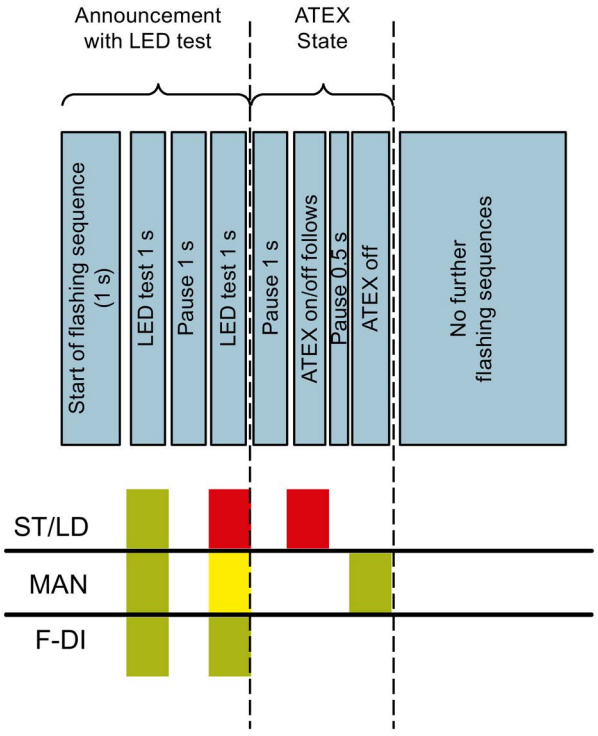


Figure 4-6 ATEX off display

4.8 Address space

Process image of the outputs

Table 4- 1 Contents of process image of the outputs (in bytes 0 to 1)

Process data	Meaning	Relevant for
DQ 0.0	Motor CW	All
DQ 0.1	Motor CCW	Reversing starters only
DQ 0.2	-	-
DQ 0.3	Trip RESET	All
DQ 0.4	Emergency start	All (except activate "EX motor" parameter)
DQ 0.5	-	-
DQ 0.6	-	-
DQ 0.7	Cold start	All except fail-safe versions
DQ 1.0	-	-
DQ 1.1	-	-
DQ 1.2	-	-
DQ 1.3	-	-
DQ 1.4	-	-
DQ 1.5	-	-
DQ 1.6	-	-
DQ 1.7	Disable quick stop	All

Process image of the inputs

Table 4- 2 Process image of the inputs (in bytes 0 to 3)

Process data	Meaning	Relevant for
DI 0.0	Ready (automatic)	All
DI 0.1	Motor ON	All
DI 0.2	Group fault	All
DI 0.3	Group warning	All
DI 0.4	Input 1	All (with 3DI/LC module)
DI 0.5	Input 2	All (with 3DI/LC module)
DI 0.6	Input 3	All (with 3DI/LC module)
DI 0.7	Input LC	All (with 3DI/LC module)
DI 1.0	Motor current I_{curr} [%] bit 0	All
DI 1.1	Motor current I_{curr} [%] bit 1	All
DI 1.2	Motor current I_{curr} [%] bit 2	All
DI 1.3	Motor current I_{curr} [%] bit 3	All
DI 1.4	Motor current I_{curr} [%] bit 4	All
DI 1.5	Motor current I_{curr} [%] bit 5	All
DI 1.6	Manual local mode	All (with 3DI/LC module)
DI 1.7	-	-
DI 2.0	Ready to start for motor ON	All
DI 2.1	Motor CW	All
DI 2.2	Motor CCW	Reversing starters only
DI 2.3	Quick stop active	All
DI 2.4	Energy saving mode active	All
DI 2.5	DI module inserted	All
DI 2.6	Explosion protection of the motor active	Fail-safe starters only
DI 2.7	-	-
DI 3.0	Thermal motor model overload	All
DI 3.1	-	-
DI 3.2	I_e current limit tripping	All
DI 3.3	F-DI status	Fail-safe starters only
DI 3.4	Residual current detected	All
DI 3.5	Asymmetry detected	All
DI 3.6	Overtemperature	All
DI 3.7	-	-

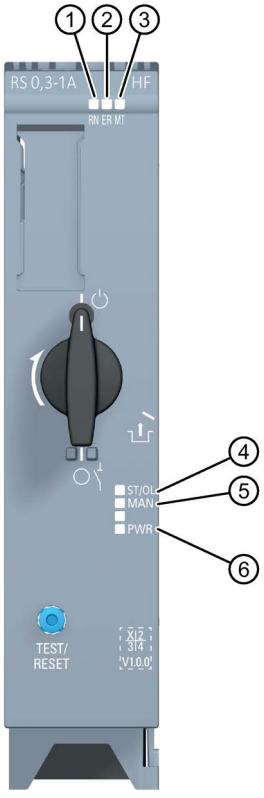
Alarms/diagnostic messages

5

5.1 Status and error displays

LED display

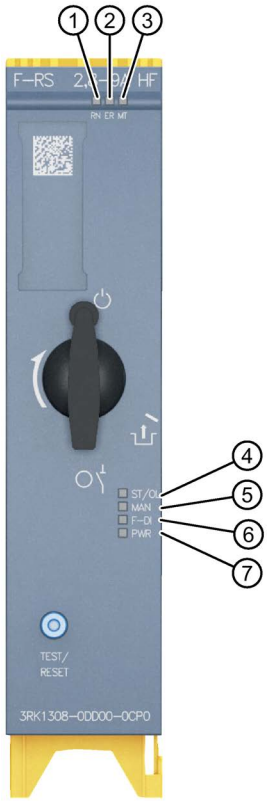
The figure below shows the LED display on the SIMATIC ET 200SP motor starter:



①	RN	(green)	- Run
②	ER	(red)	- Error
③	MT	(yellow)	- Maintenance
④	ST/OL	(red/green)	- State/overload
⑤	MAN	(yellow)	- Manual (manual local mode)
⑥	PWR	(green)	- Power

Figure 5-1 LED display on the SIMATIC ET 200SP motor starter

The figure below shows the LED display on the fail-safe SIMATIC ET 200SP motor starter:



①	RN	(green)	- Run
②	ER	(red)	- Error
③	MT	(yellow)	- Maintenance
④	ST/OL	(red/green)	- State/overload
⑤	MAN	(yellow)	- Manual (manual local mode)
⑥	F-DI	(green)	- Fail-safe digital input
⑦	PWR	(green)	- Power

Figure 5-2 LED display on the fail-safe SIMATIC ET 200SP motor starter

Meaning of the LEDs

The tables below give the meanings of the status and fault displays:

RN/ER/MT LED

Table 5- 1 RN/ER/MT status and error displays

LEDs			Meaning	Explanation
RN (RUN)	**ER (ERROR)**	**MT (MAINT)**		
■ On	Not relevant	Not relevant	Operating state "RUN", the SIMATIC ET 200SP motor starter is in a "normal" application and executes the control commands. The current operating mode is not relevant.	-
☼ Flashes	Not relevant	Not relevant	Start (Cfg + Par.) Self-test Module deactivated Parameterization error	System operating state "System startup" A parameterization fault during startup prevents exiting of this state. The SIMATIC ET 200SP motor starter reports a fault.
				Wait until the SIMATIC ET 200SP motor starter is ready.
				Firmware update
				The module has been deconfigured.
Not relevant	Not relevant	■ On	Maintenance demanded (warning)	Group warning At least one Maintenance demanded alarm has been transferred to the controller. Possible causes: • Motor model has exceeded warning limit • Current value has exceeded or undershot warning limit • Start disabled, SIMATIC ET 200SP motor starter too warm (without ON command)
Not relevant	☼ Flashes at ≥ 3 s	Not relevant	Error	Group fault At least one Error alarm has been transferred to the controller. Possible causes: • Electronics supply voltage too low or too high • Motor protection disconnection • Thermal overload of the SIMATIC ET 200SP motor starter • Missing load voltage, phase failure/missing load • The mechanical rotary interlock is not in the READY position.
■ On	OFF	☼ Flashes	PROFIenergy active	-

ST/OL (STATE/OVERLOAD) LED

Table 5- 2 Status display ST/OL

ST/OL LED	Motor operating state	Meaning
■ On	Operation	ON command for motor active
□ Off	STOP	The motor is switched off. It is not known whether the motor is still rotating or not.
☼ Flashes at 3 s	Overload	The thermal motor model or device protection model has tripped.

MAN (MANUAL) LED

Table 5- 3 Status display MAN

MAN LED	Meaning	Remedy
□ Off	Manual local mode deactivated	-
■ On	Manual local mode activated	-

PWR (POWER) LED

Table 5- 4 Status display PWR

PWR LED	Meaning	Remedy
□ Off	Supply voltage not present or too low	Check the supply voltage.
■ On	Supply voltage present	-

LED F-DI for fail-safe motor starters

Table 5- 5 Status display F-DI

LED F-DI	Meaning	Remedy
□ Off	LOW level at the fail-safe digital input on the BaseUnit in the case of a fail-safe motor starter.	-
■ On	HIGH level at the fail-safe digital input on the BaseUnit in the case of a fail-safe motor starter.	-

LED combinations

Table 5- 6 Status displays ST/OL/MAN/PWR

LEDs			Meaning	Explanation
ST/OL (State/ Overload)	**MAN (Manual)**	**PWR (Power)**		
Lights up for 4 s	Lights up for 4 s	Lights up for 4 s	LED/fan test	All LEDs are switched on for 4 s (triggered by pressing the blue button).
Flashes	Flashes	Lights up	Firmware update active or canceled	-
OFF	OFF	OFF	No supply voltage	No supply voltage available A detected undervoltage (in the case of still functioning electronics) is not reported as power OFF, but as a fault.
Flashes	Flashes	Lights up	Device fault	Non-correctable fault detected following self-diagnostics (contactor contacts, switching element, etc.). Remedy: Check the logbook entries. If necessary, replace the device.

5.2 TEST/RESET button

The RESET button has the following functions:

Designation	Tripping	Description
LED/fan test	Press of a button for less than two seconds	The LED/fan test is activated. All LEDs (ST/OL, MAN, PWR) light up and the fan is switched on for 4 s. An LED/fan test is not possible in the case of fail-safe motor starters with F-DI deactivated (safety-related shutdown by low level).
RESET function	Press of a button	If a group fault is active, you can acknowledge this fault using the blue button. You can acknowledge device faults in principle only via ON/OFF of the control voltage. Note: If a fault is active, you cannot execute the LED/fan test.

Additional functions in the case of fail-safe motor starters

Confirming ATEX parameters	Press of a button	You confirm display of the parameters via an LED flashing sequence by pressing the RESET button twice.
Discarding ATEX parameterization	Press of a button for longer than five seconds.	By pressing the button for longer than five seconds, you discard newly set ATEX parameters and you return to the original parameterization.
Displaying ATEX parameterization	Press of a button for longer than five seconds.	By pressing the button for longer than five seconds, you can display the currently set ATEX parameters during operation.
Switching to commissioning mode	Press of a button	In "Manual local" mode, confirm the change to commissioning mode by the fail-safe motor starter by pressing the button.

5.3 Interrupts

The SIMATIC ET 200SP motor starter supports diagnostic interrupts and maintenance. You can read out the diagnoses of the motor starter in the following data sets:

- Data set 72: Read device faults (Page 120)
- Data set 73: Read trips (Page 122)
- Data set 75: Read events (Page 124)
- Data set 92: Read device diagnosis (Page 126)

A diagnostics message is output for each diagnostics event and the ER LED flashes on the module when group fault diagnostics are enabled. You can read out the diagnostic messages in the diagnostics buffer of the CPU, for example. You can evaluate the error codes via the user program. The following table shows the individual diagnostic messages:

Error type channel diagnostics	Fault text	Remedial measures
0003_h	Overvoltage	Cause: The supply voltage is above the tolerance limit. Remedy: Change the power supply.
$001F_h$	Channel temporarily unavailable	Wait until the firmware update is completed.
$100A_h$	Test mode current flow	Current is flowing in the motor feeder although the motor feeder is in test mode or the test position (TPF). Possible causes: The main circuit is not interrupted in test operation.
1021_h	Phase unbalance	The limit value for phase unbalance has been exceeded. Phase unbalance can cause an overload. Possible causes: Failure of the phase, fault in the motor windings Remedy: Check the motor feeder and the motor.

Error type channel diagnostics	Fault text	Remedial measures
1022h	Thermal motor model overload	The motor feeder has been overloaded. The motor temperature rise has exceeded a limit. Remedy: Please check the motor and the applications that are being driven by the motor. After a trip, you can switch the motor on again after the cooling time has expired, or after the thermal motor model has been deleted.
134Bh	Trip reset not possible	Trip reset is currently not possible (e.g. because the cooling phase is in progress). Remedy: Repeat the action later (e.g. after the cooling time has elapsed).
1093h	Sensor supply overload	The output driver for the sensor supply is overloaded. Remedy: Check the cabling and the sensor.
1036h	Receiving new safety-related parameters (fail-safe motor starters only)	You have modified safety-related parameters. These have not yet been confirmed.
1040h	Threshold I exceeded	The current has exceeded a limit. Remedy: Please check the application that is being driven by the motor.
1041h	Threshold I undershot	The current has undershot a limit. Remedy: Please check the application that is being driven by the motor.
104Ch	Motor blocking	The maximum motor current has exceeded a limit for blocking protection. Possible cause: The motor is blocked. Remedy: Please check the application that is being driven by the motor.
1080h	Device fault	Non-correctable fault detected following self-diagnostics (contactor contacts, switching element, etc.). Remedy: Check the logbook entries. If necessary, replace the device.
1083h	Switching element overload	Switching element (switching contact, power semiconductor) too hot. Check the ambient conditions linked to cooling. You might have to take derating into consideration. Check the number of switching operations. Also check whether the fan is working properly.
1084h	Electronics supply voltage too low	The supply voltage is below the permissible value. Remedy: Check the power supply (load measurement, voltage range)
1088h	No switching element supply voltage	No supply voltage has been detected or the mechanical rotary interlock is not in the READY position. Remedy: Check the power supply to the switching elements and the cabling or turn the mechanical rotary interlock to the READY position.

Error type channel diagnostics	Fault text	Remedial measures
1095h	Parameterization error	The module is not yet parameterized or is incorrectly parameterized or the safety-related parameters have been rejected. Remedy: Correct the parameterization.
1096h	Process image error	The process image output (PIQ) contains invalid control bit combinations (e.g. control bits for clockwise and counter-clockwise set simultaneously). Remedy: Check and correct the process image output (PIQ).
109Dh	Input Action	A warning or trip signal is active on at least one input. Remedy: Check the application.
109Eh	Emergency end position CW	The "CW" emergency end position has been passed. Remedy: Check the end position of the drive.
109Fh	Emergency trip end position CCW	The "CCW" emergency end position has been passed. Remedy: Check the end position of the drive.
10A5h	Phase failure or fuse defective	Possible causes: Phase failure, fault in the motor winding, fuse in the device defective Remedy: Check the motor feeder (main circuit) and the motor. Clear the short-circuit in the system and replace the device.

5.4 Maintenance

A maintenance alarm is output for each group warning and the MT LED lights up on the module when group warning diagnostics are enabled. You can read out the diagnostic messages in the diagnostics buffer of the CPU, for example. You read the maintenance alarms in data set 75 (Page 124) of the motor starter.

Extended maintenance

You will find general information on extended maintenance in "Diagnostics" in the SIMATIC PROFINET Function Manual (https://support.industry.siemens.com/cs/de/de/view/49948856/en).

The PROFINET interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET according to the standard IEC 61158-6-10. The aim is early detection and correction of potential faults. The motor starter's full functionality (maintenance) is available with firmware version V3.3 of the interface module.

The maintenance information is generated in STEP 7 with the following system messages:

- Maintenance request - symbolized by a yellow screwdriver.
- Faults - symbolized by a red screwdriver

See also

SIMATIC ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293)

Technical data

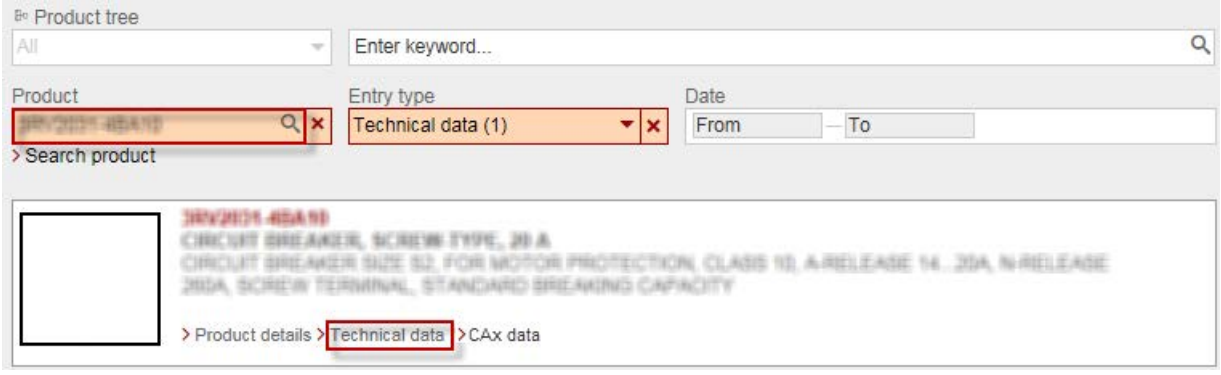
6

6.1 Technical data in Siemens Industry Online Support

Technical data sheet

You can also find the technical data of the product at Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "Technical data link.



6.2 Final conditions for safety-related parameters

The safety-related parameters in the data sheet have been determined on the basis of the following final conditions:

- Side-by-side mounting at rated current I_n
- 100% ON period of electronics
- 40 °C ambient temperature
- DIN EN 60721-3-7 noxious gas environment: class 3C2

T1 proof test interval

The T1 proof test interval is defined by the device's internal tests and by the switching cycle duration.

$T1_{min}$ = 10 min is fulfilled if the motor starter's switching cycle duration is less than ten minutes.

$T1_{max}$ = 1 month is achieved if the motor is operated in uninterrupted duty and the test switching cycle has been run after one month.

Validity of safety engineering data

The safety engineering data specified in the data sheet is valid under the following prerequisites:

The specified PFH/PFD value is valid until the electrical endurance (B10) or the service life has been reached. Replace the device if either the electrical lifetime or the service life has been exceeded. The application is outside of the specification if the maximum number of starting operations is exceeded once per hour.

Note

Definition of "number of starting operations"

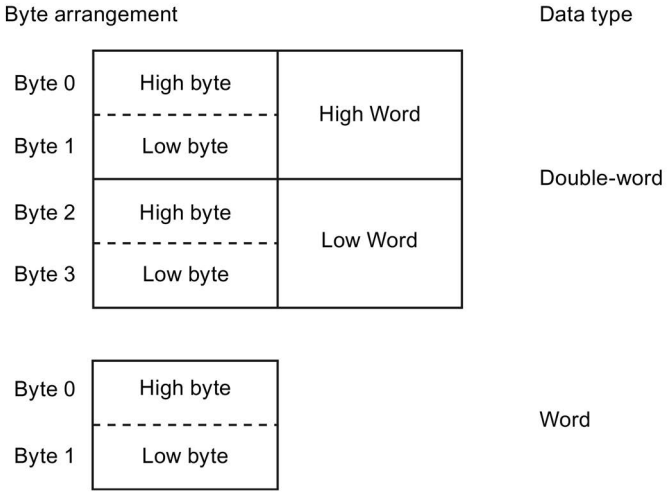
The "number of starting operations" stands for the frequency of switching of the main conducting path switching elements, i.e. switching on and off of the connected motor and not requesting of STO via the power supply or the fail-safe digital input.

Data sets

A

A.1 Byte arrangements

When data longer than one byte is stored, the bytes are arranged as follows ("big endian"):



A.2 DS72 logbook - Read device error

Byte	Data type	Meaning	Range of values	Increment
Entry 1 (= latest entry)				
0 … 3	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
4 … 5	Signed 16	Object number	0 … ±32767	1
Entry 2 (= second-latest entry)				
6 … 9	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
10 - 11	Signed 16	Object number	0 … ±32767	1
… …				
Entry 21 (last, oldest entry)				
120 … 123	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
124 … 125	Signed 16	Object number	0 … ±32767	1

The data set call "Logbook device fault" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

Note

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete logbooks yourself.

The supported object numbers and their meanings are shown in the table below: in the case of standard motor starters, you can acknowledge faults by switching off the supply voltage and by switching it on again. Replace the motor starter if the fault occurs again. In the case of fail-safe motor starters, there are some faults that you cannot acknowledge. Always replace the fail-safe motor starter if the relevant message in the "Fail-safe motor starter defective" column is marked with an "x".

Table A- 1 Assignment of object number to device error message

Object No.	Device fault messages	Fail-safe motor starter defective
308	Switching element defective	x
417	Stack overflow	-
418	Stack underflow	-
437	Watchdog overflow	-
456	EEPROM: memory defective	x
458	EEPROM: CRC error "Device parameter"	x
460	EEPROM: Contains invalid data	-
464	ROM error	x
476	Current measuring defective	x
478	Bypass element does not close	-
479	Bypass element does not open	x
480	Bypass element protection has opened unintentionally during operation	-
486	Program execution check: Sequential program execution error	-
487	Program execution check: Logical programming error	-
490	Incorrect power section detected	-
1414	Switching element short-circuited	x
1417	Bypass element defective	x
1466	Contact 1 failed	x
1467	Contact 2 failed	x
381	Self-test error	-
1407	Electronics supply voltage too high	-
1482	Current measuring range overshot	x
20010	Direct-on-line or reversing relay defective (Available for fail-safe motor starters only)	x
20011	12 V power supply defective (Available for fail-safe motor starters only)	x
20012	F-DI defective (Available for fail-safe motor starters only)	x
20013	Hard switching of relays (Available for fail-safe motor starters only)	x
20015	Relay control defective feedback message (Available for fail-safe motor starters only)	x
20017	Residual current detection or bypass element does not close	-

A.3 DS73 logbook - Read triggering operations

Byte	Data type	Meaning	Range of values	Increment
Entry 1 (latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 … ±32767	
Entry 2 (second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
10 ... 11	Signed 16	Object number	0 … ±32767	
… …				
Entry 21 (last, oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 … ±32767	

The data set call "Logbook trips" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

Note

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete the logbook.

The supported object numbers and their meaning are shown in the table below:

Table A- 2 Assignment of object number to trips message

Object No.	Trips message	Comment
305	Safety-related tripping	Fail-safe motor starters only
309	Switching element overload	-
317	Electronics supply voltage too low	-
328	Motor overload trip	Tripping of the thermal motor model
333	Mechanical rotary interlock is not in the READY position	-
334	I_e upper limit violation	-
335	I_e lower limit violation	-
338	Residual current tripping	-
339	Tripping due to motor blocking	-
341	Asymmetry tripping	-
348	Input tripping	-
349	Input trip CW	-
350	Input trip CCW	-
354	Sensor supply overload	
355	Process image error	-
365	Invalid parameter value	Group fault only on startup
384	No external startup parameters received	-
1406	Cold start tripping	Non-fail-safe motor starters only
20016	Insufficient temperature	-

A.4 DS75 logbook - Read events

Byte	Data type	Meaning	Range of values	Increment
User data (technology data)				
Entry 1 (latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 … ±32767	
Entry 2 (second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
10 ... 11	Signed 16	Object number	0 … ±32767	
… …				
Entry 21 (oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 … 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 … ±32767	

The data set call "Logbook events" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

Note

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete the logbook.

The supported object numbers and their meaning are shown in the table below:

Table A- 3 Assignment of object number to event message

Object No.	Event messages	Comment
	Warnings	
327	Thermal motor model overload	In the case of a group fault, the message "Motor overload trip" is also queued.
337	Residual current detected	-
340	± Asymmetry detected	-
351	Input warning	-
365	Invalid parameter value	Not in the case of startup since it is a group fault
366	Parameters cannot be changed in ON state	-
1539	Warning limit - motor heating exceeded	-
1541	± I_e-warning limit exceeded	-
1542	± I_e-warning limit undershot	-
	Actions	
310	± Emergency start active	-
357	Automatic mode	Enter at the time of changeover
359	Manual local mode	Enter at the time of changeover
376	Firmware update successful	-
378	Firmware update has errors	-
454	Internal communication fault	-
1520	± Energy-saving mode active	-
1580	Switching element hot	-

±: Event is entered as "incoming" (+) and "outgoing" (-) event. Other messages are entered only as "incoming" messages

A.5 DS92 Read device diagnostics

Object No.	Byte.Bit	Meaning	Relevant for
User data (technology data) Switching/controlling			
301	0.0	Ready (automatic) The device is ready for operation via the controller. There is no connection to the mechanical rotary interlock.	All
306	0.1	Motor CW	All
307	0.2	Motor CCW	Reversing starter
309	0.3	Switching element overload	All
308	0.4	Switching element defective	All
310	0.5	Emergency start active	All
302	0.6	Group fault	All
304	0.7	Group warning	All
-	1.0-9	Reserved	-
Protection function (motor, cable, short-circuit)			
-	2.0-2	Reserved	
327	2.3	Thermal motor model overload	All
328	2.4	Overload tripping	All
-	2.5	Reserved	-
330	2.6	Cooling time active	All
305	2.7	F-DI status	Fail-safe motor starters
-	3.0-1	Reserved	-
333	3.2	Mechanical rotary interlock is not in the READY position	All
-	3.3-6	Reserved	-
352	3.7	Input control	All
340	4.0	Asymmetry detected	All
341	4.1	Asymmetry tripping	All
334	4.2	I_e upper limit violation	All
335	4.3	I_e lower limit violation	All
-	4.4	-	-
337	4.5	Residual current detected	All
338	4.6	Residual current tripping	All
339	4.7	Tripping due to motor blocking	All
344	5.0	Input 1	All
345	5.1	Input 2	All
346	5.2	Input 3	All
347	5.3	Input LC	All
348	5.4	Input tripping	All
349	5.5	Input trip CW	All

Object No.	Byte.Bit	Meaning	Relevant for
351	5.6	Input warning	All
350	5.7	Input trip CCW	All
-	6.0-1	Reserved	-
353	6.2	Quick stop active	All
354	6.3	Sensor supply overload	All
-	6.4-6	Reserved	-
317	6.7	Electronics supply voltage too low	All
Communication			
-	7.0	Reserved	-
356	7.1	CPU or master STOP	All
357	7.2	Automatic mode	All
-	7.3	Reserved	-
359	7.4	Manual local (local control) (no connection to the mechanical rotary interlock)	All
-	7.5-6	Reserved	-
355	7.7	Process image error	reversing starter
-	8.0	Reserved	-
365	8.1	Invalid parameter value • During operation • During starting • Rejected safety-related parameters	All
366	8.2	Parameters cannot be changed in ON state	All
-	8.3	Reserved	-
384	8.4	No external startup parameters received	All
-	8.5-7	Reserved	-
-	9.0-1	Reserved	-
381	9.2	Error during self-test	Fail-safe motor starters only
-	9.3-7	Reserved	-
367	10-11	Incorrect parameter number (as word)	All
	12-13	Reserved	All
Device functions			
1405	14.0	Cold start active	Non-fail-safe motor starters only
1406	14.1	Cold start tripping	Non-fail-safe motor starters only
-	14.2-7	Reserved	-
-	15-18	Reserved	-

Object No.	Byte.Bit	Meaning	Relevant for
Switching/controlling			
1407	19.0	Electronics supply voltage too high	All
1470	19.1	Ready for motor ON	All
1414	19.2	Switching element short-circuited	All
1417	19.3	Bypass element defective	All
-	19.4-7	Reserved	-
-	20	Reserved	-
-	21.0-1	Reserved	-
Protection function			
1482	21.2	Current measuring range overshot	All
-	21.3-7	Reserved	-
Communication (operating modes)			
357	22.0	Automatic mode (redundant to Bit 7.2, no connection to the mechanical rotary interlock)	All
-	22.1-2	Reserved	-
359	22.3	Manual local mode (redundant to Bit 7.4, no connection to the mechanical rotary interlock)	All
-	22.4-7	Reserved	-
-	23	Reserved	-
Prewarnings			
-	24-25	Reserved	-
Maintenance			
-	26-31	Reserved	-
Quick Stop			
1508	32.0	Quick Stop 1 - direction-independent	All
1509	32.1	Quick Stop 1 - clockwise	All
1510	32.2	Quick Stop 1 - counter-clockwise	Reversing starter
-	32.3-7	Reserved	-
-	33	Reserved	-
End position			
1507	34.0	Input operational trip - end position CW	All
1506	34.1	Input operational trip - end position CCW	All
-	34.2-7	Reserved	-
-	35	Reserved	-
Energy saving function			
-	36.0-5	Reserved	-
1522	36.6	Start_Pause command is pending	All
1520	36.7	Energy saving mode active	All
-	37	Reserved	-
Operating states			
-	38-49	Reserved	-

Object No.	Byte.Bit	Meaning	Relevant for
		Ex motor protection	
1535	50.0	Explosion protection of the motor active	Fail-safe motor starters only
-	50.1	Reserved	-
1537	50.2	New safety-related parameters received	-
-	50.3-7	Reserved	-
-	51	Reserved	-
		Warnings	
-	52.0-3	Reserved	-
1541	52.4	I_e warning limit exceeded	All
1542	52.5	I_e warning limit undershot	All
-	52.6-7	Reserved	-
-	53	Reserved	-

A.6 DS94 Read measured values

Object No.	Byte.Bit	Coding	Meaning	Range of values	Increment
	User data (technology data)				
	Measured values (volatile)				
504	0	Unsigned 8	Phase current $I_{L1(\%)}$	0 ... 796 %	3.125 %
505	1	Unsigned 8	Phase current $I_{L2(\%)}$	0 ... 796 %	3.125 %
506	2	Unsigned 8	Phase current $I_{L3(\%)}$	0 ... 796 %	3.125 %
-	3 ... 6	0x00	Reserved	-	-
503	7	Unsigned 8	Unbalance	0 ... 255 %	1 %
502	8 ... 9	Unsigned 16	Motor heating	0 ... 1,000 %	1 %
-	10 ... 27	0x00	Reserved	-	-
513	28 ... 31	Signed 32	Phase current $I_{L1(rms)}$	±0 ... 20,000 A	0.01 A
514	32 ... 35	Signed 32	Phase current $I_{L2(rms)}$	±0 ... 20,000 A	0.01 A
515	36 ... 39	Signed 32	Phase current $I_{L3(rms)}$	±0 ... 20,000 A	0.01 A
516	40 ... 41	Unsigned 16	Electronics supply voltage	0 ... 1,500 V	0.1 V
-	42 ... 63	0x00	Reserved	-	-

A.7 DS95 Read statistics

Object No.	Byte.Bit	Coding	Meaning	Range of values	Increment
	User data (technology data)				
-	0	0	Reserved	-	-
-	1.0-5	0	Reserved	-	-
-	1.6-7	11_B	Bit 6 operating hours resolution 1 second Bit 7 operating hours selection 1 operating hour - device	11 (fixed)	1
-	2 ... 3	0x00	Reserved	-	-
682	4 ... 7	Unsigned 32	Device operating hours in seconds	0 ... (2^{32}-1)	1 s
603	8 ... 11	Unsigned 32	Number of motor CW starts	0 ... (2^{32}-1)	1
604	12 ... 15	Unsigned 32	Number of starts motor CCW	0 ... (2^{32}-1)	1
605	16 ... 17	Unsigned 16	Number of motor overload trips Is incremented on tripping by: • Blocking current monitoring • Overload protection	0 ... (2^{16}-1)	1
-	18 ... 19	0x00	Reserved	-	-
609	20 ... 23	Signed 32	Motor current $I_{max\ (rms)}$	±0 ... 20,000	0.01 A
608	24 ... 27	Signed 32	Last tripping current $I_{A\ (rms)}$	±0 ... 20,000	0.01 A
602	28 ... 31	Unsigned 32	Motor operating hours in seconds	0 ... (2^{32}-1)	1 s
615	32 ... 49	0x00	Reserved	-	-
616	50 ... 51	Unsigned 16	Number of switching element overload trips	0 ... (2^{16}-1)	1
20020	52 ... 53	Unsigned 16	Number of hard switching operations of the relay	0 ... (2^{16}-1)	1
-	54 ... 89	0x00	Reserved	-	-

A.8 Read/write DS201 device parameter 1

DS201 contains the second part of the device parameters.

If incorrect parameters are sent to the motor starter in DS201, these incorrect parameters will also be reported back when reading DS201. In the case of incorrect parameters, the object number of the first incorrect parameter is output in WORD 10 of DS92.

The defaults for factory settings of the motor starter appear in italics in the Value range column. In the engineering system, a distinction is made between the default values of the input actions and the current range of the defaults of the motor starter.

Object No.	Byte.Bit	Range of values	Meaning	See Chapter ...
-	0.0	[0]	Reserved	-
3	0.1	*[0]: 3-phase* [1]: 1-phase	Load type (only for direct-on-line starters)	Load type (Page 36)
2209	0.2-0.3	*[0]: No* [1]: Yes	EX motor application (ATEX operation)	Ex motor application (Page 63)
6	0.4 - 0.7	[3]: CLASS 5 (10a) *[0]: CLASS 10*	Trip class	Overload protection (Page 42)
5	1.0 - 1.1	*[0]: Trip without restart* [1]: Tripping with restart (not during ATEX operation) [2]: Warning (not during ATEX operation)	Response to overload - TMM	Overload protection (Page 42)
4	1.2	*[0]: Retention of the thermal motor model on restart* [1]: Deletion of the thermal motor model on restart (not during ATEX operation)	The charge state of the thermal motor model is deleted at run-up. In this way, unintentional early trips can be prevented if the motor starter has been switched off for an extended period.	Overload protection (Page 42)
20000	1.3	[*0]: No warning in the case of safety-related tripping [0019H]* [1]: Warning in the case of safety-related tripping [0019H]	Response to safety-related tripping with F-DI	Response to safety-related tripping (Page 63)
34	1.4	*[0]: Switch substitute value* [1]: Retain last value	Response to CPU/master STOP	Response to CPU/master STOP (Page 64)
19	1.5	[0]: Warning (not in the case of fail-safe motor starters) *[1]: Tripping*	Response to residual current detection	Response to residual current detection (Page 52)
20	1.6	[0]: Warning (not during ATEX operation) *[1]: Tripping*	Response to asymmetry	Asymmetry monitoring (Page 61)
-	1.7	[0]	Reserved	-
25	2.0	[0]: NC contact *[1]: NO contact*	Input 1 level	Inputs (Page 65)
27	2.1	See input 1 level	Input 2 level	Inputs (Page 65)
29	2.2	See input 1 level	Input 3 level	Inputs (Page 65)

Object No.	Byte.Bit	Range of values	Meaning	See Chapter ...
193	2.3	*[0]: Enable* [1]: Disable	Group fault diagnostics	Group fault diagnostics/group warning diagnostics (Page 64)
80	2.4	*[0]: Non-retentive* [1]: Retentive	Input 1 signal	Inputs (Page 65)
81	2.5	See input 1 signal	Input 2 signal	Inputs (Page 65)
82	2.6	See input 1 signal	Input 3 signal	Inputs (Page 65)
191	2.7	[0]: Enable *[1]: Disable*	Group warning diagnostics	Group fault diagnostics/group warning diagnostics (Page 64)
194	3	[0]: No action [1]: Trip without restart [2]: Trip with restart [3]: Trip end position CW [4]: Trip end position CCW [5]: Group warning [7]: Emergency start (not during ATEX operation) *[8]: Motor CW* [9]: Motor CCW [11]: Quick Stop (direction-independent) [12]: Trip RESET [13]: Cold start (not during ATEX operation) [14]: Quick Stop clockwise [15]: Quick Stop counter-clockwise [37]: Operational trip end position CW [38]: Operational trip end position CCW	Input 1 action	Inputs (Page 65)
195	4	See input 1 - action *[9]: Motor CCW (default for reversing starters)*	Input 2 action	Inputs (Page 65)
196	5	See input 1 - action *[13]: Cold start (default for standard motor starters)*	Input 3 action	Inputs (Page 65)
2	6 - 7	0.3 … 12 A/10 mA *The maximum current is preset.*	Rated operational current I_e The rated operational current is MLFB-dependent, and thus also the maximum setting range.	Rated operational current (Page 35)
15	8	18.75 … 100 %/3.125 % [6 … 32] *[0]: Deactivated*	Lower current limit	Upper/lower current limit (Page 55)
16	9	50 … 400 %/3.125 % [16 … 128] *[0]: Deactivated*	Upper current limit	Upper/lower current limit (Page 55)

See also

Trip without restart (Page 71)

Trip with restart (Page 71)

A.9 Read/write DS202 device parameter 2

DS202 contains the second part of the device parameters.

If incorrect parameters are sent to the motor starter in DS202, these incorrect parameters will also be reported back when reading DS202. In the case of incorrect parameters, the object number of the first incorrect parameter is output in WORD 10 of DS92.

The defaults appear in italics in the Value range column.

Object No.	Byte.Bit	Range of values	Meaning	See Chapter ...
18	0.0 - 0.3	*1* … 7.5 s/0.5 s [2 … 15] *Default value is [2]: 1 s.*	Blocking time	Blocking time and blocking current (Page 56)
-	0.4 - 0.7	[0]: Reserved	Reserved	-
2210	1	0 … 99 %/1 % [0 … 99] [0]: *Deactivated*	Warning limit - motor heating	Overload protection (Page 42)
-	2 - 3	[0]: Reserved	Reserved	-
-	4 - 5	[0]: Reserved	Reserved	-
17	6	150 ... 1000 %/50 % [3 ... 20] *Default value is [16]: 800 %*	Blocking current	Blocking time and blocking current (Page 56)
-	7	[0]: Reserved	Reserved	-
2213	8	18.75 … 100 %/3.125 % [6 … 32] [0]: Deactivated *Default value is [7]: 21.875 %*	Lower current warning limit	Upper/lower current warning limit (Page 55)
2214	9	50 … 400 %/3.125 % [16 … 128] [0]: Deactivated *Default value is [36]: 112.5 %*	Upper current warning limit	Upper/lower current warning limit (Page 55)

A.10 Read DS203 device parameter 1

DS203 contains the second part of the incorrect parameter with which the motor starter is working. The defaults appear in italics in the Value range column.

Object No.	Byte.Bit	Range of values	Meaning	See Chapter ...
-	0.0	[0]	Reserved	-
3	0.1	*[0]: 3-phase* [1]: 1-phase	Load type (only for direct-on-line starters)	Load type (Page 36)
2209	0.2 - 0.3	*[0]: No* [1]: Yes	Ex motor	Ex motor application (Page 63)
6	0.4 - 0.7	[3]: CLASS 5 (10a) *[0]: CLASS 10*	Trip class	Overload protection (Page 42)
5	1.0 - 1.1	*[0]: Trip without restart* [1]: Trip with restart [2]: Warn only	Response to overload - TMM	Trip without restart (Page 71) Trip with restart (Page 71)
4	1.2	*[0]: Retention of the thermal motor model on restart* [1]: Deletion of the thermal motor model on restart	The charge state of the thermal motor model is deleted at run-up. In this way, unintentional early trips can be prevented if the motor starter has been switched off for an extended period.	Overload protection (Page 42)
-	1.3	[0]	Reserved	-
34	1.4	*[0]: Switch substitute value 0* [1]: Retain last value	Response to CPU/master STOP	Response to CPU/master STOP (Page 64)
19	1.5	[0]: Warn *[1]: Tripping*	Response to residual current detection	Response to residual current detection (Page 52)
20	1.6	[0]: Warn *[1]: Tripping*	Response to asymmetry	Asymmetry monitoring (Page 61)
-	1.7	[0]	Reserved	-
25	2.0	[0]: NC contact *[1]: NO contact*	Input 1 level	Inputs (Page 65)
27	2.1	See input 1 level	Input 2 level	Inputs (Page 65)
29	2.2	See input 1 level	Input 3 level	Inputs (Page 65)
193	2.3	*[0]: Enable* [1]: Disable	Group fault diagnostics	Group fault diagnostics/group warning diagnostics (Page 64)
80	2.4	*[0]: Non-retentive* [1]: Retentive	Input 1 signal	Inputs (Page 65)
81	2.5	See input 1 signal	Input 2 signal	Inputs (Page 65)
82	2.6	See input 1 signal	Input 3 signal	Inputs (Page 65)
191	2.7	[0]: Enable *[1]: Disable*	Group warning diagnostics	Group fault diagnostics/group warning diagnostics (Page 64)

Object No.	Byte.Bit	Range of values	Meaning	See Chapter ...
194	3	[0]: No action [1]: Trip without restart [2]: Trip with restart [3]: Trip end position CW [4]: Trip end position CCW [5]: Group warning [7]: Emergency start *[8]: Motor CW* [9]: Motor CCW [11]: Quick Stop (direction-independent) [12]: Trip RESET [13]: Cold start [14]: Quick Stop clockwise [15]: Quick Stop counter-clockwise [37]: Operational trip end position CW [38]: Operational trip end position CCW	Input 1 action	Inputs (Page 65)
195	4	See input 1 - action *[9]: Motor CCW (default)*	Input 2 action	Inputs (Page 65)
196	5	See input 1 - action *[0]: No action (default for fail-safe motor starters)* *[13]: Cold start (default for standard motor starters)*	Input 3 action	Inputs (Page 65)
2	6 - 7	0.3 … 9 A/10 mA *The maximum current is preset.*	Rated operational current I_e The rated operational current is MLFB-dependent, and thus also the maximum setting range.	Rated operational current (Page 35)
15	8	18.75 … 100 %/3.125 % [6 … 32] *[0]: Deactivated*	Lower current limit	Upper/lower current limit (Page 55)
16	9	50 … 400 %/3.125 % [16 … 128] *[0]: Deactivated*	Upper current limit	Upper/lower current limit (Page 55)

See also

Group warning (Page 74)

A.11 Read DS204 device parameter 2

DS204 contains the second part of the incorrect parameters with which the motor starter is working.

The defaults appear in italics in the Value range column.

Object No.	Byte.Bit	Range of values	Meaning	See Chapter ...
18	0.0 - 0.3	*1* … 7.5 s/0.5 s [2 … 15] *Default value is [2]: 1 s.*	Blocking time	Blocking time and blocking current (Page 56)
-	0.4 - 0.7	[0]: Reserved	Reserved	-
2210	1	0 … 99 %/1 % [0 … 99] [0]: *Deactivated*	Warning limit - motor heating	Overload protection (Page 42)
-	2 - 3	[0]: Reserved	Reserved	-
-	4 - 5	[0]: Reserved	Reserved	-
17	6	150 ... 1000 %/50 % [3 ... 20] *Default value is [16]: 800 %*	Blocking current	Blocking time and blocking current (Page 56)
-	7	[0]: Reserved	Reserved	-
2213	8	18.75 … 100 %/3.125 % [6 … 32] [0]: Deactivated *Default value is [7]: 21.875 %*	Lower current warning limit	Upper/lower current warning value (Page 55)
2214	9	50 … 400 %/3.125 % [16 … 128] [0]: Deactivated *Default value is [36]: 112.5 %*	Upper current warning limit	Upper/lower current warning limit (Page 55)

A.12 I&M data

A.12.1 I&M data

The following I&M data (Identification & Maintenance function) are supported by all ET 200SP motor starters:

Number	Name	Comment
I&M 0	Device identification	This is stored in the device on initialization
I&M 1	Equipment identifier	These are entered in the engineering system.
I&M 2	Installation	
I&M 3	Description	

Note

With PROFINET, the I&M data can be accessed via data sets 0xAFF0 - 0xAFF3 (PNO).

With PROFIBUS, the I&M data can be accessed via data set 255.

A.12.2 I&M 0: Read device identification

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0020	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M0 data block 0			
6 ... 7	Unsigned16	MANUFACTURER_ID	42 = Manufacturer ID SIEMENS
8 ... 27	Char[20]	ORDER_ID	Article number (MLFB)
28 ... 43	Char[16]	SERIAL_NUMBER	Serial number
44 ... 45	Unsigned16	HARDWARE REVISION	Hardware revision or product version
46 ... 49	Char	SOFTWARE_REVISION	Firmware version
50 ... 51	Unsigned16	REV_COUNTER	Provides information about the parameterized changes on the module. The "REV_ COUNTER" is incremented after each change.
52 ... 53	Unsigned16	PROFILE_ID	Gives information about the PROFIBUS profile supported by the device and the line of products belonging to the device.
54 ... 55	Unsigned16	PROFILE_SPECIFIC_TYPE	Used to supplement the object "PROFILE_ID" and contains further information on the profile.
56 ... 57	Unsigned16	IM_VERSION	Provides information about the version of the identification data (01 01hex = Version 1.1).
58 ... 59	Unsigned16	IM_SUPPORTED	Provides information about the available identification data (Index 2 to 4).

A.12.3 I&M 1: Read/write equipment identifier

The following data are saved:

Byte	Length	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0021	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 1			
6 ... 37	Char[32]	TAG FUNCTION	Plant identifier Fill unused positions with blanks (0x20)
38 ... 59	Char[22]	TAG LOCATION	Location designation Fill unused positions with blanks (0x20)

A.12.4 I&M 2: Read/write installation

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0022	Block type
2 ... 3	Unsigned16	0x0012	Block length = 18
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 2			
6 ... 21	Char[16]	IM_DATE	Specification of an input date (YYYY-MM-DD HH:MM)

A.12.5 I&M 3: Read/write description

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0023	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 3			
6 ... 59	Char[54]	IM_DESCRIPTOR	Comment Fill unused positions with blanks (0x20)

Circuit examples

B

B.1 Connection examples for motor starters

B.1.1 Induction machine

Direct-on-line starter

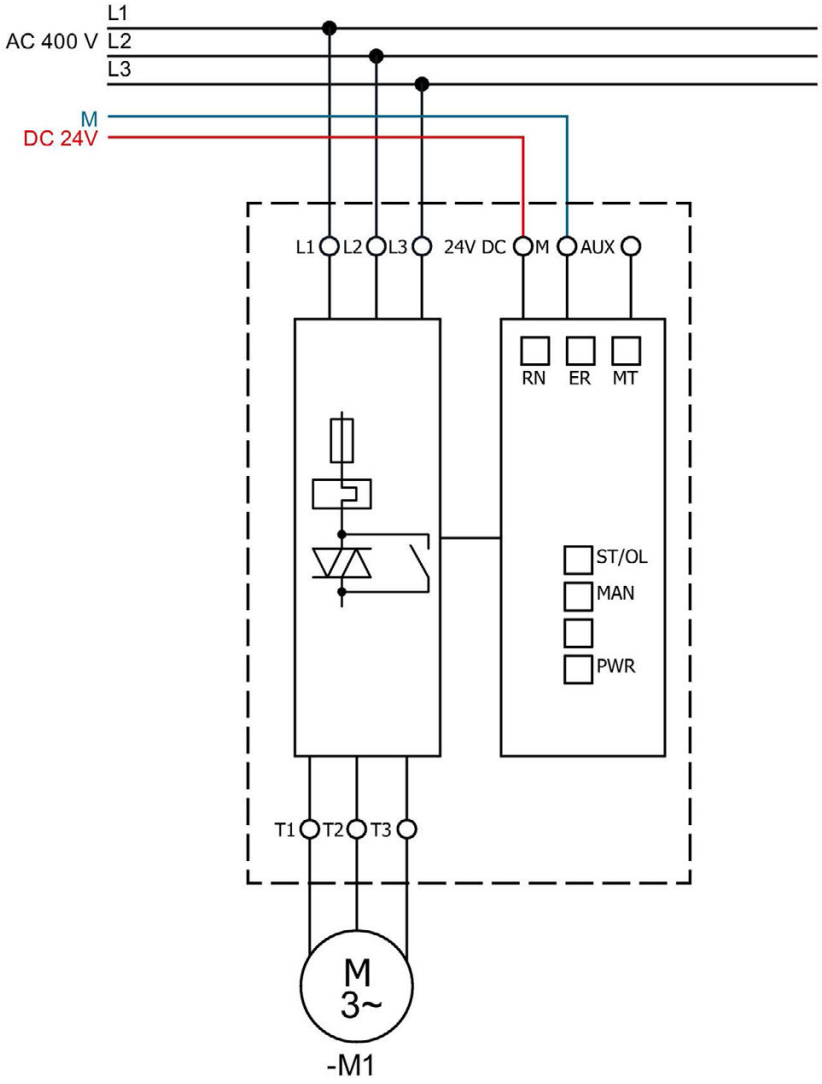
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starter: 3RK1308-0A*00-0CP0

Reversing starter

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starter: 3RK1308-0B*00-0CP0



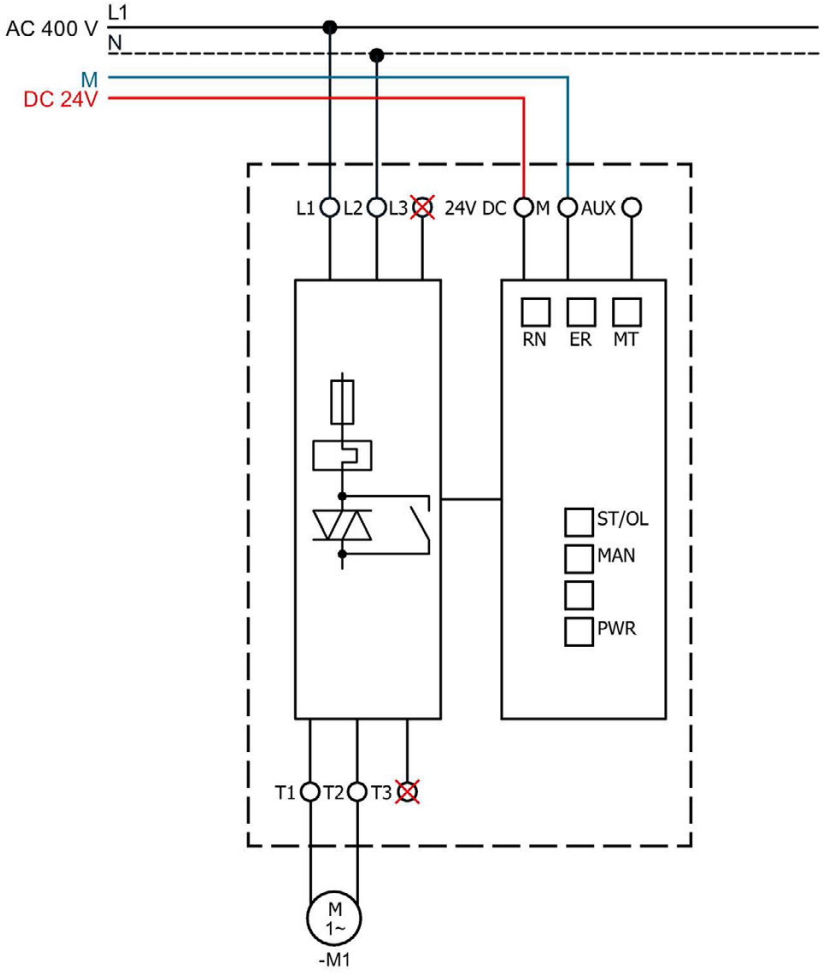
In the multi-pole representation, the N and PE conductors are not shown separately.

Do not connect PE or N to the neutral point.

B.1.2 Single-phase motor

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0



In the multi-pole representation, the PE conductor is not shown separately.

B.1.3 Resistive load

Star connection

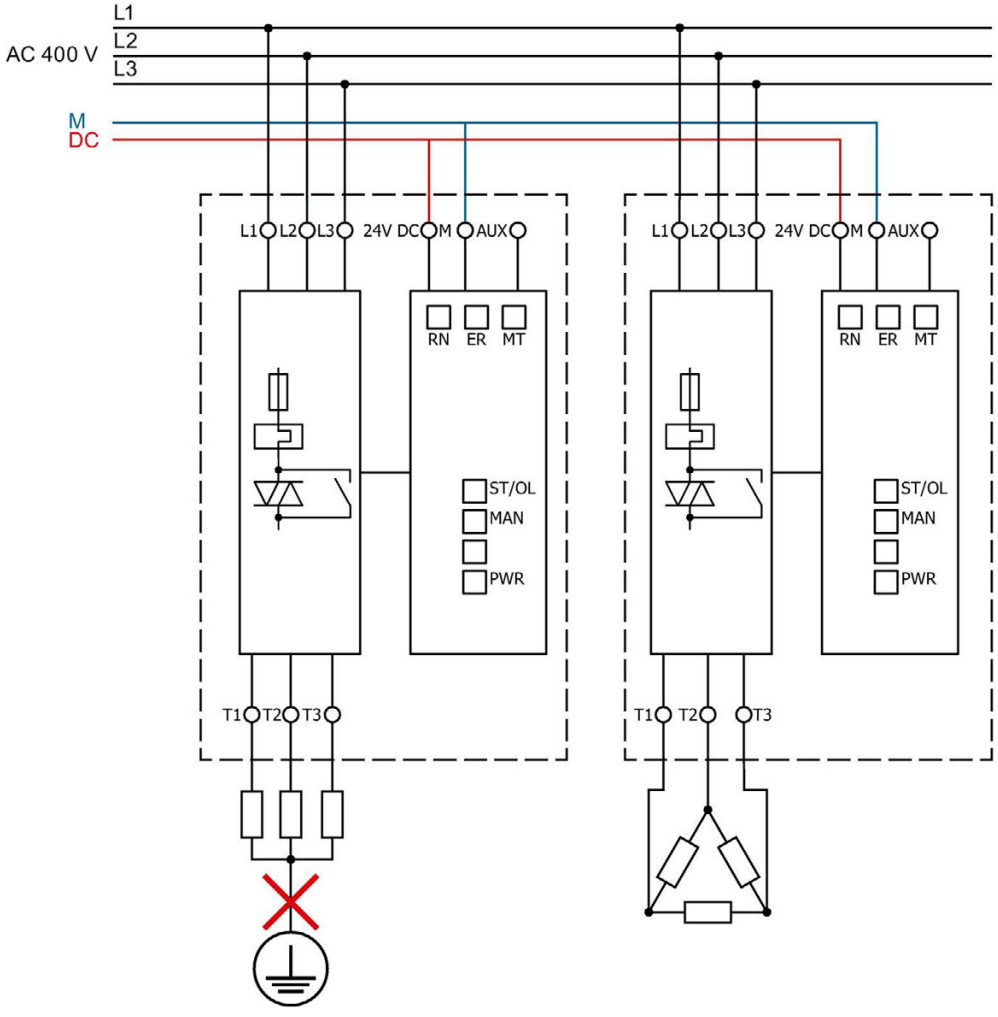
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0

Delta connection:

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0



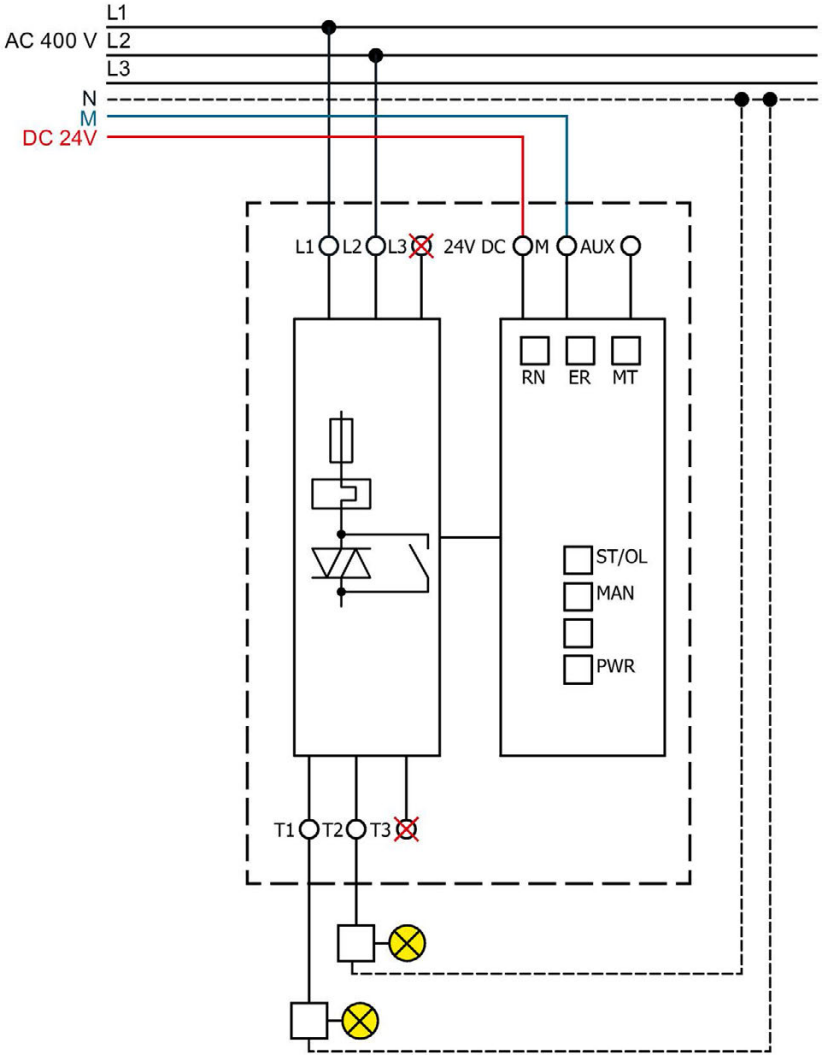
Do not connect PE or N to the neutral point.

In the multi-pole representation, the N and PE conductors are not shown separately.

B.1.4 Gas discharge lamps

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0



In the multi-pole representation, the PE conductor is not shown separately.

Note

Motor model und response to overload of the gas discharge lamp

Observe the set motor model and the overload response of the gas discharge lamp for the parameterization of the motor starter.

B.2 Connection examples for fail-safe motor starters

B.2.1 General information

Specifications for the power supply

Keep to the specifications for the 24 V DC supply. For further information, see the ET 200SP System Manual.

Fail-safe laying to the fail-safe input of the motor starter

Keep to the specifications for fail-safe laying of the cables of safety-related sensors.

Motor starter protectors

Design the motor starter protectors on the basis of the devices and loads used. Pay attention in particular to the startup behavior of loads.

Safety classification

The achievable safety category depends on the components used.

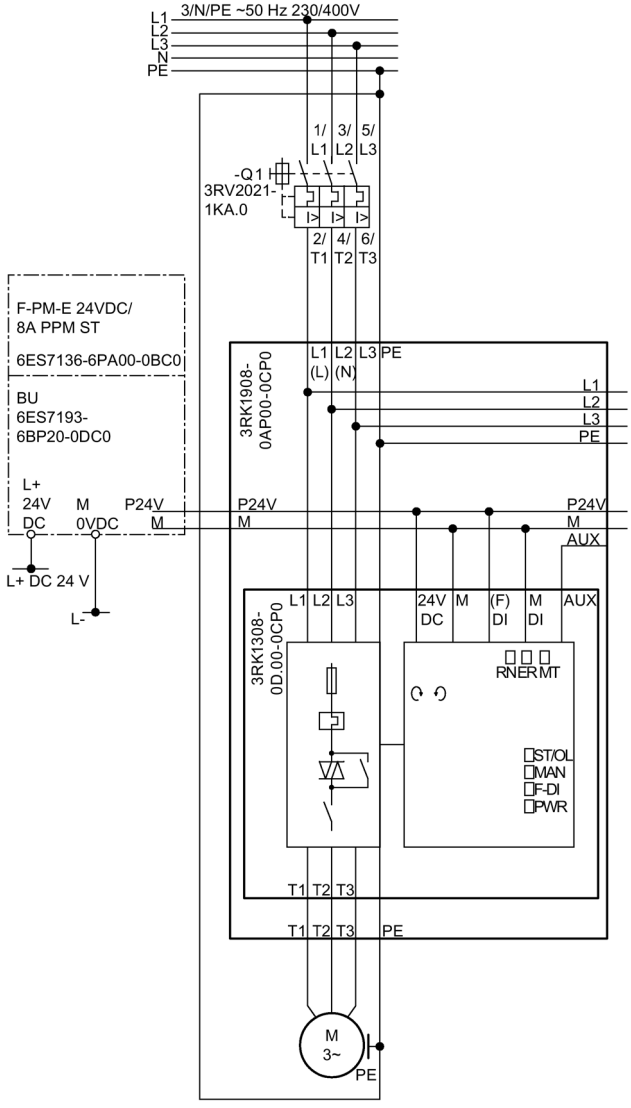
B.2.2 F-PM-E tripping

Article numbers:

- BaseUnit: 3RK1908-0AP00-0CP0
- Motor starter: 3RK1308-0C*00-0CP0 or 3RK1308-0D*00-0CP0
- F-PM-E 24 V DC/8A PPM: 6ES7136-6PA00-0BC0

Use F-PME tripping to realize group tripping of several motor starters simultaneously. The F-PM-E safely switches the motor starter's 24 V power supply. The fail-safe motor starter safely trips the connected motor load without torque after disappearance of the 24 V power supply.

In the event of safety shutdown with F-PM-E, there is no detailed diagnosis of the motor starter via the data sets and the process image of the inputs.



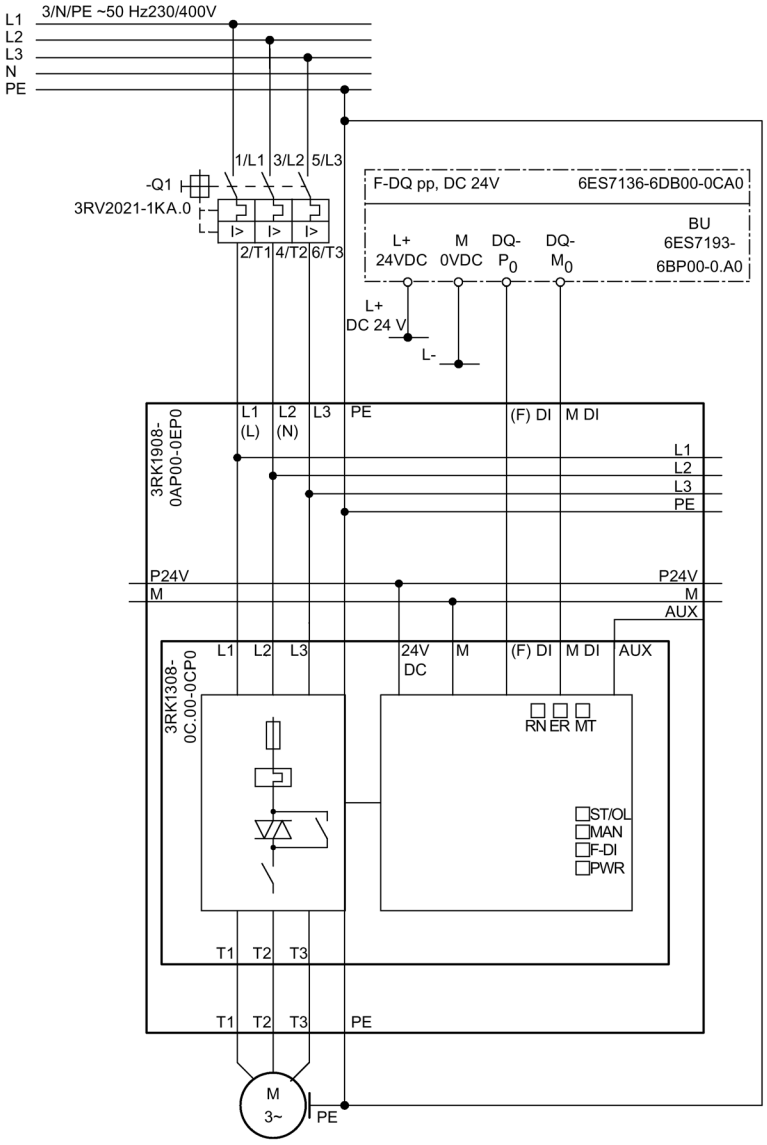
B.2.3 Shutdown via a safety-related actuator via F-DQ

Article numbers:

- BaseUnit: 3RK1908-0AP00-0EP0
- Motor starter: 3RK1308-0C*00-0CP0 or 3RK1308-0D*00-0CP0
- F-DQ device: 6ES7136-6DB00-0CA0

To implement selective shutdown of one single motor starter, use a fail-safe F-DQ device or the signal of a fail-safe sensor. The motor connected to the motor starter is shut down with a direct connection of fail-safe sensors on the BaseUnit (BU30-MS6).

The sensor connected to the fail-safe digital input on the motor starter's BaseUnit requires the same ground potential as the ground connection "M" on the motor starter's BaseUnit.



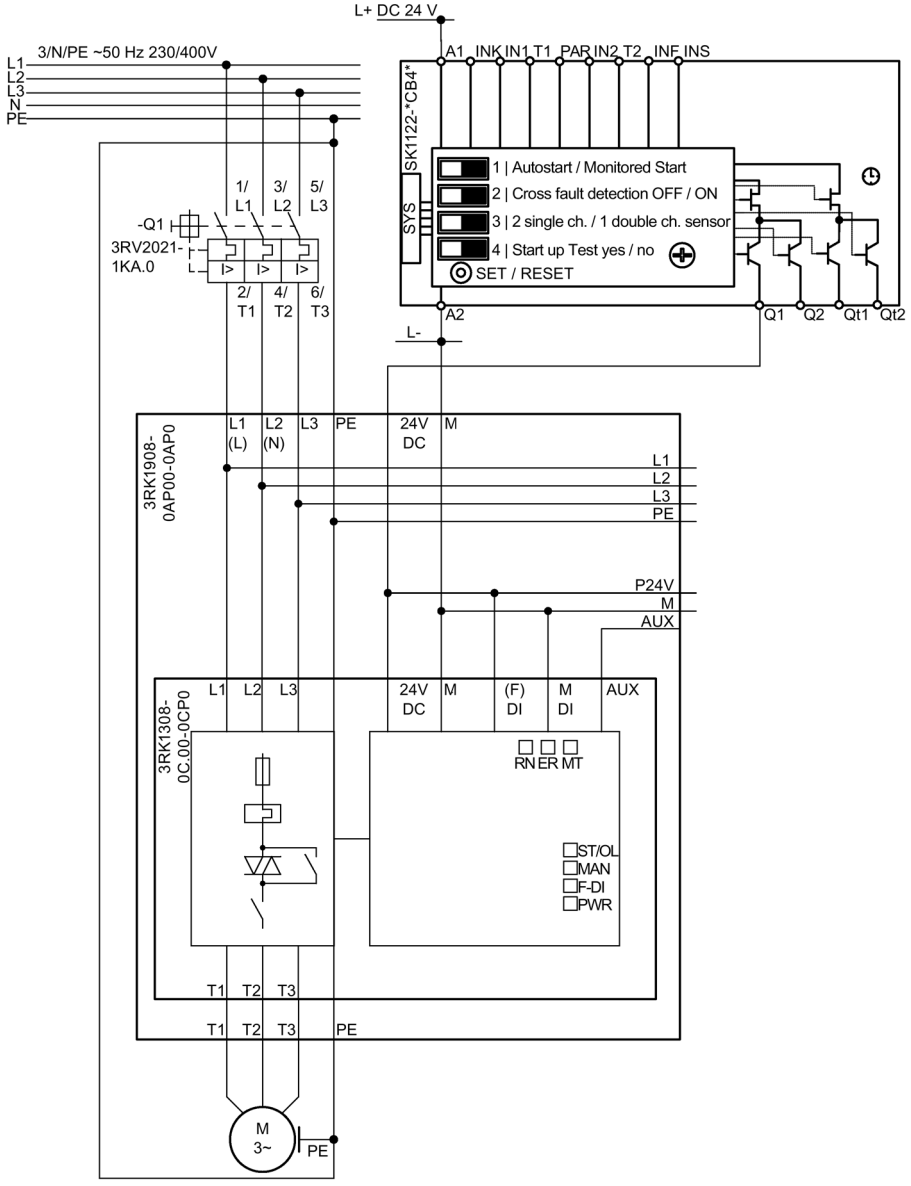
B.2.4 Safety Local

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starter: 3RK1308-0C*00-0CP0 or 3RK1308-0D*00-0CP0
- Safety relays 3SK1: 3SK1122-*CB4*

Use a standard CPU in the case of shutdown via a safety relay. The motor starter's 24 V power supply is safely tripped with a safety relay.

Connect the ground connection "M" on the motor starter's BaseUnit to the same ground potential as the ground connection "M" on the 3SK1.



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SIEMENS

SIMATIC

ET 200SP Technology Module TM Count 1x24V (6ES7138-6AA00-0BA0)

Manual

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10/2013

A5E33002339-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding design and commissioning of the ET 200SP is available in the ET 200SP system manual.

The counting and measuring functions of the TM Count 1x24V technology module are described in more detail in the Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Conventions

Please observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP and S7-1500 systems consists of the respective system manuals, function manuals and device manuals.

The STEP 7 information system (TIA Portal) also helps you configure and program your automation system.

Overview of the documentation provided for technology module TM Count 1x24V

The following table lists further documentation that you will need when using the TM Count 1x24V technology module.

Table 1- 1 Documentation for technology module TM Count 1x24V

Topic	Documentation	Most important contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installing • Connecting • Commissioning
	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	
	Device manual ET 200SP Interface Module (http://support.automation.siemens.com/WW/view/en/55683316/133300)	• Connecting • Interrupts, diagnostics, error, and system alarms • Technical specifications • Dimensional drawing
	Device manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	• Technical specifications
Interference-free installation of control systems	Function manual Interference-free Installation of Control Systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection

Topic	Documentation	Most important contents
Counting and measuring	Function manual Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820)	• Counting functions • Measuring functions • Position detection • Control and feedback interface
Motion Control	Function manual S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279)	• Configuration • Programming • Commissioning • Diagnostics

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7138-6AA00-0BA0

View of the module

Figure 2-1 View of the TM Count 1x24V module

Properties

The TM Count 1x24V technology module has the following properties:

- Technical properties
  - One channel
  - Interfaces:

    24 V encoder signals A, B and N from sourcing, sinking or push pull encoders and sensors

    24 V encoder supply output, short-circuit proof

    DI0, DI1 and DI2 digital input signals

    DQ0 and DQ1 digital output signals

    L+ supply voltage
  - Count range: 32 bits
  - Monitoring of encoder signals for wire break
  - Hardware interrupts configurable
  - Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Supported encoder/signal types
  - 24 V incremental encoder with and without N signal
  - 24 V pulse encoder with direction signal
  - 24 V pulse encoder without direction signal
  - 24 V pulse encoders for up & down pulses
- Supported system functions
  - Isochronous mode
  - Firmware Update
  - Identification data I&M

Accessories

The following accessories can be used with the module and are not included in the scope of delivery:

- Labeling strip
- Color identification labels
- Reference identification labels
- Shield connector

A BaseUnit of the A0 type is required to operate the technology module. For an overview of the BaseUnits that you can use with the technology module, please refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

For detailed information on the installation procedure, refer to the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Detection of counting signals

Counting refers to the detection and summation of events. The counters of the technology module detect encoder signals and pulses and evaluate them accordingly. The count direction can be specified using encoder or pulse signals or through the user program.

You can control the counting processes with the digital inputs.

You can specify the counter characteristics using the functions described below.

Counting limits

The counting limits define the counter value range used. The counting limits are configurable and can be modified during runtime with the user program.

The maximum possible counting limit is 2147483647 (2^{31}–1). The minimum possible counting limit is –2147483648 (–2^{31}).

You can configure the response of the counter at the counting limits:

- Continue or stop counting upon violation of a counting limit (automatic gate stop)
- Set counter value to start value or to other counting limit upon violation of a counting limit

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime with the user program.

Depending on the parameter assignment, the technology module can set the current counter value to the start value upon synchronization, upon Capture function activation, upon violation of a counting limit or when the gate is opened.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured.

The control of the hardware gate takes place externally via the digital inputs of the technology module. Control of the software gate takes place via the user program. The hardware gate can be enabled through parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture

You can configure an external reference signal edge that triggers the saving of the current counter value as Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of the N signal at the encoder input

You can configure whether counting continues from the current counter value or from the start value after the Capture function.

Synchronization

You can configure the edge of an external reference signal to load the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of the N signal at the encoder input
- Rising edge of the N signal at the encoder input depending on the level of the assigned digital input

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output will be prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the counter value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.2 Measured value determination

The following measuring functions are available:

Measurement type	Description
Frequency measurement	The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses and returned in hertz as the floating point number.
Period measurement	The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses and returned in seconds as the floating point number.
Velocity measurement	The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses and other parameters, and returned in the configured unit of measurement.

The measured value and the counter value are available concurrently in the feedback interface.

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time. Setting longer update time intervals allows uneven measured variables to be smoothed and increases measuring accuracy.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After closing, the last measured value captured continues to be returned.

Measuring ranges

The measuring functions have the following measuring range limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	800 kHz*
Period measurement	1.25 µs*	25 s
Velocity measurement	Depends on the configured number of "increments per unit" and the "time base for velocity measurement"	

* Applies to 24 V incremental encoders and "quadruple" signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

2.2.3 Switching the outputs at comparison values

You define two comparison values that can control the two digital outputs independent of the user program. The comparison values are configurable and can be modified during runtime with the user program.

Comparison values in the Counting mode

You define two comparison values in the Counting mode. If the current counter value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

Comparison values in the Measuring mode

You define two comparison values in the Measuring mode. If the current measured value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

2.2.4 Position input for Motion Control

You can use the technology module with an incremental encoder for position detection with S7-1500 Motion Control . Position detection is based on the counting function of the technology module which evaluates the captured encoder signals and sends them to the S7-1500 Motion Control.

In the device configuration of the technology module in STEP 7 (TIA Portal), select "Position detection for Motion Control".

Additional information

A detailed description of the use of Motion Control and its configuration is available in the function manual S7-1500 Motion Control as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279).

2.2.5 Additional functions

Hardware interrupts

The technology module can trigger a hardware interrupt in the CPU, for example, if a compare event occurs, in the event of overflow or underflow, in the event of a zero crossing of the counter and/or of a change of count direction (direction reversal). You can specify which events (Page 39) are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger a diagnostic interrupt in the event of a missing supply voltage or an error at the digital outputs, for example. Select the diagnostic interrupts (Page 37) in the device configuration freely.

Input filter

To suppress interference, you can configure an input filter for the 24 V encoder inputs and for the digital inputs.

Distributed application

You can use the technology module in a distributed system by means of an interface module in the ET 200SP distributed I/O device. The following applications are possible:

- Distributed operation in an S7-1500 system
- Distributed operation in an S7-1200 system
- Distributed operation in an S7-300/400 system
- Distributed operation in a third-party system

Isochronous mode

The technology module supports the system function "Isochronous mode". This system function enables counter values and measured values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A change in the state of a digital input immediately affects the planned reaction of the technology module and changes the status bit of the digital input in the feedback interface (Page 29).

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. The counter value and the measured value as well as status bits are captured at time T_i and made available in the feedback interface for retrieval in the current bus cycle.

In isochronous mode, there is always data consistency across all bytes in the feedback interface.

Wiring

3

3.1 Pin assignment

The TM Count 1x24V is used with a BaseUnit of the A0 type.

The encoder signals, the digital input and output signals and the encoder supply are connected to the BaseUnit of the technology module. The supply voltage feed on the light BaseUnit BU...D of the associated potential group supplies the module and the digital outputs, and generates the encoder supply voltage.

BaseUnit

The BaseUnit is not included in the scope of delivery of the module and must be ordered separately.

For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

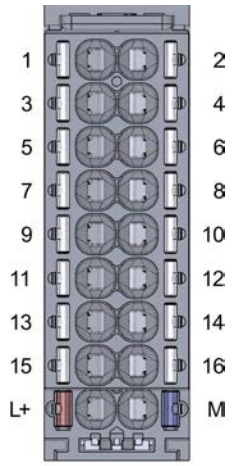
You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) device manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Terminal assignment of the BaseUnit

The table below shows the pin assignment, using the BaseUnit BU15-P16+A0+2B as an example.

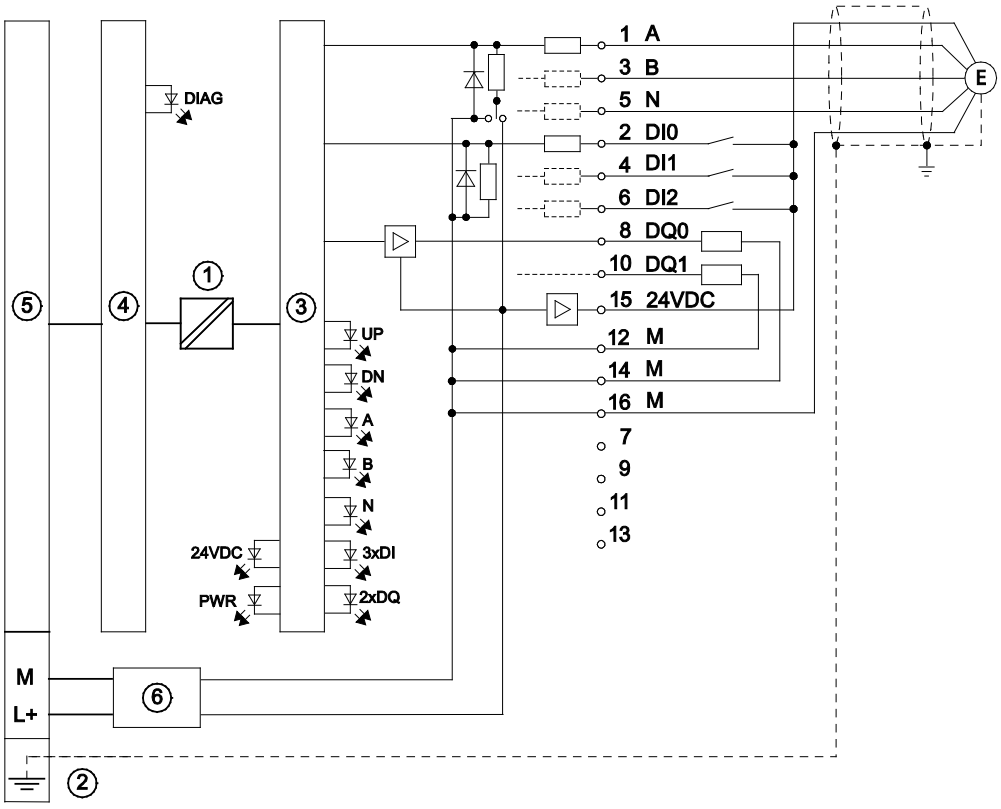
Table 3- 1 Pin assignment of the BaseUnit BU15-P16+A0+2B

View	Signal name		Designation				
			24 V incremental encoder		24 V pulse encoder		
			With signal N	Without signal N	with direction signal	without direction signal	up/down
	1	A	Encoder signal A		Counting signal A		Up counting signal A
	3	B	Encoder signal B		Direction signal B	—	Down counting signal B
	5	N	Encoder signal N	—			
	2	DI0	Digital input DI0				
	4	DI1	Digital input DI1				
	6	DI2	Digital input DI2				
	8	DQ0	Digital output DQ0				
	10	DQ1	Digital output DQ1				
	7	—	—				
	9	—	—				
	11	—	—				
	13	—	—				
	Supply voltage, encoder supply and ground						
	15	24VDC	24 V encoder supply				
	12	M	Ground for encoder supply, digital inputs and digital outputs				
	14	M					
	16	M					
		L+	DC 24V Supply voltage				
		M	Ground for supply voltage				

Block diagram

The figure below shows the block diagram of the technology module with a connected incremental encoder.

You must ground the shields of the cables between encoder and technology module both through the shield terminal on the BaseUnit (shield bracket and terminal) and also on the encoder.



① Electrical isolation
② Shield terminal on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ Input filter

Figure 3-1 Block diagram with incremental encoder

L+/M supply voltage

Connect the supply voltage (DC 24V) to the L+ and M connections. An internal protective circuit protects the technology module from polarity reversal of the supply voltage. The technology module monitors the connection of the supply voltage.

24VDC encoder supply

To supply the encoder and sensors at the digital inputs, the technology module supplies the DC 24V supply voltage at the 24VDC output with reference to M. Voltage is supplied from the L+/M supply voltage and monitored for short circuits and overload.

24 V encoder signals/count signals

The 24 V encoder signals are designated A, B and N. You can connect the following encoder types:

- Incremental encoder with signal N:

  The signals A, B and N are connected by means of the correspondingly labeled terminals. Signals A and B are the two incremental signals phase-shifted by 90°. N is the zero mark signal which returns one pulse per revolution.

- Incremental encoder without signal N:

  The signals A and B are connected by means of the correspondingly labeled terminals. Signals A and B are the two incremental signals phase-shifted by 90°. The N terminal remains disconnected.

- Pulse encoders without direction signal:

  The counting signal is connected to the A terminal. The count direction is specified via the control interface. The B and N terminals remain disconnected.

- Pulse encoders with direction signal:

  The counting signal is connected to the A terminal. The direction signal is connected to the B terminal. The N terminal remains disconnected.

- Pulse encoders with counting signal up/down:

  The up counting signal is connected to the A terminal. The down counting signal is connected to the B terminal. The N terminal remains disconnected.

The inputs are not electrically isolated from each other. The inputs are isolated against the backplane bus.

You can connect the following encoders or sensors at inputs A, B and N:

- Sourcing output:
  The inputs A, B and N are switched by the encoder or sensor after 24VDC .
- Sinking output:
  The inputs A, B and N are switched by the encoder or sensor after ground M .
- Push pull:
  The inputs A, B and N are switched by the encoder or sensor alternately after 24VDC and ground M . Monitoring for wire break is possible with this type of encoder/sensor. The wire break detection procedure (alternate switching) allows the counter value to change in the event of an error (wire break) even without count pulses until the wire break is detected.

Input filter for 24 V encoder signals

To suppress interferences, you can configure an input filter for the counting inputs A, B and N. The selected filter frequency is based on a pulse-break ratio of between 40:60 and 60:40. This produces a set minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can specify the following values for the filter frequency:

Table 3- 2 Filter frequency and respective minimum pulse/break time

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz (default)	2.0 µs

Digital inputs DI0, DI1 and DI2

There are three digital inputs. The digital inputs are used for gate control, synchronization and the Capture function. Alternatively, you can use one or more digital inputs without the mentioned functions and read the signal state of the respective digital input via the feedback interface.

The digital inputs are not electrically isolated from each other.

Input filters for digital inputs

To suppress interferences, you can configure an input filter for the digital inputs.

You can specify the following values for the filter time:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Digital outputs DQ0 and DQ1

There are two digital outputs. The two digital outputs DQ0 and DQ1 can be activated/switched directly by the specified comparison values or by the user program.

The digital outputs are not isolated from each other.

The digital outputs are 24 V sourcing outputs in reference to M and can carry a rated load current of 0.5 A. They are protected from overload and short-circuit.

Note

Relays and contactors can be connected direct without external circuitry. You can find information on the maximum possible operating frequencies and the inductive loads at the digital outputs in the section Technical specifications (Page 41).

Configuring/address space

4

4.1 Configuring

Introduction

The technology module is configured and assigned parameters with the configuration software.

The technology module functions are controlled and monitored by the user program.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Distributed operation in an S7-1500 system	• S7-1500 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): • Device configuration with hardware configuration (HWCN) • Parameter setting with High_Speed_Counter technology object	Counting and measuring functions: High_Speed_Counter instruction for the technology object
		STEP 7 (TIA Portal): Device configuration with hardware configuration (HWCN) in operating mode "Position Detection for Motion Control"	Control by means of a technology object
Distributed operation in an S7-300/400 or S7-1200 system	• S7-300/400 or S7-1200 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN) STEP 7: Device configuration and parameter settings with HSP	Direct access to the control and feedback interface (Page 27) of the TM Count 1x24V in the I/O data
Distributed operation in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Count 1x24V	Third-party configuration software: Device configuration and parameter settings with GSD file	Direct access to the control and feedback interface (Page 27) of the TM Count 1x24V in the I/O data

Additional information

A detailed description of the counting and measuring functions and their configuration is available:

- In the Counting, Measurement and Position Input Function Manual available as download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Counting, measurement and position detection" > Counting, measurement and position detection (S7-1500)"

A detailed description of the use of Motion Control and its configuration is available:

- In the S7-1500 Motion Control function manual available as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Motion Control > Motion Control (S7-1200, S7-1500)"

Hardware Support Package

The Hardware Support Packages (HSP) are available for download from the Internet (http://support.automation.siemens.com/WW/view/en/72341852).

Note

If you integrate the TM Count 1x24V via HSP in an S7-300/400 system, you can use the "Isochronous mode" system function.

GSD file

The GSD files for the ET 200SP distributed I/O system are available for download from the Internet (http://support.automation.siemens.com/WW/view/en/57138621).

4.2 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module to CPU STOP for each channel in the basic parameters of the device configuration.

Table 4- 1 Response of the technology module to CPU STOP depending on parameter assignment

Basic parameters	Reaction to CPU STOP
Continue operation	The technology module remains fully functional. Incoming count pulses are processed. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.

4.3 Address space

Address space of the technology module

Table 4- 2 Range of the input addresses and output addresses of the TM Count 1x24V

	Inputs	Outputs
Range	16 bytes	12 bytes

Table 4- 3 Range of the input and output addresses of the TM Count 1x24V in the "Position detection for Motion Control" mode

	Inputs	Outputs
Range	16 bytes	4 bytes

Additional information

A description on how to use the control and feedback interface of TM Count 1x24V can be found in the section Control and feedback interface (Page 27).

4.4 Control and feedback interface

Information on using the control and feedback interface can be found in the section Configuring (Page 23).

A detailed description of the TM Count 1x24V control and feedback bits is available in the Counting, Measurement and Position Detection function manual which can be downloaded from the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

Note

The control and feedback interface is compatible with the control and feedback interface of the TM Count 2x24V technology module of the S7-1500 automation system.

4.4.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface

The following table shows control interface assignment:

Offset to the start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (the significance of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (the significance of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0*	Specifies the significance of the value in Slot 0				
		Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
		0	0	0	0	No action, idle
		0	0	0	1	Load counter value
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	

Offset to the start address	Parameter	Meaning				
Byte 8	LD_SLOT_1*	Specifies the significance of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle
		0	0	0	1	Load counter value
		0	0	1	0	Reserve
		0	0	1	1	Load start value
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit
		0	1	1	1	Load high counting limit
		1	0	0	0	Reserve
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Capture function enable				
	EN_SYNC_DN	Bit 6: Enable synchronization down				
	EN_SYNC_UP	Bit 5: Enable synchronization up				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: Enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate				
Byte 10	SET_DIR	Bit 7: Count direction (for encoders without direction signal)				
	–	Bits 2 to 6: Reserve; bits must be set to 0				
	RES_EVENT	Bit 1: Reset of saved events				
	RES_ERROR	Bit 0: Reset of saved error states				
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0				

* If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the first value is taken internally from Slot 0 and then the value from Slot 1 is taken. This may lead to unexpected intermediate states.

4.4.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Offset to the start address	Parameter	Meaning
Bytes 0 to 3	COUNT VALUE	Current counter value
Bytes 4 to 7	CAPTURED VALUE	The last acquired Capture value
Bytes 8 to 11	MEASURED VALUE	Current measured value
Byte 12	–	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Incorrect encoder signal
	POWER_ERROR	Bit 0: Supply voltage L+ too low
Byte 13	–	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate state
	STS_READY	Bit 4: Technology module started up and configured
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and carried out (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and carried out (toggling)
	RES_EVENT_ACK	Bit 1: Reset of event bits active
	–	Bit 0: Reserve; set to 0
Byte 14	STS_DI2	Bit 7: Status DI2
	STS_DI1	Bit 6: Status DI1
	STS_DI0	Bit 5: Status DI0
	STS_DQ1	Bit 4: Status DQ1
	STS_DQ0	Bit 3: Status DQ0
	STS_GATE	Bit 2: Status of internal gate
	STS_CNT	Bit 1: Count pulse detected within the last 0.5 s
	STS_DIR	Bit 0: Direction of last counter value change
Byte 15	STS_M_INTERVAL	Bit 7: Count pulse detected in previous measurement interval
	EVENT_CAP	Bit 6: Capture event has occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: An overflow has occurred
	EVENT_UFLW	Bit 1: An underflow has occurred
	EVENT_ZERO	Bit 0: A zero pass has occurred

Interrupts/diagnostic messages

5

5.1 Status and error displays

LEDs

The figure below shows you the LED displays (status and error displays) of TM Count 1x24V.

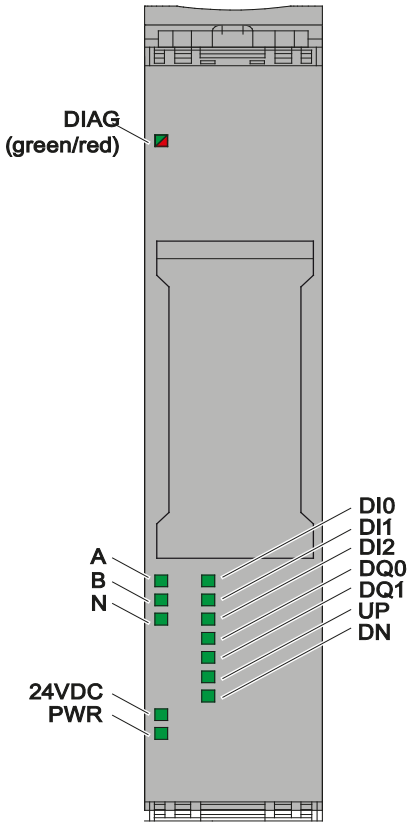


Figure 5-1 LEDs of the TM Count 1x24V

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic messages can be found in the section Diagnostic messages (Page 34).

Table 5- 1 Status and error displays DIAG

LED DIAG	Meaning	To correct or avoid errors
Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the CPU or on the interface module.
Flashes	Technology module not configured	---
On	Technology module configured but no module diagnostics	
Flashes	Technology module configured and module diagnostics (at least one error pending)	Evaluate the diagnostic messages and eliminate the error.

Table 5- 2 PWR/24VDC status displays

LEDs		Meaning	To correct or avoid errors
PWR	24VDC		
Off	Off	Supply voltage missing	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
On	On	Supply voltage is present and OK	---
On	Off	Short-circuit or overload at the encoder supply or supply voltage too low	• Check the encoder wiring. • Check the loads connected to the encoder supply. • Check the supply voltage.

ChannelLEDs

The LEDs A, B, N and DIm indicate the current level of the associated signals. The LEDs of the digital outputs DQm indicate the desired state.

The LEDs UP and DN indicate the logical counting direction.

The flashing frequency of the channel LEDs is limited to ca. 12 Hz. If higher frequencies are present, the channel LEDs will flash at 12 Hz instead of indicating the current status.

Table 5- 3 A/B/N/DIm/DQm status displays

A/B/N/DIm/DQm LEDs	Meaning
□ Off	Counter input / digital input / digital output at 0 level
■ On	Counter input / digital input / digital output at 1 level

Table 5- 4 Status displays UP/DN

LEDs		Meaning
UP	DN	
□ Off	□ Off	No count pulse has been detected for the last 0.5 s.
■ On	□ Off	The last count pulse has incremented the counter and took place no more than 0.5 s ago.
□ Off	■ On	The last count pulse has decremented the counter and took place no more than 0.5 s ago.

5.2 Diagnostic messages

Diagnostic alarms

If a diagnostic alarm is pending, the DIAG LED flashes red.

The diagnostic alarms are displayed as clear text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 5- 5 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Error	9_H	• Internal module error occurred • Possible cause: Technology module defective	Replace technology module
Load voltage missing	11_H	No technology module L+ supply voltage	• Check BaseUnit type • Check the wiring of the supply voltage L+ on the BaseUnit
Hardware interrupt lost	16_H	• Technology module cannot send an interrupt because a previous interrupt has not been processed • Possible causes: – Parameter assignment error – Too many hardware interrupts in too short a time	Change interrupt processing in the CPU and re-assign technology module parameters correspondingly
Module temporarily unavailable	$1F_H$	• No normal operation of the technology module possible • Possible cause: Technology module is performing a firmware update	Wait until technology module is available again
Internal error	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	103_H	Firmware error	Run firmware update
		Technology module defective	Replace technology module
Short circuit or overload at external encoder supply	$10E_H$	• Error at encoder supply • Possible causes: – Short circuit – Overload	• Check encoder wiring • Check consumers connected to encoder supply
Error at digital outputs	$10F_H$	• Error at the digital outputs • Possible causes: – Short circuit – Overload – External feed	• Check wiring at the digital outputs • Check consumers connected to the digital outputs

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Faulty external auxiliary voltage	110_H	• Error at supply voltage L+ • Possible causes: – Low voltage – Wiring of L+ supply voltage defective	• Check the L+ supply voltage • Check the wiring of the supply voltage L+ on the BaseUnit
Illegal A/B signal ratio	500_H	• Time profile of signals A and B of the incremental encoder does not meet certain specifications • Possible causes: – Signal frequency too high – Encoder faulty – Process wiring faulty	• Check process wiring • Check encoder/sensor • Check parameter assignment
Wire break at digital input A, B or N	505_H	Channel not connected	Connect the channel
		Resistance of encoder circuit too high	• Use a different encoder type or modify the wiring, for example, use shorter cables with larger cross-sections • Check encoders
		Interruption of the line between technology module and encoder	Check process wiring
		Sensor used is sourcing output or sinking output only	Correct parameter assignment
Overheating	506_H	Possible causes: • Short circuit or overload at the digital outputs or output of the encoder supply • Ambient temperature outside specifications	• Check process wiring • Improve cooling • Check connected loads

5.3 Interrupts

5.3.1 Trigger a diagnostic interrupt

Enabling the diagnostic interrupts

You enable the diagnostic interrupt for wire break and the diagnostic interrupts for additional errors in the basic parameters during device configuration.

A list of all errors that can trigger a diagnostic interrupt is available at Cause of the error triggering a diagnostic interrupt (Page 37).

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  Once you have remedied the error, the DIAG LED goes out.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN, even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

Detailed information on the error event is available with the instruction "RALRM" (read additional interrupt information).

Default setting

These diagnostic interrupts are not enabled in the default setting.

5.3.2 Cause of the error triggering a diagnostic interrupt

Which errors can trigger a diagnostic interrupt?

The technology module can trigger the following diagnostic interrupts:

Table 5- 6 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• Wire break at digital input A, B or N	Monitoring is active if a push-pull switching encoder has been configured. A detected error only triggers a diagnostic interrupt if "Enable diagnostic interrupt for wire break" has been enabled in the device configuration.
• Error • Load voltage missing • Hardware interrupt lost • Module temporarily unavailable • Short circuit or overload at external encoder supply • Error at digital outputs • Faulty external auxiliary voltage • Illegal A/B signal ratio • Overheating	Monitoring is always active. A detected error only triggers a diagnostic interrupt if "Enable additional diagnostic interrupts" has been enabled in the device configuration.

5.3.3 Triggering of a Hardware Interrupt

Introduction

For the technology module, you can configure which events are to trigger a hardware interrupt during operation.

What is a Hardware Interrupt?

The technology module will trigger a hardware interrupt as configured in response to specific events/states. When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Activating the hardware interrupts

You activate the hardware interrupts in STEP 7 (TIA Portal) under "Basic parameters > Hardware interrupts" during device configuration of the technology module.

A list of the individual hardware interrupts is available at Events which can trigger a hardware interrupt (Page 39).

Lost hardware interrupt

If an event occurs which is supposed to trigger a hardware interrupt but there is an identical, previous event which has not yet been processed, no further hardware interrupt will be triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostic interrupt, depending on the parameter assignment.

Default setting

No hardware interrupts are activated in the default setting.

5.3.4 Events which can trigger a hardware interrupt

Which events can trigger a hardware interrupt?

A hardware interrupt is triggered if the condition for changing the respective status bit or event bit in the feedback interface is fulfilled.

The EventType tag, among others, is entered in the start information of the assigned hardware interrupt OB when a hardware interrupt is triggered. The EventType tag specifies the number of the event type to which the event triggering the interrupt belongs.

You can configure hardware interrupts to be triggered for the following event types:

Hardware interrupt	EventType number
Internal gate opening (Gate start)	1
Internal gate closing (Gate stop)	2
Overflow (high counting limit violated)	3
Underflow (low counting limit violated)	4
Compare event for DQ0 has occurred	5
Compare event for DQ1 has occurred	6
Zero pass	7
New Capture value available[1)]	8
Synchronization of the counter by an external signal	9
Direction reversal[2)]	10

1) Can only be configured in Counting mode

2) The feedback bit STS_DIR has the default value "0". A hardware interrupt is not triggered when the first counter value is changed immediately after switching on the technology module in the *down direction*.

You can activate any combination of events to trigger hardware interrupts.

Technical specifications

6

	6ES7138-6AA00-0BA0
Product type designation	TM Count 1x24V
General information	
BaseUnits that can be used	BU type A0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12 SP1 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
Supply voltage	
Load voltage L+	
Rated value (DC)	24 V
Low limit of valid range (DC)	19.2 V
High limit of valid range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	60 mA; without load
Encoder supply	
Number of outputs	1
24 V encoder supply	
24 V	Yes; L+ (-0.8 V)
Short-circuit protection	Yes
Output current, max.	300 mA
Power loss	
Power loss, typ.	1 W
Address area	
Occupied address area	
Inputs	16 bytes
Outputs	12 bytes; 4 bytes with Motion Control
Digital inputs	
Number of inputs	3
Digital inputs, configurable	Yes
Input characteristics to IEC 61131, Type 3	Yes

	6ES7138-6AA00-0BA0
Digital input functions, configurable	
Gate start/stop	Yes
Capture	Yes
Synchronization	Yes
Freely assignable digital input	Yes
Input voltage	
Rated value, DC	24 V
For signal "0"	-30 V to +5 V
For signal "1"	+11 V to +30 V
Permitted voltage at input, min.	-30 V
Permitted voltage at input, max.	30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (at rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
• at "0" to "1", min.	6 µs; with parameter assignment "none"
• at "1" to "0", min.	6 µs; with parameter assignment "none"
For counters/technological functions	
• Configurable	Yes
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Digital outputs	
Type of digital output	Transistor
Number of outputs	2
Digital outputs, configurable	Yes
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	1 A
Limiting of inductive shutdown voltage to	L+ (-33 V)
Control of a digital input	Yes
Digital output functions, configurable	
Switch at comparison values	Yes
Freely assignable digital output	Yes
Output switching capacity	
With resistive load, max.	0.5 A; per digital output
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ

	6ES7138-6AA00-0BA0
Output voltage	
for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A; per digital output
for signal "1" permissible range, max.	0.6 A; per digital output
for signal "1" minimum load current	2 mA
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	50 µs
"1" to "0", max.	50 µs
Switching frequency	
With resistive load, max.	10 kHz
With inductive load, max.	0.5 Hz; to IEC 947-5-1, DC-13; observe derating curve
With lamp load, max.	10 Hz
Total current of outputs	
Max. current per module	1 A
Cable length	
Cable length shielded, max.	1000 m
Cable length unshielded, max.	600 m
Encoders	
Supported encoders	
2-wire sensor	Yes
• Permitted quiescent current (2-wire sensor), max.	1.5 mA
Encoder signals, incremental encoders (asymmetrical)	
Input voltage	24 V
Input frequency, max.	200 kHz
Counting frequency, max.	800 kHz; with quadruple evaluation
Signal filter, configurable	Yes
Cable length shielded, max.	600 m; depends on input frequency, encoder and cable quality; max. 50 m with 200 kHz
Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
Incremental encoder with A/B tracks, phase-shifted by 90°, and zero track	Yes
Pulse encoder	Yes
Pulse encoder with direction	Yes
Pulse encoder with one pulse signal per count direction	Yes
24 V encoder signal	
• Permitted voltage at input, min.	-30 V
• Permitted voltage at input, max.	30 V
Interface hardware	
Input characteristics to IEC 61131, Type 3	Yes
Sinking/sourcing input	Yes

	6ES7138-6AA00-0BA0
Isochronous mode	
Isochronous mode (application synchronized until terminal)	Yes
Bus cycle time (TDP), min.	250 µs
Interrupts/diagnostics/status information	
Activation of substitute values	Yes; configurable
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	Yes
Diagnostic messages	
Monitoring of supply voltage	Yes
Wire break	Yes
Short circuit	Yes
A/B transition error with incremental encoder	Yes
Group error	Yes
LED diagnostics display	
Monitoring of supply voltage	Yes, green PWR LED
For module diagnostics	Yes; green / red DIAG LED
Count down status display (green)	Yes
Count up status display (green)	Yes
Integrated functions	
Number of counters	1
Counting frequency (counters), max.	800 kHz; with quadruple evaluation
Counting functions	
Can be used with TO High_Speed_Counter	Yes
Continuous counting	Yes
Counter response configurable	Yes
Hardware gate by means of digital input	Yes
Software gate	Yes
Event-triggered stop	Yes
Synchronization by means of digital input	Yes
Counting range, configurable	Yes
Comparator	
• Number of comparators	2
• Direction-dependent	Yes
• Can be changed from user program	Yes
Position detection	
Suitable for S7-1500 Motion Control	Yes

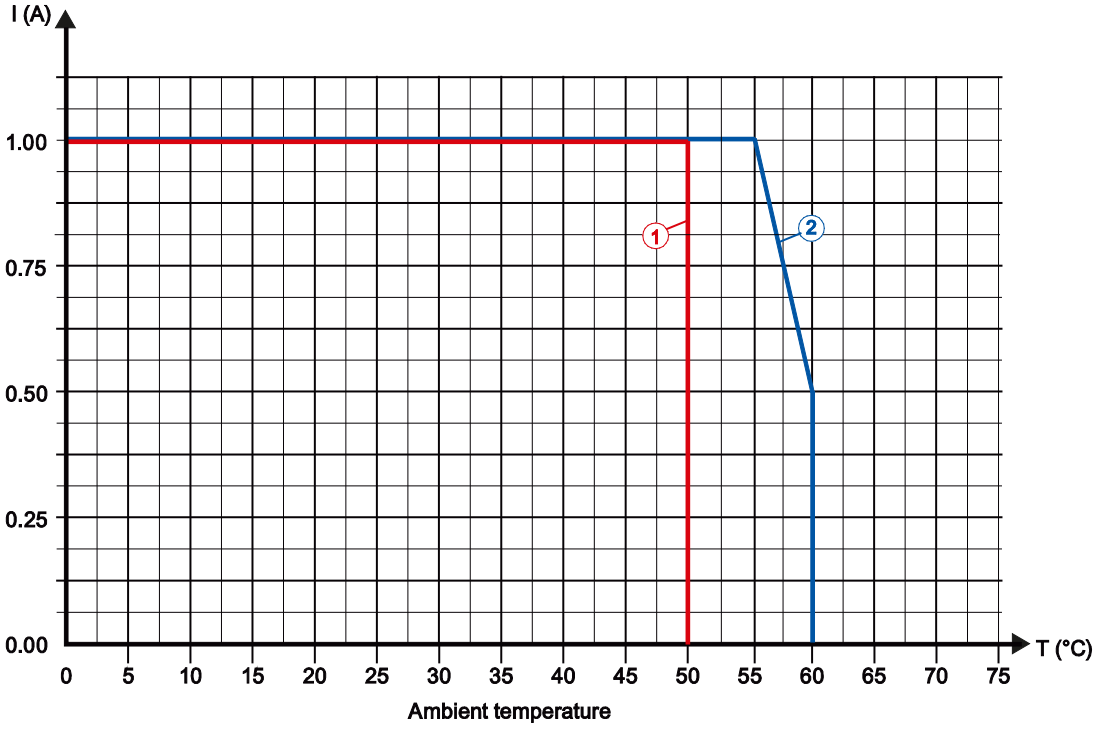
	6ES7138-6AA00-0BA0
Measuring functions	
Measuring time, configurable	Yes
Dyn. measuring time adjustment	Yes
Number of threshold values, configurable	2
Measuring range	
• Frequency measurement, min.	0.04 Hz
• Frequency measurement, max.	800 kHz
• Period measurement, min.	1.25 µs
• Period measurement, max.	25 s
Accuracy	
• Frequency measurement	100 ppm; depends on measuring interval and signal evaluation
• Velocity measurement	100 ppm; depends on measuring interval and signal evaluation
• Period measurement	100 ppm; depends on measuring interval and signal evaluation
Electrical isolation	
Electrical isolation channels	
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between the different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Ambient conditions	
Operating temperature	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C; note derating
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; note derating
Dimensions	
Width	15 mm
Weights	
Weight, approx.	45 g

Derating information for total current of outputs

If the digital outputs of the TM Count 1x24V are operated with resistive or inductive loads, you should derate the total current of the loads at the digital outputs of the technology module. The total current is the sum of the load currents at all digital outputs of the module (without encoder supply).

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Load resistance: 48 Ω (IEC 947-5-1)



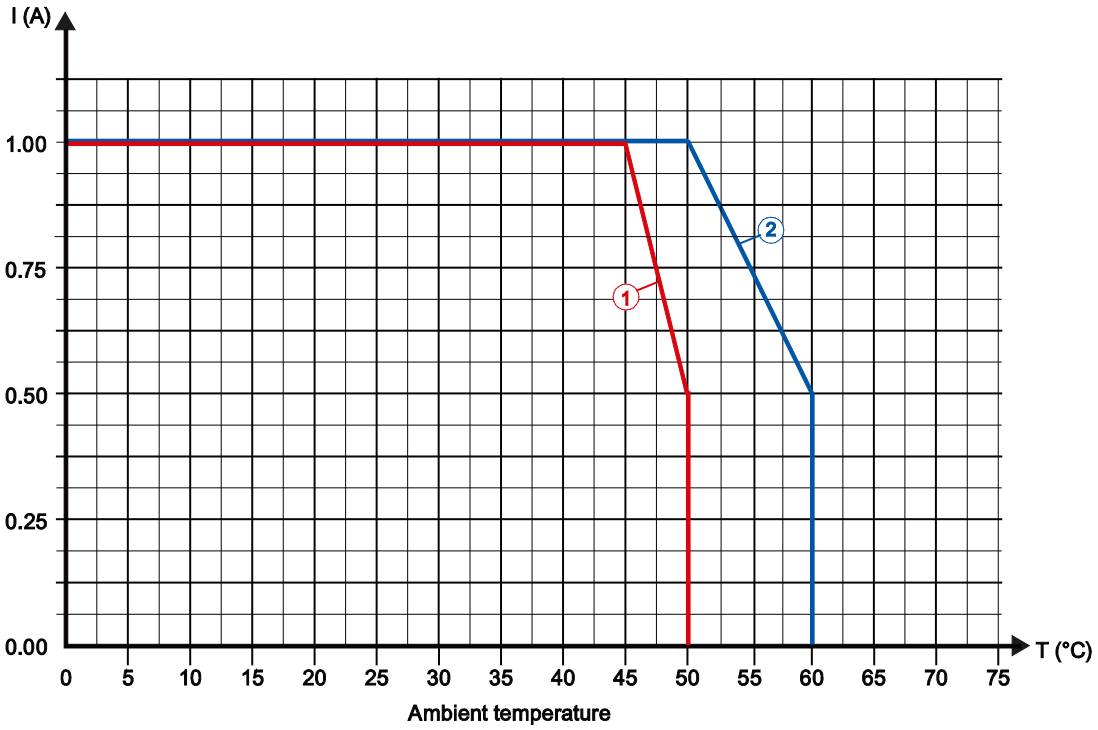
① Vertical installation of the system

② Horizontal installation of the system

Figure 6-1 Total current depending on ambient temperature and mounting position for resistive loads

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Maximum switching frequency at digital outputs of 0.5 Hz
- Load resistance: 48 Ω (IEC 947-5-1)
- Load inductance: 1150 mH (IEC 947-5-1)



① Vertical installation of the system
② Horizontal installation of the system

Figure 6-2 Total current by ambient temperature and mounting position for inductive loads

Note

If the switching frequency is greater than 0.5 Hz or there is greater inductance at the digital outputs, the total current must be reduced further.

Dimensional drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Parameter data records

A

You may edit the module parameters in RUN. The WRREC instruction is used to transfer the parameters to the module using data record 128.

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in the STEP 7 (TIA Portal) Online Help.

Structure of the data record for a distributed configuration with PROFINET

The table below shows you the structure of data record 128 for TM Count 1x24V with 1 channel. The values in byte 0 to byte 3 are fixed and may not be changed. The value in byte 4 can only be changed by means of new parameter assignment and not in RUN mode.

Table A- 1 Parameter data record 128 for central and distributed configuration with PROFINET

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of the parameter data = 48							
2	Reserved[2)]							
3	Reserved[2)]							
4...51	**Counting channel**							
4	**Operating mode**							
4	Reserved[2)]				Operating mode:			
					0000_B: Reserved			
					0001_B: Counting			
					0010_B: Measuring			
					0011 to 1111_B: Reserved			
5	**Basic parameters**							
5	Reserved[2)]					Enable additional diagnostic interrupts[1)]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10_B: Continue operation	
							11_B: Reserved	

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
6...7	**Counter inputs**							
6	Sensor type:		Signal evaluation:		Signal type:			
	00_B: Sourcing output		00_B: Single		0000_B: Pulse (A)			
	01_B: Sinking output		01_B: Double		0001_B: Pulse (A) and direction (B)			
	10_B: Push-pull (sinking and sourcing output)		10_B: Quadruple		0010_B: Count up (A), count down (B)			
	11_B: Reserved		11_B: Reserved		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101 to 1111_B: Reserved			
7	Reaction to signal N:		Invert direction[1]	Enable diagnostics interrupt at wire break[1]	Filter frequency:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
					0001_B: 200 Hz			
	01_B: Synchronization at signal N				0010_B: 500 Hz			
					0011_B: 1 kHz			
	10_B: Capture at signal N				0100_B: 2 kHz			
	11_B: Reserved				0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011 to 1111_B: Reserved			
8...9	**Hardware interrupts**[1]							
8	Reserved[2]	Reserved[2]	Reserved[2]	Change of direction	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop	Gate start
9	Synchroni-zation of the counter by an external signal	New Capture value available	Reserved[2]	Zero pass	Reserved[2]	Comparison event for DQ1 has occurred	Reserved[2]	Comparison event for DQ0 has occurred

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
10...15	**Behavior of DQ0/1**							
10	Set output (DQ1):				Set output (DQ0):			
	0000_B: Use by user program				0000_B: Use by user program			
	0001_B: Between comparison value and high counting limit; Measuring: Measured value >= comparison value				0001_B: Between comparison value and high counting limit; Measuring: Measured value >= comparison value			
	0010_B: Between comparison value and low counting limit; Measuring: Measured value <= comparison value				0010_B: Between comparison value and low counting limit; Measuring: Measured value <= comparison value			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B: Reserved			
	0101_B: After set command from CPU until comparison value				0101_B: After set command from CPU until comparison value			
	0110_B: Not between comparison value 0 and 1				0110 to 1111_B: Reserved			
	0111 to 1111_B: Reserved							
11	Count direction (DQ1):		Count direction (DQ0):		Reserved[2)]	Reserved[2)]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Reserved		00_B: Reserved					
	01_B: Forward		01_B: Forward					
	10_B: Backward		10_B: Backward					
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0):							
13	WORD: Value range in ms/10: 0 to 65535_D							
14	Pulse duration (DQ1):							
15	WORD: Value range in ms/10: 0 to 65535_D							
16	**Behavior of DI0**							
16	Behavior of counter value after Capture (DI0):	Edge selection (DI0):		Select level (DI0):	Reserved[2)]	Set function of DI (DI0):		
		00_B: Reserved				000_B: Gate start/stop (level-triggered)		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)		
	0_B: Continue counting	11_B: At rising and falling edge		1_B: Active with low level		011_B: Synchronization		
						100_B: Enable synchronization at signal N		
	1_B: Set to start value and continue counting					101_B: Capture		
						110_B: Digital input without function		
						111_B: Reserved		

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
17	**Behavior of DI1**: See Byte 16							
18	**Behavior of DI2**: See Byte 16							
19	Frequency:	Reserved[2)]			Filter time:			
	0_B: Once				0000_B: None			
					0001_B: 0.05 ms			
	1_B: Periodic				0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Reserved			
20...43	**Values**							
20...23	High counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
24...27	Comparison value 0: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Operating mode Measuring: REAL: Floating point number in the configured unit of the measured variable							
28...31	Comparison value 1: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D: or 80000000 to $7FFFFFFF_H$; Operating mode Measuring: REAL: Floating point number in the configured unit of the measured variable							
32...35	Start value: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
36...39	Low counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
40...43	Update time: DWORD: Value range in µs: 0 to 25000000_D							
44	**Counter behavior at limits and gate start**							
44	Reaction to gate start:		Reaction to violation of a counting limit:			Reset when counting limit is violated:		
	00_B: Set to start value		000_B: Stop counting			000_B: To other counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Reserved		010 to 111_B: Reserved			010 to 111_B: Reserved		

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
45	**Specify measured value**							
45	Reserved[2]			Time base for velocity measurement:			Measured variable:	
				000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Reserved	
				100_B: 60 s/1 min				
				101 to 111_B: Reserved				
46	Increments per unit:							
47	WORD: Value range: 1 to 65535_D							
48	Set the hysteresis range: Value range: 0 to 255_D							
49...51	Reserved[2]							

[1] You enable a specific parameter by setting the corresponding bit to 1.

[2] Reserved bits must be set to 0.

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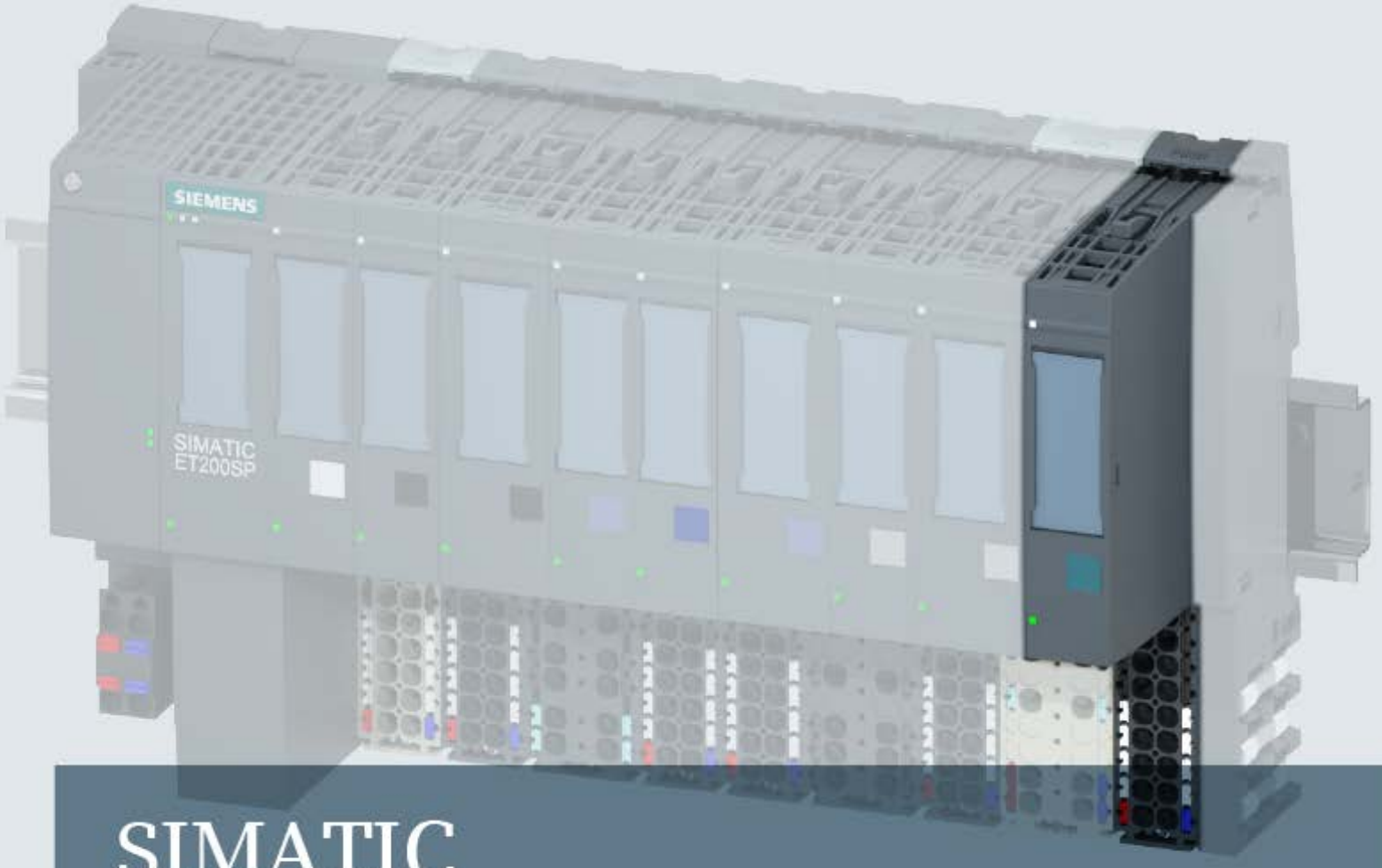

SIMATIC

ET 200SP

Technology Module TM PosInput 1 (6ES7138-6BA00-0BA0)

Edition 04/2016

SIEMENS

SIMATIC

ET 200SP
Technology module TM PosInput 1 (6ES7138-6BA00-0BA0)

Manual

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04/2016

A5E33015755-AC

Legal information

Warning notice system

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding the design and commissioning of the ET 200SP is available in the ET 200SP system manual.

The counting and measuring functions as well as the position input of the TM PosInput 1 technology module are described in more detail in the Counting, measurement and position input (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Conventions

Please observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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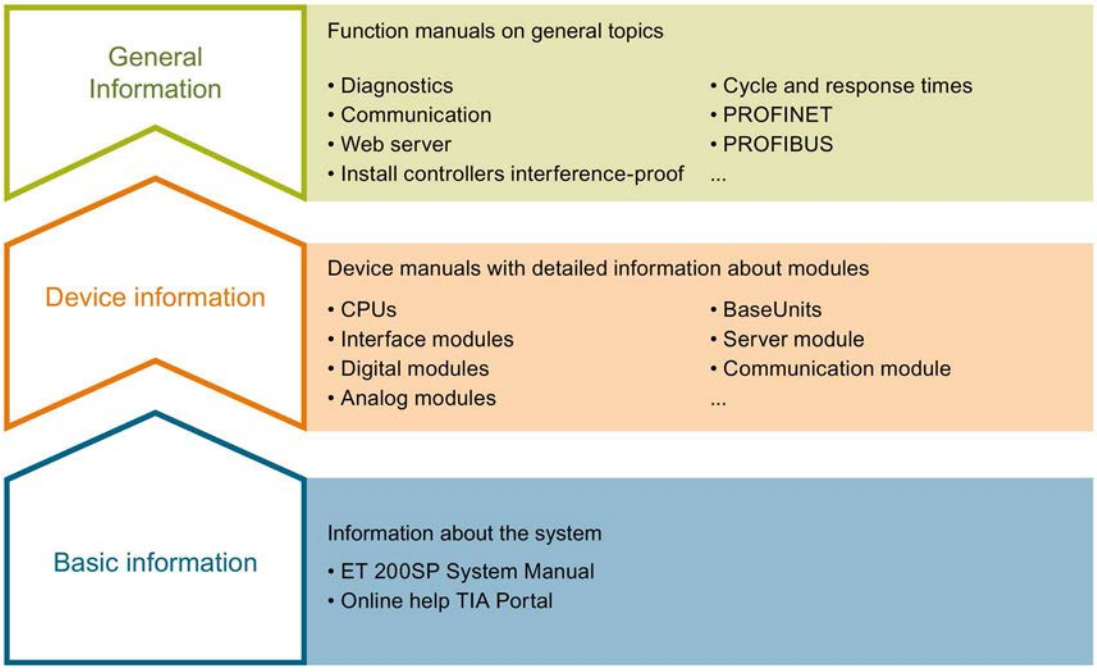
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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- Manuals, characteristics, operating manuals, certificates
- Product master data

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Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

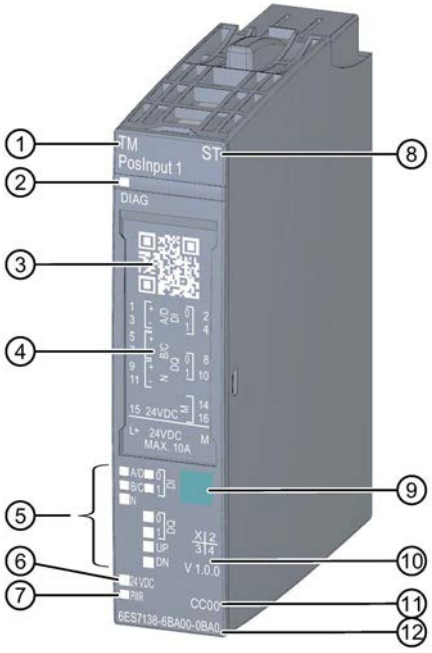
2

2.1 Properties

Article number

6ES7138-6BA00-0BA0

View of the module



① Module type and designation
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for encoder supply
⑦ LED for supply voltage
⑧ Function class
⑨ Module type color coding
⑩ Function and firmware version
⑪ Color code for selecting the color-coded labels
⑫ Article number

Image 2-1 View of the TM PosInput 1 module

Properties

The TM PosInput 1 technology module has the following properties:

- Technical properties
  - One channel
  - Interfaces:

    SSI encoder signals DAT and CLK or RS422/TTL encoder signals A, B and N

    24 V encoder supply output, short-circuit proof

    Digital inputs signals DI0 and DI1

    Digital output signals DQ0 and DQ1

    L+ supply voltage
  - Position value range: 31 bits
  - Count range: 32 bits
  - Fast Mode configurable
  - Monitoring of encoder signals for wire break, short-circuit and offset voltage
  - Hardware interrupts configurable
  - Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Supported encoder/signal types
  - SSI absolute encoder
  - RS422/TTL incremental encoder with and without signal N
  - RS422/TTL pulse encoder with direction signal
  - RS422/TTL pulse encoder without direction signal
  - RS422/TTL pulse encoders for up & down pulses
- Supported system functions
  - Isochronous mode
  - Firmware Update
  - Identification data I&M

Accessories

The following accessories can be used with the module and are not included in the product package:

- Labeling strip
- Color identification labels
- Reference identification labels
- Shield connector

A BaseUnit of the A0 type is required to operate the technology module. For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

For detailed information on the installation procedure, refer to the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Acquisition of encoder signals

2.2.1.1 Position input with SSI absolute encoder

You can use the TM PosInput 1 technology module with an SSI absolute encoder for position input. The technology module reads the position via a synchronous, serial interface from the SSI absolute encoder and sends it to the controller.

You can switch the digital outputs of the technology module exactly at defined position values, independently of the user program. Position input with an SSI absolute encoder does not involve gate control.

Gray-dual conversion

Gray-code and dual-code SSI absolute encoders are supported.

Range for position value

You can specify a frame length of 10 bits to 40 bits for the SSI absolute encoder. The configurable bit numbers of the LSB and the MSB of the position value in the frame define the value range. The technology module can read in a position value with a maximum length of 31 bits and transfer it to the PLC. The position value is treated as unsigned positive value and can assume values between 0 and $2^{(MSB-LSB+1)}-1$.

Complete SSI frame

Instead of having a measured variable returned, you can choose to have the least significant 32 bit of the current unprocessed SSI frame returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface.

Capture (Latch)

You can save the current position value as Capture value using the edge of the digital input. The Capture function is triggered by rising, falling or both edges.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output will be prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the position value fluctuate around this position. If a comparison value or a position value limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.1.2 Counting with incremental or pulse encoder

Counting refers to the recording and adding up of events. The counters of the technology module detect encoder signals and pulses and evaluate them accordingly. The count direction can be specified using encoder or pulse signals or through the user program.

You can control the counting processes with the digital inputs.

You can specify the counter characteristics using the functions described below.

Counting limits

The counting limits define the counter value range used. The counting limits are configurable and can be modified during runtime with the user program.

The maximum possible counting limit is 2147483647 (2^{31}–1). The minimum possible counting limit is –2147483648 (–2^{31}).

You can configure the response of the counter at the counting limits:

- Continue or stop counting upon violation of a counting limit (automatic gate stop)
- Set counter value to start value or to other counting limit upon violation of a counting limit

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime with the user program.

Depending on the parameter assignment, the technology module can set the current counter value to the start value upon synchronization, upon Capture function activation, upon violation of a counting limit or when the gate is opened.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured.

The control of the hardware gate takes place externally via the digital inputs of the technology module. Control of the software gate takes place via the user program. The hardware gate can be enabled through parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture (Latch)

You can configure an external reference signal edge that triggers the saving of the current counter value as Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of the N signal at the encoder input

When using a digital input, you can specify whether counting is to continue from the current counter value or from the start value after the Capture function. When using the rising edge of the N signal at the encoder input, counting is to continue from the current counter value after the Capture function.

Synchronization

You can configure the edge of an external reference signal to load the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of the N signal at the encoder input
- Rising edge of the N signal at the encoder input depending on the level of the assigned digital input

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output will be prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the counter value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.2 Measured value determination

The following measuring functions are available:

Measurement type	Description
Frequency measurement	The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in Hertz as floating point number.
Period measurement	The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in seconds as floating point number.
Velocity measurement	The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and other parameters, and returned in the configured unit of measurement.

The measured value and the counter value are available concurrently in the feedback interface. Instead of having a measured variable returned, you can choose to have the least significant 32 bit of the current unprocessed SSI frame returned when using an SSI absolute encoder.

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time. Setting longer update time intervals allows uneven measured variables to be smoothed and increases measuring accuracy.

Gate control for incremental and pulse encoders

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After closing, the last measured value captured continues to be returned.

Measuring ranges

The measuring functions have the following measuring range limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	4 MHz*
Period measurement	0.25 µs*	25 s
Velocity measurement	Depends on the configured number of "increments per unit" and the "time base for velocity measurement"	

* Applies to incremental encoders and "Quadruple" signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value or position value increased or decreased during the relevant time period.

2.2.3 Switching the outputs at comparison values

You define two comparison values that can control the two digital outputs independent of the user program. The comparison values are configurable and can be modified during runtime with the user program.

Comparison values in the Counting mode

Depending on the encoder, you define two position or counter values as comparison values in the Counting mode. If the current position or counter value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

Comparison values in the Measuring mode

You define two comparison values in the Measuring mode. If the current measured value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

2.2.4 Position input for Motion Control

You can use the technology module for position input with S7-1500 Motion Control .

In the device configuration of the technology module in STEP 7 (TIA Portal), select "Position input for Motion Control" mode.

When using an incremental encoder or pulse encoder, the position input is based on the counting function of the technology module. With an SSI absolute encoder, the absolute value is read in via a synchronous, serial interface and prepared according to the parameter assignment to be made available for S7-1500 Motion Control.

Additional information

A detailed description of the use of Motion Control and its configuration is available in the function manual S7-1500 Motion Control as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279).

2.2.5 Fast Mode

You can use the technology module in Fast Mode for very fast detection of the numerical or position value in case of compressed functionality. In Fast Mode, you have access to a reduced feedback interface but not to a control interface. This means you can use a shorter send clock for the CPU.

The range of functions of the technology module has the following additional limitations in Fast Mode:

- Parameter change in RUN only possible with data record 128
- Count/position value range: 25 bits
- No measured value available
- No software gate available
- No complete SSI frame available
- No Capture function available
- No hardware interrupts available
- Combined error message (feedback bit) that is acknowledged automatically

To do this, select "Fast Mode" operating mode in the device configuration of the technology module in STEP 7 (TIA Portal).

2.2.5.1 Fast Mode with SSI absolute encoder

You can use the technology module with an SSI absolute encoder for position input. The technology module reads the position value via a synchronous serial interface from the SSI absolute encoder and makes it available to the controller.

You can switch the digital outputs of the technology module exactly at defined position values, independently of the user program. The comparison values can only be changed with data record 128 in RUN. Position input with an SSI absolute encoder does not involve gate control.

Gray-dual conversion

Gray-code and dual-code SSI absolute encoders are supported.

Range for position value

You can specify a frame length of 10 bits to 40 bits for the SSI absolute encoder. The configurable bit numbers of the LSB and the MSB of the position value in the frame define the value range. The technology module can read a position value with a maximum length of 25 bits and communicate it to the controller. The position value is treated as unsigned positive value and can assume values between 0 and $2^{(MSB-LSB+1)}-1$.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output will be prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the position value fluctuate around this position. If a comparison value or a position value limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.5.2 Fast Mode with incremental or pulse encoder

Counting refers to the recording and adding up of events. The counters of the technology module detect encoder signals and pulses and evaluate them accordingly. The counting direction can be specified using encoder or pulse signals.

You can control the counting processes with the digital inputs.

When you are using an incremental encoder or pulse encoder in Fast Mode, you can specify the counter characteristics using the functions described below.

Counting limits

The counting limits define the counter value range used. The counter limits are configurable and can be modified during runtime using data record 128 but not through the control interface.

The maximum possible counting limit is 33554431 (2^{25}–1). The minimum possible counting limit is 0.

You can configure the response of the counter at the counting limits:

- Continue or stop counting upon violation of a counting limit (automatic gate stop with configured hardware gate)
- Set counter value to start value or to other counting limit upon violation of a counting limit

Start value

You can configure a start value within the counting limits. The start value can only be modified during runtime with data record 128.

Depending on the parameter assignment, the technology module can set the current counter value to the start value upon synchronization, upon violation of a counting limit or when the configured hardware gate is opened.

Gate control

Opening and closing the hardware gate (HW gate) defines the period of time during which the counting signals are recorded.

The control of the hardware gate takes place externally via the digital inputs of the technology module. The hardware gate can be enabled through parameter assignment. All count signal are recorded when you do not configure a hardware gate. A software gate is not available.

Synchronization

You can configure the edge of an external reference signal to load the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of the N signal at the encoder input
- Rising edge of the N signal at the encoder input depending on the level of the assigned digital input

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output will be prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the counter value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.6 Additional functions

Hardware interrupts

The technology module can trigger a hardware interrupt in the CPU, for example, if a compare event occurs, in the event of a zero crossing and/or a change of count direction (direction reversal). You can specify which events (Page 68) are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger a diagnostic interrupt in the event of a missing supply voltage or an error at the digital outputs, for example. Select the diagnostic interrupts (Page 66) in the device configuration freely.

Monitoring of encoder signals

The technology module monitors signals of an encoder for wire breaks, short-circuits and offset voltages. In the case of an SSI absolute value encoder, the technology module also monitors SSI frames for errors.

If you enable the diagnostic interrupts, the technology module triggers a diagnostic interrupt in the event of a corresponding error.

Input filter

To suppress interference, you can configure an input filter for the RS422/TTL encoder inputs and for the digital inputs.

Distributed application

You can use the technology module in a distributed configuration by using an interface module in the ET 200SP distributed I/O system. The following applications are possible:

- Distributed operation in an S7-1500 system
- Distributed operation in an S7-1200 system
- Distributed operation in an S7-300/400 system
- Distributed operation in a third-party system

Isochronous mode

The technology module supports the "isochronous mode" system function in distributed mode. This system function enables position, counter and measured values to be recorded in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A change in the state of a digital input immediately affects the planned reaction of the technology module and changes the status bit of the digital input in the feedback interface (Page 51).

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. The position or counter value and, if required, the measured value and the status bits as well are captured at the time T_i and made available in the feedback interface for retrieval in the current bus cycle.

In isochronous mode, there is always data consistency across all bytes in the feedback interface.

Additional information

A detailed description of the isochronous mode is available in the PROFINET with STEP 7 function manual as download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

Wiring

3

3.1 Pin assignment

The TM PosInput 1 is used with a BaseUnit of the A0 type.

The encoder signals, the digital input and output signals and the encoder supply are connected to the BaseUnit of the technology module. The supply voltage feed on the light BaseUnit BU...D of the associated potential group supplies the module and the digital outputs, and generates the encoder supply voltage.

BaseUnit

The BaseUnit is not included in the product package of the module and must be ordered separately.

For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

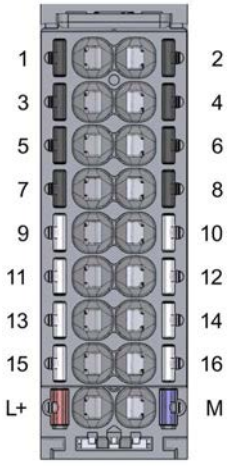
You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) device manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Pin assignment of the BaseUnit

The table below shows the pin assignment, using the BaseUnit BU15-P16+A0+2B as an example.

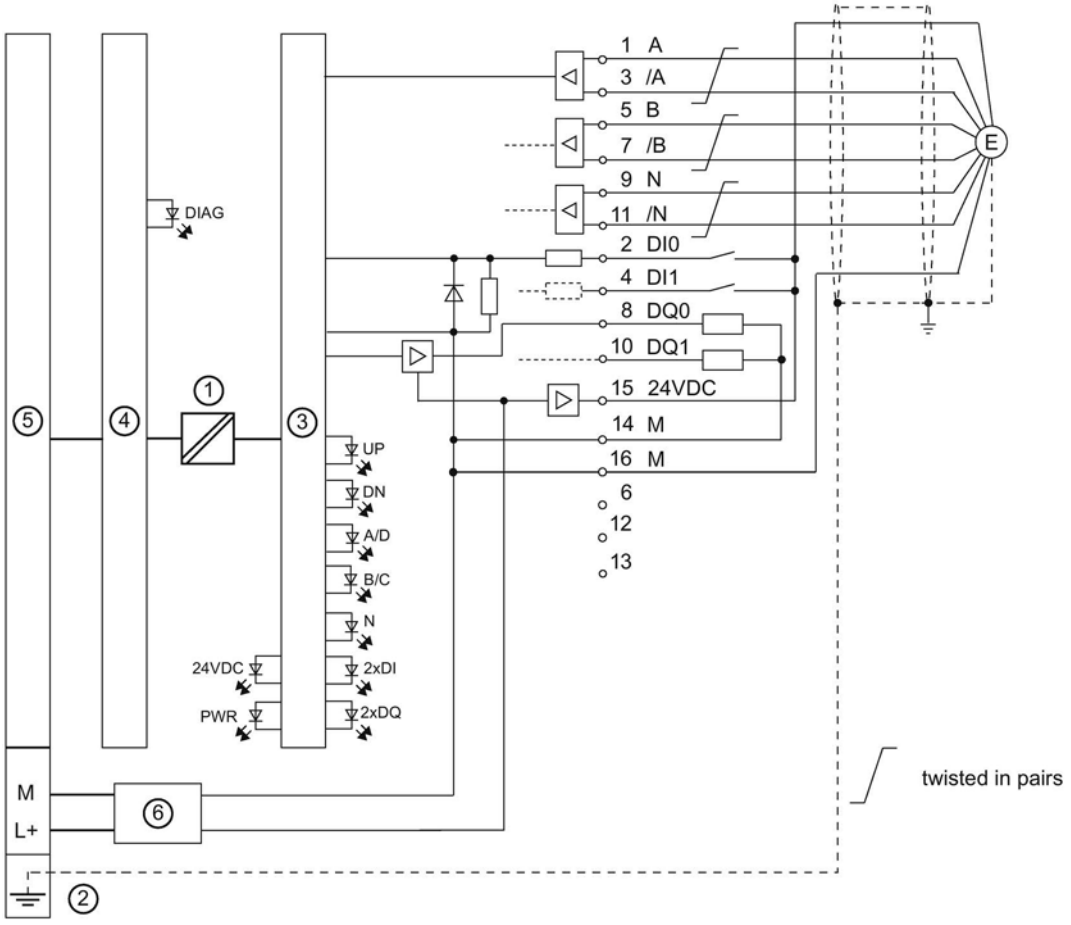
Table 3- 1 Pin assignment of the BaseUnit BU15-P16+A0+2B

View	Signal name		Designation					
			RS422/TTL incremental encoder		RS422/TTL pulse encoder			SSI absolute encoder
			with signal N	without signal N	with direction signal	without direction signal	up/down	
	1	A or D	Encoder signal A		Counting signal A		Up counting signal A	SSI data signal DAT
	3	/A or /D	Encoder signal /A (RS422 only)		Counting signal /A (RS422 only)		Up counting signal /A (RS422 only)	SSI data signal /DAT
	5	B or C	Encoder signal B		Direction signal B	—	Down counting signal B	SSI clock signal CLK
	7	/B or /C	Encoder signal /B (RS422 only)		Direction signal /B (RS422 only)		Down counting signal /B (RS422 only)	SSI clock signal /CLK
	9	N	Encoder signal N	—				
	11	/N	Encoder signal /N (RS422 only)	—				
	2	DI0	Digital input DI0					
	4	DI1	Digital input DI1					
	8	DQ0	Digital output DQ0					
	10	DQ1	Digital output DQ1					
	6	—	—					
	12	—	—					
	13	—	—					
	Supply voltage, encoder supply and ground							
	15	24VDC	24 V encoder supply					
	14	M	Ground for encoder supply, digital inputs and digital outputs					
	16	M						
		L+	DC 24V supply voltage					
		M	Ground for supply voltage					

Block diagrams

You must ground the shields of the cables between encoder and technology module both through the shield terminal on the BaseUnit (shield bracket and terminal) and also on the encoder.

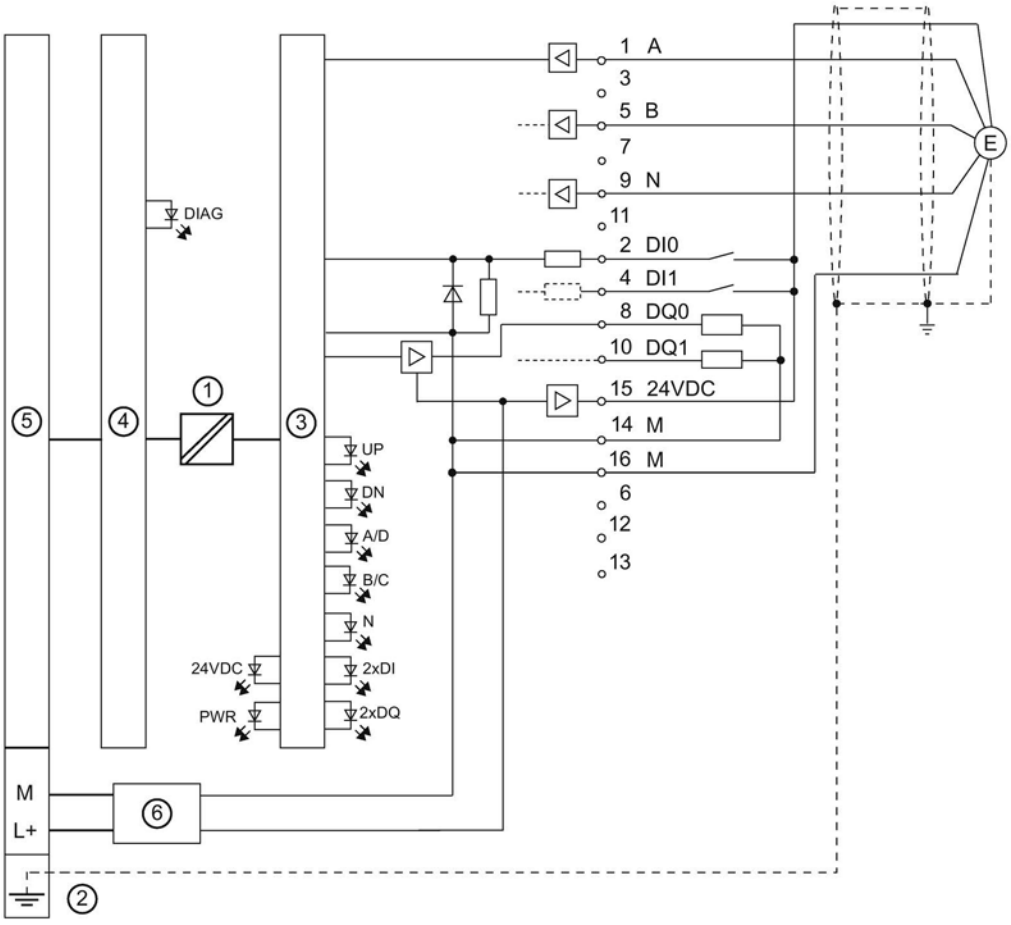
The figure below shows the block diagram of the technology module with one connected RS422 incremental encoder.



① Electrical isolation
② Shield connection on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ Input filter

Image 3-1 Block diagram with RS422 incremental encoder

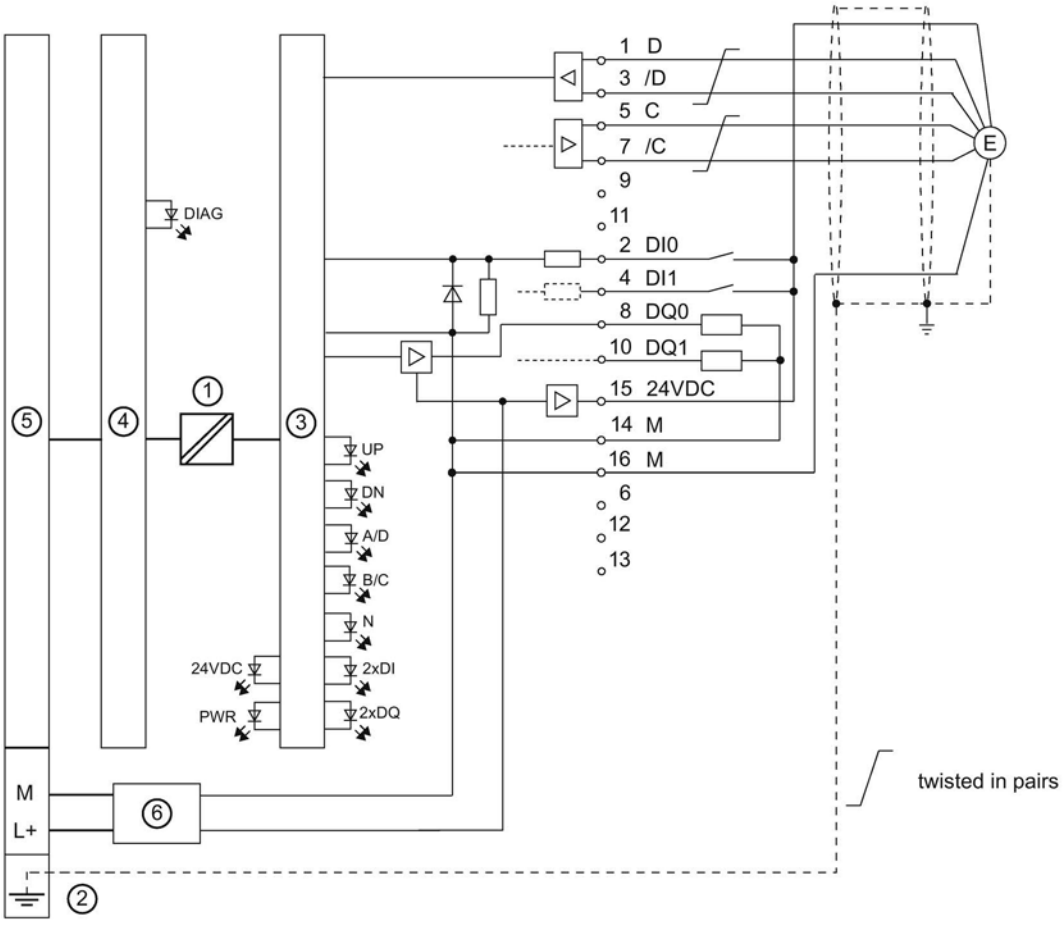
The figure below shows the block diagram of the technology module with one connected TTL incremental encoder.



① Electrical isolation
② Shield connection on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ Input filter

Image 3-2 Block diagram with TTL incremental encoder

The figure below shows the block diagram of the technology module with one connected SSI absolute encoder.



① Electrical isolation
② Shield connection on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ Input filter

Image 3-3 Block diagram with SSI absolute encoder

L+/M supply voltage

Connect the supply voltage (DC 24V) to the L+ and M connections. An internal protective circuit protects the technology module from polarity reversal of the supply voltage. The technology module monitors the connection of the supply voltage.

24VDC encoder supply

To supply the encoder and sensors at the digital inputs, the technology module supplies the DC 24V supply voltage at the 24VDC output with reference to M. Voltage is supplied from the L+/M supply voltage and monitored for short circuits and overload.

RS422/TTL encoder signals/count signals and SSI encoder signals

The TM PosInput 1 can process either counting or SSI encoder signals. The counting encoder signals are designated A, B and N and use either the RS422 or TTL signal standard. The SSI encoder signals are designated DAT (letter D) and CLK (letter C) and use the RS422 signal standard.

An encoder signal with TTL standard uses a single cable. An RS422 encoder signal uses one cable pair and the count/SSI information is transmitted as differential voltage. This ensures interference-free transmission of RS422 encoder signals even with high frequencies over long distances. The RS422 line pairs must be twisted together in the cable.

You can connect the following encoder types:

- SSI absolute encoder:

  The SSI encoder signals CLK and DAT are connected via the C and D terminals. The N terminals remain disconnected.

- RS422/TTL incremental encoder with signal N:

  The encoder signals A, B and N are connected using the terminals labeled accordingly. A and B are the two incremental signals phase-shifted by 90°. N is the zero mark signal which returns one pulse per revolution.

- RS422/TTL incremental encoder without signal N:

  The encoder signals A and B are connected via the terminals labeled accordingly. A and B are the two incremental signals phase-shifted by 90°. The N terminals remain disconnected.

- RS422/TTL pulse encoder without direction signal:

  The counting signal is connected at the A terminals. The count direction is specified via the control interface. The B and N terminals remain disconnected.

- RS422/TTL pulse encoder with direction signal:

  The counting signal is connected at the A terminals. The direction signal is connected at the B terminals. The N terminals remain disconnected.

- RS422/TTL pulse encoder with up/down count signal:

  The up counting signal is connected at the A terminals. The down counting signal is connected at the B terminals. The N terminals remain disconnected.

The inputs are not electrically isolated from each other. The inputs are isolated against the backplane bus.

Note

The RS422 signal standard offers greater interference immunity than the TTL signal standard. If your incremental encoder or pulse encoder supports the RS422 **and** the TTL signal standard, we recommend using the RS422 signal standard.

Input filter for RS422/TTL signals from incremental encoders and pulse encoders

To suppress interference, you can configure an input filter for the encoder inputs A, B and N. The selected filter frequency is based on a pulse-break ratio of between 40:60 and 60:40. This results in a specific minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can specify the following values for the filter frequency:

Table 3- 2 Filter frequency and respective minimum pulse/break time

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz	2.0 µs
500 kHz	0.8 µs
1 MHz (default)	0.4 µs

Digital inputs DI0 and DI1

Two digital outputs are available. The digital inputs are used for gate control, synchronization and the Capture function. Alternatively, you can use one or both digital inputs without the functions named and read the signal state of the respective digital input via the feedback interface.

The digital inputs are not electrically isolated from each other.

Input filters for digital inputs

To suppress interferences, you can configure an input delay for the digital inputs.

You can specify the following values for the input delay:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Digital outputs DQ0 and DQ1

There are two digital outputs. The two digital outputs DQ0 and DQ1 can be activated/switched directly by the specified comparison values or by the user program.

The digital outputs are not isolated from each other.

The digital outputs are 24 V sourcing outputs in reference to M and can carry a rated load current of 0.5 A. They are protected from overload and short-circuit.

Note

Relays and contactors can be connected direct without external circuitry. You can find information on the maximum possible operating frequencies and the inductive loads at the digital outputs in the section Technical specifications (Page 69).

Configuring/address space

4

4.1 Configuring

Introduction

The technology module is configured and assigned parameters with the configuration software.

The technology module functions are controlled and monitored by the user program.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Distributed operation in an S7-1500 system	• S7-1500 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): • Device configuration with hardware configuration • Parameter settings with technology object (e.g. High_Speed_Counter)	Position input with SSI absolute encoder: Direct access to the control and feedback interface (Page 48) of the TM PosInput 1 in the I/O data Counting and measuring functions: High_Speed_Counter instruction for the technology object
		STEP 7 (TIA Portal): Device configuration with hardware configuration in "Position input for Motion Control" operating mode	Control by an axis technology object of the Motion Control category
		STEP 7 (TIA Portal): Device configuration with hardware configuration in "Fast Mode " operating mode	Direct access to the feedback interface (Page 52) of the TM PosInput 1 in the I/O data

Applications	Components required	Configuration software	In the user program
Distributed operation in an S7-300/400 or S7-1200 system	• S7-300/400 or S7-1200 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration STEP 7: Device configuration and parameter settings with HSP	Direct access to the control and feedback interface (Page 48) of the TM PosInput 1 in the I/O data
Distributed operation in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM PosInput 1	Third-party configuration software: Device configuration and parameter settings with GSD file	Direct access to the control and feedback interface (Page 48) of the TM PosInput 1 in the I/O data

Additional information

A detailed description of the counting and measuring functions and their configuration is available:

- In the Counting, measurement and position input function manual available as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

A detailed description of the use of Motion Control and its configuration is available:

- In the S7-1500 Motion Control function manual, available as a download from the Internet (http://support.automation.siemens.com/WW/view/en/59381279)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Motion Control > Motion Control (S7-1200, S7-1500)"

Hardware Support Package

If the technology module is not yet integrated in your TIA Portal version, you can integrate is as of TIA Portal V13 SP1 with the HSP0184.

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

GSD file

The or GSD file for the ET 200SP distributed I/O system is available for download from the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

See also

Parameters (Page 38)

4.2 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module to CPU STOP for each channel in the basic parameters of the device configuration.

Table 4- 1 Response of the technology module to CPU STOP depending on parameter assignment

Basic parameters	Reaction to CPU STOP
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the position value is read in. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the function "In case of comparison value for a pulse duration" is set at CPU stop, the digital output is reset after expiry of the pulse duration. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

4.3 Address space

Address space of the technology module

Table 4- 2 Range of the input addresses and output addresses of the TM PosInput 1

	Inputs	Outputs
Range	16 bytes	12 bytes

Table 4- 3 Range of the input and output addresses of the TM PosInput 1 in the "Position input for Motion Control" mode

	Inputs	Outputs
Range	16 bytes	4 bytes

Table 4- 4 Range of the input and output addresses of the TM PosInput 1 in the "Fast Mode" operating mode

	Inputs	Outputs
Range	4 bytes	0 bytes

Additional information

A description on how to use the control and feedback interface of TM PosInput 1 can be found in the section Control and feedback interface (Page 48).

4.4 Parameters

You can use various parameters to define the properties of the technology module. Depending on the settings, not all parameters are available. You can change the parameter assignment in the user program using data record 128 (Page 77).

You have the following options for setting the module's parameters:

Parameter setting via ...	Basic procedure
Hardware configuration and technology object in STEP 7 (TIA Portal)	1. Set the device configuration in the hardware configuration. "Operating with technology object" must be set as the operating mode. 2. Assign the parameters using the technology object. 3. Download the parameter assignment to the module.
Hardware configuration in STEP 7 (TIA Portal)	1. Set the device configuration in the hardware configuration. "Manual operation", "Fast Mode" or "Position input for Motion Control" must be set as the operating mode. 2. Set the parameters in the hardware configuration. 3. Download the parameter assignment to the module.
Hardware configuration in STEP 7 using HSP file	1. Install the corresponding HSP file. You will then find the module in the Hardware catalog under "ET 200SP". 2. Set the device configuration and the parameters in the hardware configuration. 3. Download the parameter assignment to the module.
Hardware configuration using GSD file for distributed operation on the PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the Hardware catalog under "Other field devices". 2. Set the parameters of the PROFINET GSD file in the hardware configuration. 3. Download the parameter assignment to the module.
Hardware configuration using GSD file for distributed operation on the PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the Hardware catalog under "Other field devices". 2. Set parameters of the PROFIBUS GSD file in the hardware configuration. The following tables with [1] highlighted parameters are not configured in the PROFIBUS GSD file. 3. Download the parameter assignment to the module. This will download the parameters marked with [1] in the following tables with the default setting. You can change these parameters in the user program using data record 128 (Page 77).

The parameters are listed in the following tables.

Parameters of the TM PosInput 1 with incremental or pulse encoder

If you use an incremental or pulse encoder, you can set the following parameters:

Table 4- 5 Configurable parameters and their defaults

Parameter	Value range	Default setting	Re-configuration in RUN
Operating mode	• Counting • Measuring	Counting	No
Interface standard	• RS422, symmetrical • TTL (5 V), asymmetric	RS422, symmetrical	Yes
Reaction to CPU STOP[1]	• Output substitute value • Keep last value • Continue operation	Output substitute value	Yes
Enable diagnostic interrupt on wire break[2]	• Deactivated • Activated	Deactivated	Yes
Enable additional diagnostic interrupts	• Deactivated • Activated	Deactivated	Yes
Signal type	• Pulse (A) • Pulse (A) and direction (B) • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • Incremental encoder (A, B, N)	Pulse (A) and direction (B)	Yes
Signal evaluation for counter inputs	• Single • Double • Quadruple	Single	Yes

Parameter	Value range	Default setting	Re-configuration in RUN
Filter frequency for counter inputs[1]	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • 200 kHz • 500 kHz • 1 MHz	1 MHz	Yes
Invert direction(counter inputs)[1]	• Deactivated • Activated	Deactivated	Yes
Reaction to signal N[1]	• No reaction to signal N • Synchronization at signal N • Captureat signal N	No reaction to signal N	Yes
Signal selection for reference mark 0[3]	• DI0 • Signal N of the incremental encoder	DI0	Yes
Hardware interrupt:Gate start[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt: Gate stop[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt: Overflow (high counting limit violated)[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Underflow (low counter limit violated)[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Change of direction[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Comparison event for DQ0 occurred[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Comparison event for DQ1 occurred[1]	• Deactivated • Activated	Deactivated	Yes

Parameter	Value range	Default setting	Re-configuration in RUN
Hardware interrupt:Zero point[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt: New Capture value available[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Synchronization of the counter by an external signal[1]	• Deactivated • Activated	Deactivated	Yes
Set output	• Use by user program • Between comparison value and high limit • Between comparison value and low counter limit • At comparison value for a pulse duration • After set command from CPU until comparison value • Between comparison value 0 and 1 • Not between comparison value 0 and 1 • Digital output without function[4]	DQ0, DQ1: Between comparison value and high limit (Fast Mode: Digital output without function)	Yes
Substitute value for DQ[1]	• 0 • 1	DQ0, DQ1: 0	Yes
Count direction of the DQ function[1]	• Up • Down • In both directions	In both directions	Yes
Pulse duration [ms/10][1]	0...65535	5000 (corresponds to 0.5 s)	Yes
Setting function of the DI	• Gate start/stop (level-triggered) • Gate start (edge-triggered) • Gate stop (edge-triggered) • Synchronization • Enable synchronization at signal N • Capture • Digital input without function	• DI0:Gate start/stop (level-triggered) • DI1:Digital input without function	Yes
Select level for DI[1]	• Active with high level • Active with low level	Active with high level	Yes

Parameter	Value range	Default setting	Re-configuration in RUN
Select edge for DI[1]	• At rising edge • At falling edge • At rising and falling edge	At rising edge	Yes
Behavior of counter value after Capture with DI[1]	• Continue counting • Set to start value and continue counting	Continue counting	Yes
Input delay for digital inputs[1]	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	0.1 ms	Yes
Frequency of synchronization[1]	• Once • Periodic	Once	Yes
Count direction for synchronization[4]	• Up • Down • In both directions	Up	Yes
High counting limit[1]	-2147483647...2147483647 (Fast Mode: 1...33554431)	2147483647 (Fast Mode: 33554431)	Yes
Comparison value 0[1]	-2147483648...2147483647 (Fast Mode: 0...33554431)	0	Yes
Comparison value 1[1]	-2147483648...2147483647 (Fast Mode: 0...33554431)	10	Yes
Start value[1]	-2147483648...2147483647 (Fast Mode: 0...33554431)	0	Yes
Low counting limit[1]	-2147483648...2147483646 (Fast Mode: 0...33554430)	-2147483648 (Fast Mode: 0)	Yes
Reset when counting limit is violated	• To other counting limit • To start value	To other counting limit	Yes
Reaction to violation of a counting limit	• Stop counting • Continue counting	Continue counting	Yes

Parameter	Value range	Default setting	Re-configuration in RUN
Reaction to gate start	• Set to start value • Continue with current value	Continue with current value	Yes
Measured variable	• Frequency • Period • Velocity	Frequency	Yes
Update time [µs] of the measuring function[1]	0...25000000	10000 (corresponds to 10 ms)	Yes
Time base for velocity measurement[1]	• 1 ms • 10 ms • 100 ms • 1 s • 60 s/1 min	60 s/1 min	Yes
Increments per unit[1]	1...65535	1	Yes
Hysteresis[1]	0...255	0	Yes
Steps per revolution:[3]	1...65535	1	Yes
Reference speed[3] [10^{-2} rpm]	600...21000000	300000 (corresponds to 3000 rpm)	Yes
Potential group	• Use the potential group of the left module (dark BaseUnit) • Enable new potential group (light BaseUnit)	Use the potential group of the left module (dark BaseUnit)	No

1 This parameter cannot be configured using PROFIBUS GSD file. The parameter is loaded to the module with the default setting and can be adapted using the data record 128.

2 When a GSD file is used, this diagnostic interrupt is activated via the "Enable additional diagnostic interrupts" parameter and cannot be set separately.

3 Only available in "Position input for Motion Control" operating mode

4 Only available in "Fast Mode" operating mode

Parameters of the TM PosInput 1 with SSI absolute encoder

If you use an SSI absolute encoder, you can set the following parameters:

Table 4- 6 Configurable parameters and their defaults

Parameter	Value range	Default setting	Re-configuration in RUN
Operating mode	• Counting • Measuring	Counting	No
Reaction to CPU STOP[1]	• Output substitute value • Keep last value • Continue operation	Output substitute value	Yes
Enable additional diagnostic interrupts	• Deactivated • Activated	Deactivated	Yes
Enable diagnostic interrupt on wire break[2]	• Deactivated • Activated	Deactivated	Yes
Monoflop time[1]	• Automatically • 16 µs • 32 µs • 48 µs • 64 µs	Automatically	Yes
Type of code	• Gray • Dual	Gray	Yes
Parity	• None • Even • Odd	None	Yes
Invert direction (position value)[1]	• Deactivated • Activated	Deactivated	Yes
Transmission rate	• 125 kHz • 250 kHz • 500 kHz • 1 MHz • 1.5 MHz • 2 MHz	125 kHz	Yes
Frame length	10 bits to 40 bits	13 bits	Yes

Parameter	Value range	Default setting	Re-configuration in RUN
Bit number LSB of the position value	0...38	0	Yes
Bit number MSB of the position value	1...39	12	Yes
Hardware interrupt:Change of direction[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Comparison event for DQ0 occurred[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Comparison event for DQ1 occurred[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt:Zero point[1]	• Deactivated • Activated	Deactivated	Yes
Hardware interrupt: New Capture value available[1]	• Deactivated • Activated	Deactivated	Yes
Set output	• Use by user program • Between comparison value and high limit • Between comparison value and low counter limit • Between comparison value 0 and 1 • Not between comparison value 0 and 1 • At comparison value for a pulse duration • After set command from CPU until comparison value • Digital output without function[4]	DQ0, DQ1: Between comparison value and high limit (Fast Mode: Digital output without function)	Yes
Substitute value for DQ[1]	• 0 • 1	DQ0, DQ1: 0	Yes
Count direction of the DQ function[1]	• Up • Down • In both directions	In both directions	Yes
Pulse duration [ms/10][1]	0...65535	5000 (corresponds to 0.5 s)	Yes

Parameter	Value range	Default setting	Re-configuration in RUN
Behavior of DI	• Capture • Digital input without function	DI0, DI1:Digital input without function	Yes
Select edge for DI[1]	• At rising edge • At falling edge • At rising and falling edge	At rising edge	Yes
Input delay for digital inputs[1]	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	0.1 ms	Yes
Comparison value 0[1]	-2147483648...2147483647 (Fast Mode: 0...33554431)	0	Yes
Comparison value 1[1]	-2147483648...2147483647 (Fast Mode: 0...33554431)	10	Yes
Measured variable	• Frequency • Period • Velocity • Complete SSI frame	Frequency	Yes
Update time [µs] of the measuring function[1]	0...25000000	10000 (corresponds to 10 ms)	Yes
Time base for velocity measurement[1]	• 1 ms • 10 ms • 100 ms • 1 s • 60 s/1 min	60 s/1 min	Yes
Increments per unit[1]	1...65535	1	Yes
Hysteresis[1]	0...255	0	Yes
Steps per revolution:[3]	1...65535	1	Yes

Parameter	Value range	Default setting	Re-configuration in RUN
Reference speed[3] [10^{-2} rpm]	600...21000000	300000 (corresponds to 3000 rpm)	Yes
Potential group	• Use the potential group of the left module (dark BaseUnit) • Enable new potential group (light BaseUnit)	Use the potential group of the left module (dark BaseUnit)	No

1 This parameter cannot be configured using PROFIBUS GSD file. The parameter is loaded to the module with the default setting and can be adapted using the data record 128.

2 When a GSD file is used, this diagnostic interrupt is activated via the "Enable additional diagnostic interrupts" parameter and cannot be set separately.

3 Only available in "Position input for Motion Control" operating mode

4 Only available in "Fast Mode" operating mode

4.5 Control and feedback interface

Information on using the control and feedback interface can be found in the chapter Configuring (Page 33).

A detailed description of the TM PosInput 1 control and feedback bits is available in the Counting, measurement and position input function manual which can be downloaded from the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

Note

The control and feedback interface is compatible with the control and feedback interface of the TM PosInput 2 technology module of the S7-1500 automation system.

Note

Operating with technology object

If you are using a technology object, the control and feedback interface is operated by the technology object. This means you do not have to write directly to the control interface.

Fast Mode

If you are using the "Fast Mode" operating mode, a control interface is not available. The feedback interface (Page 52) has an adapted assignment in Fast Mode. In addition, you can find Explanations about the feedback bits (Page 52).

4.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface

The following table shows control interface assignment:

Offset to the start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (significance of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (significance of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0*	Specifies the significance of the value in Slot 0				
		Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Invalid
		0	0	1	1	Load Start value (with incremental encoder or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load Low counting limit (with incremental encoder or pulse encoder)
		0	1	1	1	Load High counting limit (with incremental encoder or pulse encoder)
		1	0	0	0	Invalid
		to				
		1	1	1	1	

Offset to the start address	Parameter	Meaning				
Byte 8	LD_SLOT_1*	Specifies the significance of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Invalid
		0	0	1	1	Load Start value (with incremental encoder or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load Low counting limit (with incremental encoder or pulse encoder)
		0	1	1	1	Load High counting limit (with incremental encoder or pulse encoder)
		1	0	0	0	Invalid
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Capture function enable				
	EN_SYNC_DN	Bit 6: Enable synchronization down (with incremental encoder or pulse encoder)				
	EN_SYNC_UP	Bit 5: Enable synchronization up (with incremental encoder or pulse encoder)				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: Enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate (with incremental encoder or pulse encoder)				
Byte 10	SET_DIR	Bit 7: Count direction (for encoders without direction signal)				
	–	Bits 2 to 6: Reserve; bits must be set to 0				
	RES_EVENT	Bit 1: Reset of saved events				
	RES_ERROR	Bit 0: Reset of saved error states				
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0				

* If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the first value is taken internally from Slot 0 and then the value from Slot 1 is taken. This may lead to unexpected intermediate states.

4.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Offset to the start address	Parameter	Meaning
Bytes 0 to 3	COUNT_VALUE	DINT: Current counter value or position value
Bytes 4 to 7	CAPTURED_VALUE	DINT: The last acquired Capture value
Bytes 8 to 11	MEASURED_VALUE	REAL: Current measured value or DWORD: complete SSIframe
Byte 12	—	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Faulty encoder signal or SSI frame
	POWER_ERROR	Bit 0: Supply voltage L+ too low
Byte 13	—	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate status (with incremental encoder or pulse encoder)
	STS_READY	Bit 4: Technology module started up and configured
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and carried out (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and carried out (toggling)
	RES_EVENT_ACK	Bit 1: Reset of event bits active
	—	Bit 0: Reserve; set to 0
Byte 14	—	Bit 7: Reserve; set to 0
	STS_DI1	Bit 6: Status DI1
	STS_DI0	Bit 5: Status DI0
	STS_DQ1	Bit 4: Status DQ1
	STS_DQ0	Bit 3: Status DQ0
	STS_GATE	Bit 2: Internal gate status (with incremental encoder or pulse encoder)
	STS_CNT	Bit 1: Count pulse or position value change detected within the last ca. 0.5 s
	STS_DIR	Bit 0: Direction of last counter value or position value change
Byte 15	STS_M_INTERVAL	Bit 7: Count pulse or position value change detected in previous measurement interval
	EVENT_CAP	Bit 6: Capture event occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred (with incremental encoder or pulse encoder)
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: An overflow has occurred
	EVENT_UFLW	Bit 1: An underflow has occurred
	EVENT_ZERO	Bit 0: A Zero crossing has occurred

4.5.3 Assignment of the feedback interface in Fast Mode

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface in Fast Mode:

Offset to the start address	Parameter	Meaning
Bytes 0 to 3	LS	Bit 31: In isochronous mode: Sign of life (toggling); without isochronous mode: set to 0
	STS_READY	Bit 30: Technology module started up and configured
	—	Bit 29: Reserve; set to 0
	EXT_F	Bit 28: Group error
	STS_DI0	Bit 27: Status DI0
	STS_DIR	Bit 26: Direction of last counter value or position value change
	STS_DI1	Bit 25: Status DI1
	COUNT_VALUE	Bits 0 to 24: Current counter value or position value

Notes on the feedback bits

Feedback bit	Notes
COUNT_VALUE	This value returns the current counter value or position value in the first 25 bits of a DINT value.
EXT_F	This bit indicates that one of the following errors has occurred at the encoder signals for the technology module: • Supply voltage error • Illegal transition of A/B signals (with incremental encoder) • RS422/TTL error • SSI encoder error or SSI frame error (with SSI absolute encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostic interrupts, refer to the section Diagnostic messages (Page 62). The bit is reset automatically as soon as an error no longer exists.
LS	In isochronous mode, this bit indicates through a status change (toggling) as sign of life that a new counter value or position value has been detected in the respective application cycle. This bit is set to 0 in non-isochronous mode.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DI1	This bit indicates the status of digital input DI1.

Feedback bit	Notes
STS_DIR	This bit indicates the count direction of the last count pulse or the direction of the last position value change. 0 means: Down 1 means: Up
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.

Interrupts/diagnostic messages

5

5.1 Status and error displays

LEDs

The following figure shows you the LED displays (status and error displays) of TM PosInput 1.

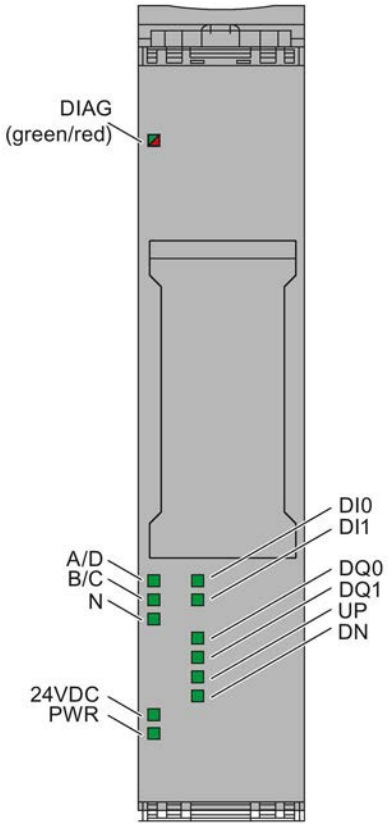


Image 5-1 LEDs of the TM PosInput 1

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic messages (Page 62).

Table 5- 1 Status and error displays DIAG

LED DIAG	Meaning	To correct or avoid errors
Off	Backplane bus supply of the ET 200SP not OK	Check the supply voltage or turn it on at the interface module.
Flashes	Technology module not configured	---
On	Technology module configured but no module diagnostics	
Flashes	Technology module configured and module diagnostics (at least one error pending)	Evaluate the diagnostic alarms and eliminate the error.

Table 5- 2 PWR/24VDC status displays

LEDs		Meaning	To correct or avoid errors
PWR	24VDC		
Off	Off	No supply voltage	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
On	On	Supply voltage is present and OK	---
On	Off	Short-circuit or overload at the encoder supply or supply voltage too low	• Check the encoder wiring. • Check the loads connected to the encoder supply. • Check the supply voltage.

Channel LEDs

The LEDs A, B, N and DIm indicate the current level of the associated signals. The LEDs of the digital outputs DQm indicate the desired state.

The flashing frequency of the channel LEDs is limited to approximately 12 Hz. If higher frequencies are present, the channel LEDs will flash at 12 Hz instead of indicating the current status.

If you are using an SSI absolute encoder, the LEDs D and C light up green during the transmission of encoder frames. The LEDs D and C are off when an error has occurred.

Table 5- 3 A/B/N/DIm/DQm status displays

A/B/N/DIm/DQm LEDs	Meaning
□ Off	Counter input/digital input/digital output at 0 level
■ On	Counter input/digital input/digital output at 1 level

Table 5- 4 Status displays UP/DN

LEDs		Meaning
UP	DN	
□ Off	□ Off	No count pulse has been detected for the last 0.5 s.
■ On	□ Off	The last count pulse incremented the counter and occurred no more than 0.5 s ago.
□ Off	■ On	The last count pulse decremented the counter and occurred no more than 0.5 s ago.

5.2 Parameter validation error

If you make the parameter settings in STEP 7 (TIA Portal) or in STEP 7 , the parameter values are checked before they are transferred to the technology module. This process prevents parameter errors.

In other use cases, the technology module checks the transferred parameter data record. If the technology module finds invalid or inconsistent parameter values, it outputs an error code (see below). The new parameter data record is rejected in this case, and work continues with the current parameter values until a valid parameter data record has been transferred.

WRREC

When the CPU is in RUN, you can change the parameter data record with the instruction WRREC (Write Record).

Example:

Let us assume that an invalid value, for example 9, is written to the module for the operating mode with WRREC. As a consequence, the module rejects the entire parameter data record. You can recognize this by evaluating the STATUS output parameter of the WRREC instruction. The STATUS output parameter is output as an ARRAY[1..4] of BYTE data with the value 16#DF80E111:

Example of WRREC STATUS data	Address	Meaning
DF_H	STATUS[1]	Error when writing a data record via PROFINET IO (IEC 61158-6)
80_H	STATUS[2]	Error when reading or writing a data record via PROFINET IO (IEC 61158-6)
$E1_H$	STATUS[3]	Module-specific error
11_H	STATUS[4]	Error code from the table below: The "Operating mode" parameter has an invalid value.

Error codes

If you are using an incremental encoder or pulse encoder, WRREC can include the following error codes after transfer of a parameter data record to the module:

Error code	Parameter	Validation criteria
11_H	Operating mode	Invalid value
12_H	Response to a CPU Stop	Invalid value
13_H	Signal type	Invalid value
15_H	Filter frequency for counter inputs	Invalid value
16_H	Reaction to signal N	Invalid value
17_H	Setting function of the DI	Invalid value
18_H	• Setting function of the DI (DI0) • Setting function of the DI (DI1)	The same function is configured for DI0 and DI1
19_H	• Setting function of the DI (DIm) • Edge selection (DIm)	• Invalid value • "Gate start (edge-controlled)" configured as function for DIm and "At rising and falling edge" • "Gate stop (edge-controlled)" configured as function for DIm and "At rising and falling edge" • "Synchronization" configured as function for DIm and "At rising and falling edge"
$1A_H$	Input delay for digital inputs	Invalid value
$1B_H$	Set output	Invalid value
$1C_H$	Count direction of the DQ function	Invalid value
$1D_H$	Reset when counting limit is violated	Invalid value
$1E_H$	Reaction to violation of a counting limit	Invalid value
20_H	Reaction to gate start	Invalid value
21_H[1]	• Counter low limit • Comparison value 0 • Comparison value 1	Counter low limit > comparison value 0/1
22_H[1]	• Counter high limit • Comparison value 0 • Comparison value 1	Counter high limit < comparison value 0/1
23_H	• Counter low limit • Start value	Start value < Counter low limit
24_H	• Counter high limit • Start value	Start value > Counter high limit
25_H	Update time	Higher than maximum value

Error code	Parameter	Validation criteria
26_H[2]	Reference speed	• Less than minimum value • Higher than maximum value
27_H	Measured variable	Invalid value
28_H	Time base for velocity measurement	Invalid value
29_H	Increments per unit	Invalid value
$2A_H$	• Counter low limit • Counter high limit	Counter low limit >= Counter high limit
$2B_H$	• Comparison value 0 • Comparison value 1	Comparison value 0 >= Comparison value 1
$2C_H$	Signal evaluation	Invalid value
$2D_H$	Set output	• "Between comparison value 0 and 1" configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ0 • "Between comparison value 0 and 1" configured for DQ1, but for DQ0 "Use by user program" not configured. • "Not between comparison value 0 and 1" configured for DQ1, but for DQ0 "Use by user program" not configured.
$2E_H$	• Setting function of the DI • Operating mode	"Capture" configured in the "Measuring" operating mode
$3A_H$[3]	Count direction for synchronization	Invalid value

1 Only for "Counting" operating mode

2 Only for "Position input for Motion Control" operating mode

3 Only for "Fast Mode" operating mode

If you are using an SSI absolute encoder, WRREC can include the following error codes after transfer of a parameter data record to the module:

Error code	Parameter	Validation criteria
11_H	Operating mode	Invalid value
12_H	Response to a CPU Stop	Invalid value
13_H	Signal type	Invalid value
18_H	• Setting function of the DI (DI0) • Setting function of the DI (DI1)	The same function is configured for DI0 and DI1
19_H	• Setting function of the DI (DIm) • Edge selection (DIm)	• Invalid value • "Gate start (edge-controlled)" configured as function for DIm and "At rising and falling edge" • "Gate stop (edge-controlled)" configured as function for DIm and "At rising and falling edge" • "Synchronization" configured as function for DIm and "At rising and falling edge"
$1A_H$	Input delay for digital inputs	Invalid value
$1B_H$	Set output	Invalid value
$1C_H$	Count direction of the DQ function	Invalid value
21_H[1]	• Counter low limit • Comparison value 0 • Comparison value 1	Counter low limit > comparison value 0/1
22_H[1]	• Counter high limit • Comparison value 0 • Comparison value 1	Counter high limit < comparison value 0/1
25_H	Update time	Higher than maximum value
26_H[2]	Reference speed	• Less than minimum value • Higher than maximum value
27_H	Measured variable	Invalid value
28_H	Time base for velocity measurement	Invalid value
29_H	Increments per unit	Invalid value
$2B_H$	• Comparison value 0 • Comparison value 1	Comparison value 0 >= Comparison value 1
$2D_H$	Set output	• "Between comparison value 0 and 1" configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ0 • "Between comparison value 0 and 1" configured for DQ1, but for DQ0 "Use by user program" not configured. • "Not between comparison value 0 and 1" configured for DQ1, but for DQ0 "Use by user program" not configured.

Error code	Parameter	Validation criteria
$2E_H$	• Setting function of the DI • Operating mode	"Capture" configured in the "Measuring" operating mode
$2F_H$	Setting function of the DI	Invalid value
30_H	Monoflop time	Invalid value
31_H	Transmission rate	Invalid value
32_H	Parity	Invalid value
33_H	Frame length	Invalid value
34_H	• Bit number LSB of the position value • Bit number MSB of the position value • Frame length	• Bit number LSB of the position value < 0 • Bit number LSB of the position value > Bit number of the MSB of the position value • Bit number MSB of the position value – Bit number LSB of the position value >= 31 • Bit number MSB of the position value > Frame length
35_H	Pulse duration	Less than minimum value

1 Only for "Counting/Position input" operating mode

2 Only for "Position input for Motion Control" operating mode

5.3 Diagnostic messages

Diagnostic alarms

If a diagnostic alarm is pending, the DIAG LED flashes red.

The diagnostics are displayed as plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 5- 5 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Error	9_H	• Internal module error occurred • Possible cause: Technology module defective	Replace technology module
Parameter assignment error	10_H	• The received parameter data record is invalid • The configured BaseUnit is not the used BaseUnit	• Checking parameter data record • Checking BaseUnit
Load voltage missing	11_H	• No technology module L+ supply voltage • Possible cause: BaseUnit-Incorrect type	• Check BaseUnit type • Check the wiring of the supply voltage L+ on the BaseUnit
Hardware interrupt lost	16_H	• Technology module cannot send an interrupt because a previous interrupt has not been processed • Possible causes: – Parameter assignment error – Too many hardware interrupts in too short a time	• Change interrupt processing in the CPU and re-assign technology module parameters correspondingly • Checking frequency of the interrupts from the process
Module temporarily unavailable	$1F_H$	• No normal operation of the technology module possible • Possible cause: Technology module is performing a firmware update	• Wait until technology module is available again • If firmware update aborts: – Check minimum firmware version required – Check supply voltage – Repeat firmware update
Internal error	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	103_H	Firmware error	Run firmware update
		Technology module defective	Replace technology module

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Short circuit or overload at external encoder supply	$10E_H$	• Error at encoder supply • Possible causes: – Short circuit – Overload	• Check encoder wiring • Check consumers connected to encoder supply
Error at the digital outputs	$10F_H$	• Error at the digital outputs • Possible causes: – Short circuit – Overload	• Check wiring at the digital outputs • Check consumers connected to the digital outputs
Supply voltage error	110_H	• Error at supply voltage L+ • Possible causes: – Low voltage – Wiring of L+ supply voltage defective	• Check the L+ supply voltage • Check the wiring of the supply voltage L+ on the BaseUnit • Checking total consumption of the load group
Illegal A/B signal ratio	500_H	• Time profile of signals A and B of the incremental encoder does not meet certain specifications • Possible causes: – Signal frequency too high – Encoder faulty – Process wiring faulty	• Check process wiring • Check encoder/sensor • Check parameter assignment
RS422/TTL error	502_H	• Error at connection of the RS 422, TTL encoder or SSI absolute encoder • Possible causes: – Wire break – No encoder connected – Cable too long – Short circuit – Overload – External voltage – Overheating – Parameter assignment error	• Check process wiring • Check encoder/sensor • Check parameter assignment

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Error at SSI encoder	503H	• Error at SSI absolute encoder connection • Possible causes: – Wire break – Cable too long – Frame error (error of the start bit or stop bit) – Parity error – Parameter assignment error	• Check process wiring • Check SSI absolute encoder • Check parameter assignment
Overheating	506H	• Module temperature is too high • Possible causes: – Short circuit or overload at the digital outputs or outputs of the encoder supplies – Ambient temperature outside specifications – Contamination in module prevents cooling	• Check process wiring • Improve cooling • Check connected loads

5.4 Interrupts

5.4.1 Trigger a diagnostic interrupt

Enabling the diagnostic interrupts

You enable the diagnostic interrupt for wire break and the diagnostic interrupts for additional errors in the basic parameters during device configuration.

A list of all errors that can trigger a diagnostic interrupt is available at Cause of the error triggering a diagnostic interrupt (Page 66).

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  Once you have remedied the error, the DIAG LED goes out.
- The S7-1500 CPU interrupts processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

Detailed information on the error event is available with the instruction "RALRM" (read additional interrupt information).

Default setting

The diagnostic interrupt for wire break and the diagnostic interrupts for additional errors are not enabled by default.

5.4.2 Cause of the error triggering a diagnostic interrupt

Which errors can trigger a diagnostic interrupt?

The technology module can trigger the following diagnostic interrupts:

Table 5- 6 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Error • Parameter assignment error • Module temporarily unavailable • Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• RS422/TTL error	Monitoring is always active. A detected error only triggers a diagnostic interrupt if "Enable diagnostic interrupt for wire break" has been enabled in the device configuration.
• Load voltage missing • Hardware interrupt lost[1] • Short circuit or overload at external encoder supply • Error at the digital outputs • Supply voltage error • Error at SSI encoder • Illegal A/B signal ratio • Overheating	Monitoring is always active. A detected error only triggers a diagnostic interrupt if "Enable additional diagnostic interrupts" has been enabled in the device configuration.

[1] Not available in "Position input for Motion Control" and "Fast Mode"

5.4.3 Triggering of a Hardware Interrupt

Introduction

For the technology module, you can configure which events are to trigger a hardware interrupt during operation.

What is a Hardware Interrupt?

The technology module will trigger a hardware interrupt as configured in response to specific events/states. When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Activating the hardware interrupts

You can use hardware interrupts in the following operating modes:

- Operating with technology object
- Manual mode

You activate the hardware interrupts in STEP 7 (TIA Portal) under "Basic parameters > Hardware interrupts" during device configuration of the technology module.

A list of the individual hardware interrupts is available at Events which can trigger a hardware interrupt (Page 68).

Lost hardware interrupt

If an event occurs which is supposed to trigger a hardware interrupt but there is an identical, previous event which has not yet been processed, no further hardware interrupt will be triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostic interrupt, depending on the parameter assignment.

Default setting

No hardware interrupts are activated in the default setting.

5.4.4 Events which can trigger a hardware interrupt

Which events can trigger a hardware interrupt?

A hardware interrupt is triggered if the condition for changing the respective status bit or event bit in the feedback interface is fulfilled.

The EventType tag, among others, is entered in the start information of the assigned hardware interrupt OB when a hardware interrupt is triggered. The EventType tag specifies the number of the event type to which the event triggering the interrupt belongs.

You can configure hardware interrupts to be triggered for the following event types:

Hardware interrupt	EventType number
Internal gate opening (Gate start)[1)]	1
Internal gate closing (Gate stop)[1)]	2
Overflow (high counting limit violated)[1)]	3
Underflow (low counting limit violated)[1)]	4
Comparison event for DQ0 occurred	5
Comparison event for DQ1 occurred	6
Zero crossing	7
New Capture value available[2)]	8
Synchronization of the counter by an external signal[1)]	9
Change of direction[3)]	10

1) Not for SSI absolute encoder

2) Can only be configured in Counting mode

3) The feedback bit STS_DIR has the default value "0". A hardware interrupt is not triggered when the first counter value or position value is changed immediately after switching on the technology module in *down direction*.

You can activate any combination of events to trigger hardware interrupts.

Technical specifications

6

	6ES7138-6BA00-0BA0
General information	
Product type designation	TM PosInput 1
BaseUnits that can be used	BU type A0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Installation type/mounting	
Rack mounting possible	Yes
Rail mounting possible	Yes
Supply voltage	
Load voltage L+	
Rated value (DC)	24 V
Low limit of valid range (DC)	19.2 V
High limit of valid range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	75 mA; without load
Encoder supply	
Number of outputs	1
24 V encoder supply	
24 V	Yes; L+ (-0.8 V)
Short-circuit protection	Yes
Output current, max.	300 mA
Power loss	
Power loss, typ.	1.9 W
Address area	
Occupied address area	
Inputs	16 bytes; 4 bytes with Fast Mode
Outputs	12 bytes; 4 bytes with Motion Control; 0 bytes with Fast Mode

	6ES7138-6BA00-0BA0
Digital inputs	
Number of inputs	2
Digital inputs, configurable	Yes
Input characteristics to IEC 61131, Type 3	Yes
Digital input functions, configurable	
Gate start/stop	Yes; only with pulse & incremental encoder
Capture	Yes; not available with Fast Mode
Synchronization	Yes; only with pulse & incremental encoder
Freely assignable digital input	Yes
Input voltage	
Rated value (DC)	24 V
For signal "0"	-30 ... +5 V
For signal "1"	+11 ... +30 V
Permitted voltage at input, min.	-30 V
Permitted voltage at input, max.	30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (at rated value of input voltage)	
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
• at "0" to "1", min.	6 µs; with parameter assignment "none"
• at "1" to "0", min.	6 µs; with parameter assignment "none"
For counters/technological functions	
• Configurable	Yes
Cable length	
Shielded, max.	1000 m
unshielded, max.	600 m
Digital outputs	
Type of digital output	Transistor
Number of outputs	2
Digital outputs, configurable	Yes
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	1 A
Limiting of inductive shutdown voltage to	L+ (-33 V)
Control of a digital input	Yes
Digital output functions, configurable	
Switch at comparison values	Yes
Freely assignable digital output	Yes; not available with Fast Mode

	6ES7138-6BA00-0BA0
Output switching capacity	
With resistive load, max.	0.5 A; per digital output
With lamp load, max.	5 W
Load resistance range	
Low limit	48 Ω
High limit	12 kΩ
Output voltage	
for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A; per digital output
for signal "1" permissible range, max.	0.6 A; per digital output
for signal "1" minimum load current	2 mA
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	50 µs
"1" to "0", max.	50 µs
Switching frequency	
With resistive load, max.	10 kHz
With inductive load, max.	0.5 Hz; to IEC 60947-5-1, DC-13; observe derating curve
With lamp load, max.	10 Hz
Total current of outputs	
Current per module, max.	1 A
Cable length	
Shielded, max.	1000 m
unshielded, max.	600 m
Encoders	
Encoder signals, incremental encoder (symmetrical)	
Input voltage	RS 422
Input frequency, max.	1 MHz
Counting frequency, max.	4 MHz; with quadruple evaluation
Signal filter, configurable	Yes
Cable length shielded, max.	32 m; with 1 MHz
Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
Incremental encoder with A/B tracks, phase-shifted by 90°, and zero track	Yes
Pulse encoder	Yes
Pulse encoder with direction	Yes
Pulse encoder with one pulse signal per count direction	Yes

	6ES7138-6BA00-0BA0
Encoder signals, incremental encoders (asymmetrical)	
Input voltage	5 V TTL (only push-pull encoders)
Input frequency, max.	1 MHz
Counting frequency, max.	4 MHz; with quadruple evaluation
Signal filter, configurable	Yes
Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
Incremental encoder with A/B tracks, phase-shifted by 90°, and zero track	Yes
Pulse encoder	Yes
Pulse encoder with direction	Yes
Pulse encoder with one pulse signal per count direction	Yes
Encoder signals, absolute encoder (SSI)	
Input signal	to RS 422
Frame length, configurable	10 ... 40 bits
Clock frequency, max.	2 MHz; 125 kHz, 250 kHz, 500 kHz, 1 MHz, 1.5 MHz or 2 MHz
Binary code	Yes
Gray code	Yes
Cable length shielded, max.	320 m; Cable length, RS-422 SSI absolute encoders, Siemens type 6FX2001-5, 24 V supply: 125 kHz, 320 meters shielded, max.; 250 kHz, 160 meters shielded, max.; 500 kHz, 60 meters shielded, max.; 1 MHz, 20 meters shielded, max.; 1.5 MHz, 10 meters shielded, max.; 2 MHz, 8 meters shielded, max.
Parity bit, configurable	Yes
Monoflop time	16, 32, 48, 64 µs & automatic
Multi-turn	Yes
Single-turn	Yes
Interface hardware	
RS 422	Yes
TTL 5 V	Yes; only push-pull encoders
Isochronous mode	
Isochronous mode (application synchronized until terminal)	Yes

	6ES7138-6BA00-0BA0
Interrupts/diagnostics/status information	
Activation of substitute values	Yes; configurable
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	Yes; not available with Fast Mode
Diagnostic messages	
Monitoring of supply voltage	Yes
Wire break	Yes
Short circuit	Yes
A/B transition error with incremental encoder	Yes
Frame error with SSI encoder	Yes
Group error	Yes
LED diagnostics display	
Monitoring of the supply voltage (PWR LED)	Yes, green PWR LED
For module diagnostics	Yes; green / red DIAG LED
Count down status display (green)	Yes
Count up status display (green)	Yes
Integrated functions	
Number of counters	1
Counting frequency (counters), max.	4 MHz; with quadruple evaluation
Counting functions	
can be used with TO High_Speed_Counter	Yes; only with pulse & incremental encoder
Continuous counting	Yes
Counter response configurable	Yes
Hardware gate by means of digital input	Yes
Software gate	Yes; not available with Fast Mode
Event-triggered stop	Yes
Synchronization by means of digital input	Yes
Counting range, configurable	Yes
Comparator	
• Number of comparators	2
• Direction-dependent	Yes
• Can be changed from user program	Yes
Position detection	
Incremental detection	Yes
Absolute detection	Yes
Suitable for S7-1500 Motion Control	Yes

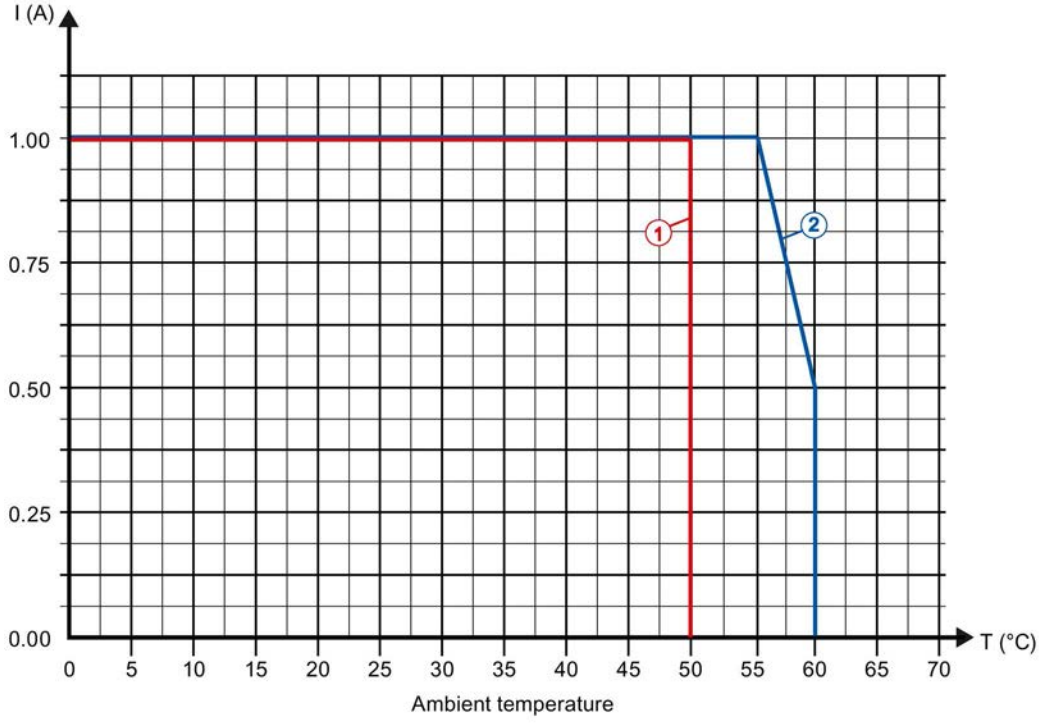
	6ES7138-6BA00-0BA0
Measuring functions	
Measuring time, configurable	Yes
Dynamic measuring time adjustment	Yes
Number of threshold values, configurable	2
Measuring range	
• Frequency measurement, min.	0.04 Hz
• Frequency measurement, max.	4 MHz
• Period measurement, min.	0.25 µs
• Period measurement, max.	25 s
Accuracy	
• Frequency measurement	100 ppm; depends on measuring interval and signal evaluation
• Period measurement	100 ppm; depends on measuring interval and signal evaluation
• Velocity measurement	100 ppm; depends on measuring interval and signal evaluation
Electrical isolation	
Electrical isolation channels	
Between the channels and backplane bus	Yes
Permitted potential difference	
Between the different circuits	75 V DC / 60 V AC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C; note derating
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; note derating
Dimensions	
Width	15 mm
Weights	
Weight, approx.	45 g

Derating information for total current of outputs

If the digital outputs of the TM PosInput 1 are operated with resistive or inductive loads, you should derate the total current of the loads at the digital outputs of the technology module. The total current is the sum of the load currents at all digital outputs of the module (without encoder supply).

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Load resistance: 48 Ω (IEC 947-5-1)

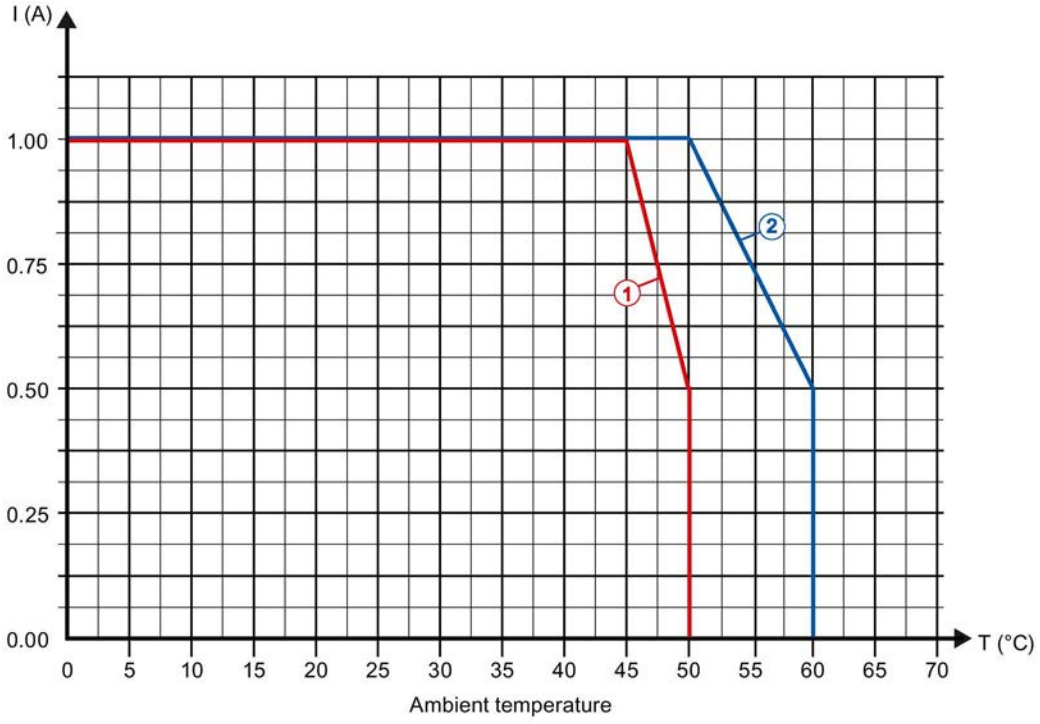


① Vertical installation of the system
② Horizontal installation of the system

Image 6-1 Total current depending on ambient temperature and mounting position for resistive loads

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Maximum switching frequency at digital outputs of 0.5 Hz
- Load resistance: 48 Ω (IEC 947-5-1)
- Load inductance: 1150 mH (IEC 947-5-1)



① Vertical installation of the system
② Horizontal installation of the system

Image 6-2 Total current by ambient temperature and mounting position for inductive loads

Note

If the switching frequency is greater than 0.5 Hz or there is greater inductance at the digital outputs, the total current must be reduced further.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Parameter data record

A

You have the option to change the parameter assignment of the module with the user program while the CPU is in RUN. The parameters are transferred to the module using the using data record 128, for example with the instruction WRREC.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in the section Parameter validation error (Page 57) or in the online help of STEP 7 (TIA Portal).

Structure of data record 128 for Operating with technology object and Manual mode

The following table shows you the structure of data record 128 for TM PosInput 1for operating modes "Operating with technology object" and "Manual mode". The values in byte 0 to byte 3 are fixed and may not be changed. The value in byte 4 can only be changed by means of new parameter assignment and not in RUN mode of the CPU.

Table A- 1 Parameter data record 128: Operating modes "Operating with technology object", "Manual mode"

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of the parameter data per channel = 48							
2	Reserved[2)]							
3	Reserved[2)]							
4	**Operating mode**							
4	Reserved[2)]				Operating mode:			
					0000_B: Invalid			
					0001_B: Counting/Position input			
					0010_B: Measuring			
					0011 to 1111_B: Invalid			

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
5	**Basic parameters**							
5	Interface standard:	Reserved[2]				Enable additional diagnostic interrupts[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
	0_B: RS422, symmetrical						10_B: Continue operation	
	1_B:TTL (5 V), asymmetric						11_B: Invalid	
6...7	**Counter inputs** (parameters for incremental encoders and pulse encoders)							
6	Reserved[2]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Pulse (A)			
			01_B: Double		0001_B: Pulse (A) and direction (B)			
			10_B: Quadruple		0010_B: Count up (A), count down (B)			
			11_B: Invalid		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Invalid			
7	Reaction to signal N:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Filter frequency[4]:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
	01_B: Synchronization at signal N				0001_B: 200 Hz			
	10_B: Capture at signal N				0010_B: 500 Hz			
	11_B: Invalid				0011_B: 1 kHz			
					0100_B: 2 kHz			
					0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011_B: 500 kHz			
					1100_B: 1 MHz			
					1101 to 1111_B: Invalid			

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
6...7	**Counter inputs** (parameters for SSI absolute encoder)							
6	Monoflop time[4]:			Code type:	Signal type:			
	000_B: Automatically			0_B: Gray	0000_B: Pulse (A)			
	001_B: 16 µs			1_B: Dual	0001_B: Pulse (A) and direction (B)			
	010_B: 32 µs				0010_B: Count up (A), count down (B)			
	011_B: 48 µs				0011_B: Incremental encoder (A, B phase-shifted)			
	100_B: 64 µs				0100_B: Incremental encoder (A, B, N)			
	101 to 111_B: Invalid				0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Invalid			
7	Parity[4]:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Reserved[2]	Transmission rate[4]:		
	00_B: None					000_B: 125 kHz		
	01_B: Even					001_B: 250 kHz		
	10_B: Odd					010_B: 500 kHz		
	11_B: Invalid					011_B: 1 MHz		
						100_B: 1.5 MHz		
						101_B: 2 MHz		
						110 to 111_B: Invalid		
8...9	**Hardware interrupts**[1]							
8	Reserved[2]	Reserved[2]	Reserved[2]	Change of direction	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop[3]	Gate start[3]
9	Synchronization of the counter by an external signal[3]	New capture value available	Reserved[2]	Zero crossing	Reserved[2]	Comparison event for DQ1 occurred	Reserved[2]	Comparison event for DQ0 occurred

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
10...15	**Behavior of a DQ**							
10	Set output (DQ1):				Set output (DQ0):			
	0000_B: Use by user program				0000_B: Use by user program			
	0001_B: Between comparison value and counter high limit; Measuring:Measured value >= comparison value				0001_B: Between comparison value and counter high limit; Measuring:Measured value >= comparison value			
	0010_B: Between comparison value and counter low limit; Measuring:Measured value <= comparison value				0010_B: Between comparison value and counter low limit; Measuring:Measured value <= comparison value			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B: Invalid			
	0101_B: After set command from CPU until comparison value				0101_B: After set command from CPU until comparison value			
	0110_B: Not between comparison value 0 and 1				0110 to 1111_B: Invalid			
	0111 to 1111_B: Invalid							
11	Count direction (DQ1):		Count direction (DQ0):		Reserved[2]	Reserved[2]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Invalid		00_B: Invalid					
	01_B: Forward		01_B: Forward					
	10_B: Backward		10_B: Backward					
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0):							
13	UINT: Value range in ms/10: 0 to 65535_D							
14	Pulse duration (DQ1):							
15	UINT: Value range in ms/10: 0 to 65535_D							
16	**Behavior of DI0**							
16	Behavior of counter value after Capture[3] (DI0):	Edge selection (DI0):		Select level (DI0):	Reserved[2]	Set function of DI (DI0):		
		00_B: Invalid				000_B: Gate start/stop (level-triggered)[3]		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)[3]		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)[3]		
	0_B: Continue counting	11_B: At rising and falling edge		1_B: Active with low level		011_B: Synchronization[3]		
						100_B: Enable synchronization at signal N[3]		
	1_B: Set to start value and continue counting					101_B: Capture		
						110_B: Digital input without function		
						111_B: Invalid		

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
17	**Behavior of DI1**: See Byte 16							
18	Reserved[2]							
19	Frequency:	Reserved[2]			Input delay:			
	0_B: Once				0000_B: None			
	1_B: Periodic				0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Invalid			
20...43	**Values**							
20...23	High counting limit[3]: DINT: Value range: –2147483647 to 2147483647_D or –7FFFFFFF to $7FFFFFFF_H$							
24...27	Comparison value 0: Operating mode Counting: DINT: Value range: –2147483648 to 2147483646_D or –80000000 to $7FFFFFFE_H$; Measuring mode: REAL: Floating point number in the configured unit of the measured variable							
28...31	Comparison value 1: Operating mode Counting: DINT: Value range: –2147483647 to 2147483647_D or –7FFFFFFF to $7FFFFFFF_H$; Measuring mode: REAL: Floating point number in the configured unit of the measured variable							
32...35	Start value[3]: DINT: Value range: –2147483648 to 2147483647_D or– 80000000 to $7FFFFFFF_H$							
36...39	Low counting limit[3]: DINT: Value range: –2147483648 to 2147483646_D or 80000000 to $7FFFFFFE_H$							
40...43	Update time: DINT: Value range in µs: 0 to 25000000_D							
44	**Counter behavior at limits and gate start**							
44	Reaction to gate start[3]:		Reaction to violation of a counting limit[3]:			Reset when counting limit is violated[3]:		
	00_B: Set to start value		000_B: Stop counting			000_B: To other counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Invalid		010 to 111_B: Invalid			010 to 111_B: Invalid		

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
45	**Specify measured value**							
45	Reserved[2]			Time base for velocity measurement:			Measured variable:	
				000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Complete SSI frame	
				100_B: 60 s/1 min				
				101 to 111_B: Invalid				
46	Increments per unit:							
47	UINT: Value range: 1 to 65535_D							
48	Set the hysteresis range: Value range: 0 to 255_D:							
49...51	**Parameters for SSI absolute encoder**							
49	Reserved[2]		Frame length[4]: 10 to 40_D: Value range					
50	Reserved[2]		Bit number LSB of the position value: 0 to 38_D: Value range					
51	Reserved[2]		Bit number MSB of the position value: 0 to 39_D: Value range					

1) You activate a specific parameter by setting the corresponding bit to 1.

2) Reserved bits must be set to 0.

3) For signal type "Absolute encoder (SSI)": Reserved[2]

4) In isochronous mode, the parameter can have an effect on the isochronous parameters of the Sync domain. Because the isochronous parameters are not checked in RUN, overflows can occur. You prevent overflows by selecting the option with the greatest time demand during offline parameter assignment.

Structure of data record 128 in Fast Mode

The following table shows you the structure of data record 128 for TM PosInput 1 for "Fast Mode" operating mode. The values in byte 0 to byte 3 are fixed and may not be changed.

Table A- 2 Parameter data record 128: "Fast Mode" operating mode

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of the parameter data per channel = 48							
2	Reserved[2)]							
3	Reserved[2)]							
4	**Operating mode**							
4	Reserved[2)]				Operating mode:			
					0000_B: Invalid			
					0001_B: Counting / Position input			
					0010 to 1111_B: Invalid			
5	**Basic parameters**							
5	Interface standard:	Reserved[2)]				Enable additional diagnostic interrupts[1)]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
	0_B: RS422, symmetrical						10_B: Continue operation	
	1_B:TTL (5 V), asymmetric						11_B: Invalid	

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
6...7	**Counter inputs** (parameters for incremental encoders and pulse encoders)							
6	Reserved[2)]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Pulse (A)			
			01_B: Double		0001_B: Pulse (A) and direction (B)			
			10_B: Quadruple		0010_B: Count up (A), count down (B)			
			11_B: Invalid		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Invalid			
7	Reaction to signal N:		Invert direction[1)]	Enable diagnostic interrupt on wire break[1)]	Filter frequency[4)]:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
	01_B: Synchronization at signal N				0001_B: 200 Hz			
	10 to 11_B: Invalid				0011_B: 1 kHz			
					0100_B: 2 kHz			
					0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011_B: 500 kHz			
					1100_B: 1 MHz			
					1101 to 1111_B: Invalid			

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
6...7	**Counter inputs** (parameters for SSI absolute encoder)							
6	Monoflop time[4]:			Code type:	Signal type:			
	000_B: Automatic			0_B: Gray	0000_B: Pulse (A)			
	001_B: 16 µs			1_B: Dual	0001_B: Pulse (A) and direction (B)			
	010_B: 32 µs				0010_B: Count up (A), count down (B)			
	011_B: 48 µs				0011_B: Incremental encoder (A, B phase-shifted)			
	100_B: 64 µs				0100_B: Incremental encoder (A, B, N)			
	101 to 111_B: Invalid				0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Invalid			
7	Parity[4]:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Reserved[2]	Transmission rate[4]:		
	00_B: None					000_B: 125 kHz		
	01_B: Even					001_B: 250 kHz		
	10_B: Odd					010_B: 500 kHz		
	11_B: Invalid					011_B: 1 MHz		
						100_B: 1.5 MHz		
						101_B: 2 MHz		
						110 to 111_B: Invalid		
8...9	Reserved[2]							
10...15	**Behavior of a DQ**							
10	Set output (DQ1):				Set output (DQ0):			
	0000_B: Digital output without function				0000_B: Digital output without function			
	0001_B: Between comparison value and counter high limit				0001_B: Between comparison value and counter high limit			
	0010_B: Between comparison value and counter low limit				0010_B: Between comparison value and counter low limit			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B to 1111_B: Invalid			
	0101 to 1111_B: Invalid							
11	Count direction (DQ1):		Count direction (DQ0):		Reserved[2]	Reserved[2]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Reserved		00_B: Reserved					
	01_B: Up		01_B: Up					
	10_B: Down		10_B: Down					
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0):							
13	UINT: Value range in ms/10: 0 to 65535_D							
14	Pulse duration (DQ1):							
15	UINT: Value range in ms/10: 0 to 65535_D							

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
16	**Behavior of DI0**							
16	Reserved[2]	Edge selection (DI0):		Select level (DI0):	Reserved[2]	Set function of DI (DI0):		
		00_B: Invalid				000_B: Gate start/stop (level-triggered)[3]		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)[3]		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)[3]		
		11_B: Invalid		1_B: Active with low level		011_B: Synchronization[3]		
						100_B: Enable synchronization at signal N[3]		
						101_B: Invalid		
						110_B: Digital input without function		
						111_B: Invalid		
17	**Behavior of DI1**: See Byte 16							
18	Reserved[2]							
19	Frequency:	Count direction for synchronization		Reserved[2]	Input delay:			
	0_B: Once	00_B: Invalid			0000_B: None			
	1_B: Periodically	01_B: Up			0001_B: 0.05 ms			
		10_B: Down			0010_B: 0.1 ms			
		11_B: In both directions			0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Invalid			

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
20...43	**Values**							
20...23	High counting limit[3]: Value range: 1 to 33554431_D or 1 to $01FFFFFF_H$							
24...27	Comparison value 0: Value range: 0 to 33554430_D or 0 to $01FFFFFE_H$							
28...31	Comparison value 1 Value range: 1 to 33554431_D or 1 to $01FFFFFF_H$							
32...35	Start value[3]: Value range: 0 to 33554431_D or 0 to $01FFFFFF_H$							
36...39	Counter low limit[3]: Value range: 0 to 33554430_D or 0 to $01FFFFFE_H$							
40...43	Reserved[2]							
44	**Counter behavior at limits and gate start**							
44	Reaction to gate start[3]:		Reaction to violation of a counting limit[3]:			Reset when counting limit is violated[3]:		
	00_B: Set to start value		000_B: Stop counting			000_B: To other counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Invalid		010 to 111_B: Invalid			010 to 111_B: Invalid		
45...47	Reserved[2]							
48	Set the hysteresis range: Value range: 0 to 255_D:							
49...51	**Parameters for SSI absolute encoder**							
49	Reserved[2]		Frame length[4]: 10 to 40_D: Value range					
50	Reserved[2]		Bit number LSB of the position value: 0 to 38_D: Value range					
51	Reserved[2]		Bit number MSB of the position value: 0 to 39_D: Value range					

1) You enable a specific parameter by setting the corresponding bit to 1.

2) Reserved bits must be set to 0.

3) For signal type "Absolute encoder (SSI)": Reserved[2]

4) In isochronous mode, the parameter can have an effect on the isochronous parameters of the Sync domain. Because the isochronous parameters are not checked in RUN, overflows can occur. You prevent overflows by selecting the option with the greatest time demand during offline parameter assignment.

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SIEMENS

Weighing systems

Electronic weighing system SIWAREX WP321

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Introduction 1

1.1 Purpose of the manual

This manual contains all the necessary information on setting up, installing, wiring and commissioning the SIWAREX WP321 electronic weighing system.

1.2 Basic knowledge required

Knowledge of weighing technology as well as general knowledge of the SIMATIC system including the TIA Portal are necessary in order to understand the manual.

1.3 Manual - range of validity

This manual is valid for:

Type designation	Order No.	as of version	
SIWAREX WP321	7MH4138-6AA00-0BA0	HW V.1	FW V. 1.0

Note

This manual contains a description of all electronic weighing systems available at the time the manual was published. We reserve the right to include a Product Information with the latest information on the module.

Safety notes

2

2.1 General safety instructions

WARNING

Non-compliance with warning notes or non-qualified handling of the system

Failure to observe the warning notes or handling of the device/system by non-qualified personnel can result in serious injury or damage to property. This means only qualified personnel are permitted to handle this device/system.

WARNING

Permission for installation in machines

Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Machinery Directive 89/392/EEC.

Note

The specifications of the manual for the SIMATIC ET 200SP system apply for configuration, installation and commissioning in the SIMATIC environment. This chapter includes additional information on hardware configuration, installation and preparation for operation of the SIWAREX WP321.

The safety notes must be observed.

Note

The device was developed, manufactured, tested and documented in compliance with the relevant safety standards. The device does usually not pose any risks of material damage or personal injury.

2.2 IT Security

Siemens provides automation and drive products with industrial security functions that support the secure operation of plants or machines. They are an important component in a holistic industrial security concept. With this in mind, our products undergo continuous development. We therefore recommend that you keep yourself informed with respect to our product updates. Detailed technical information can be found at:
http://support.automation.siemens.com (http://www.siemens.de/automation/csi_en_WW).

To ensure the secure operation of a plant or machine it is also necessary to take suitable preventive action (e.g. cell protection concept) and to integrate the automation and drive components into a state-of-the-art holistic industrial security concept for the entire plant or machine. Products used from other manufacturers should also be taken into account here. You will find further information under:
http://www.siemens.com/industrialsecurity (http://www.siemens.com/industrialsecurity).

Description

3

3.1 Product overview

SIWAREX WP321 is a versatile and flexible weighing module that can be operated as a static weighing instrument.

The electronic weighing system can be used in SIMATIC ET 200SP and uses all features of a modern automation system, such as integrated communication, operation and monitoring, the diagnostics system as well as the configuration tools in the TIA Portal or SIMATIC Step7 and WinCC flexible.

3.2 Area of application

The electronic weighing system described here is the perfect solution for applications in which signals from weighing or force sensors are acquired and processed. The SIWAREX WP321 is a very accurate electronic weighing system.

It can be used in almost all industrial weighing applications not requiring official calibration. Use in potentially explosive atmospheres (with Ex interface SIWAREX IS) it's also possible.

3.3 System integration in SIMATIC

The electronic weighing system described here is a technology module for SIMATIC ET 200SP. It can be used as desired in the configuration of the automation solution, including the weighing application. You can create optimal solutions for small and medium-sized plants by combining the suitable SIMATIC modules. You can create customized or industry-specific solutions in no time with the help of the configuration package available under the "Ready for use" application for SIMATIC.

Solutions are possible with S7-300, S7-1200 as well as S7-1500 CPUs. TIA Portal or Step 7 Classic can be used as the configuration software.

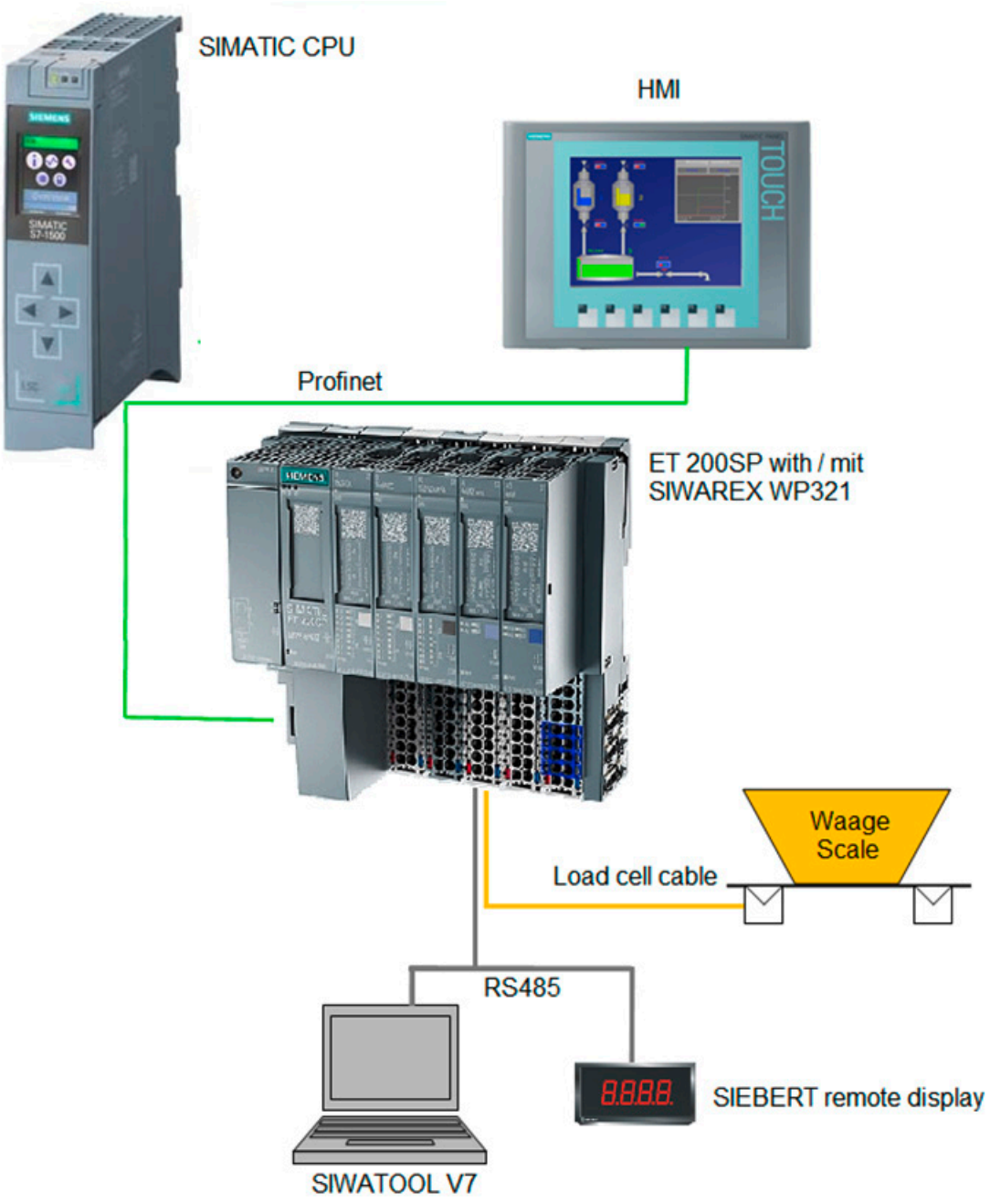


Figure 3-1 System overview

3.4 Customer benefits

The electronic weighing system described here is characterized by decisive advantages:

- Uniform design technology and consistent communication in SIMATIC ET 200SP
- Parameter assignment by means of an operator panel, STEP7 user program or PC
- Uniform configuration option in the SIMATIC TIA Portal or SIMATIC Step7
- Measuring of weight with a resolution of up to +/- 2 million parts
- High accuracy 0.05%
- High measuring rate of 100 Hz
- Limit monitoring
- Flexible adaptation to varying requirements
- Easy adjustment of the scale using the SIWATOOL program
- Automatic calibration is possible without the need for calibration weights
- Module replacement is possible without recalibrating the scale
- Use in Ex Zone 2 / ATEX approval
- Intrinsically safe load cell supply for Ex Zone 1 (SIWAREX IS option)
- Diagnostics functions

3.5 Scope of delivery

The scope of supply consists of the SIWAREX WP321 weighing module. Required accessories → Accessories (Page 115)

Note

The SIWAREX WP321 configuration package is required for configuration of the SIWAREX WP321 electronic weighing system → Accessories (Page 115). The configuration package is not included in the scope of delivery of the module.

Application planning

4

4.1 Functions

The primary task of the electronic weighing system is the measurement and registration of the current weight value. The integration in SIMATIC gives you the option to process the weight value directly in the PLC (**P**rogrammabel**L**ogic **C**ontroller).

The SIWAREX WP321 is calibrated at the factory. This allows for automatic calibration of the scale without the need for calibration weights and replacement of modules without the need for recalibrating the scale.

A PC for setting the parameters of the electronic weighing system can be connected via the RS485 interface.

The SIWAREX WP321 electronic weighing system can also be used in potentially explosive atmospheres (Zone 2). The load cells are supplied intrinsically safe in Zone 1 applications when you use the optional Ex interface SIWAREX IS.

4.2 Parameter assignment options

4.2.1 Parameter assignment with the PC

You can set the scale parameters with the convenience of the familiar Windows interface by using the "SIWATOOL" PC parameter assignment software.

You can use the program for commissioning the scale without any knowledge of automation technology. When servicing is required, you can analyze and test the processes in the scale independently of the automation system or Operator Panel with the help of the PC. You can read out the diagnostic buffer from the SIWAREX module to assist you in the event analysis.

The figure below illustrates the structure of the individual program windows.

Figure 4-1 SIWATOOL overview

SIWATOOL does not only offer support when you set the scale but also when you analyze the diagnostic buffer that can be saved after being read out of the module together with the parameters. The display of the current scale status can be configured.

You can switch between several languages in the program.

You require an RS485/USB converter (see Accessories (Page 115)).

4.2.2 Parameter assignment with the SIMATIC Panel

SIWAREX WP321 parameters can be assigned using a SIMATIC Panel connected to the SIMATIC CPU. The "Ready-for-use" application software is used for this.

Mounting

5

5.1 Installation guideline

When assembling the SIMATIC components together with the electronic weighing system described here, the setup, installation and wiring guidelines for the SIMATIC ET 200SP must be observed (see system manual "SIMATIC ET 200SP, ET 200SP distributed I/O system", order no.: A5E03576848).

This manual describes additional installation and wiring aspects specific to the electronic weighing system.

5.2 EMC-compliant setup

5.2.1 Introduction

The electronic weighing system described here was developed for use in industrial environments and complies with high EMC requirements. It ensures safe operation even in harsh environmental conditions. Nevertheless, you should still carry out EMC planning before installing your devices in order to determine any sources of interference and include them in your considerations.

EMC

EMC (electromagnetic compatibility) describes the capability of electrical equipment to operate without errors in a given electromagnetic environment, without being subject to external influence and without influencing external devices in any way.

5.2.2 Possible effects of interference

Electromagnetic interferences can influence the electronic weighing system described here in various ways:

- Electromagnetic fields having a direct influence on the system
- Interferences transported by communication cables
- Interferences having an effect via process cables
- Interferences entering the system via the power supply and/or protective ground

Interferences can impair the fault-free functioning of the electronic weighing system.

5.2.3 Coupling mechanisms

Depending on the propagation medium (conducted or non-conducted) and the distance between the interference source and the device, interferences can enter the faulty device through four different coupling mechanisms:

- Electrical coupling
- Capacitive coupling
- Inductive coupling
- Radiation coupling

5.2.4 Five basic rules for securing EMC

Observe these five basic rules to secure EMC.

Rule 1: Large area grounding contact

- When installing the devices, make sure that the surfaces of inactive metal parts are properly bonded to chassis ground (see following sections).
- Bond all inactive metal parts to chassis ground, ensuring large area and low-impedance contact (large cross-sections).
- When using screw connections on varnished or anodized metal parts, support contact with special contact washers or remove the protective insulating finish on the points of contact.
- Wherever possible, avoid the use of aluminum parts for ground bonding. Aluminum oxidizes very easily and is therefore less suitable for ground bonding.
- Provide a central connection between chassis ground and the ground/protective conductor system.

Rule 2: Proper cable routing

- Organize your wiring system into cable groups (high-voltage/power supply/signal/measurement/data cables).
- Always route high-voltage and data cables in separate ducts or in separate bundles.
- Install the measurement cables as close as possible to grounded surfaces (e.g. supporting beans, metal rails, steel cabinet walls).

Rule 3: Fixing the cable shielding

- Ensure proper fixation of the cable shielding.
- Always use shielded data cables. Always connect both ends of the data cable shielding to ground on a large area.
- Keep unshielded cable ends as short as possible.
- Always use metal/metalized connector housings only for shielded data cables.

Rule 4: Special EMC measures

- All inductors that are to be controlled should be connected with suppressors.
- For cabinet lighting in the immediate range of your controller, use interference suppressed fluorescent lamps.

Rule 5: Homogeneous reference potential

- Create a homogeneous reference potential and ground all electrical equipment.
- Use sufficiently dimensioned equipotential bonding conductors if potential differences exist or are expected between your system components. Equipotential bonding is absolutely mandatory for applications in hazardous areas.

5.3 Mounting on the SIMATIC ET 200SP

The electronic weighing system described here is a module of the SIMATIC ET 200SP series and can be directly connected to the automation system's bus system. The 15 mm wide module has very low installation and cabling requirements.

The module is snapped onto the ET 200SP base unit (BU). You must use base units of type A0 (→ Accessories (Page 115)).

The load cells, power supply and serial interfaces are connected via the terminal box.

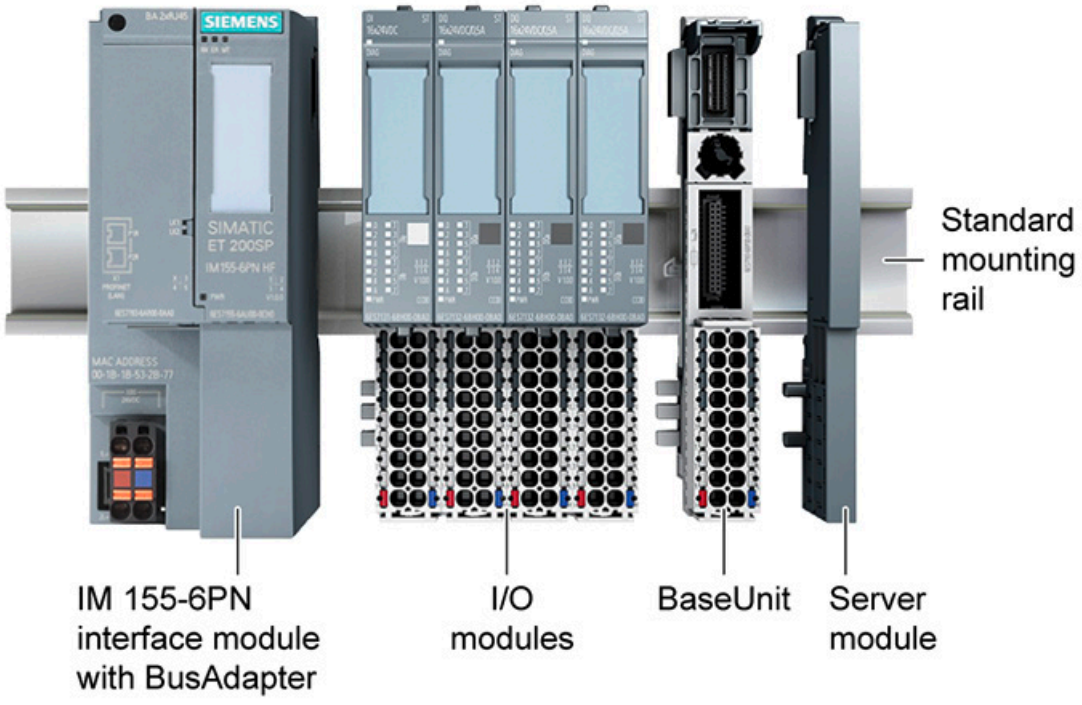


Figure 5-1 Installation of the I/O or SIWAREX modules

5.4 Configuration of the hardware in SIMATIC

A station has a maximum width of 1 m, and you can use up to 64 modules depending on the type of PN head-end, or up to 15 modules with the Profibus version. Observe the system conditions when planning the configuration.

Each SIWAREX electronic weighing system requires 16 bytes of the I/O area. Address assignment is carried out in the TIA Portal or in the SIMATIC Manager during hardware configuration.

Connection

6

All external connections are made via the terminal box.

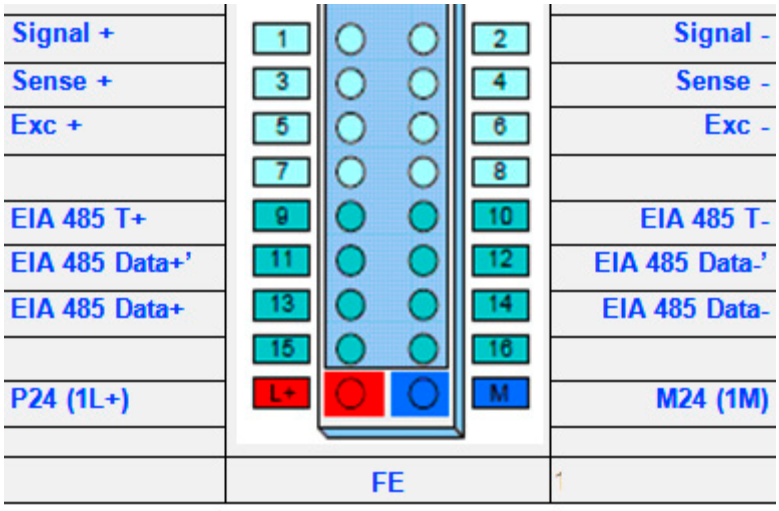


Figure 6-1 SIWAREX WP321 process terminals on the base unit

6.1 24 V connection

The 24 V DC supply voltage is connected by means of the corresponding terminals on the base unit.

Table 6- 1 Connection of the 24 V supply

Labeling	Function
L +	+24 V voltage supply
M	Ground voltage supply

6.2 Connecting the load cells

Pickups can be connected to the SIWAREX WP321 electronic weighing system which are equipped with strain gauges (full bridge) and meet the following requirements.

- Characteristic value 1 to 4 mV/V
- A supply voltage of 5 V is permitted

The power supply for the load cells is 4.85 V.

Observe the following rules for connection of analog (DMS) load cells

1. The use of a junction box (SIWAREX JB junction box) is required when more than one load cell is connected (the load cells must be connected in parallel). If the distance of a load cell to the SIWAREX WP321 or the junction box is greater than the available length of the load cell connection cable, use the SIWAREX EB extension box.
2. The cable shield is always applied at the cable gland of the junction box (SIWAREX JB) or the extension box. If there is a risk of equipotential bonding through the cable shield, connect a equipotential equalization conductor parallel to the load cell cable.

3. Twisted wire pairs that are also shielded are required for the specified cables:
   - Sensor cable (+) and (-)
   - Measuring voltage cable (+) and (-)
   - Supply voltage cable (+) and (-)

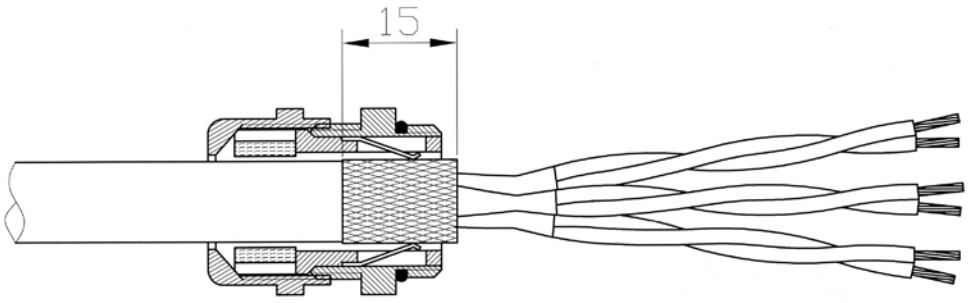


Figure 6-2 Shielding in the screw gland

We recommended that you use the cables listed in chapter Accessories (Page 115).

4. The shield must be applied to the ground in close proximity to the SIWAREX WP321. The maximum distance between the SIWAREX WP321 and the load cell is relevant when you use the recommended cables.

Labeling	Function	Connection pin
Sig-	Measurement cable load cell -	2
Sig+	Measurement cable load cell -	1
Sen-	Sensor cable load cell -	4
Sen+	Sensor cable load cell +	3
Exc-	Supply load cell -	6
Exc+	Supply load cell +	5

6.3 Shield connection

Make sure you observe the correct design of the shield support for the shielded cables. It is the only way to ensure immunity of the system.

A cable is shielded to attenuate the effects of magnetic, electrical and electromagnetic interference on the cable. Interference currents on cable shielding are diverted to ground by conductive isolation rails. To avoid interference as a result of these currents, it is imperative to provide a low-impedance connection to the ground.

Only use cables equipped with a shielding braid. Shielding density must be at least 80%.

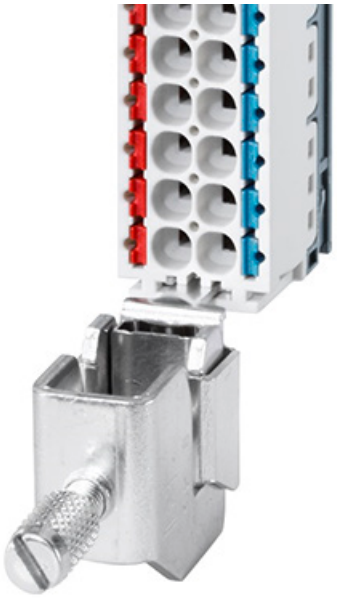


Figure 6-3 Shield connection and shield terminal

6.4 Connection of RS485 serial interface

The following devices can be connected to the serial interface:

- Siebert display type S102 (connections: see chapter Connection of Siebert display via RS485 (Page 30))
- PC with RS485/USB converter (see accessories) for use of SIWATOOL

Table 6- 2 Termination of RS485 serial interface

Labeling	Function	Connection pin
RS485: T+	RS485 termination +: Is used at the physical end of the bus for inserting termination jumpers	9
RS485: T-	RS485 termination -: Is used at the physical end of the bus for inserting termination jumpers	10
RS485: D+'	RS485 data line +': Is used at the physical end of the bus for inserting termination jumpers and in between for looping through the bus cables	11
RS485: D-'	RS485 data line -': Is used at the physical end of the bus for inserting termination jumpers and in between for looping through the bus cables	12
RS485: D+	RS485 data cable +	13
RS485: D-	RS485 data cable -	14

If a SIWAREX WP321 module is connected to SIWATOOL or a Siebert display, insert wire jumpers between the T+ and D+' terminals and between the T- and D-' terminals.

6.5 Connection of Siebert display via RS485

A Siebert display S102 with the order no. S102-W6/14/0R-000/0B-SM can be connected to the RS485 interface of the weighing module. Connect a 24 V DC supply to the Siebert display, and connect the latter to the RS485 interface of the weighing module as shown in the following diagram.

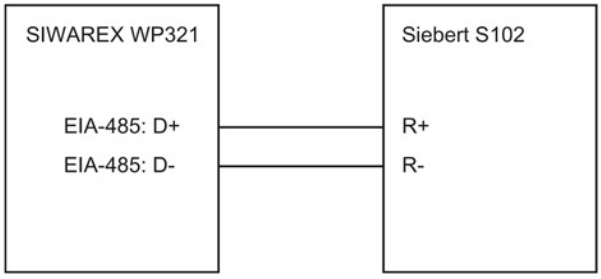


Figure 6-4 Connection of Siebert display S102

The RS485 interface in the DR13 of the SIWAREX WP321 is set as follows:

- Baud rate: 9 600 bit/s
- Character parity: Even
- Number of data bits: 8
- Number of stop bits: 1

The S102 is set as follows:

Table 6- 3 Settings of Siebert display S102

Menu item	Setting	Meaning	
1 Interface	485	RS485 interface	
9 Station address	01	Address meaning:	
		Address	**Weight value**
		01	Weight
		02	Total
		03	Net
		04	Tare
t Timeout	2	e.g. timeout after 2 seconds	
C	0.0	No decimal point	
F Segment test	----*	No segment test when switching on	
	8.8.8	Segment test when switching on	

Commissioning 7

Commissioning essentially comprises:

- Checking the scale construction
- Specifying the parameters
- Calibration
- Verifying the envisaged functionality

7.1 Factory-set parameters

The electronic weighing system described here is provided with factory-set parameters. The parameters have been provided for a typical 100 kg scale based on three load cells. Parameters which can be entered in % or time are preset in such a way that they provide good results for most applications.

With these default parameters, commissioning can be carried out in 5 minutes (see chapter 5-minute quick start with the operator panel and the Ready-for-Use software (Page 32)).

7.2 Commissioning tools

The following options are available for commissioning the electronic weighing system:

- Operator panel via SIMATIC CPU
- SIWATOOL

If the SIWAREX is only connected to the ET 200SP station, commissioning of the scale can be carried out using the SIWATOOL program. Operator panel and automation system are unnecessary. In the event of a fault, additional SIWATOOL diagnostics functions enable fast analysis of the cause.

7.3 5-minute quick start with the operator panel and the Ready-for-Use software

7.3.1 Start

The 5-minute quick start is carried out in this example using a TP700 Comfort Panel connected to the SIMATIC CPU. The panel communicates with the SIWAREX module via the SIMATIC CPU.

To carry out the quick start, select the "1.0 Setup" function in the main menu and then "1.2 Quick Start". You will be guided through the individual tasks for setting the most important parameters.

The remaining parameters are factory-set in such a way that they can be used in most cases without any changes.

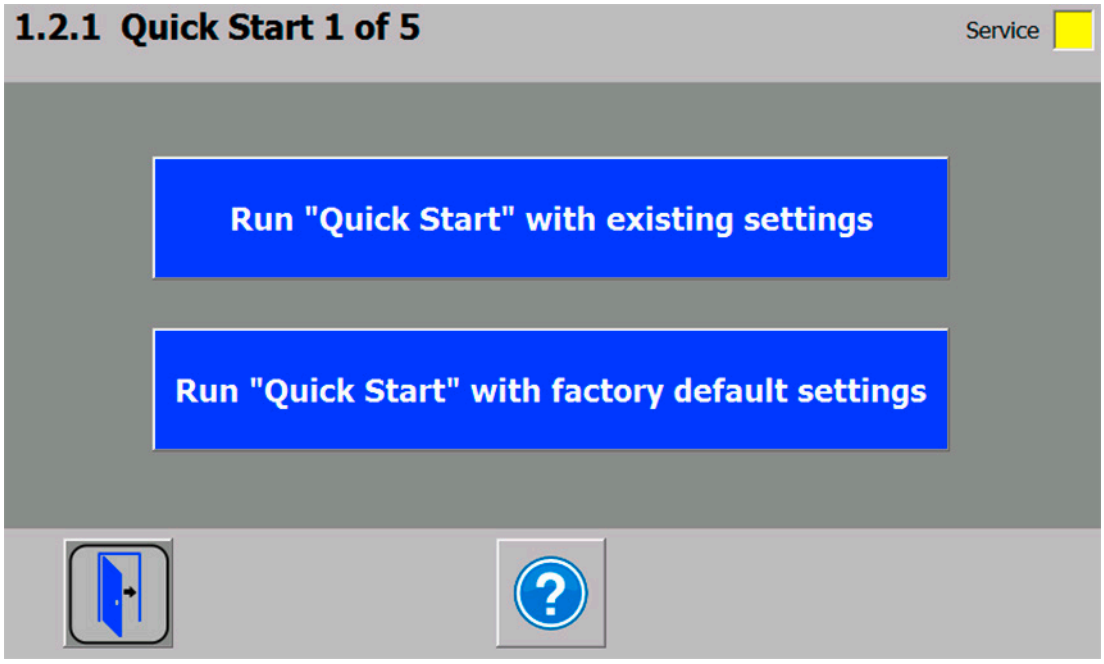


Figure 7-1 Quick start step 1

7.3.2 Factory setting of the parameters

The quick start is based on the factory setting of the parameters. Therefore, the previous parameter settings must be reset prior to the quick setup. Service mode must be switched on first. Resetting to the factory setting can then be carried out.

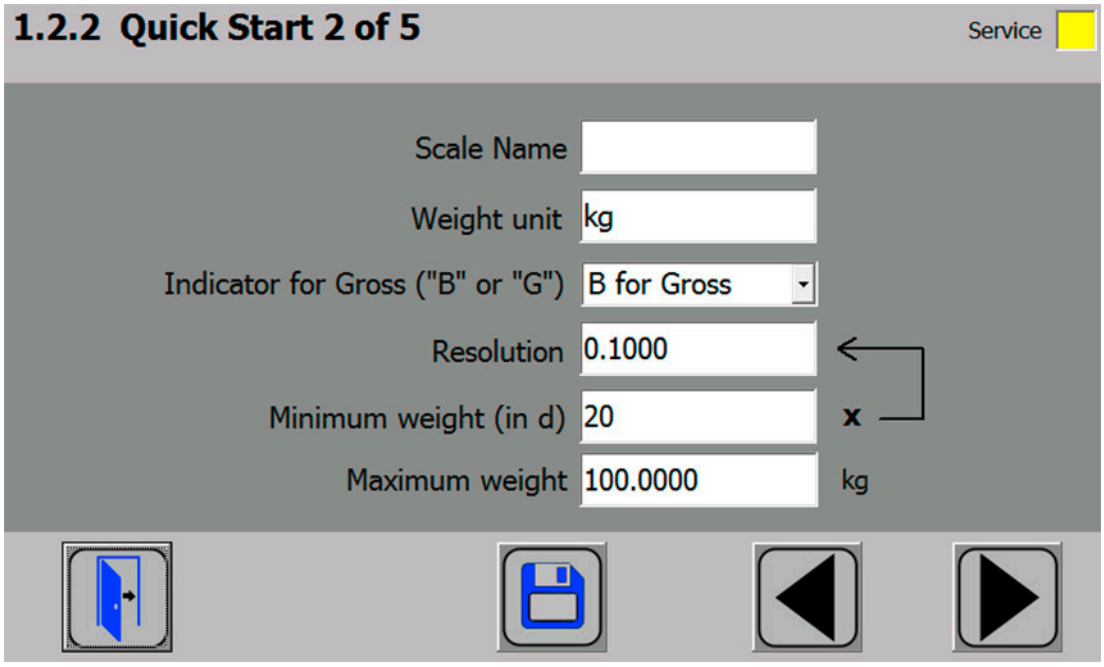


Figure 7-2 Quick start step 2

7.3.3 Selecting the calibration method

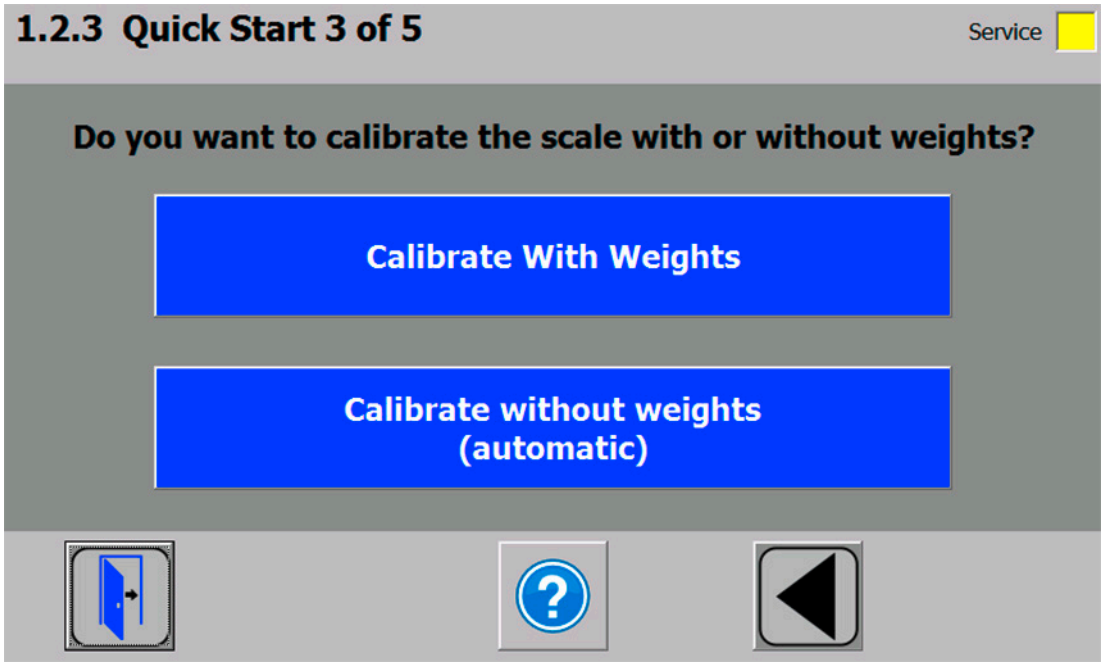


Figure 7-3 Quick start step 3

The module can always be calibrated in two different ways:

- Using reference weights: in the case of a calibration with weights, mechanical influences of the scale construction are also partially taken into account.
- Without weights, using the technical specifications of the connected load cell(s): in the case of automatic calibration, the accuracy of the scale is influenced by the mechanical properties to a greater extent than with calibration using reference weights.

With both methods, make sure that the mechanical properties of the scale are flawless prior to calibration.

7.3.4 Defining the calibration weights

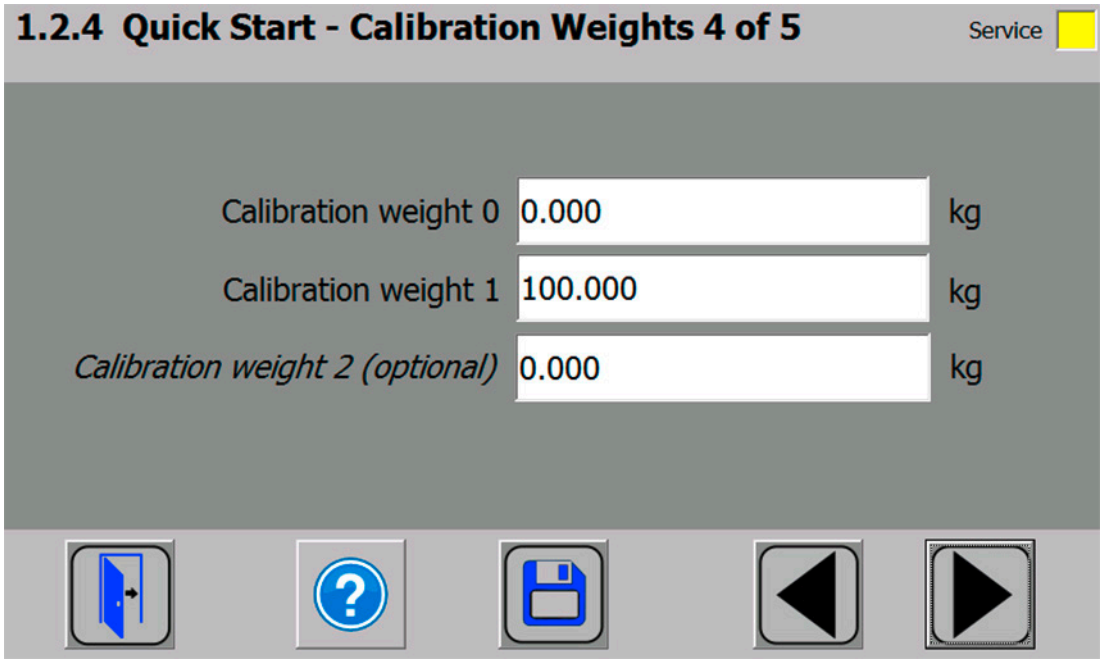


Figure 7-4 Quick start step 4a

In step 4 you enter the calibration weights which are to be positioned on the scale during the calibration. If the scale is not empty and the current contents are known, you can define an "Calibration weight 0" with the current contents of the scale. With an empty scale, this parameter remains as 0 kg. "Calibration weight 1" usually defines the first reference point of the scale characteristic. A further reference point ("Calibration weight 2") can also be set in addition. This is optional, and may not be necessary depending on the mechanical properties of the scale.

Note that the interval between the calibration weights must be at least 2% of the nominal load of the scale. With a 1 000 kg scale, a calibration weight of at least 20 kg must therefore be used.

7.3.5 Setting calibration points

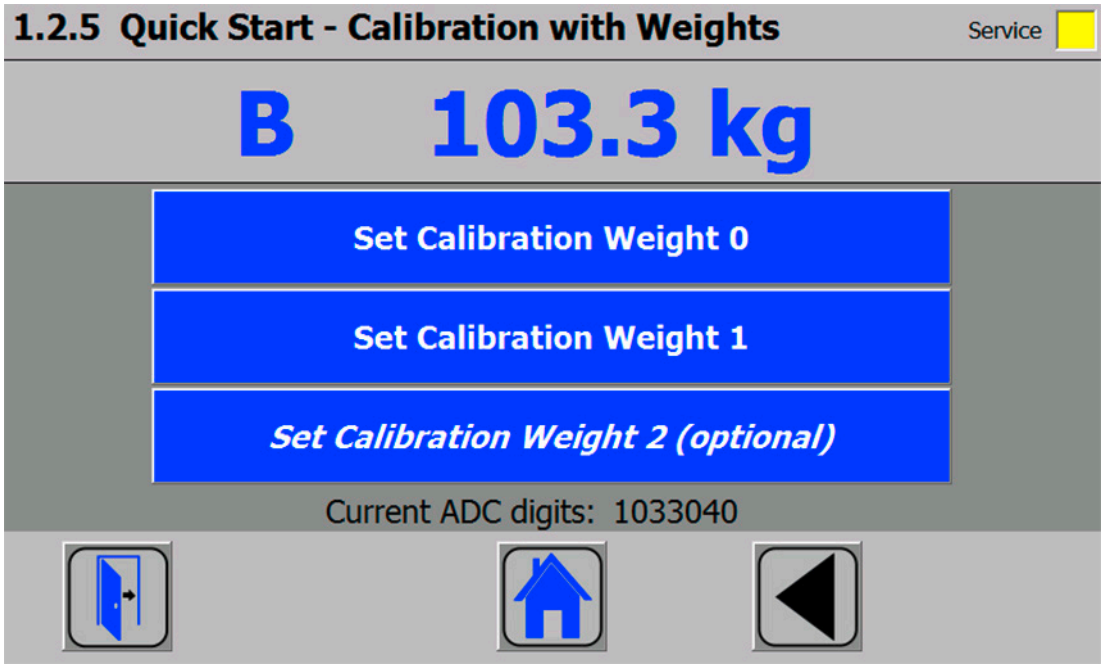


Figure 7-5 Quick start step 5a

Carry out the calibration commands at the end of the quick start:

1. Carry out the "Set calibration weight 0" command. The "Calibration weight 0" defined in step 4 is now visible in the display.
2. Place the "Calibration weight 1" defined in step 4 on the scale construction, and execute the "Set calibration weight 1" command.
3. If an "Calibration weight 2" was selected:
   Place "Calibration weight 2" defined in step 4 on the scale construction, and execute the "Set calibration weight 2" command.
4. Calibration of the scale is now complete. Return to the start screen by clicking on the house icon.

7.3.6 Calibrating the scale automatically

The scale can also be calibrated without weights. To do this, it is necessary to enter data specific to the load cells. In addition, it is essential that the scale is empty.

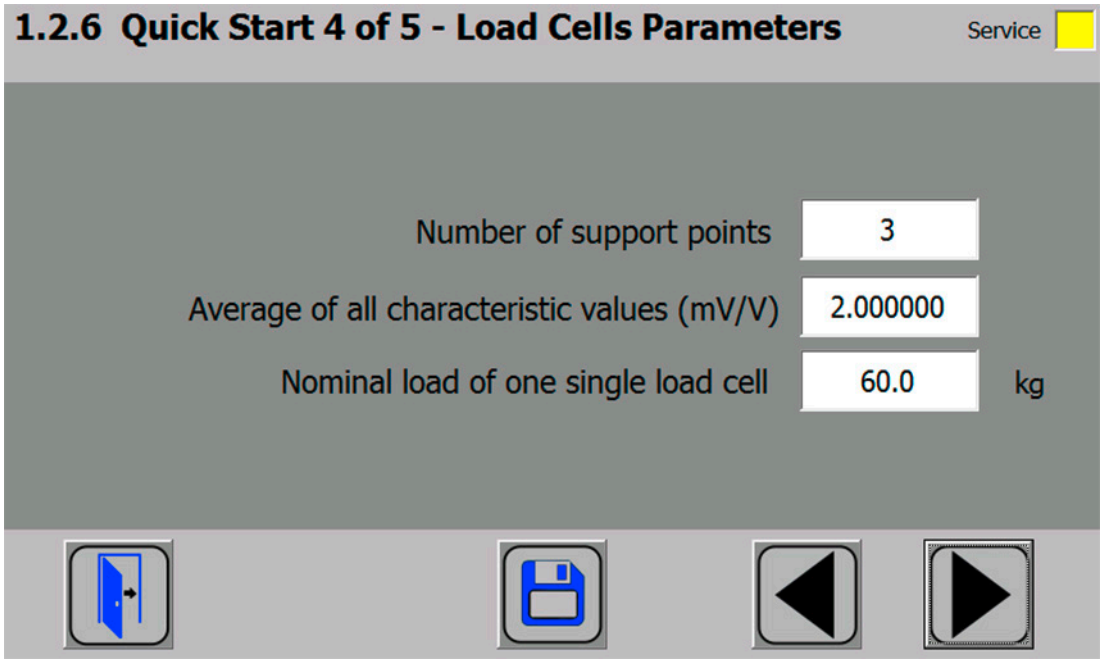


Figure 7-6 Quick start step 4b

The number of points of support corresponds with a silo, for example, to the number of clamps or feet of the silo. A quadratic platform scale with a load cell at each corner has 4 support points. The characteristic values of the individual load cells are required to calculate the average characteristic value of the cells.

The equation for the calculation is as follows:
(characteristic of cell 1 + characteristic of cell 2 + characteristic of cell n) / n

If the exact characteristic values are unknown, it is permissible to also use rounded-off numbers (e.g. 1.0 mV/V, 2.0 mV/V). The nominal load of an individual load cell (not the nominal load of the complete scale!) must subsequently be defined.

7.3.7 Performing the automatic calibration

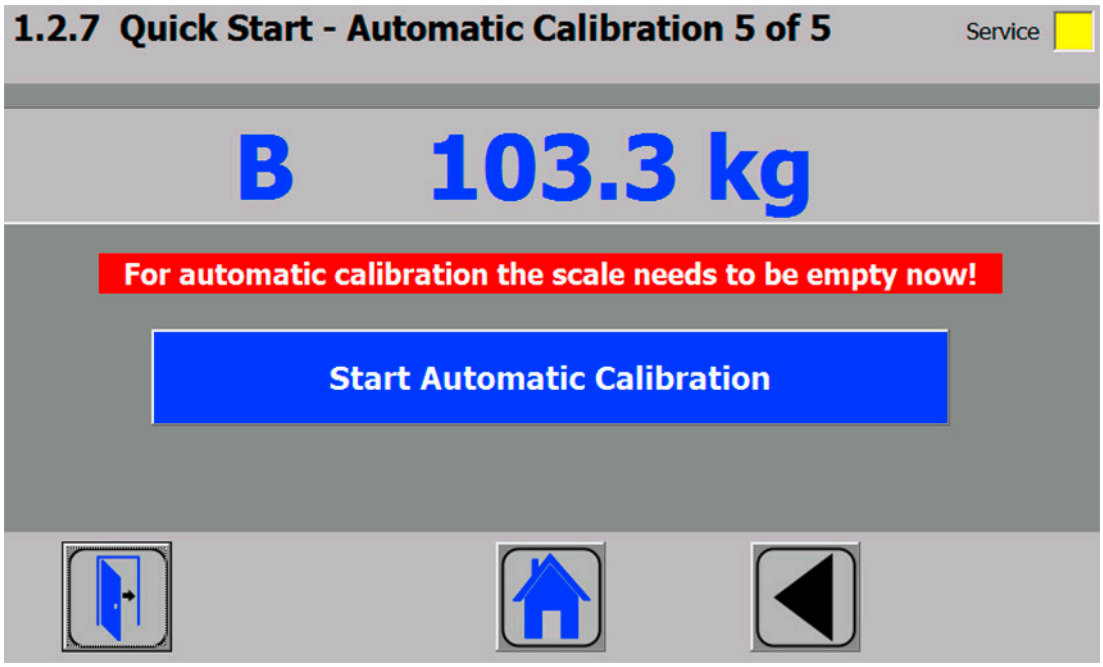


Figure 7-7 Quick start step 5b

Subsequently enter the "Perform automatic calibration" command with the scale empty. The scale is calibrated directly, and clicking on the house icon returns you to the start screen.

7.3.8 Checking the scale following calibration

If the scale is only used for company-internal purposes, a simple check is sufficient.

Perform the following steps:

1. The scale is unloaded and shows "0 kg".
2. Place a known reference weight on the scale.
   Check the displayed value.
3. If a second known reference weight is available, place it on the scale in addition.
   Check whether the scale displays the sum of the reference weights.
4. Remove the reference weights from the scale.
   Check that the display is "0 kg" again.

7.4 5-minute quick start with SIWATOOL

General information on using the SIWATOOL program can be found in chapter "Service with the SIWATOOL program (Page 42)".

For the quick setup, the required parameters are marked in bold font in data records DR 3 and DR 10. The procedure is described below.

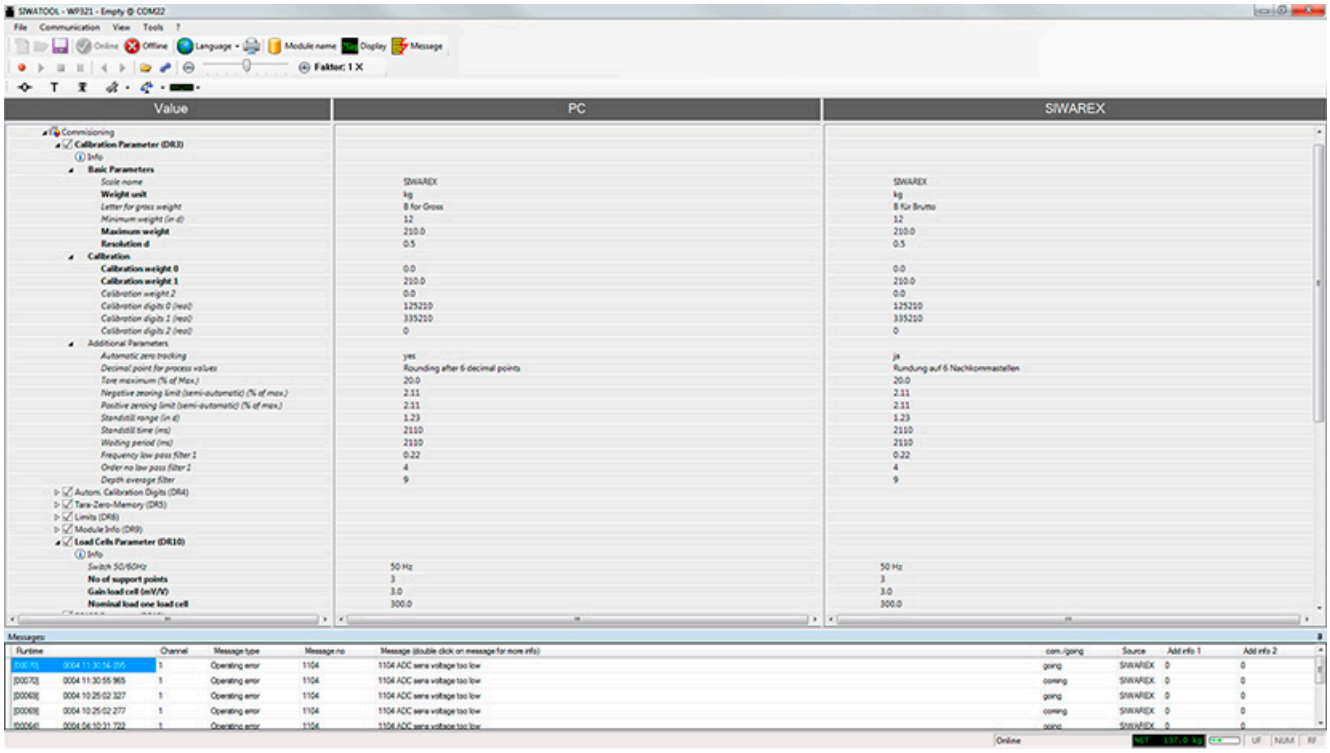


Figure 7-8 Quick setup with marked parameters

7.4.1 Activate service mode

Service mode must be activated in order to change the calibration parameters. You can find the command in the "Service Commands" group (spanner icon).

7.4.2 Load factory setting

The quick setup is based on the standard settings of the weighing module. The factory setting must therefore be reset prior to the quick start. Firstly, service mode is activated; the factory setting is subsequently loaded using the "Load factory setting (11)" command.

7.4.3 Input of required parameters

For commissioning, you must enter the following parameters in data record DR 3 and send these to the module:

- Unit of weight
- Required maximum weighing range of the scale
- Scale interval

Sending/receiving a data record is always carried out by right-clicking on the data record name in the "Value" column in the tree structure.

For example, if data record 3 is to be sent, right-click on "Calibration parameter (DR3)". A submenu is then opened with the option for sending the respective data record to the weighing module or for reading it from the module. All data records can only be sent as complete packets to the SIWAREX or read from it. It is not possible to read or write individual parameters within a data record. Therefore the complete data record must initially be received for every change to parameters within it. The desired parameter can then be edited, and the data record returned. If the data record is not received, the danger exists that different offline parameters will be sent to the scale and overwrite previously active and intentionally defined parameters.

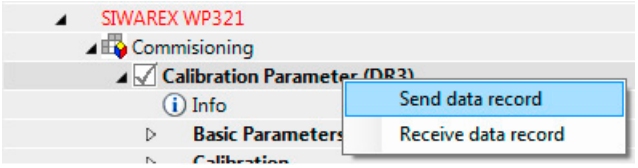


Figure 7-9 Sending/receiving a data record with SIWATOOL V7

You must subsequently enter the required parameters in data record DR 10 and send these to the module.

- Number of support points
- Characteristic value of a load cell in mV/V, or the mean value of the characteristic values if there is more than one load cell
- Rated load of a load cell

7.4.4 Complete automatic calibration

- The scale must be empty (only mechanical dead load).
- Activate the "Automatic Calibration 82" command.

7.4.5 Receive all data

Activate the "Receive all data" function in the communication menu.

All parameters can now been saved as a backup file on the hard disk. If a module is replaced, the backup file can be downloaded to the new module within a few seconds. At the time of input of the backup file, the scale is directly in the calibrated state again – without a new calibration.

7.4.6 Checking the scale following calibration

If the scale is only used for company-internal purposes, a simple check is sufficient.

Perform the following steps:

1. The scale is unloaded and shows "0 kg".
2. Place a known reference weight on the scale.
   Check the displayed value.
3. If a second known reference weight is available, place it on the scale in addition.
   Check whether the scale displays the sum of the reference weights.
4. Remove the reference weights from the scale.
   Check that the display is "0 kg" again.

7.5 Service with the SIWATOOL program

You can use the SIWATOOL program to commission the scale independently of the SIMATIC automation system. You require an RS485/USB converter (see section "Accessories") in order to connect the PC to the SIWAREX. You can then connect the RS485 interface of the SIWAREX to the USB port of the PC.

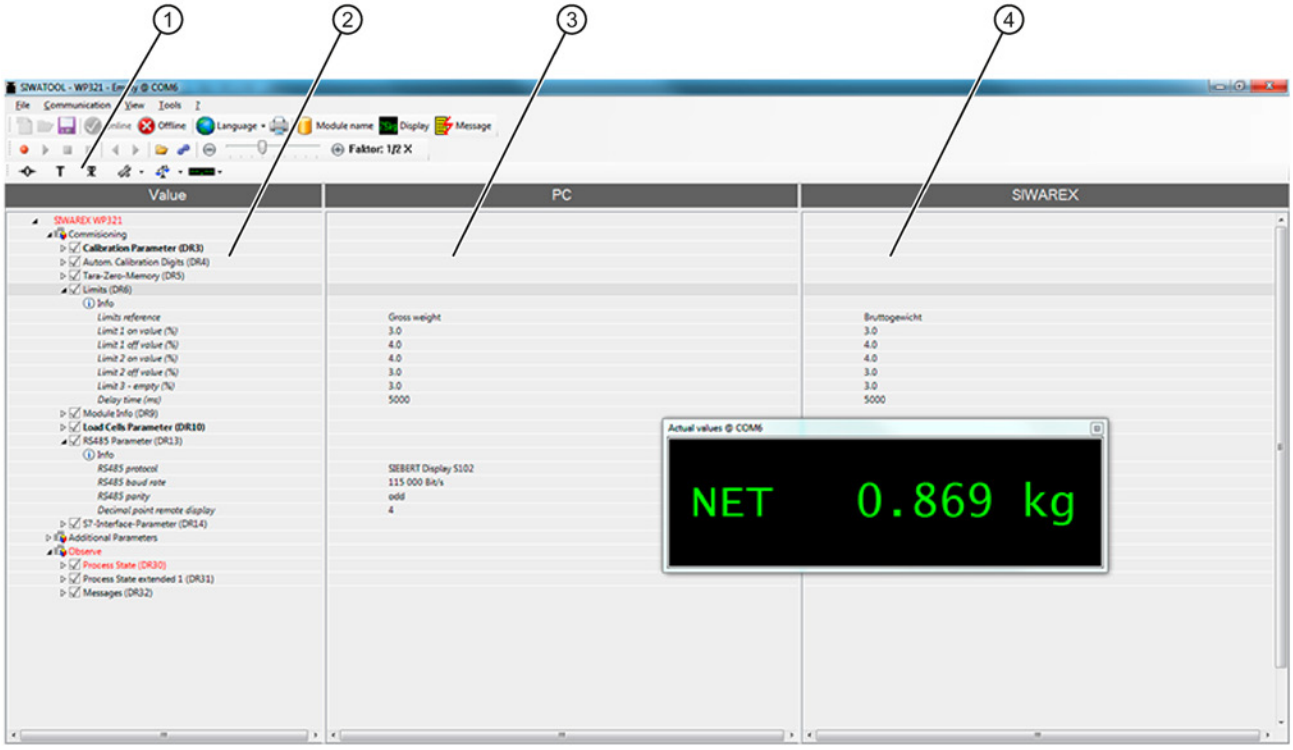
The SIWATOOL program is included in the configuration package.

Install the SIWATOOL program (SIWATOOL catalog) on your PC for commissioning.

See also

Accessories (Page 115)

7.5.1 Windows and functions of SIWATOOL



① Control elements for SIWATOOL and operation of the scale

② Parameter list of the SIWATOOL module

③ Offline values of the SIWAREX module

④ Online values of the connected SIWAREX module

Figure 7-10 Layout of the SIWATOOL user interface

For sending, receiving and transferring, select the corresponding data record and call the command list with a right mouse click.

The complete data record (all parameters of the data record) is always transferred, not just individual parameters.

7.5.2 Offline parameter assignment

All scale parameters can be edited and saved without an electronic weighing system.

This reduces the setup time. You can thus prepare the parameters for several scales in your office, and subsequently transfer them to the electronic weighing system during setup.

Data from one scale currently in operation can be exported and used to set up another scale.

7.5.3 Online parameter assignment

To switch to online mode, connect the PC to the SIWAREX module via an RS485/USB converter. Set the appropriate interface in the communication menu.

You can change all parameters in the SIWAREX module in online mode. The message window shows the current contents of the message buffer of the SIWAREX module. The current process values are displayed in the "Online" column.

For test purposes, you can send various commands to the SIWAREX module. Differences between the online/offline data are marked in red by SIWATOOL. This affects both the associated data record and the individual parameter.

In order to archive data, all data can be exported from the SIWAREX module and saved as a file or printed.

Note

You can edit all data in the SIWAREX module in online mode. The changes are not automatically imported to the corresponding scale data block in the SIMATIC CPU.

To download the data to the SIWAREX module, select the data record with a right mouse click and send it explicitly to the SIWAREX module.

Online parameter trends can be recorded and played back using the recorder function located at the top right-hand edge of SIWATOOL. You can use the "Configure recorder" button to select the data records to be recorded and to set the save parameters. The playback speed can be set using a slider.

7.5.4 Available help options

SIWATOOL offers various help options for operation:

- Info card

  You can select the "Info" item directly underneath the individual data records in the navigation tree. This info card explains how the data record influences the scale behavior.

- Tooltip

  If you move the mouse over a button or parameter, a corresponding help text is displayed.

- Help

  Click on the menu option "Help" to call up the SIWATOOL help. The Help can be opened separately.

7.5.5 Entering parameters with SIWATOOL

There is a defined procedure for handling parameters. The current parameters in the SIWAREX module are displayed in the right-hand window, while the parameter values on the PC are displayed in the left-hand window. The new parameter value is entered first in the left-hand window. If several parameters of the data record are to be changed, they are entered consecutively. The data record is subsequently selected in the tree view and sent to the SIWAREX modules using the right mouse button.

Parameters are always changed as complete data records, rather than individually.

Scale parameters and functions

8

8.1 Parameters and functions

All parameters are set to default values in the factory. You can restore the configuration to factory settings using the "Load factory settings" command.

The scales are ready for operation with the default parameter settings. You do not need to re-enter all parameters. The advantage of this solution is that you can decide the default values to be retain and the parameters that need to be adapted for your application.

All parameters are divided into data records (DR). The data records are organized in steps (tasks) to be implemented during commissioning or during the process.

The scale functions governed by the parameters are also described in the parameter description below.

First, the parameters of a given data record are displayed in a table. The detailed parameter description for the parameters of this data record then follows.

When it receives new parameters, the SIWAREX module runs a validation check. In the event of a parameter assignment error, the data record is not applied (not saved) by the SIWAREX module and a data/operator error is reported.

8.2 DR 2 command code

DR 2 is a special data record used to transfer commands to the SIWAREX module by SIWATOOL.

8.3 DR 3 calibration parameters

The calibration parameters need to be checked and if necessary modified for all scales.

The scale is basically defined by calibration parameters and calibration operation.

Procedure

- Check all parameters and modify them as required.
- Transfer the DR 3 data record from SIWATOOL to the scale.
- Calibrate the scale.
- Transfer the DR 3 data record from the scale to SIWATOOL.

Table 8- 1 Assignment of data record 3

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	3	-	-
Length	Data record length information	USHORT	2	r	124	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Scale name header	Maximum length and actual length of string for scale name	UBYTE[2]	2	rw	12,12	-	-
Scale name (Page 48)	Scale name specified by user	CHAR[12]	12	rw	" "	-	-
Unit of weight header	Maximum length and actual length of string for unit of weight (e.g.: g, kg, t, ...)	UBYTE[2]	2	rw	04,04	-	-
Unit of weight (Page 48)[1)]	Unit of weight	CHAR[4]	4	rw	"kg••"	-	-
Gross identifier header	Maximum length and actual length of string for unit of weight	UBYTE[2]	2	rw	02,02	-	-
Gross identifier (Page 48)	Abbreviation of gross (B or G), only one byte is used!	CHAR[2]	2	rw	"B"	"B"	"G"
Reserve	Reserve	USHORT	8	rw	0	-	-
Maximum weighing range (Page 49) [1)]	Maximum weight	FLOAT	4	rw	100	> wb_min* ZIF.step	maximum number range
Calibration weights 0, 1, 2 and calibration digits	Calibration weight 0[1)] (usually the zero point)	FLOAT	4	rw	0	1	9 999 999
	Calibration weight 1[1)]	FLOAT	4	rw	100	1	9 999 999
	Calibration weight 2	FLOAT	4	rw	0	1	9 999 999

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
0, 1, 2 (Page 49)	Calibration digits 0 determined during calibration with calibration weight 0	FLOAT	4	rw	0	-3 999 999	+3 999 999
	Calibration digits 1 determined during calibration with calibration weight 1	FLOAT	4	rw	2 000 000	-3 999 999	+3 999 999
	Calibration digits 2 determined during calibration with calibration weight 2	FLOAT	4	rw	0	-3 999 999	+3 999 999
Scale interval (Page 49) [1)]	Weighing range1 scale interval (1*10**k, 2*10**k, 5*10**k]; k: -3 … 2)	FLOAT	4	rw	0,1	0.001	50
Reserve	Bit 1: Reserve	BIT	2	rw	0	0	1
Reserve	Bit 2: Reserve	BIT	0	rw	0	0	1
Automatic zero adjustment (Page 49)	Autom. zeroing device (zero tracking device) 0: Autom. zeroing off 1: Autom. zeroing on	BIT	0	rw	0	0	1
Reserve (13 bits)	Bit 3: Reserve	BIT	0	rw	0	0	1
Decimal places for process values (Page 49)	0: No rounding 1: Rounding to 1 decimal place 2: Rounding to 2 decimal places 3: Rounding to 3 decimal places 4: Rounding to 4 decimal places 5: Rounding to 5 decimal places 6: Rounding to 6 decimal places	USHORT	2	rw	0	0	6
Maximum tare load (Page 49)	Range of subtractive tare unit [in % of max. weighing range]	FLOAT	4	rw	0	0	250
Reserve	Reserve	FLOAT	8	rw	1,0	0	100.0
Maximum negative zeroing limit (Page 50)	Negative range of semi-automatic zeroing device [in % of max. weighing range]	FLOAT	4	rw	1	0	100.0
Maximum positive zeroing limit (Page 50)	Positive range of semi-automatic zeroing device [in % of max. weighing range]	FLOAT	4	rw	3,0	0	100.0
Standstill range (Page 51)	Standstill range (in d)	FLOAT	4	rw	0,1	0	maximum number range+
Standstill time (Page 51)	Standstill time 1 in ms	TIME	4	rw	2 000	10	10 000

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Standstill waiting time (Page 52)	Waiting time until standstill. 0: Any scale commands dependent on standstill are rejected immediately in the absence of standstill. >0: Maximum waiting time until command is executed	TIME	4	rw	2 000	0	10 000
Low-pass filter limit frequency (Page 52)	Low-pass filter limit frequency: 0: Filter disabled	FLOAT	4	rw	0,5	tbd	tbd
Low-pass filter number (Page 52)	Filter number 2*(1…5)	USHORT	2	rw	4	2	10
Reserve	Reserve	USHORT	2	rw	0	-	-
Reserve	Reserve	FLOAT	4	rw	0	tbd	tbd
Reserve	Reserve	USHORT	2	rw	4	2	10
Mean value filter depth (Page 53)	Filter for digit values, permitted filter depth: 0 … 250	USHORT	2	rw	10	0	250

1) Parameter for calculation of calibration points

8.3.1 Scale name

You can select any name, but it may not exceed 12 characters. You can enter any designation.

8.3.2 Unit of weight

A string with up to four digits can be specified as the unit of weight, e.g.: t, kg, lbs. The defined unit of weight applies to all weight specifications. Entries are not be converted if the unit of weight has changed. Entries must be left-aligned.

8.3.3 Gross identifier

The gross identifier specifies the letter, B (for brutto) or G (for gross), to be used in the display for gross weights.

8.3.4 Maximum weighing range

The weight can only be used with the defined scale interval below the maximum weight (+ 9 d, d = scale interval). The maximum weight is defined during commissioning. Exceeding the maximum weight is indicated in the status (DR30).

The maximum weight depends on the number and type of load cells used.

8.3.5 Calibration weights 0, 1, 2 and calibration digits 0, 1, 2

The calibration weights and corresponding calibration digits define the characteristic curve of the scales. A detailed description can be found in section Calibration procedure (Page 54).

8.3.6 Scale interval

The scale interval for the weighing range can be defined in accordance with EN 45501 (0.0001 to 50).

8.3.7 Automatic zero adjustment

If required, you can carry out semi-automatic zeroing of the scale using the "Zeroing" command.

The automatic adjustment sets the scale to zero without a further command in the event of slow zero drifting. Slow drift is assumed if the OIML R76 criteria are met.

Note

If this function is enabled, the scale may eventually read zero after a slow drift even if they are fully loaded. The function can, however, be limited by specifying a maximum and minimum weight for zeroing.

8.3.8 Decimal places for process values

This parameter is used to specify the number of decimal places to which the process values are to be rounded. This value decouples the main display of the weight values from the values used in the control software.

8.3.9 Maximum tare load

The weighing module accepts any external tare specification which is less than the maximum tare load (percentage of maximum weighing range). Tare commands are also accepted provided that the current gross weight is less than the configured maximum tare load.

8.3.10 Maximum negative zeroing limit

Zeroing defines the current weight of the scales as zero.

You can limit the effect of the zeroing function. The limitation is based not on the current gross weight, but rather on the weight which the scales would display had there been no zeroing (time of scale calibration).

8.3.11 Maximum positive zeroing limit

You can limit the effect of the zeroing function. The limitation is based not on the current weight, but rather on the weight which the scales would display had there been no zeroing (time of scale calibration).

8.3.12 Standstill range

Standstill monitoring checks whether the scales are correctly balanced. Scale standstill is registered if the weight changes by less than a specified fluctuation in d (standstill value) over a specified time (standstill time). Standstill monitoring is used in static scale mode (commands: zeroing, taring). The diagram below illustrates how standstill monitoring works.

The current weight can only be registered in legal trade applications if standstill is reached.

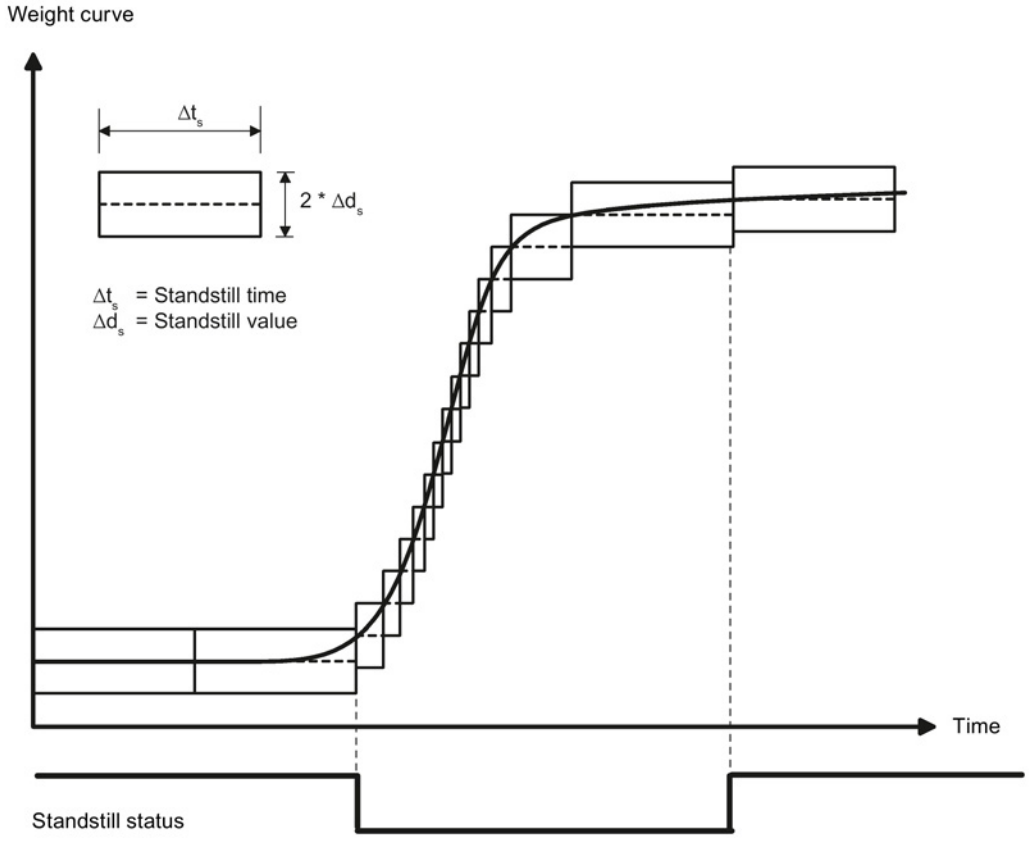


Figure 8-1 Standstill monitoring

8.3.13 Standstill time

Standstill monitoring checks whether the scales are correctly balanced. Scale standstill is registered if the weight changes by less than a specified fluctuation in d (standstill value) over a specified time (standstill time). Standstill monitoring is used in static scale mode (with the following commands: zeroing, taring).

8.3.14 Standstill waiting time

Standstill waiting time is a maximum waiting time for standstill on execution of a command which depends on standstill (taring, zeroing). A technology message is generated if the command cannot be executed during the standstill waiting time because there is no standstill.

If the standstill waiting time is equal to zero, a command requiring standstill is rejected immediately if there is no standstill.

8.3.15 Low-pass filter limit frequency

There is a critically damped low-pass filter for suppressing faults. The diagram below shows the step response of the filter (f_g = 2 Hz). The entry "0" means that the filter is switched off. A limit frequency of between 0.01 and 20.0 Hz can be specified.

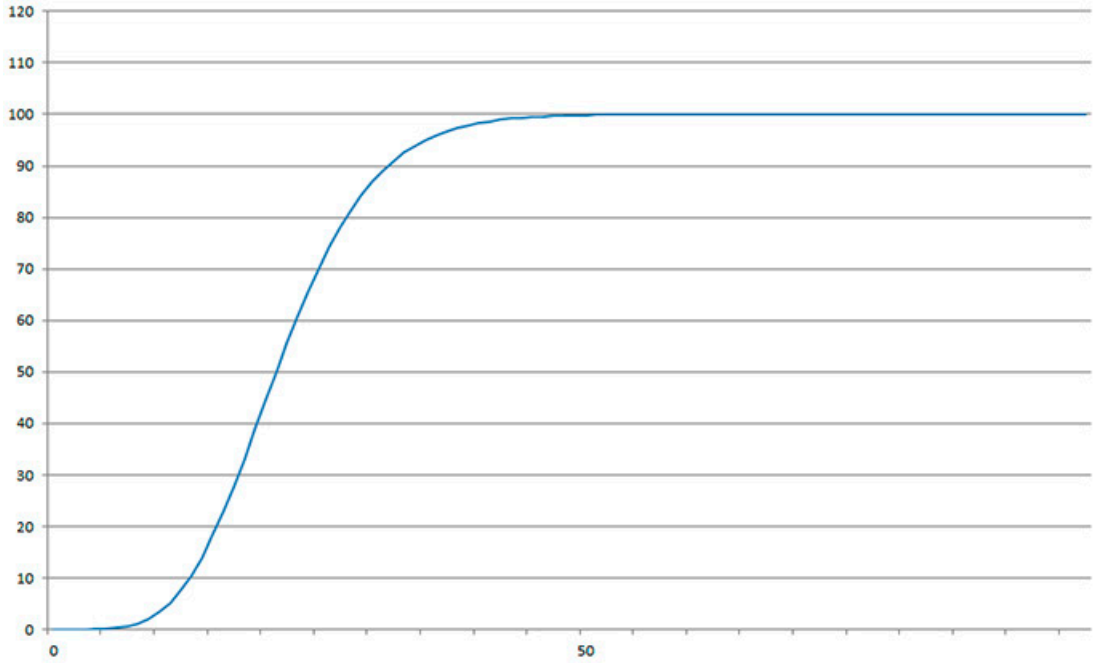


Figure 8-2 Step response of the digital low-pass filter when f_g = 2 Hz

The definition of the limit frequency is extremely important for the suppression of faults. Defining the limit frequency defines the "speed" of the scale's response to changes in the measured value.

A value of 5 Hz, for example, results in a relatively rapid response to a change in weight; a value of 0.5 Hz makes the scale "slower".

8.3.16 Low-pass filter number

The number of the filter defines the effect of damping. The values 2 and 4 can be set. The higher the selected filter number, the higher the effect.

8.3.17 Mean value filter depth

The mean value filter is used to steady the weight against random interference. The weight is the mean value of n (n = max. 250) weights which are recorded by the weighing module every 10 ms, e.g. when n = 10, the mean of 10 weights is calculated. Every 10 ms, the oldest value is discarded and the newest value included in the calculation.

8.4 Calibration procedure

8.4.1 Calibration with calibration weights

The incoming analog measured value from the load cells is converted into a digital value in an analog-to-digital converter. A weight is calculated using this digital value. This weight is then used by all weighing module functions for messages and for determining the status.

The characteristic curve of the measuring system must be defined before the weight can be calculated from the digital value. In the simplest case, the characteristic curve is defined with points 0 and 1. The first working point (point 0) is defined by the empty scale (no load) at their own weight. The load cells return a voltage measurement to the weighing module as a result of the weight of the scales themselves. Following analog-to-digital conversion of the measured voltage, the zero point is assigned to the digital value (calibration digits for the zero point).

If the scales are loaded with a defined standard weight (e.g. 50% of the measuring range), the new digital value returned by the analog-to-digital converter is assigned the standard weight.

The characteristic curve can also be determined with a third point, which must be higher than point 1.

Make sure that the difference between two calibration weights is at least 40 000 digits, as the calibration command may otherwise be rejected.

The calibration procedure involves the following steps:

- Activation of service mode using the "Service mode on" command.
- Define the calibration weight and other parameters of the DR 3 data record.
- Transfer the DR 3 data record to the scales.
- Trigger "Adjustment weight 0 valid" for empty scales.
- Load the scale with the defined standard weight.
- Trigger "Adjustment weight 1 valid".
- Transfer data record DR 3 from the scale to SIWATOOL and save the data on a data medium.

You must follow the correct calibration sequence with increasing calibration weights.

Example

Zero point = 0.0 kg (always)	equals 326348 digits
Calibration weight 1 = 100 kg	equals 1324765 digits

Load cell characteristic value	Calibration digit 1 (ca.) when rated load is
1 mV/V	500 000
2 mV/V	1 000 000
4 mV/V	2 000 000

This defines the characteristic curve and the scale can now calculate weights for the full measuring range.

The diagram below illustrates the relationship between calibration digits and the calibration weight.

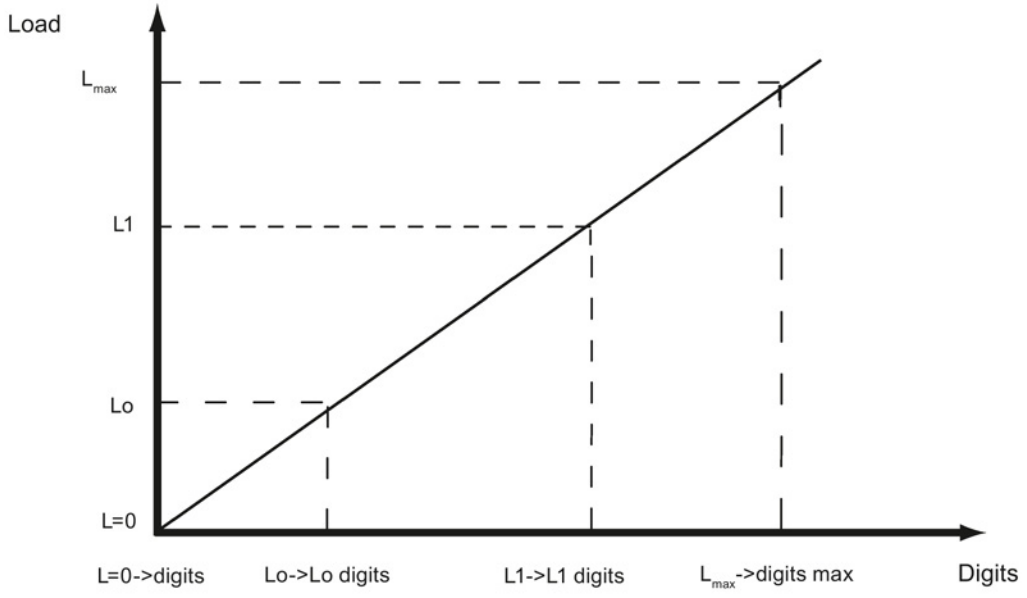


Figure 8-3 Calibration digits and calibration weight

Load	Comment	Load	Digits
L=0	Load cells empty		Approx. 0
Lo	Calibration weight 0 "Zero point"	0 kg	e.g. 70 682 for calibration point 0
L1	Calibration weight 1	e.g. 60 kg	e.g. 308 452 for calibration digits 1
L_{max}	Rated load of the load cell(s)	e.g. 100 kg	1 000 000
L_{max} +10 %	Rated weight + approximately 10%	e.g. approximately 110 kg	1 090 000

You do not need to perform calibration if the calibration digits and the calibration weights are known to the weighing module described here. They are simply sent to SIWAREX by data record DR 3 and the scale is ready for use immediately.

The SIWATOOL program facilitates rapid calibration.

Following commissioning and calibration, all data records must be read from the weighing module and saved as a scale file.

Identical scales can be put into operation immediately. Connect the PC to the new scale and enable the "Send all data records" function in service mode. This transfers the parameters for calibration weights and calibration digits, and the characteristic curve is determined immediately. The same applies when you change a weighing module.

Note

Two working points are usually sufficient for determining the scale's characteristic curve. An additional working point is only required for non-linear systems.

Specification of negative calibration points is not possible. However, the characteristic can also be used in the negative range down to -2 000 000 digits. To achieve this, the characteristic curve generated in the positive range is extended into the negative range.

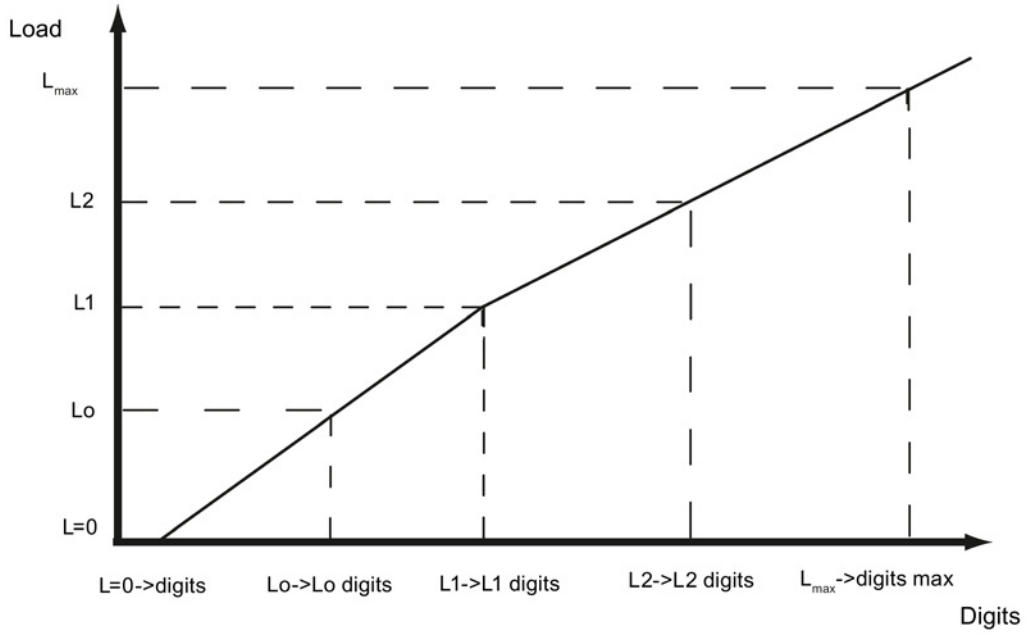


Figure 8-4 Linearizing the scale's characteristic curve

Load	Comment	Load	Digits
L=0	Load cells empty		Approx. 0
Lo	Calibration weight 0 "Zero point"	0 kg	e.g. 76 082 for calibration point 0
L1	Calibration weight 1	e.g. 60 kg	e.g. 386 452 for calibration digits 1
L2	Calibration weight 2	e.g. 80 kg	e.g. 451 367 for calibration digits 2
L_{max}	Rated load of the load cell(s)	e.g. 100 kg	1 000 000
L_{max} +10 %	Rated weight + approximately 10%	e.g. approximately 110 kg	1 090 000

8.4.2 Automatic calibration

Scales can be rapidly commissioned with automatic calibration. The accuracy of the scale greatly depends on the entered parameters and the mechanical properties of the scale. However, you achieve the best level of accuracy for the scales by using calibration weights.

During initial commissioning with automatic calibration, you must reset the module using the "Load factory settings" command.

Subsequently specify the load cell parameters in data record 10. Command 82 "Perform automatic calibration" then uses this data and the currently applied dead load to calculate the characteristic curve of the scale. The characteristic curve is active immediately.

Note

The characteristic curve data in data record 3 active prior to execution of command 82 is directly overwritten.

Automatic calibration requires the following criteria:

- Correct mechanical installation of the scale
- Scale is empty (only mechanical installation (= dead load) present on the cells)
- Load cells are evenly loaded
- There are no shunt circuits

8.5 DR 4 Output of calculated calibration digits

Date record DR 4 outputs the digits calculated from automatic scale calibration.

This data record cannot be sent to the scale.

Table 8- 2 Assignment of data record 4

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	4	-	-
Length	Data record length information	USHORT	2	r	28	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Calibration digits 0, 1, 2 (calculated) (Page 58)	Calibration digits 0 (calculated): Calibration digits calculated in "Automatic Calibration"	LONG	4	r	?		
	Calibration digits 1 (calculated): Calibration digits calculated in "Automatic Calibration"	LONG	4	r	0		
	Calibration digits 2 (calculated): Calibration digits calculated in "Automatic Calibration"	LONG	4	r	0		
Reserve 1	Reserve	SHORT	2	r	0	-	-
Reserve 2	Reserve	USHORT	2	r	0	-	-
Reserve 3	Reserve	FLOAT	4	r	0	-	-

8.5.1 Calibration digits 0, 1, 2 (calculated)

The calculation is based on the parameters from DR 3 and DR 10 identified by bold font and is activated by the command no. 82.

8.6 DR 5 zeroing memory

Data record DR 5 displays the current values in the tare memory and the zeroing memory.

Procedure

- Check all parameters
- Transfer the data record to the scale

Table 8- 3 Assignment of data record 5

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	5	-	-
Length	Data record length information	USHORT	2	r	40	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Effective tare weight - from specification (Page 60)	Current tare weight from specification as process value	FLOAT	4	rw	0	0	Depends on specification in DR 3
Effective tare weight (semi-automatic) (Page 60)	Current tare weight from semi-automatic mode as process value	FLOAT	4	rw	0	0	Depends on specification in DR 3
Reserve	Reserve	FLOAT	4	rw	0	-	-
Zero weight (semi-automatic) (Page 60)	Current zeroing weight (affected by zeroing)	FLOAT	4	rw	0	Depends on specification in DR 3	Depends on specification in DR 3
Current zero tracking weight (Page 60)	Zero point correction weight affected by automatic zeroing	FLOAT	4	rw	0	Depends on specification in DR 3	Depends on specification in DR 3
Dead load (Page 60)	Dead load determined during calibration	FLOAT	4	r	0	Depends on specification in DR 3	Depends on specification in DR 3
Reserve 1	Reserve	SHORT	2	rw	0	-	-
Reserve 2	Reserve	USHORT	2	rw	0	-	-
Reserve 3	Reserve	FLOAT	4	rw	0	-	-

8.6.1 Effective tare weight - from specification

A tare weight can be specified in data record DR 15. You activate the specified tare weight with a command (see command 1013). From this point on, the activated tare weight is factored into the weight calculations. The "Delete tare" command deactivates the active tare weight. This does not delete the specification in data record DR 15.

8.6.2 Effective tare weight (semi-automatic)

The corresponding command (see command 1011) applies the current gross weight as the active tare weight. From this point on, the activated tare weight is factored into the weight calculations. The "Delete tare" command deactivates the active tare weight.

8.6.3 Zero weight (semi-automatic)

The zero weight command (see command 1001) entered by the user sets the current gross weight to "Zero" provided it is within the defined zero setting limits. The current gross weight is saved as the zero weight. The zeroing weight must be within the specified range (usually +3 / -1 % of the set zero point).

8.6.4 Current zero tracking weight

The current zero tracking weight is recorded in this parameter if automatic zero tracking is activated.

8.6.5 Dead load

The characteristic curve of the scales is determined during calibration. When there is no load, the main display returns "0". The dead load is the weight of the empty scales, i.e. the weight of the scales themselves.

8.7 DR 6 limit value settings

The switch-on and switch-off values for the limits are configured in data record DR 6.

Procedure

- Check all parameters and modify them as required
- Transfer the data record to the scale

Table 8- 4 Assignment of data record 6

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	6	-	-
Length	Data record length information	USHORT	2	r	60	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
DR 6 limit value settings (Page 61)	Gross / net basis of limit values 1 and 2 0: Limit value 1 and limit value 2 are based on the gross value 1: Limit value 1 and limit value 2 are based on the net value	USHORT	2	rw	0	0	1
Reserve	Reserve	USHORT	2	rw	0	0	-
Limit value 1 ON (Page 63)	Switch-on point for limit value 1 (% of measuring range)	FLOAT	4	rw	0	maximum number range	maximum number range
Reserve	Reserve	TIME	4	rw	0	0	maximum number range+
Limit value 1 OFF (Page 63)	Switch-off point for limit value 1 (% of measuring range)	FLOAT	4	rw	0	maximum number range	maximum number range
Reserve	Reserve	TIME	4	rw	0	0	maximum number range+
Limit value 2 ON (Page 63)	Switch-on point for limit value 2 (% of measuring range)	FLOAT	4	rw	0	maximum number range	maximum number range

Variable	Note	Type	L	Rw	Default	Min.	Max.
Reserve	Reserve	TIME	4	rw	0	0	maxi-mum number range+
Limit value 2 OFF (Page 63)	Switch-off point for limit value 2 (% of measuring range)	FLOAT	4	rw	0	maxi-mum number range	maxi-mum number range
Reserve	Reserve	TIME	4	rw	0	0	maxi-mum number range+
Limit value "Empty" ON (Page 63)	Limit value "empty" ON (always based on gross value) (% of measuring range)	FLOAT	4	rw	0	maxi-mum number range	maxi-mum number range
Delay time for limits (Page 64)	Uniform delay time for limits in ms	TIME	4	rw	0	0	maxi-mum number range+
Reserve	Reserve	USHORT	2	rw	0	-	-
Reserve	Reserve	USHORT	2	rw	0	-	-
Reserve	Reserve	FLOAT	4	rw	0	-	-

Value	Limit values relate to
0	Gross weight
1	Net weight

The limit value "Empty" always relates to gross weight zero.

8.7.1 Limit value 1 ON, limit value 2 ON, limit value 1 OFF, limit value 2 OFF

The switch-on and switch-off points can be specified separately for each limit value as a percentage of the measuring range. This allows both minimum and maximum value violation monitoring with hysteresis. A delay time for switch-on and switch-off can also be specified. Either the current net weight or the current gross weight can be selected as the reference value for limits 1 and 2.

Maximum value monitoring is implemented with the following specifications:

- Switch-on value > switch-off value

Minimum value monitoring is implemented with the following specification:

- Switch-on value < switch-off value

The diagram below illustrates the function of limit values 1 and 2.

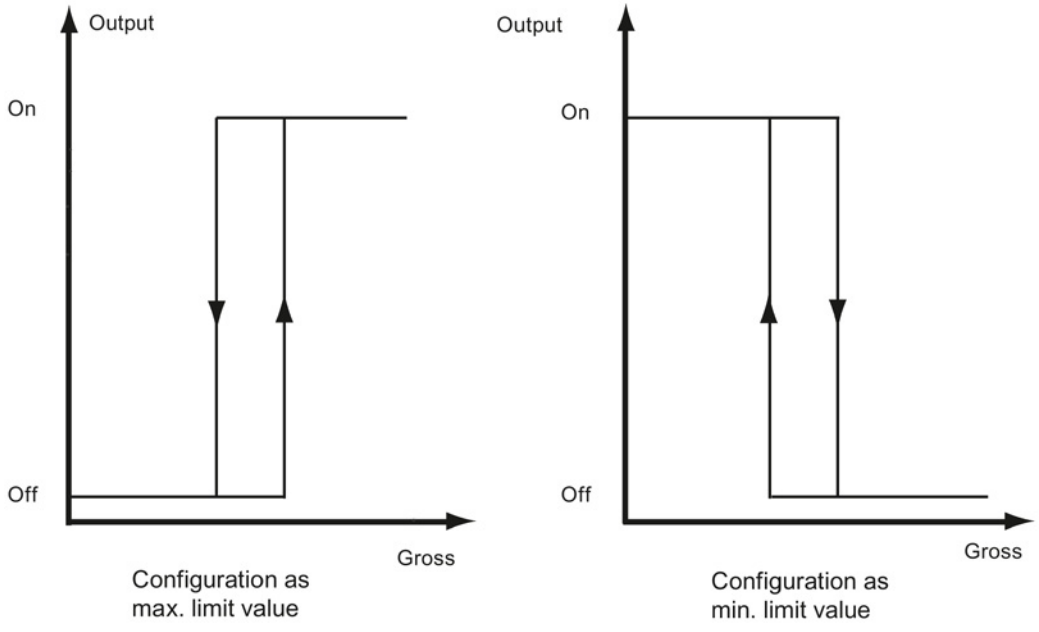


Figure 8-5 Limit value configuration

8.7.2 Limit value "Empty" ON

The value for the empty range is a limit value below which the weighing module registers and returns the status "empty". The values are entered as a percentage of the measuring range. The "Empty" limit always refers to the current gross weight in the scale.

8.7.3 Delay time for limits

If the weight reaches the specified switch value, a delay time (defined in ms) is launched. Once the delay time is over, the limit switch changes status provided the weight still reaches the specified switch value.

This delay time applies to the switch-on and switch-off values 1 and 2 and to the switch-on limit for the empty value. The empty value does not have a switch-off delay.

8.8 DR 9 module information

No entries can be made in data record DR 9. This data record provides information on the inner workings of the SIWAREX module. This information is used to identify the module at the manufacturer plant (e.g. in the event of repairs). The entries in the data record are of no importance to the user for operation.

Table 8- 5 Assignment of data record 9

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	9	-	-
Length	Data record length information	USHORT	2	r	68	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Order number - header	Maximum and current string length for the order number	UBYTE[2]	2	r	16,16	-	-
Order number	Order number of the module 7MH ..	CHAR[16]	16	r	"7MH …"	-	-
Serial number - header	String header	UBYTE[2]	2	r	12,12	-	-
Serial number	Serial number " XXX00001"	CHAR[12]	12	r	" "	-	-
Firmware type - header	String header	UBYTE[2]	2	r	2,2	-	-
Firmware type	Reference V - Release B - Test etc.	CHAR[2]	2	r	'V '	-	-
Firmware version - 1st position	Version 1.	USHORT	2	r	1	-	-
Firmware version - 2nd position	Version 2.	USHORT	2	r	0	-	-
Firmware version - 3rd position	Version 3.	USHORT	2	r	0	-	-
Hardware version number	ES hardware version number (e.g. 03)	USHORT	2	r	1	-	-
OS version header	String header	UBYTE[2]	2	r	2,2	-	-
OS version (loader) - designation	Reference V - Release B - Test etc.	CHAR[2]	2	r	'V '	-	-
OS version (loader) - designation	e.g. version n	USHORT	2	r	'V '	-	-

Variable	Note	Type	L	Rw	Default	Min.	Max.
Reserve	Reserve	USHORT	6	r	0	-	-
Reserve 4	0	FLOAT	4	r	0	-	-

8.9 DR 10 load cell parameters

The parameters of the analog load cells must be checked prior to the automatic calibration and modified if necessary. Only the parameters identified by bold font and asterisk (*) need be entered.

Procedure

- Check the parameters and modify them as required
- Transfer the data record to the scale
- Adjust the scales

Table 8- 6 Assignment of data record 10

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	10	-	-
Length	Data record length information	USHORT	2	r	44	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Reserve		USHORT	2	rw	1	1	6
50/60 Hz toggling (Page 68)	50/60 Hz toggling	USHORT	2	rw	0	0	1
Number of support points (Page 68)[1)]	Number of support points	USHORT	2	rw	0	0	8
Reserve		USHORT	2	rw	0	0	0
Load cell characteristic value (Page 68)[1)]	Characteristic value of the load cell (n) [mV/V], the mean value is used if there is more than one cell.	FLOAT	4	rw	2	> 0.1	10
Reserve		FLOAT	4	rw	0		
Rated load of a load cell (Page 68)[1)]	Rated load of a load cell	FLOAT	4	rw	60	-	-
Reserve	Reserve	FLOAT	4	rw	0	-	-
Reserve	Reserve	FLOAT	4	rw	0	-	-
Reserve	Reserve	SHORT	2	rw	0	-	-
Reserve	Reserve	USHORT	2	rw	0	-	-
Reserve	Reserve	FLOAT	4	rw	0	-	-

[1)] Parameter for calculation of calibration points with theoretical calibration

8.9.1 50/60 Hz toggling

To improve the suppression of faults caused by the supply network, you can specify the network frequency for signal filtering. The measuring rate is 100 Hz for the 50 Hz setting, and 120 Hz for the 60 Hz setting.

8.9.2 Number of support points

If no anchor points are used, the number of support points is equal to the number of load cells.

If anchor points are used in addition to load cells, the number of support points is equal to the total number of load cells and fixed support points.

8.9.3 Load cell characteristic value

The load cell characteristic value is required to correctly interpret the output voltage from the load cell. This specification is also necessary for determining load cell overload. The exact value can be entered if the measurement log for the load cell is available. The mean value can be entered if there is more than one load cell.

Example

Characteristic value = 2.018 mV/V

8.9.4 Rated load of a load cell

The rated load of a load cell is required for checking the maximum weighing range of the scales. The rated load is entered in the specified units of weight.

8.10 DR 13 RS485 parameters

The parameters which define the response of the RS485 interface are specified in data record DR 13. If the interface is not used, the default values can be retained.

Procedure

- Check the parameters and modify them as required
- Transfer the data record to the scale

Table 8- 7 Assignment of data record 13

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	13	-	-
Length	Data record length information	USHORT	2	r	24	-	-
Application	Information about which application the data record belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
RS485 protocol (Page 70)	0: No protocol 2: SIEBERT display	USHORT	2	rw	1	0	2
RS485 baud rate (Page 70)	0: 9 600 bps 1: 19 200 bps 2: 38 400 bps 3: 57 600 bps 4:115 000 bps	USHORT	2	rw	3	0	6
RS485 character parity (Page 70)	Character parity 0: Even 1: Odd	BIT	2	rw	0	0	1
Bit 1		BIT	0	rw	0	0	1
Bit 2		BIT	0	rw	0	0	1
Reserve (13 bits)	Reserve	BIT	0	rw	0	0	1
Reserve	Reserve	USHORT	2	rw	20	1	255
Decimal place for Siebert indicator (Page 70)	Decimal place for Siebert display	SHORT	2	rw	0	-	-
Reserve	Reserve	USHORT	2	rw	0	-	-
Reserve	Reserve	FLOAT	4	rw	0	-	-

8.10.1 RS485 protocol

This parameter defines the protocol for communication via the RS485 interface. The SIWATOOL program does not require any presettings.

Value	Protocol
0	No communication/protocol
2	SIEBERT display

8.10.2 RS485 baud rate

This parameter defines the baud rate for the RS485 interface.

Value	Baud rate
0	9 600 bps
1	19 200 bps
2	38 400 bps
3	57 600 bps
4	115 000 bps

8.10.3 RS485 character parity

This parameter defines the character parity for the RS485 interface.

Value	Character parity
0	Even
1	Odd

8.10.4 Decimal place for Siebert indicator

A fixed decimal place must be specified if a Siebert indicator is used. The following values are permitted: 0 ... 4

8.11 DR 14 SIMATIC interface parameters

The parameters which define the response of the SIMATIC interface are specified in data record DR 14. It is possible to define the process values to be output on the basis of the I/O area.

Procedure

- Check the parameters and modify them as required
- Transfer the data record to the scale

Table 8- 8 Assignment of data record 14

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	14	-	-
Length	Data record length information	USHORT	2	r	16	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Selection of process value 1, 2 (Page 72)	Code for the selection of the process variable to be updated	USHORT	2	rw	4	0	10
Selection of process value 1, 2 (Page 72)	Code for the selection of the process variable to be updated	USHORT	2	rw	6	0	10
Reserve 1	Reserve	SHORT	2	rw	0	0	-
Reserve 2	Reserve	USHORT	2	rw	0	0	-

8.11.1 Selection of process value 1, 2

The current process values can be read to the SIMATIC CPU with the DR 30 and DR 31 data records and the FB SIWA function block. The transfer of a larger data record is based on "acyclic services". It may take several SIMATIC CPU cycles and therefore have a negative effect on system performance.

The I/O interface of the SIWAREX module is the best option if a process value is to be rapidly transferred to the SIMATIC CPU as soon as it is created in the SIWAREX module. Data is applied cyclically by FB 41 and provided as a tag in the scales data block.

The relevant code from the table below must be entered to define the tag for output via the I/O interface.

Table 8- 9 Selection table for process value 1,2

Process value	Decimal code	From DR	Format
No process selected	0	-	-
Gross process	1	30	FLOAT
Net process	2	30	FLOAT
Tare process	3	30	FLOAT
Legal trade G/N weight	4	30	FLOAT
G/N weight_x10	5	30	FLOAT
Unfiltered digit value	9	31	LONG
Filtered digit value	10	31	LONG
Refresh counter	12	30	USHORT
Async. error bits (32 bits): Bits 0..15: operator error Bits 16..31: technology error	15	32	LONG

8.12 DR 15 manual tare specification

Data recorder DR 15 is used for an external specification of a tare weight.

Procedure

- Enter the tare weight
- Transfer the data record to the scale
- Enable the tare weight using command 1013

Table 8- 10 Assignment of data record 15

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	15	-	-
Length	Data record length information	USHORT	2	r	16	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Specification of tare weight (Page 73)	Tare specification memory (manual tare value)	FLOAT	4	rw	0	0	Depends on specification in DR 3
Reserve	Reserve	FLOAT	4	rw	0	0	-

8.12.1 Specification of tare weight

You can enter a tare weight. If a tare weight is to be applied, it must be enabled with the corresponding command. The tare weight must not exceed the maximum tare load specified in data record DR 3.

8.13 DR 30 current process values

Current states and process values in the scales can be monitored using process values and advanced process values from data record DR 31. Monitoring selected data during commissioning is extremely useful as it helps you to optimize parameters.

Procedure

- Read data record DR 30 cyclically or on a time-triggered basis
- Display/analyze the required tags

It is not always necessary to cyclically read data record DR 30. If the relevant process tags have already been selected in data record DR 14 (→ DR 14 SIMATIC interface parameters (Page 71)), they are immediately transferred via the I/O interface. In this case, these tags and all status bits and messages are accessible without data record communication.

Table 8- 11 Assignment of data record 30

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	30	-	-
Length	Data record length information	USHORT	2	r	44	-	-
Application	Information about which application the data record belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	255
1/4d zero	Set if gross is less than ± 0.25e	BIT	2	r	0	-	-
9e max	Set if the weight of the gross weighing range is exceeded by more than 9 display intervals (d)	BIT	0	r	0	-	-
Tared	Set if the tare memory is not equal to zero	BIT	0	r	0	-	-
Manual tare set (pT)	Set if the tare memory is assigned an external specified value	BIT	0	r	0	-	-
Reserve		BIT	0	r	0	-	-
Waiting for standstill	Set if module is waiting for standstill to execute command	BIT	0	r	0	-	-
Standstill	Set if standstill condition is met	BIT	0	r	0	-	-
Reserve		BIT	0	r	0	-	-
Empty	Set if "Empty" condition is met	BIT	0	r	0	-	-
Limit value 1	Limit value 1 has responded	BIT	0	r	0	-	-
Limit value 2	Limit value 2 has responded	BIT	0	r	0	-	-

Variable	Note	Type	L	Rw	Default	Min.	Max.
Reserve (5 bits)		BIT	0	r	0	-	-
DS32 error status change	Is set interface-specific with each DS32 change	BIT	2	r	0	-	-
Reserve (7 bits)		BIT	0	r	0	-	-
Calibrated	SIWAREX is calibrated	BIT	0	r	0	-	-
Service mode	Service mode is enabled	BIT	0	r	0	-	-
Reserve (3 bits)		BIT	0	r	0	-	-
SIMATIC connection inactive	Set if no connection to the SIMATIC exists on the part of the application	BIT	0	r	0	-	-
Startup	Startup has taken place (is deleted again after 5 seconds)	BIT	0	r	0	-	-
Fault status	Operating fault	BIT	0	r	0	-	-
Gross process weight (Page 76)	Gross weight (process value)	FLOAT	4	r	0	-	-
Net process weight (Page 76)	Net weight (process value)	FLOAT	4	r	0	-	-
Tare process weight (Page 76)	Tare weight (process value)	FLOAT	4	r	0	-	-
Gross / net weight (Page 76)	Gross or net weight	FLOAT	4	r	0	-	-
Gross / net weight with increased resolution (x 10) (Page 76)	Legal trade G/N weight with 10x resolution	FLOAT	4	r	0	-	-
Refresh counter for process values (Page 76)	Refresh counter incremented by 1 if weight values have been changed	USHORT	2	r	0	-	-
Operating time (hours)	Total operating time of the module (hours)	USHORT	2	r	0	-	-
Operating time (minutes)	Total operating time of the module (minutes)	USHORT	2	r	0	-	-
Reserve 3	Reserve	FLOAT	4	r	0	-	-

8.13.1 Gross process weight

The current gross weight. Values are rounded as specified in data record DR 3 with the "Decimal places for process values" (Page 49) parameter.

8.13.2 Net process weight

The current net weight. Values are rounded as specified in data record DR 3 with the "Decimal places for process values" (Page 49) parameter.

8.13.3 Tare process weight

The current tare weight. Values are rounded as specified in data record DR 3 with the "Decimal places for process values" (Page 49) parameter.

8.13.4 Gross / net weight

The current weight for the main display. The resolution corresponds to the scale interval (Page 49) specified in data record DR 3.

8.13.5 Gross / net weight with increased resolution (x 10)

The current weight for the main display in higher resolution. The resolution corresponds to the scale interval specified in data record DR 3 x 10.

8.13.6 Tare weight

The current tare weight (scale interval from DR 3). The resolution corresponds to the scale interval specified in data record DR 3.

8.13.7 Refresh counter for process values

Measured values are calculated every 10 ms in the SIWAREX module. A counter is incremented by 1 each time. Once the counter reaches the value 65536, it starts again from zero. The counter can be used as a time stamp for data record DR 30.

8.14 DR 31 advanced current process values

Current states and process values in the scales can be monitored using advanced process values and process values (DR 30). This data is not required for standard operation of the scales.

Monitoring selected data during trial operation is extremely useful as it helps you to optimize parameters.

Procedure

- Read data record DR 31
- Display/analyze the required tags

Table 8- 12 Assignment of data record 31

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	31	-	-
Length	Data record length information	USHORT	2	r	24	-	-
Application	Information about which application the data record belongs to	USHORT	2	r	201	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
Unfiltered digit value (Page 77)	Unfiltered digit value of AD converters / digital load cells	LONG	4	r	0	-	-
Filtered digit value (Page 77)	Filtered digit value of AD converters / digital load cells after dig. filter 1	LONG	4	r	0	-	-
Reserve 1		SHORT	2	r	0	-100	100
Refresh counter for process values (Page 78)	Refresh counter incremented by 1 if weight values have been changed	USHORT	2	r	0	-	-
Reserve 2		FLOAT	4	r	0	-	-

8.14.1 Unfiltered digit value

The unfiltered digit value is the internal measured value immediately before filtering.

8.14.2 Filtered digit value

The filtered digit value is the internal measured value immediately after filtering.

8.14.3 Refresh counter for process values

Measured values are calculated every 10 ms in the SIWAREX module. A counter is incremented by 1 each time. Once the counter reaches the value 65536, it starts again from zero. The counter can be used as a time stamp for data record DR 31.

8.15 DR 32 Message display

Data record 32 indicates all pending message bits. The bit "Error status changed" is present in the status bits of the DR30. If this bit is set, the message area of the DR32 has been changed.

The DR32 indicates which message has been newly added or deleted. The data record is automatically read by the SIMATIC FB in the event of an error. Following successful reading, the status bit is reset in DR30.

Table 8- 13 Assignment of data record 32

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	32	-	-
Length	Data record length information	USHORT	2	r	26	-	-
Application	Information about which application the data record belongs to	USHORT	2	r	101	-	-
Version identifier	Information on the current data record version	USHORT	2	r	1	1	65 635
1000	Operator error	BIT	2	r	0	0	1
Reserve	-	BIT		r	0	0	1
1104	Undervoltage	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
1105	Overload	BIT		r	0	0	1
1106	Underload	BIT		r	0	0	1
1002	RAM error	BIT		r	0	0	1
1102	ADC error	BIT		r	0	0	1
1005	Hardware interrupt lost	BIT		r	0	0	1
1003	Checksum error data	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
1004	Checksum error program	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
1001	RESET / restart following error	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
2000	Technology error	BIT	2	r	0	0	1
2001	Taring or zeroing timeout	BIT		r	0	0	1
Reserve (14 bits)	-	BIT		r	0	0	1
5000	Data or operating error exists	BIT	2	r	0	0	1
5001	Command code or data record unknown	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
5003	Leaving calibration mode not possible	BIT		r	0	0	1
5004	Command or data transmission only available in service mode	BIT		r	0	0	1

Variable	Note	Type	L	Rw	Default	Min.	Max.
5005	Command or data transmission not possible because service mode is active	BIT		r	0	0	1
5006	Command or data transmission not possible because BUSY	BIT		r	0	0	1
5007	Command or data transmission not possible because module is faulty or ODIS is active	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
5101	Command is not permissible in this operating state	BIT		r	0	0	1
5102	Command not possible because not at standstill	BIT		r	0	0	1
5104	Command not possible because range is exceeded	BIT		r	0	0	1
5105	Load cell parameter not plausible	BIT		r	0	0	1
Reserve		BIT		r	0	0	1
5107	Shifting characteristic not possible	BIT		r	0	0	1
7000	Permitted number range violated	BIT	2	r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
7002	Specifications of string lengths not plausible	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
7006	Command only possible in test field	BIT		r	0	0	1
7007	The calibration weights or calibration digits are not plausible	BIT		r	0	0	1
7008	Zeroing/zero setting or tare parameter not plausible	BIT		r	0	0	1
7009	Standstill range / standstill wait time not plausible	BIT		r	0	0	1
7010	Scale interval / rounding not plausible	BIT		r	0	0	1
7011	Filter parameter not plausible	BIT		r	0	0	1
7014	Time input not plausible	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
7019	RS485 parameter error	BIT		r	0	0	1
Reserve	-	USHORT	2	r	0	-	-
Reserve	-	USHORT	2	r	0	-	-
Reserve	-	USHORT	2	r	0	-	-

8.15.1 Error bytes 0 to 7

In these areas, messages are represented by bits. A set bit means that the corresponding message is activated. The message bit is set following a data or operator error and automatically reset approximately 3 seconds later.
Message bits are analyzed by the operator panel message system.

The data/operator errors (error numbers 1xxx) are present in the first two bytes. These are followed by two bytes with technology errors (error numbers 2xxx) and six bytes with data and operator errors (error numbers 5xxx and 7xxx).

8.16 DR 34 ASCII main display value

The ASCII weight corresponds to the value on the main display of the scales and can be used for a supplementary display as well as the legal trade main display.

Table 8- 14 Assignment of data record 34

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	USHORT	2	r	34	-	-
Length	Data record length information	USHORT	2	r	26	-	-
Application	Information about which application the DR belongs to	USHORT	2	r	201	-	-
Version identi-fier	Information on the current data record version	USHORT	2	r	1	1	65 635
ASCII display string header	Maximum length and actual length of string	UBYTE[2]	2	r	16,2	-	-
Content of main display as ACII string (Page 83)	For display of the weight value and other current values (see below)	CHAR[16]	16	r	" "	-	-

8.16.1 Content of main display as ACII string

The following values can be displayed:

Variable	Command
Switch on increased resolution	701
Current tare weight	705
Gross/net display	710
Net process value	714
Gross process value	715
Serial number	871
Firmware version	875

Below are some display examples. Commands are used to toggle the display values.

The values to be displayed are suppressed if a fault is present.

	Value designation		Blank	Display value										Unit of weight (from DR 3)
	N: Net, B/G: Gross, T: Tare, pT: Preset tare, S: Sum, ...													
Weight (Tare ≠ 0)	N	•	•	•	•	•	2	2	0	,	5	0		•kg•
Neg. weight (Tare = 0)	B	•	•	•	•	•	•	-	0	,	0	3		•t••
Weight in increased resolution	•	•	•	•	•	•	1	0	,	0	0	3		HIGH
Operator error	B	•	•	•	•	•	•	l	r	r	o	r		****
Tare display activated (pt)	p	T	•	•	•	•	•	5	0	,	5	0		•kg•
Tare display activated	T	•	•	•	•	•	•	5	0	,	5	0		•kg•

Messages

9

9.1 Message types

The messages in the electronic weighing system described here are divided into three types.

System status messages

System status messages can be generated spontaneously at any time by an unexpected event. They include internal and external hardware problems which can occur spontaneously during weighing.

Data and operating errors

The data and operating errors are always a response to a command due to a plausibility check.

These are data errors if a plausibility error has been detected in a data packet which was sent to the module and receipt of the packet has been rejected by the module.

These are operating errors if the module cannot execute the sent command in its current operating state.

Technology errors

Technology errors occur spontaneously due to the process flow of a weighing.

Status bits, on the other hand, are not messages. The status displays describe the status of the scale during normal operation and can be monitored or evaluated at any time.

9.2 Message paths

You can read out the messages using different paths. You define the path for forwarding and processing of messages during configuration.

The messages are processed for two basic purposes:

- For display or recording on an operator panel for the operator
- For linking in the control software to control specific reactions in the process.

The following message paths are possible:

- Output of the message buffer to the SIWATOOL program (takes place automatically)
- Output by means of function block as bit field in Scale data block
- Certain operating errors can be transmitted as diagnostic interrupts to the SIMATIC CPU and evaluated by OB82

9.3 Evaluating messages with the help of SIWATOOL

The electronic weighing system has a message buffer that can hold up to 10 entries. If the number of messages in the message buffer exceeds 10, the oldest entry is overwritten. The message buffer can be read out at any time with the help of SIWATOOL (menu item "Read out all data records") and saved together with the scale parameters. This facilitates the detection, analysis and correction of errors in the system.

9.4 Detecting messages with the help of FB SIWA

All messages of the SIWAREX module can be completely detected and processed in the controller with the help of the SIWAREX WP321 function block. The messages can be evaluated directly in a signaling system by means of a bit signaling area in the scale data block. The message texts are stored in the signaling system. The message text is output when a bit becomes "1".

9.5 Message list

The message list is an overview of all messages that the SIWAREX module can generate. A message can be quickly identified by the message code (number).

9.5.1 System status message list

Operator error (code 1000 to 1999)	Error code	Description and remedy
1000 operating error exists	1000	Group message, at least one operating error exists.
1001 Watchdog	1001	Watchdog, error is displayed for at least 10 seconds. A serious error has occurred in the function of SIWAREX, e.g. program error, severe electromagnetic influence on device, etc. Contact the SIWAREX Support if the error occurs multiple times.
1002 RAM error	1002	RAM error. An error has occurred in the memory; the memory content is no longer correct. The module must be switched off. If the error occurs again, SIWAREX is defective.
1003 Checksum incorrect parameter	1003	Checksum error at parameter. Critical error because the parameters are no longer safe.
1004 Checksum incorrect program	1004	Checksum error program code. Critical error because the program is no longer safe.
1102 ADU error	1102	AD converter error when reading in the measured value. If the error occurs again, make sure that the EMC recommendations are observed (chapter EMC-compliant setup (Page 20)).
1104 Undervoltage	1104	Undervoltage at sensor cables
1105 Overload	1105	Overload of scale (ca. 110%)
1106 Underload	1106	Underload of scale (ca. -10%)

9.5.2 Technology error message list

Technology error (code 2000 to 4999)	Error code	Description and remedy
2000 Technology error exists	2000	Group message, at least one technology error exists
2001 Taring/zeroing timeout	2001	Taring of scale or set to zero is not possible because a standstill was not reached during the standstill time. The command was discarded.

9.5.3 Data and operating errors message list

Data and operating errors (code 5000 to 8999)	Error code	Description and remedy
5000 Data and operating error exists	5000	Group error, a bit is set in the data and operating error bits
5001 Command code or data record unknown	5001	Command code or data record is not known with current application
5003 Cannot exit service mode	5003	Cannot exit service mode; calibration incomplete
5004 Command or data transmission only available in service mode	5004	Activation of service mode is required to execute command or transmit data
5005 Command or data transmission not possible because service mode is active	5005	Command can currently not be executed because service mode is active
5006 Command or data transmission not possible because of BUSY	5006	Command can currently not be executed because module is BUSY (data record or command transmission already active, …)
5007 Command or data transmission not possible because module is faulty or SIMATIC CPU stop	5007	Command can currently not be executed because of a problem or SIMATIC CPU stop
5101 Command is not permissible in this operating state	5101	Command is not permissible in the current operating state
5102 Command not possible because there is no standstill	5102	Scale command (set to zero, tare, log, …) cannot be executed because standstill is missing.
5104 Command not possible because range is exceeded	5104	Command (e.g. set to zero, tare, calibrate command) cannot be executed because the permitted range has been exceeded.
5105 Load cell parameters not plausible	5105	Load cell parameters in data record DR 10(a) or data record DR 11(d) not plausible (number, supporting points, load specifications, etc.).
5107 Characteristic cannot be moved	5107	Characteristic cannot be moved due to possibility of range violation.
7000 Permitted number range violated	7000	The permitted number range, such as for weight values, was violated.
7002 Specifications of string lengths not plausible	7002	The string header in a specified string variable is not plausible.
7007 The calibration weights or calibration digits are not plausible	7007	Specifications for calibration weights or digits in data record DR 3 are incorrect (minimum distance, reversal of incline).
7008 Zeroing or tare parameter not plausible	7008	The specifications (data record DR 3) or tare specifications (data record DR 15) are not plausible.
7009 Standstill range / standstill wait time	7009	Standstill range or standstill wait time are not plausible.
7010 Scale interval / rounding	7010	Scale interval or selection for rounding to decimal places is not plausible.
7011 Filter parameters	7011	Specification of filter parameters is not plausible.

9.5.4 Messages by LEDs on the module

The LEDs on the front of the SIWAREX module signal the following status and error messages.

Item	Color	Labeling	Function
Line 1			
H1	red	**DIAG**	System fault
H2	Green		Ready
H11	yellow		Limit 1 responded
H12	yellow		Service mode
H13	yellow		Limit 2 responded
H14			Not used
H15	yellow	**{E}**	Empty message
H16			Not used
H17	Green		Standstill triggered
H18			Not used
H19	Green	**0**	¼ d zero status
H20			Not used
H21		**Max**	Weighing range exceeded
H22			Not used
H23	Green	**LC**	Load cell(s) ready for operation (LED off = load cells faulty)
H24			Not used
H25	yellow	**Rx/Tx**	EIA-RS485 communication active
H26			Not used
H40	Green	**PRW**	Status of local 24 V supply

Command lists

10

The commands for the electronic weighing system described here can be transmitted by several interfaces:

- by the Operator Panel via the controller to the SIWAREX module
- by SIWATOOL directly to the SIWAREX module

A data or command error is signaled if a command cannot be executed or if the sent data record is rejected.

Command code	Command	Description	Service
1... 99	**Service commands**		
1	Service mode On	Turn on service mode	x
2	Service mode Off	Turn off service mode	x
11	Load factory setting	The command resets the SIWAREX to the "Ex factory" status: - All parameters and saved data are loaded with the default values. - All message buffers are reset.	x
60	Calibration point 0 valid	Calibration point 0 valid / save values for calibration point 0.	x
61	Calibration point 1 valid	Calibration point 1 valid / save values for calibration point 1.	x
62	Calibration point 2 valid	Calibration point 2 valid / save values for calibration point 2.	x
81	Characteristic shift	Move calibration characteristic. The command defines the current weight of the scale as the new zero point (0 kg) and shifts the complete characteristic without changing the gradient. The command can be used, for example, in order to compensate parts used for mounting calibration weights on the scale at the end of the calibration.	x
82	Perform automatic calibration	Calculation of scale characteristic using the load cell parameters from data record 10. The calculated characteristic is entered directly in data records 3 and 4 and thus immediately enabled following execution of the command. The scale must be empty when the command is executed.	x

Command code	Command	Description	Service
83	Perform calibration check	The command calculates the theoretical digital values in relation to the calibration weights using the load cell parameters from data record 10 and the adjustment weights 0, 1 and 2 from data record 3. These theoretical digits are output in data record 4. The function can be used to carry out a plausibility check for the calibration digits in data record 3 which were determined when calibrated using standard weights.	
700 … 899	**HMI display switching**		
701	Increased resolution	Activate increased resolution on main display (x 10)	x
705	Display current tare weight	Display current tare weight on main display	x
710	Activate standard display	Activate standard display gross/net	x
711	G/N display	Display gross/net weight on main display	x
712	N display		
713	G display		
714	N process value	Display net process weight on main display	x
715	B process value	Display gross process weight on main display	x
871	Show serial number	The serial number of the module is displayed	
875	Display FW version	Show firmware version in current display	x
1000 …	**Basic functions for weighing commands**		
1001	Set to zero	Set to zero	x
1011	Tare	Tare	x
1012	Delete tare	Delete current tare weight	x
1013	Tare specification valid	Activate specification of tare weight	x
1016	S7 tare specification valid	Activate specification of S7 tare weight	

The following commands can be triggered in the scale data block SCALE_DB in the area CMD1 to CMD3:

Table 10- 1 Command groups of the SIWAREX WP321

Command group	Description
1 ... 99	Commands are forwarded from the FB_SIWA via data record DR 2 to the module (scale commands, weighing commands, log commands). The meaning of the commands corresponds to the command list.
2000 + X	Reading of a data record, X corresponds to the data record number. Example: Data record 3 transmitted by SIWAREX module to the SIMATIC CPU → 2000 + 3 = command code 2003
4000 + X	Writing of a data record, X corresponds to the data record number. Example: Data record 3 transmitted by SIMATIC CPU to the SIWAREX module → 4000 + 3 = command code 4003
7001	Read all data records from SIWAREX into CPU (only for SIMATIC FB)
7002	Write data records 3, 4, 5, 6, 10, 13, 14 and 15 from CPU into SIWAREX (module must be in service mode, only for SIMATIC FB)

Additional information on transmission of commands from the control program by means of the SIMATIC interface is available in chapter Communication in SIMATIC S7-300/1200/1500 (Page 95).

Communication in SIMATIC S7-300/1200/1500 11

11.1 General information

A SIWAREX WP321 occupies 16 bytes each in the I/O areas of the CPU. Communication between SIWAREX and SIMATIC CPU is supported by the FB.

Table 11- 1 Memory requirements of the function block

	FB 1, WP321DR
Read weight and status	YES
Send commands	YES
Send parameters	YES
Main memory requirements in CPU	11 600 byte + n x 1 232 byte
Load memory requirements in CPU	138 788 byte + n x 28 470 byte

n = number of WP321 modules

The function block described above including HMI configuring can be downloaded as a predefined example project ("Ready-for-use") from the Siemens Customer Support.

11.2 Structure of the program "Ready for use"

There is one program for Step 7 Classic and another for TIA Portal. The two programs each consist of two parts:

- STEP 7 software for the SIMATIC CPU
- WinCC project (integrated in SIMATIC Manager)

All messages are saved as bit information. The message system can thus directly access the bit fields and display the message texts.

11.3 Advantages of task sharing

The weight is calculated in the SIWAREX module like in a separate electronic weighing system. However, thanks to integration in SIMATIC, it is possible to directly transfer the weight value to the PLC program. This results in sensible sharing of tasks: the weighing functions are performed in the SIWAREX module, while interlocking and signal linking are performed in the PLC.

SIWAREX "Ready for use" takes over the task of a standardized program in the SIMATIC S7.

An FB handle several tasks:

- It controls communication between the SIMATIC CPU and the SIWAREX module
- It transfers commands and adjustment values to the SIWAREX module according to the process trend
- It prepares the scale data for visualization

11.4 Hardware configuration of the electronic weighing system

The SIWAREX WP321 module can be found in the directory PLC/SIMATIC S7-1200/technology modules/weighing modules of the hardware catalog.

The following basic properties of the module are defined during hardware configuration in the TIA Portal. Note that the SIWAREX WP321 module is always completely in the process image of the CPU.

- Installation location of the module
- Address in I/O area
- Diagnostics interrupts
- Hardware interrupts
- I&M (Identification & Maintenance) data

The electronic weighing system occupies 16 bytes in the input/output area.

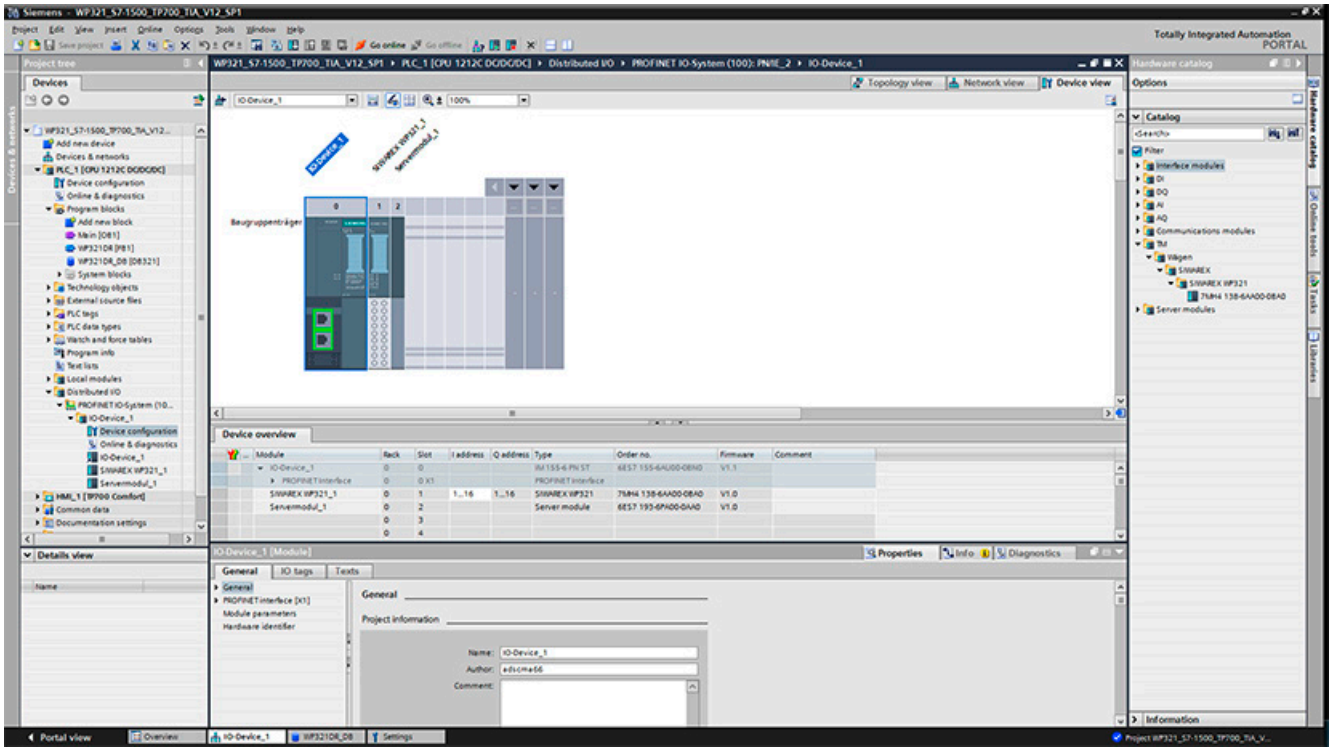


Figure 11-1 Hardware configuration in the TIA Portal

TIA Portal automatically assigns a separate I/O start address and a HW ID for every SIWAREX present in the project. These two parameters are relevant for calling the function block, and can be obtained from the properties of the respective module.

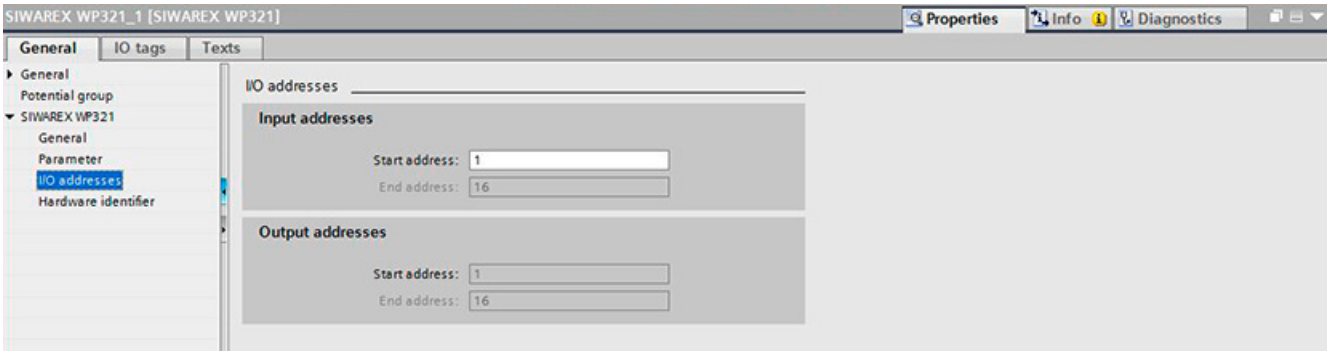


Figure 11-2 Start address of module in TIA Portal

Diagnostics interrupts can be optionally enabled or deactivated in the module properties. The configuration scope for diagnostics and hardware interrupts depends on the SIMATIC CPU used (S7-300, S7-400, S7-1200 or S7-1500) → Diagnostics interrupts (Page 105) and Hardware interrupts (Page 105)

Figure 11-3 Configuration of interrupts in TIA Portal

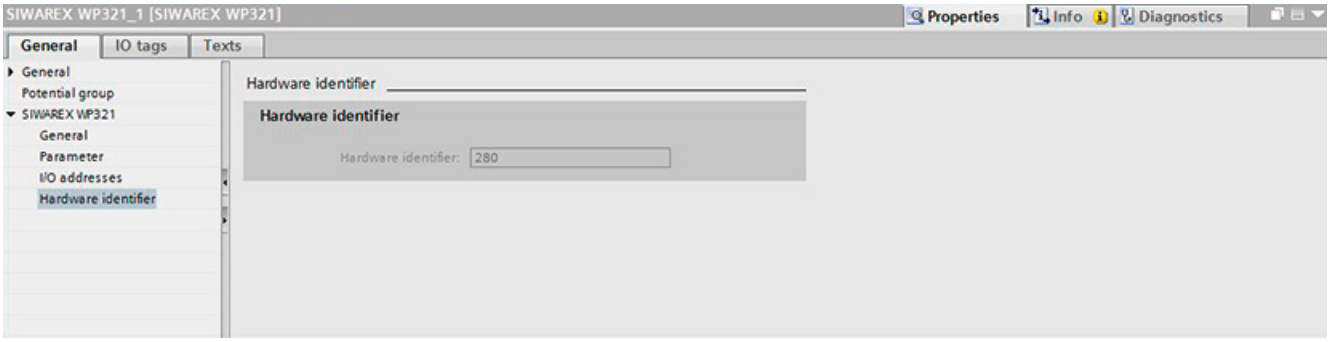


Figure 11-4 HW ID of module in TIA Portal

11.5 Calling of function block

This description is based on use of the WP321DR block with data record communication and the following data:

- **Start address** SIWAREX WP321: 1 (see → Hardware configuration of the electronic weighing system (Page 97))
- **HW ID** SIWAREX WP321: 280 (see → Hardware configuration of the electronic weighing system (Page 97))
- **Instance data block number** of SIWAREX WP321 function block: DB321

The function block can be integrated at the desired position in the user program using drag and drop. Calling of the FB must be carried out cyclically in the control program.

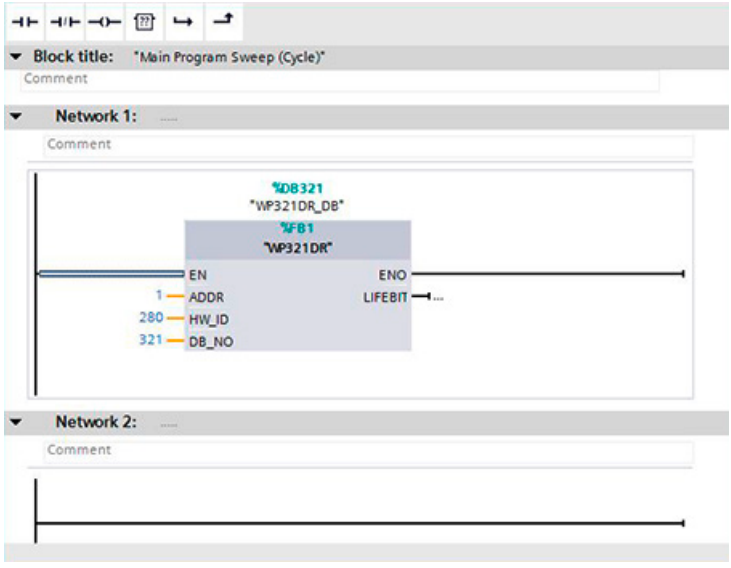


Figure 11-5 Calling of WP321DR block in user program

Function block parameter	Description
ADDR	Start address WP321 (see → Hardware configuration of the electronic weighing system (Page 97))
HW_ID	HW ID WP321 (see → Hardware configuration of the electronic weighing system (Page 97))
DB_NO	Number of FB-internal instance DB
LIFEBIT	Optional status bit can be used to monitor communication

The generated instance DB (WP321 in this case) contains all data records of the WP321 as well as all parameters required to exchange data between CPU and weighing module.

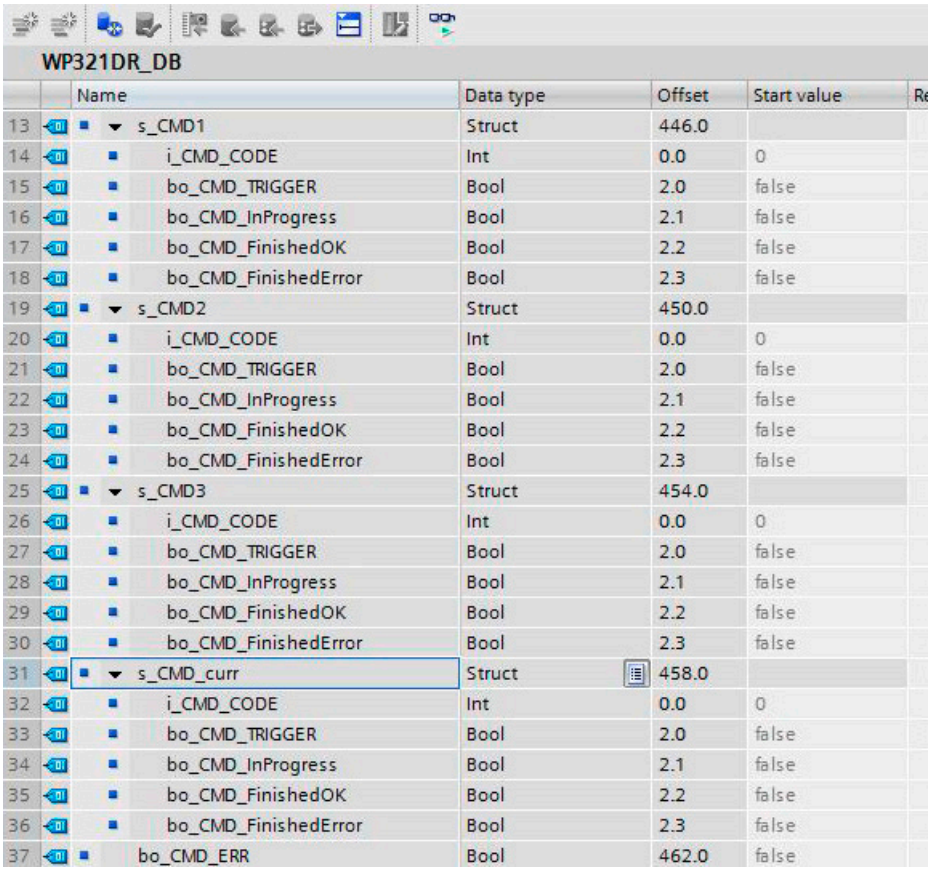
A separate FB call must be made in the user program for each weighing module. In this manner, each scale receives its own instance DB which provides the respective scale parameters. The input and output parameters of the FB must be matched to the respective WP321 for each call.

11.6 Working with the function block

Data records in SIWAREX weighing modules

All parameters in SIWAREX weighing modules are structured in data records. These data records must be considered as connected packages and can only be respectively read into the CPU or written to the SIWAREX as complete packages. Reading or writing of a single parameter within a data record is not possible. You can find a description of all data records and their parameters in chapter → Scale parameters and functions (Page 45).

Reading and writing of data records is carried out using special command codes which can be sent with three command mailboxes handled according to priority within the instance DB:



WP321DR_DB

	Name	Data type	Offset	Start value
13	s_CMD1	Struct	446.0	
14	i_CMD_CODE	Int	0.0	0
15	bo_CMD_TRIGGER	Bool	2.0	false
16	bo_CMD_InProgress	Bool	2.1	false
17	bo_CMD_FinishedOK	Bool	2.2	false
18	bo_CMD_FinishedError	Bool	2.3	false
19	s_CMD2	Struct	450.0	
20	i_CMD_CODE	Int	0.0	0
21	bo_CMD_TRIGGER	Bool	2.0	false
22	bo_CMD_InProgress	Bool	2.1	false
23	bo_CMD_FinishedOK	Bool	2.2	false
24	bo_CMD_FinishedError	Bool	2.3	false
25	s_CMD3	Struct	454.0	
26	i_CMD_CODE	Int	0.0	0
27	bo_CMD_TRIGGER	Bool	2.0	false
28	bo_CMD_InProgress	Bool	2.1	false
29	bo_CMD_FinishedOK	Bool	2.2	false
30	bo_CMD_FinishedError	Bool	2.3	false
31	s_CMD_curr	Struct	458.0	
32	i_CMD_CODE	Int	0.0	0
33	bo_CMD_TRIGGER	Bool	2.0	false
34	bo_CMD_InProgress	Bool	2.1	false
35	bo_CMD_FinishedOK	Bool	2.2	false
36	bo_CMD_FinishedError	Bool	2.3	false
37	bo_CMD_ERR	Bool	462.0	false

Figure 11-6 CMD command mailboxes

As shown in the graphics, a command mailbox always consists of a command code (Int) and four bits (Bool). A command is set by entering the desired command code in the "i_CMD_CODE" parameter and setting the respective command trigger "bo_CMD_TRIGGER". The status bits "bo_CMD_InProgress" (command being processed), "bo_CMD_FinishedOk" (command finished without errors) and "bo_CMD_FinishedError" (command rejected or finished with error) can be evaluated in the user program.

In addition, the three command mailboxes are managed and processed according to priority. CMD1 has the highest priority, CMD3 has the lowest priority. If all three command mailboxes are triggered simultaneously by the user program, for example, the function block initially

processes CMD1, then CMD2, and finally CMD3. Cyclic triggering of command mailbox 3 is also interrupted by intermediate sending of a command in mailbox 2 or 1 for processing of the respective command.

Note

Cyclic triggering of the CMD1 command mailbox makes it impossible to send commands in mailbox 2 or 3.

A summary of all existing command codes can be found in chapter →Command lists (Page 91).

The following equation for generation of a corresponding command code applies to the reading of data records from the SIWAREX to the data block:

Command code = 2000 + X (X = desired data record number)

The following equation for generation of a corresponding command code applies to the writing of data records from the data block to the SIWAREX:

Command code = 4000 + X (X = desired data record number)

Example

The following example clarifies the actions with command mailboxes and data records:

"Calibration weight" is to be set to a value of 60.5 by the CPU. Since "Calibration weight" is a parameter of data record 3 (see chapter → Scale parameters and functions (Page 45)), service mode must first be activated. This is possible using command code "1" (see chapter → Command lists (Page 91)).

The variable "i_CMD_CODE" must therefore be assigned the value "1" and the associated "bo_CMD_TRIGGER" set to TRUE. Subsequently, the module is directly in service mode (DIAG LED flashes green):

i_CMD_CODE = 1

bo_CMD_TRIGGER = TRUE

Since only complete data records can be read or written, it is recommendable to now read data record 3 into the CPU. This is carried out using command code 2003 (see chapter → Command lists (Page 91)):

i_CMD_CODE = 2003

bo_CMD_TRIGGER = TRUE

All current data from data record 3 are now present in the data block. The calibration weight is then set as desired to a value of 60.5:

CALIBRATION_WEIGHT = 60.5

The modified data record 3 must now be written into the SIWAREX again. This is carried out using command code 4003 (see chapter → Command lists (Page 91)):

i_CMD_CODE = 4003

bo_CMD_TRIGGER = TRUE

The new calibration weight is now present in the SIWAREX and can be used. Service mode for the module should subsequently be switched off again using command "2".

This procedure for reading and writing data records or parameters is identical for all data records.

11.7 I/O interface of function block

The following scale parameters are available cyclically in the data block in the controller without special reading of data records or can be sent to the scale without sending of data records:

Table 11- 2 I/O data of the function block

Parameter (read)	Meaning
SCALE_STATUS_1 (UINT)	Bytes 0 & 1 of the scale status (→ DR 30 current process values (Page 74))
SCALE_STATUS_2 (UINT)	Bytes 2 & 3 of the scale status (→ DR 30 current process values (Page 74))
Process value 1	Selection → Selection of process value 1, 2 (Page 72)
Process value 2	Selection → Selection of process value 1, 2 (Page 72)
Parameter (write)	
S7 tare specification	Specified value for tare weight. The value is applied by using the "Tare specification valid (1016)" command.

11.8 Error codes of function block

Table 11- 3 Statuses/errors when working with the function block

Error bit	Error description
bo_AppIIDError	Address module does not match the function block
bo_AppIIDDRError	Data record does not match the inserted module
bo_SFBError	Runtime error during transmission of data record
bo_RdPerError	Reading of I/O data failed
bo_LifeBitError	SIWAREX no longer responds
bo_StartUpError	Command was sent although StartUp is still TRUE
bo_WrongFW	Data record version does not match the firmware
bo_InvalidCMD	An invalid command code was sent
bo_DataOperationError	Synchronous data operation error has occurred
bo_StartUp	Startup synchronization of module running

Note

If execution of the function block is faulty, the variables shown do not correspond to the actual status in the module.

11.9 Diagnostics messages

The DIAG LED flashes red when a diagnostics message is present. Diagnostics messages are displayed as plain text in STEP 7 (TIA Portal) by means of online and diagnostics views. You can evaluate the error codes by means of the user program.

The following diagnostics messages can be signaled:

Table 11- 4 Diagnostics messages

Diagnostics message	Error code	Meaning	Remedy
Fault	9H	Internal module fault, defective	Replace technology module
Load voltage missing	11H	L+ for technology module missing	Check supply voltage on base unit
Hardware interrupt lost	16H	Technology module cannot send an interrupt because the previous interrupt has not yet been processed	Change interrupt processing in the CPU, change technology module parameter settings.
Module temporarily not available	1FH	Normal operation of module not possible because, for example, a FW update is being carried out.	Wait until the module assumes normal operation.
Undervoltage	02H	Undervoltage on sense lines	Voltage drop up to the load cell is too large. Find out why.
Overload	07H	Upper limit for sensor voltage exceeded	Eliminate scale overload
Underload	08H	Lower limit for sensor voltage fallen below	Check mechanical system of scale, check sensor wiring.
Checksum error in parameter	0DH	The checksum for the integrity of the parameters is incorrect	Download factory setting of the parameters.
Checksum error program	0EH	The checksum for the integrity of the parameters is incorrect	Download firmware again, replace module

11.10 Diagnostics interrupts

The enable for triggering of diagnostics interrupts is possible for all SIMATIC CPUs (S7-300, S7-400, S7-1200, S7-1500) and is assigned in the device configuration.

The diagnostics interrupts can be evaluated to detect fault events in the SIMATIC CPU.

Fault events (operating faults) are signaled by a diagnostics interrupt to the S7 CPU if the diagnostics interrupt is enabled (in the HW Config). You can evaluate the diagnostics messages using the local data of OB82. Contrary to the S7-1200 and S7-1500, the CPUs of the S7-300 and S7-400 systems enter the stop status following a diagnostics interrupt if the OB82 is not loaded.

Detailed information can be obtained using the "RALARM" instruction (read interrupt status).

11.11 Hardware interrupts

The enable for triggering of hardware interrupts is assigned in the device configuration.

If an event occurs that is to trigger a hardware interrupt and the same previous event has not yet been processed, no further hardware interrupt is triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostics interrupt, depending on the parameterization.

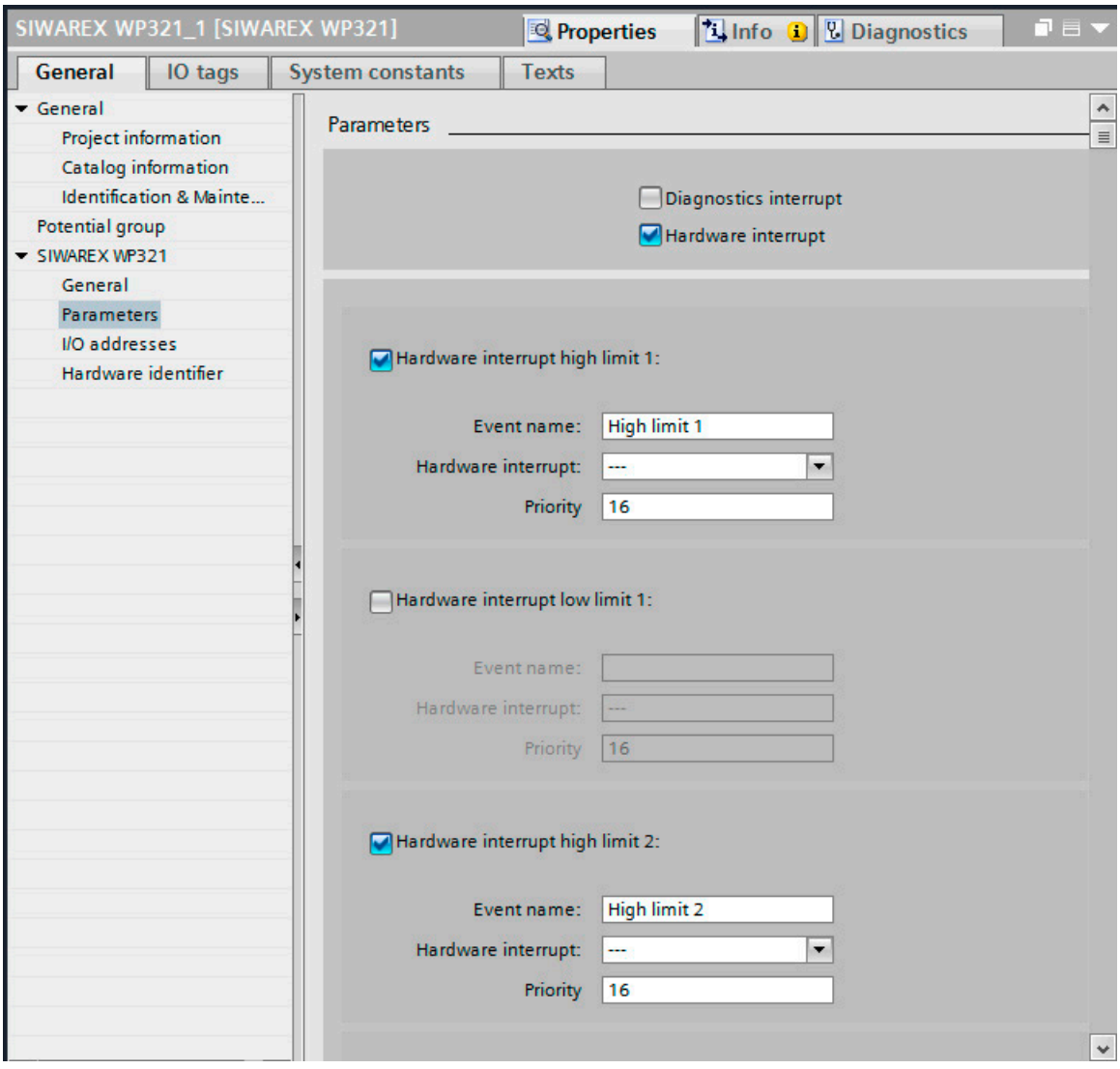


Figure 11-7 Configuration of hardware interrupts for S7-1500

You can use the hardware interrupts to detect changes in the status of limits. The change in status is entered in the interrupt OB as EventType:

PRAL #1 Limit 1 OFF → ON

PRAL #2 Limit 1 ON → OFF

PRAL #3 Limit 2 OFF → ON

PRAL #4 Limit 2 ON → OFF

Technical data

12

12.1 Technical specifications

24 V power supply

Note

A protective extra-low voltage (to EN 60204-1) is to be ensured by system power supply.

Rated voltage	24 V DC
Static low / high limits	19.2 V DC / 28.8 V DC
Dynamic low / high limits	18.5 V DC / 30.2 V DC
Non-periodic overvoltages	35 V DC for 500 ms with a recovery time of 50 s
Maximum current consumption	100 mA with 24 V DC
Typical power consumption of the module	2 W

Power supply from SIMATIC S7 backplane bus

Power consumption from SIMATIC S7 backplane bus	Typically 20 mA

Analog load cell interface connection

Error limit to DIN1319-1 at 20 °C +10 K	≤ 0.05% v.E.[1)]
Accuracy according to OIML R76 (no approval for measurements requiring verification)	
• Class	III and IV
• Resolution (d=e)	3000d
• Error percentage pi	0.4
• Step voltage	0.5 µV/e
Accuracy delivery state[2)]	typ. 0.1% v.E.
Sampling rate	100 Hz/120 Hz (depending on parameterization)
Input signal resolution	± 2 000 000 (for cells with 4 mV/V)
Measuring range	± 4 mV/V
Common mode voltage range	0.25 to 4.75 V
DMS supply[3)]	4.85 V DC ±2 %
Short-circuit and overload protection	Yes
Connection	6-wire
Sensor voltage monitoring	≤ 4 V
min. DMS input resistance	
• without Ex-i interface SIWAREX IS	40 Ω
• with Ex-i interface SIWAREX IS	50 Ω
min. DMS output resistance	4 100 Ω
Temperature coefficient range	≤ ± 5 ppm/K v. E.
Temperature coefficient zero point	≤ ± 0.1 µV/K
Linearity error	≤ 0.01 %
Measured value filtering	Low pass
Electrical isolation	500 V AC
50 Hz / 60 Hz noise suppression CMRR	> 80 dB
Input resistance	
• Signal cable	typ. $4*10^6$ Ω
• Sensor cable	typ. $2*10^6$ Ω

1) Relative accuracy! (Absolute accuracy is only reached by calibration on-site with calibration standard)

2) Accuracy for module replacement or theoretical calibration decisive

3) Value valid at sensor; voltage drops on cables are compensated up to 5 V

Cable length

Maximum cable length	500 m with SIWAREX cable, → Accessories (Page 115).

RS485 interface

Standard	EIA-485
Baud rate	up to 115 kbps*
Data bits	7 or 8
Parity	even | odd | none
Stop bits	1 or 2
Terminating resistors (can be activated)	390 Ω / 220 Ω / 390 Ω
Electrical isolation	500 V AC
Transfer protocol	ASCII for remote display from Siebert and Modbus RTU for HMI or third-party systems.
Cable length	≤ 115 kbps max. 1 000 m (fieldbus cable 2-wire, shielded, e.g. 6XV1830-0EH10)

Dimensions and weights

Dimensions	
• Width	15 mm
• Weight, approx.	31 g

Mechanical requirements and data

Testing	Standards	Test values
Vibrational load during operation	IEC 61131-2 IEC 60068-2-6 Test Fc	• 5 to 8.4 Hz: 3.5 mm out. • 8.4 to 150 Hz: 9.8 m/s² (=1G)
Shock load during operation	IEC 61131-2 IEC 60068-2-27 Test Ea	• 150 m/s² (approx. 15 g), half sine
Vibration load during transport	IEC 60068-2-6 Test Fc	• 5 to 8.4 Hz: 3.5 mm out. • 8.4 Hz to 500 Hz: 9.8 m/s²
Shock load during transport	IEC 60068-2-27: Test Ea	• 250 m/s² (25G), half sine
Free fall	IEC 61131-2 IEC 60068-2-31: Test Ec, procedure 1	• In product packaging: 300 mm drop height • In shipping package: 1.0 m drop height

12.2 Electrical, EMC and climatic requirements

Electrical protection and safety requirements

Met requirement	Standards	Comments
Safety regulations	IEC 61010-1 IEC 61131-2; UL 508 CSA C22.2 No.142 IEC 61010-2-201 FM3611	
Protection class	IEC 61140	Module is operated with protective extra-low voltage. The protective conductor connection serves only a functional earth to dissipate interference currents
IP degree of protection	IP 20 to IEC 60529	• Protection against contact with standard probe • Protection against solid bodies with diameters in excess of 12.5mm • No special protection against water
Air gaps and creepage distances	IEC 60664 IEC 61131-2 IEC 61010-1 UL 508 CSA C22.2 No. 145 EN 50156-1	• Overvoltage category II • Pollution degree 2
Isolation stability	IEC 61131-2 CSA C22.2, No. 142 UL508	Test voltage: 500 V AC or 707 V DC

Electromagnetic compatibility

Table 12- 1 Interference emission (industrial area): EN 61000-6-4

Comments	Standard	Limits
Emission of radio interferences (electromagnetic fields)	Class A industrial environment: EN 61000-6-4 IEC/CISPR 16-2-3: 2008	• 30 ... 230 MHz, 40 dB (µV/m) Q • 230 ... 1 000 MHz, 47 dB (µV/m) Q
Emission on power supply cables 24 V	Class A: Industrial environment: EN 61000-6-4 IEC/CISPR 16-2-1: 2010; EN 55016-2-1: 2009	Class A: Industrial environment • 0,15 ... 0.5 MHz, 79 dB (µV) Q • 0,15 ... 0.5 MHz, 66 dB (µV) M • 0.5 ... 30 MHz, 73 dB (µV) Q • 0.5 ... 30 MHz, 60 dB (µV) M

Table 12- 2 Interference immunity (industrial environment): EN 61000-6-2

Comments	Standard	Severity class
Burst pulses on power supply cables	EN45501 OIML R 76 EN 61000-4-4 NAMUR NE21	• 1 kV • Per polarity 1 min.
Burst pulses on data and signal cables	EN 61000-4-4 NAMUR NE21 EN 61326	• 2.0 kV, opt. 2.4 kV • 5/50 ns / 5 kHz
Electrostatic discharge (ESD)	EN 61000-4-2 NAMUR NE21 EN 61326 EN 45501	• 6 kV direct/indirect • ≥ 10 discharges pos/neg • < 1 s repeat time
Electrostatic air discharge (ESD)	EN 61000-4-2 NAMUR NE21 EN 61326 EN 45501	8 kV
Surge on power supply cables	EN 61000-4-5 IEC 61131-2 NAMUR NE21 EN 61326	• 1 kV symmetrical[1)] • 2 kV asymmetrical [1)] • 1.2/50 µs (8/20) µs pos./neg. • Internal generator resistance: 2 Ω
Surge on data and signal cables	EN 61000-4-5 IEC 61131-2 NAMUR NE21 EN 61326	• 2 kV asymmetrical
HF irradiation amplitude modulated	IEC61000-4-3 NAMUR NE21 OIML R76 EN 45501*3	• 80 to 2 000 MHz: 20 V/m
HF irradiation, cell phone frequencies	IEC 61000-4-3	• 900 MHz (± 5 MHz) • 1.89 Ghz (± 10 MHz) • 20 V/m
HF voltage on data, signal and power supply cables 0.15 to 80 MHz	IEC 61000-4-6 NAMUR NE21 EN 61326 OIML R 76	• 10 kHz to 80 MHz: 10 V_{rms} • Mod.: 80% AM with 1 kHz

1) An external protection element has to be installed to meet the requirement (e.g.: Blitzductor VT AD24V, Dehn&Söhne)

2) Not applicable for shielded cables and symmetrical ports

NOTICE

Radio interference is possible

This is a device of class A. The device may cause radio interference in residential areas. Implement appropriate measures (e.g.: use in 8MC cabinets) to prevent radio interference.

Ambient conditions

The use of SIWAREX WP321 is intended under the following conditions in SIMATIC ET 200SP.

Table 12- 3 Operating conditions to IEC 60721

Mode	IEC60721-3-3 • Class 3M3, stationary use, weather-proofed	
Storage/transport	IEC 60721-3-2 class 2M2 without precipitation	
Contaminant concentration	SO_2: < 0.5 ppm H_2S: < 0.1 ppm;	RH < 60%, no condensation

Table 12- 4 Climatic requirements

Comments	Ambient conditions	Application areas
Operating temperature:		
• Horizontal installation in S7	-25 ... +60 °C	The S7 standard modules may not be operated at temperatures below 0 °C.
• Vertical installation in S7	-25 ... +50 °C	
• Calibratable mode	-10 ... +40 °C	
Storage and transport temperature	-40 ... +85 °C	
Relative humidity	5 ... 95 %	No condensation; corresponds to relative humidity (RH) stress level 2 to DIN IEC 61131-2
Air pressure during operation	IEC 60068-2-13	1 080 ... 795 hPa (operation) (-1 000 to +2 000 m above sea level)
Air pressure during transport and storage	IEC 60068-2-13	1 080 ... 660 hPa (operation) (-1 000 to +3 500 m above sea level)

12.3 Approvals

Note

The current approvals for SIWAREX WP321 can be found on the module rating plate.

CE	**Guidelines** • 2004/108/EC "Electromagnetic Compatibility"
c UL us	In preparation
FM APPROVED	In preparation
Ex	94/9/EC ATEX, type of protection II 3 G Ex nA IIC T4 Gc

NOTICE
Applications in hazardous areas For applications in hazardous areas, observe the safety information in the document "Product Information - Use of SIWAREX modules in a Zone 2 Hazardous Area"

Accessories

13

Table 13- 1 Essential accessories

Ordering data	
Description	**Order number**
Essential accessories for SIWAREX WP321	
Base unit type BU15+A0+2D (new load group) or Base unit type BU15+A0+2B (jumpered to left)	6ES7193-6BP00-0DA0 6ES7193-6BP00-0BA0
Shield connection	6ES7193-6SC00-1AM0

Table 13- 2 Optional accessories

Ordering data	
Description	**Order No.**
SIWAREX WP321 configuration package • SIWATOOL program for adjustment of scales during commissioning • Software "Ready for use" This contains the SIMATIC S7 blocks for operation with SIMATIC 300 und S7-1500 and a project for SIMATIC Operator Panel KTP600 • Manuals in several languages	7MH4138-1AK01
SIWAREX WP321 manual in various languages	Free download from the Internet
SIWAREX WP321 "Ready for use"	Free download from the Internet
RS485/USB converter Commercially available converter with FTDI chip, e.g. USB-Nano-485 from CTI (http://www.cti-shop.com/RS485-Konverter/USB-Nano-485)	

Ordering data	
Description	**Order No.**
Digital remote display The digital remote displays can be connected directly to the SIWAREX WP321 through the RS485 interface. Suitable remote display: S102 Siebert Industrieelektronik GmbH Postfach 1180 D-66565 Eppelborn, Germany Tel.: 06806/980-0 Fax: 06806/980-999 Internet: Siebert (http://www.siebert-group.com) Detailed information can be obtained from the manufacturer.	
SIWAREX JB junction box For parallel connection of load cells	7MH4 710-1BA
SIWAREX EB extension box For extending load cell cables	7MH4 710-2AA
Ex interface, type SIWAREX IS With ATEX approval for intrinsically-safe connection of load cells, including manual, suitable for the load cell groups SIWAREX CS, U, M, FTA, and P	
• With short-circuit current < 199 mA DC	7MH4 710-5BA
• With short-circuit current < 137 mA DC	7MH4 710-5CA
Cable (optional)	

Ordering data	
Description	**Order No.**
Cable Li2Y 1 x 2 x 0.75 ST + 2 x (2 x 0.34 ST) - CY • To connect SIWAREX CS, U, M, P, A, WP321 to the junction box (JB), extension box (EB) or Ex interface (Ex-I) or between two JBs, for fixed laying • Occasional bending is possible • 10.8 mm outer diameter • For ambient temperature -20 to +70 °C	7MH4 702-8AG
Cable Li2Y 1 x 2 x 0.75 ST + 2 x (2 x 0.34 ST) - CY, blue sheath • To connect junction box (JB) or extension box (EB) in hazardous area and Ex interface (Ex-I), for fixed laying • Occasional bending is possible, blue PVC insulating sheath, approx. 10.8 mm outer diameter • For ambient temperature -20 to +70 °C	7MH4 702-8AF

Appendix A

A.1 Technical support

Technical Support

You can contact Technical Support for weighing technology:

- E-mail (mailto:support.automation@siemens.com)
- Phone: +49 (721) 595-2811

You can contact Technical Support for all IA and DT products:

- Via the Internet using the **Support Request:**
  Support request (http://www.siemens.com/automation/support-request)
- Phone: +49 (911) 895-7222
- Fax: +49 (911) 895-7223

Additional information about our Technical Support is available on the Internet at
Technical Support (http://www.siemens.com/automation/csi/service)

Service & Support on the Internet

In addition to our documentation, we offer a comprehensive knowledge base online on the Internet at:

Services & Support (http://www.siemens.com/automation/service&support)

There you will find:

- The latest product information, FAQs, downloads, tips and tricks.
- Our newsletter, providing you with the latest information about your products.
- A Knowledge Manager to find the right documents for you.
- Our bulletin board, where users and specialists share their knowledge worldwide.
- You can find your local contact partner for Industry Automation and Drives Technologies in our partner database.
- Information about field service, repairs, spare parts and lots more under "Services".

Additional Support

Please contact your local Siemens representative and offices if you have any questions about the products described in this manual and do not find the right answers.

Find your contact partner at:

Partner (http://www.automation.siemens.com/partner)

A signpost to the documentation of the various products and systems is available at:

Documentation (http://www.siemens.com/weighing/documentation)

ESD guidelines

B

B.1 ESD Guidelines

Definition of ESD

All electronic modules are equipped with large-scale integrated ICs or components. Due to their design, these electronic elements are highly sensitive to overvoltage, and thus to any electrostatic discharge.

The electrostatic sensitive components/modules are commonly referred to as ESD devices. This is also the international abbreviation for such devices.

ESD modules are identified by the following symbol:

NOTICE
ESD devices can be destroyed by voltages well below the threshold of human perception. These static voltages develop when you touch a component or electrical connection of a device without having drained the static charges present on your body. The electrostatic discharge current may lead to latent failure of a module, that is, this damage may not be significant immediately, but in operation may cause malfunction.

Electrostatic charging

Anyone who is not connected to the electrical potential of their surroundings can be electrostatically charged.

The figure below shows the maximum electrostatic voltage which may build up on a person coming into contact with the materials indicated. These values correspond to IEC 801-2 specifications.

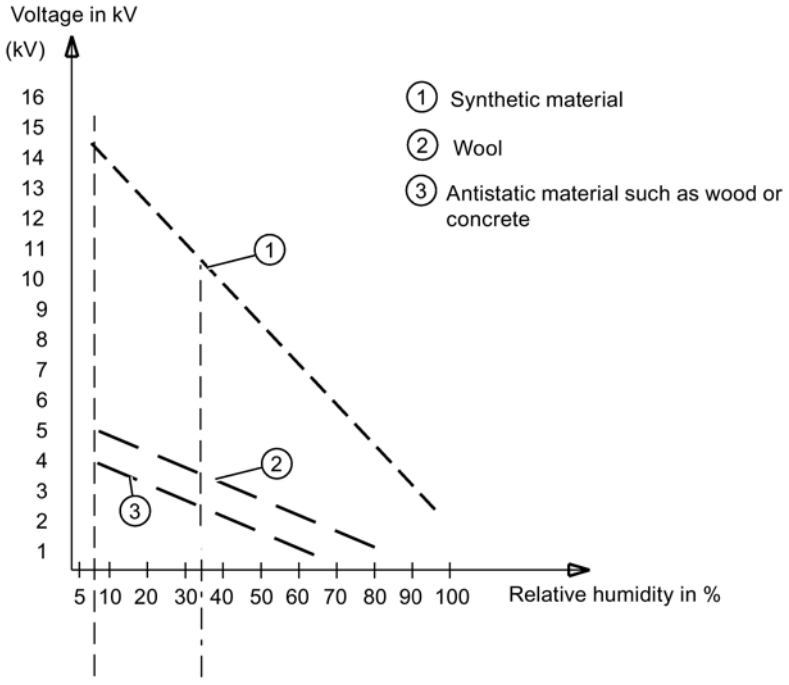


Figure B-1 Electrostatic voltages which an operator can be subjected to

Basic protective measures against electrostatic discharge

- Ensure good equipotential bonding:
  When handling electrostatic sensitive devices, ensure that your body, the workplace and packaging are grounded. This prevents electrostatic charge.
- Avoid direct contact:
  As a general rule, only touch electrostatic sensitive devices when this is unavoidable (e.g. during maintenance work). Handle the modules without touching any chip pins or PCB traces. In this way, the discharged energy can not affect the sensitive devices.

  Discharge your body before you start taking any measurements on a module. Do so by touching grounded metallic parts. Always use grounded measuring instruments.

List of abbreviations

C

C.1 List of abbreviations

ASCII	American Standard Code for Information Interchange
B	Gross weight
CPU	Central processor, in this case SIMATIC CPU
DB	Data block
FB	SIMATIC S7 function block
HMI	Human machine interface (e.g. SIMATIC Operator Panel)
HW	Hardware
NAWI	Non-automatic weighing instrument
NAW	Non-automatic scales
OIML	Organisation Internationale de Metrologie Legale
OP	Operator Panel (SIMATIC)
PC	Personal computer
pT	Preset tare (predefined tare weight with manual taring)
RAM	Random access memory
PLC	Programmable logic controller
STEP 7	Programming device software for SIMATIC S7
T	Tare weight
TM	Technology module
TP	Touch Panel (SIMATIC)
UDT	Universal Data Type (S7)
WRP	Write protection
LC	Load cell(s)
NR	Numerical range

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SIEMENS

SIMATIC

ET 200SP

Technology Module TM Timer DIDQ 10x24V (6ES7138-6CG00-0BA0)

Device manual

Version 08/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Technology module
TM Timer DIDQ 10x24V
(6ES7138-6CG00-0BA0)

Manual

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08/2014

A5E34301686-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding the design and commissioning of the ET 200SP is available in the ET 200SP system manual.

The "Time-based IO" technology supported by the TM Timer DIDQ 10x24V technology module is described in detail in the function manual High-precision input/output with Time-based IO (http://support.automation.siemens.com/WW/view/en/82527590).

Conventions

Please observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this in the appendix.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP and S7-1500 systems consists of the respective system manuals, function manuals and device manuals.

The STEP 7 information system (TIA Portal) also helps you to configure and program your automation system.

Overview of the documentation for TM Timer DIDQ 10x24V technology module

The following table lists further documentation that you will need when using the TM Timer DIDQ 10x24V technology module.

Table 1- 1 Documentation for TM Timer DIDQ 10x24V technology module

Topic	Documentation	Most important contents
System description	System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning
	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual	
	Device manual Interface Module (http://support.automation.siemens.com/WW/view/en/55683316/133300)	• Connecting • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimension drawing
	Device manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Configuring interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual	• Basics • Electromagnetic compatibility • Lightning protection

Topic	Documentation	Most important contents
Time-based IO	Function manual High-precision input/output with Time-based IO (http://support.automation.siemens.com/WW/view/en/82527590)	• Basics • Configuration • Programming • Diagnostics
Isochronous mode	PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) function manual	• Benefits • Use • Parameter settings

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Article number

6ES7138-6CG00-0BA0

View of the module

Figure 2-1 View of the TM Timer DIDQ 10x24V module

Properties

The TM Timer DIDQ 10x24V technology module has the following properties:

- Technical properties
  - 4 Digital inputs and 6 digital outputs
  - Rated output voltage 24V DC
  - Rated output current 0.5 A or 0.1 A (high-speed operation) per digital output
  - 24 V encoder supply output, short-circuit proof
  - Configurable substitute values (per digital output)
  - Configurable diagnostics
  - Configurable input filters for suppression of interference at digital inputs
- Supported encoder/signal types for digital inputs
  - 24 V incremental encoder with A and B signals
  - 24 V pulse encoder with one signal
- Supported functions
  - Time stamp function for inputs and outputs (resolution 1 µs)
  - Counting (counting range 32-bit)
  - Oversampling for inputs and outputs
  - Pulse width modulation
- Supported system functions
  - Isochronous mode
  - Firmware Update
  - Identification data I&M

Accessories

The following accessories can be used with the module and are not included in the product package:

- Labeling strip
- Color identification labels
- Reference identification labels
- Shield connector

A BaseUnit of the A0 type is required to operate the technology module. For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

For detailed information on the installation procedure, refer to the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Detection of the input signals

You can configure up to four digital inputs with the technology module. You can evaluate the signals at the digital inputs for the following functions:

Time stamp detection (Timer DI)

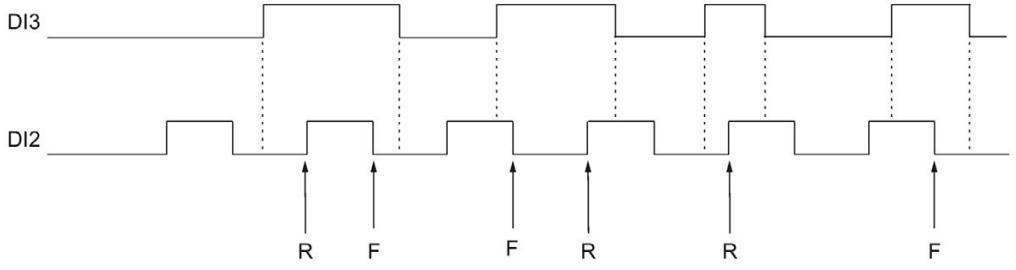
The technology module can detect an associated time stamp for an edge at a digital input. The time stamp indicates when the edge was detected in relation to a time base. These time stamps can be used, for example, to calculate a time difference.

The time stamp is based on the "Time-based IO" technology supported by the technology module and requires isochronous mode.

Hardware enable (HW enable)

You can configure a hardware enable by a digital input for the detection of time stamps. A hardware enable defines the time window in which the time stamps are acquired. You can override the hardware enable via the control interface (Page 27) with the respective SETEN bit.

The figure below shows an example for the detection of time stamps at rising and falling edges with enable of the DI2 through the high level of the DI3:



R Associated time stamp detected at rising DI2-edge

F Associated time stamp detected at falling DI2 edge

Counting

Counting refers to the recording and adding up of events. You can configure up to three counters for the technology module. You can use an incremental encoder as well as a pulse encoder at the digital inputs. The two phase-shifted signals from an incremental encoder are evaluated four times. Only the rising or falling edges are counted with the signal of a pulse encoder.

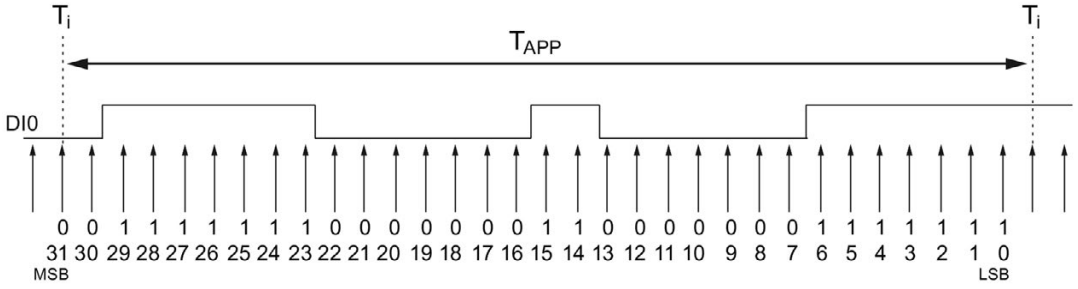
A counter starts at 0, goes up to 2^{32}-1 and starts again at 0 (overflow). The technology module can also count down if an incremental encoder is used. The counter value is returned in the feedback interface (Page 30) as a 32-bit value for each digital input.

Oversampling

The Oversampling function is used by the technology module to detect the status of the respective digital input for each application cycle (for example, OB61) at 32 points in time at regular intervals. The 32 states are returned together in the feedback interface (Page 30) as a 32-bit value.

Oversampling requires isochronous mode. If the OB of the type "Synchronous Cycle" works with a clock different than the send clock, you must use the TIO_SYNC instruction.

The figure below shows an example for Oversampling of DI0:



T_{APP} Application cycle
MSB Most significant bit
LSB Least significant bit

2.2.2 Switching the outputs

You can configure up to six digital outputs for the technology module. You can configure the following functions for switching the digital outputs:

Time-controlled switching (Timer DQ)

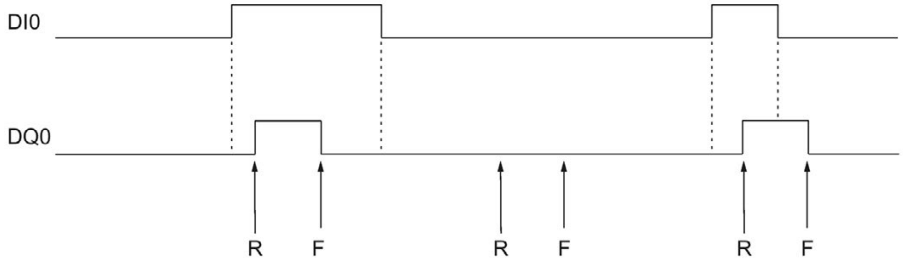
The use of time stamps enables reproducibility of controlled operations with very accurate time. Using this function, the technology module outputs edges at the respective digital output at precisely defined points in time. For example, you can implement a defined reaction time between input and output in conjunction with a digital input.

The Timer function is based on Time-based IO and requires isochronous mode.

Hardware enable (HW enable)

You can configure a hardware enable by means of a digital input for a Timer digital output. A hardware enable defines the time window in which the respective digital output can be set. The resetting of the digital output is independent of the hardware enable. You can override the hardware enable via the control interface (Page 27) with the respective SETEN bit.

The figure below shows an example for the output of rising and falling edges with enable of the DQ0 through the high level of the DI0:



R Specified time of a rising DQ0-edge

F Specified time of a falling DQ0-edge

Pulse width modulation (PWM)

The Pulse width modulation function enables you to specify the time period in the hardware configuration and the pulse-pause ratio in the control interface (Page 27) for the respective digital output. The setpoint for the pulse-pause ratio is a percentage and is evaluated with an accuracy of about 3%.

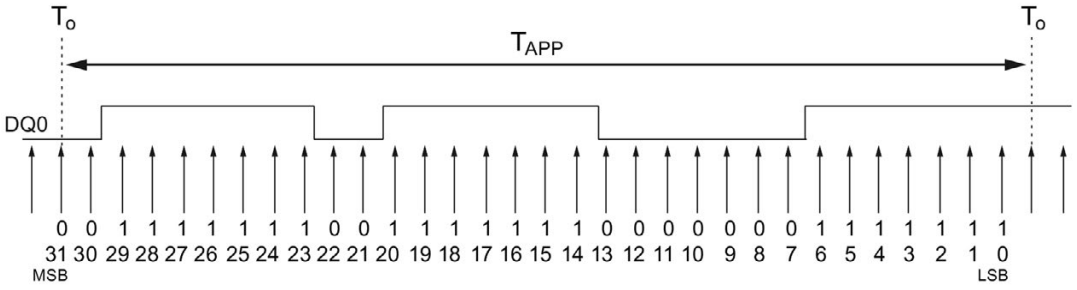
Oversampling

The Oversampling function is used by the technology module to output 32 states at regular intervals for each application cycle (for example, OB61). This allows up to 32 edges at the respective digital output per application cycle.

The 32 states are sent via the control interface (Page 27) as a 32-bit string for the respective digital output to the technology module.

Oversampling requires isochronous mode. If the OB of the type "Synchronous Cycle" works with a clock different than the send clock, you must use the TIO_SYNC instruction.

The figure below shows an example for Oversampling of DQ0:



T_{APP} Application cycle
MSB Most significant bit
LSB Least significant bit

Note

When you use the Oversampling function, make sure that the combination of application cycle and the 32-bit output sequence do not result in an output frequency which exceeds the maximum switching frequency for the digital outputs.

2.2.3 Additional functions

Isochronous mode

The technology module supports the system function "isochronous mode" in distributed mode on PROFINET. This system function is required for the following functions of the technology module:

- Time stamp detection (Timer DI)
- Time-controlled switching (Timer DQ)
- Oversampling of digital input
- Oversampling of digital output

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized.

Data processing

The time stamp, counter values and Oversampling bit string as well as status bits are detected at the time T_i and made available in the feedback interface for retrieval in the current bus cycle. The output of the current Oversampling bit stings is started at the time T_o.

Diagnostic interrupt

The technology module can trigger a diagnostic interrupt (Page 36), among other things, if no supply voltage is available or if there is an error at the digital outputs.

Input filter

To suppress interferences, you can configure an input filter for the digital inputs.

Distributed application

You can use the technology module in a distributed system by means of an interface module in the ET 200SP distributed I/O device. The following applications are possible:

- Distributed operation in an S7-1500 system
- Distributed operation in an S7-300/400 system

Centralized application

You can use the technology module centrally in the ET 200SP distributed I/O system.

Connecting

3

3.1 Pin assignment

The TM Timer DIDQ 10x24V is used with a BaseUnit of the A0 type.

The encoder signals, the digital input and output signals and the encoder supply are connected to the BaseUnit of the technology module. The supply voltage feed on the light BaseUnit BU...D of the associated potential group supplies the module and the digital outputs, and generates the encoder supply voltage.

BaseUnit

The BaseUnit is not included in the product package of the module and must be ordered separately.

For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

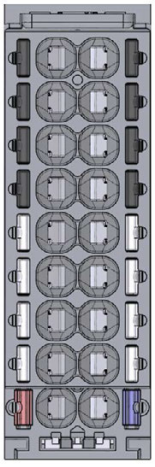
You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) device manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Pin assignment of the BaseUnit

The table below shows the pin assignment, using the BaseUnit BU15-P16+A0+2B as an example.

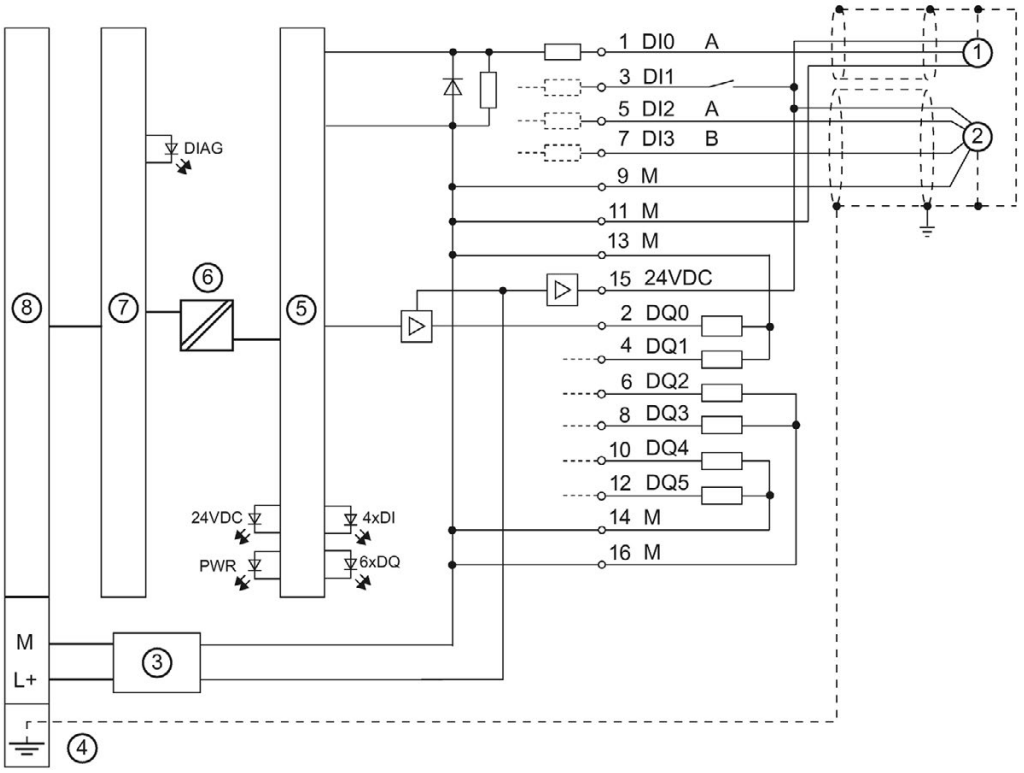
Table 3- 1 Pin assignment of the BaseUnit BU15-P16+A0+2B

Designation	Signal name		View	Signal name		Designation
Digital input DI0	DI0	1		2	DQ0	Digital output DQ0
Digital input DI1	DI1	3		4	DQ1	Digital output DQ1
Digital input DI2	DI2	5		6	DQ2	Digital output DQ2
Digital input DI3	DI3	7		8	DQ3	Digital output DQ3
Ground for encoder supply, digital inputs and digital outputs	M	9		10	DQ4	Digital output DQ4
	M	11		12	DQ5	Digital output DQ5
	M	13		14	M	Ground for encoder supply, digital inputs and digital outputs
24 V encoder supply	24VDC	15		16	M	
DC 24 V supply voltage	L+			M		Ground for supply voltage

Block diagram

When you connect encoders you must, depending on the configured input delay and potential effect of interference, ground the shields of the cables between encoder and technology module both through the shield connection on the BaseUnit (shield connection element and terminal) and at the encoder.

The figure below shows the block diagram of the technology module to which an incremental encoder and a pulse encoder are connected.



① Pulse encoder with signal A
② Incremental encoder with A and B signals
③ Input filter for supply voltage
④ Shield connection on the BaseUnit
⑤ Technology
⑥ Electrical isolation
⑦ Backplane bus interface module of the technology module
⑧ Backplane bus

Figure 3-1 Block diagram with incremental encoder and pulse encoder

L+/M supply voltage

Connect the supply voltage (DC 24V) to the L+ and M connections. An internal protective circuit protects the technology module against damage due to reversed polarity of the supply voltage. Unexpected conditions can occur at the digital outputs with reversed polarity of the supply voltage. The technology module monitors the connection of the supply voltage.

24VDC encoder supply

To supply the encoders and sensors at the digital inputs, the technology module supplies the DC 24V supply voltage at the 24VDC output with reference to M. Voltage is supplied from the L+/M supply voltage and monitored for short-circuits and overload.

Digital inputs DI0 to DI3

You can use four digital inputs. The technology module can evaluate the edges at the digital inputs for the following functions:

Table 3- 2 Evaluation of the signals at the digital inputs

Evaluation of the signals for ...	Usable digital inputs			
	DI0	DI1	DI2	DI3
Time stamp detection	✓	✓	✓	✓
Hardware enable for time stamp detection	—	—	—	✓
Hardware enable for time-controlled switching	✓	✓	✓	—
Counting with incremental encoder with signals A and B	—	—	✓	✓
Counting with pulse encoder with signal A	✓	✓	✓	—
Oversampling	✓	✓	✓	✓

When you use the counting function, you can connect the following encoder types with 24 V signals to the digital inputs:

- Incremental encoder with signals A and B:

  Signals A and B are connected via the connections of the digital inputs DI2 and DI3. Signals A and B are the two incremental signals phase-shifted by 90°.

- Pulse encoder / sensor with signal A:

  Signal A is connected via the connection of the digital input DI0, DI1 or DI2.

The digital inputs are not electrically isolated from each other or from the digital outputs. The digital inputs are electrically isolated from the backplane bus.

Input filters for digital inputs

You can configure an input filter for each digital input to suppress interference. Signals with a pulse duration below the configured input delay are suppressed.

You can specify the following values for the input delay:

- None
  (input delay of 4 µs, minimum pulse width of 3 µs)
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms

The input delay has the following effect on the functions of the signal evaluation at the digital inputs:

Table 3- 3 Influence of the input delay

Function	Influence of the input delay
Time stamp detection	The detected time stamp is moved by the input delay.
Counting	The counter value that was valid at time T_i minus the input delay is returned.
Oversampling	The detected states are moved together by the input delay.

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs. To increase the accuracy of the time stamp function, we recommend the use of shielded cables even for longer input delays. The use of shielded cables limits the jitter to maximum of 1 µs.

Digital outputs DQ0 to DQ5

You can use six digital outputs. The digital outputs can be switched directly at defined points in time or via the user program. Alternatively, you can output pulse width modulation or Oversampling at the respective digital output.

The digital outputs are not electrically isolated from each other or from the digital inputs. The digital outputs are electrically isolated from the backplane bus.

You can use each of the digital outputs as a high-speed output or as a sourcing output:

- High-speed output (default):
  The digital output works as fast push-pull switch and can carry a rated load current of 0.1 A. A push-pull switch is alternately switched to DC 24 V and ground. This makes for very steep edges.
- Sourcing output:
  The digital output works as 24 V sourcing output in reference to M and can carry a rated load current of 0.5 A.

The digital outputs are protected from overload and short-circuit.

NOTICE
Overtemperature from unsuitable loads A high-speed output generates edges that are very steep. This creates very powerful charge reversals for the connected load, which can overheat the load at very high switching frequencies. The connected load must therefore be approved for high input frequencies.

Note

If you use a digital output as sourcing output, the switch-off response / switch-off edge depends on the load. Thus, it is possible that very short pulses cannot be output correctly.

Note

Relays and contactors can be connected direct without external circuitry.

Configuring/address space

4

4.1 Configuring

Introduction

The technology module is configured and assigned parameters with the configuration software.

The technology module functions are controlled and monitored by the user program.

System environment

The technology module can be used in the following system environments:

Table 4- 1 Applications of the technology module with PROFINET IO

Applications	Components required	Configuration software	In the user program
Distributed operation in an S7-1500 system	• S7-1500 automation system • ET 200SP distributed I/O system • TM Timer DIDQ 10x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN)	Time stamp functions: TIO instructions TIO_SYNC, TIO_DI and TIO_DQ Counting, PWM and Oversampling: Direct access to the control and feedback interface (Page 27) of the TM Timer DIDQ 10x24V in the I/O data
Central operation in an S7-1500 system	• S7-1500 automation system • ET 200SP distributed I/O system • TM Timer DIDQ 10x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN)	Counting and PWM: Direct access to the control and feedback interface of the TM Timer DIDQ 10x24V in the I/O data
Distributed operation in an S7-300/400 system	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Timer DIDQ 10x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN) STEP 7: Device configuration and parameter settings with HSP	Time stamp functions*, counting, PWM and Oversampling: Direct access to the control and feedback interface (Page 27) of the TM Timer DIDQ 10x24V in the I/O data

* on request

Additional information

You can find a detailed description of the time stamp functions and their configuration with the TIO instructions TIO_SYNC, TIO_DI and TIO_DQ in:

- High-precision input/output with Time-based IO function manual available as download on the Internet (http://support.automation.siemens.com/WW/view/en/82527590)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

4.2 Reaction to CPU STOP

You set the response of the technology module to CPU STOP for each channel in the basic parameters.

Table 4- 2 Response of the technology module to CPU STOP depending on parameter assignment

Reaction to CPU STOP	Meaning
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: If you are using counters, the counter values are set to 0 and the digital outputs switch according to the parameter assignment and the setpoints.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. The last valid period duration with the last valid pulse-pause ratio is output for a configured pulse width modulation until the next STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: If you are using counters, the counter values are set to 0 and the digital outputs switch according to the parameter assignment and the setpoints.

4.3 Address space

Address space of the technology module

Table 4- 3 Range of the input addresses and output addresses of the TM Timer DIDQ 10x24V

	Inputs	Outputs
Range	26 bytes	32 bytes

Additional information

A description on how to use the control and feedback interface of TM Timer DIDQ 10x24V can be found in the chapter Control and feedback interface (Page 27).

4.4 Parameters

You can use various parameters to define the properties of the technology module in the hardware configuration. Depending on the settings, not all parameters are available. You can change the parameter assignment in the user program using data record 128 (Page 46).

If you use STEP 7 (TIA Portal), you can find the module in the Hardware catalog under "Technology modules". If you use STEP 7, you can find the module following installation of the corresponding HSP file in the Hardware catalog.

Parameters of the TM Timer DIDQ 10x24V

You can configure the following parameters:

Table 4- 4 Configurable parameters and their defaults

Parameter	Value range	Default setting
Basic parameters		
PWM period for the digital outputs	• 10 ms • 5 ms • 2 ms • 1 ms • 0.5 ms • 0.2 ms	10 ms
Reaction to CPU STOP	• Output substitute value • Keep last value	Output substitute value
Enable diagnostic interrupts	• Disabled • Enabled	Disabled
Channel parameters		
Configuration DQ/DI group (DQ0/DI0 or DQ1/DI1)	• Timer DQ with enable input • Use input/output individually	Timer DQ with enable input
Operating mode of the digital output	• Timer DQ • Oversampling • Pulse width modulation PWM	Timer DQ
Substitute value for the digital output	• 0 • 1	0
High-speed output (0.1 A)	• Disabled • Enabled	Enabled
Invert input or output signal	• Disabled • Enabled	Disabled
HW enable by the digital input	• Level-triggered • Edge-triggered	Level-triggered

Parameter	Value range	Default setting
Level selection for HW enable	• Active with high level • Active with low level	Active with high level
Configuration DQ/DI group (DQ2/DI2/DI3)	• Incremental encoder (A, B phase-shifted) • Timer-DI2 with enable input DI3 • Timer DQ2 with enable input DI2 • Use inputs individually	Incremental encoder (A, B phase-shifted)
Invert counting direction (incremental encoder)	• Disabled • Enabled	Disabled
Operating mode of the digital input	• Counter • Timer-DI • Oversampling	Timer-DI
Input delay for the digital input	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms	0.1 ms
Signal evaluation for counters	• At rising edge • At falling edge	At rising edge

4.5 Control and feedback interface

Direct access to the control and feedback interface on the PROFINET is not necessary for distributed operation in a S7-1500 system to use the time stamp functions. The TIO instructions TIO_SYNC, TIO_DI and TIO_DQ are available for this case. You can find a detailed description of the use of the TIO instructions in the High-precision input/output with Time-based IO function manual available as download on the Internet (http://support.automation.siemens.com/WW/view/en/82527590).

Additional information on using the control and feedback interface is available in the section Configuring (Page 22).

4.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface

The following table shows control interface assignment:

Table 4- 5 Control interface of the technology module

Offset to the start address	Parameter	Meaning
Byte 0	—	Bits 6 to 7: Reserved; bits must be set to 0
	SET_DQ (DQ0 ... DQ5)	Bit 5: Set DQ5
		Bit 4: Set DQ4
		Bit 3: Set DQ3
		Bit 2: Set DQ2
		Bit 1: Set DQ1
		Bit 0: Set DQ0
Byte 1	SETEN (DI0 ... DI3, DQ0 ... DQ3)	Bit 7: Override hardware enable for DQ3
		Bit 6: Override hardware enable for DQ2
		Bit 5: Override hardware enable for DQ1
		Bit 4: Override hardware enable for DQ0
		Bit 3: Override hardware enable for DI3
		Bit 2: Override hardware enable for DI2
		Bit 1: Override hardware enable for DI1
		Bit 0: Override hardware enable for DI0
Byte 2	SETEN (DQ4 ... DQ5)	Bits 2 to 7: Reserved; bits must be set to 0
		Bits 0 to 1: Override hardware enable for DQ4 to DQ5

Offset to the start address	Parameter		Meaning		
Byte 3	—		Reserved; bits must be set to 0		
Bytes 4 to 7	TEC_OUT (DQ0)		For DQ operating mode "Timer DQ":	For DQ operating mode "Over-sampling":	For DQ operating mode "Pulse width modulation PWM":
			Byte 0...1: OFF TIME: Starting time stamp of the module for resetting the DQ0	Bytes 0 to 3: 32 states for Over-sampling	Bytes 0 to 2: Reserved; bits must be set to 0
			Bytes 2 to 3: ON TIME: Starting time stamp of the module for setting the DQ0		Byte 3: Pulse-pause ratio for PWM as a per-centage
Bytes 8 to 11	TEC_OUT (DQ1)		See bytes 4 to 7		
Bytes 12 to 15	TEC_OUT (DQ2)				
Bytes 16 to 19	TEC_OUT (DQ3)				
Bytes 20 to 23	TEC_OUT (DQ4)				
Bytes 24 to 27	TEC_OUT (DQ5)				
Byte 28	SEL (DI1)	EDGESEL	Bits 5...7: edge selection for time stamp detection DI1:		
			000_B: Reserved		
			001_B: Rising edges only		
			010_B: Falling edges only		
			011_B: Rising and falling edge (order depending on occurrence)		
			100_B: Reserved		
			101_B: First rising, then falling edge		
			110_B: First falling, then rising edge		
			111_B: Reserved		
		REARM	Bit 4: cyclic time stamp detection for DI1		
	SEL (DI0)	EDGESEL	Bits 0...3: See SEL (DI1)		
		REARM			
Byte 29	SEL (DI3)		See byte 28		
	SEL (DI2)				
Bytes 30 to 31	STW	MSL	Bits 12...15: sign of life counter (Master Sign of Life)		
		—	Bits 1...11: Reserved; bits must be set to 0		
		SYN	Bit 0: Synchronization of the module with the user program		

Notes on the control bits

Control bit	Notes
SEL (DIm)	This value is supplied by the TIO instruction TIO_DI.
SET_DQm	You can use this bit to set the DQm digital output in the DQ operating mode "Timer DQ".
SETEN (DIm/DQm)	You can use this bit to override the hardware enable that is configured for a digital input DIm or digital output DQm.
STW	This value is controlled by the TIO instruction TIO_SYNC. Detailed information is available on request.
TEC_OUT (DQm)	If you use the time stamp function for the respective digital output DQm, the TIO instruction TIO_DQ returns the two output time stamps for the module in this value. If you use the Oversampling function for the respective digital output DQm, you specify the 32 states with this value. If you use pulse width modulation for the respective digital output DQm, you specify the pulse-pause ratio with this value as percentage. The following overview shows how the technology module evaluates the specified percentage.

Pulse-pause ratio for PWM

You specify the setpoint for the pulse-pause ratio as a percentage. The technology module outputs the following pulse-pause ratio in each case:

Setpoint in %	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Output value in %	0		3.13			6.25			9.38			12.50				15.63			18.75			21.88		

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
25			28.13			31.25			34.38			37.50				40.63			43.75			46.88			50		

52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
53.13			56.25			59.38			62.50				65.63			68.75			71.88			75			78.13		

80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
81.25			84.38			87.50			90.63				93.75			96.88			100	

Additional information

Detailed information about the time stamp function is available from Technical Supporton request.

4.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 4- 6 Feedback interface of the technology module

Offset to the start address	Parameter	Meaning		
Byte 0	STS_DI (DI0 ... DI3)	Bits 4 to 7: Reserved		
		Bit 3: Status DI3		
		Bit 2: Status DI2		
		Bit 1: Status DI1		
		Bit 0: Status DI0		
Byte 1	QI (DI0 ... DI3)	Bits 4 to 7: Reserved		
		Bit 3: Quality Information DI3		
		Bit 2: Quality Information DI2		
		Bit 1: Quality Information DI1		
		Bit 0: Quality Information DI0		
Byte 2	QI (DQ0 ... DQ5)	Bits 6 to 7: Reserved		
		Bit 5: Quality Information DQ5		
		Bit 4: Quality Information DQ4		
		Bit 3: Quality Information DQ3		
		Bit 2: Quality Information DQ2		
		Bit 1: Quality Information DQ1		
		Bit 0: Quality Information DQ0		
Byte 3	—	Reserved		
Bytes 4 to 7	TEC_IN (DI0)	For DI operating mode "Timer DI":	For DI operating mode "Incremental encoder (A, B phase-shifted)" or "Counter":	For DI operating mode "Over-sampling":
		Byte 0...1: 2nd TIME/OFF TIME: Second input time stamp of module	Current counter value	Oversampling value
		Byte 2...3: 1st TIME/ON TIME: First input time stamp of module		
Bytes 8 to 11	TEC_IN (DI1)	See bytes 4 to 7		
Bytes 12 to 15	TEC_IN (DI2)			
Bytes 16 to 19	TEC_IN (DI3)			
Byte 20	EN (DI1)	Bit 7: DI1 active as Timer DQ		
	LEC (DI1)	Bit 4...6: Lost edge counter for DI1		
	EN (DI0)	Bit 3: DI0 active as Timer DQ		
	LEC (DI0)	Bit 0...2: Lost edge counter for DI0		

Offset to the start address	Parameter		Meaning
Byte 21	EN (DI3)		See byte 20
	LEC (DI3)		
	EN (DI2)		
	LEC (DI2)		
Byte 22	—		Bits 6 to 7: Reserved
	EN (DQ5)		Bit 5: DQ5 active as Timer DQ
	EN (DQ4)		Bit 4: DQ4 active as Timer DQ
	EN (DQ3)		Bit 3: DQ3 active as Timer DQ
	EN (DQ2)		Bit 2: DQ2 active as Timer DQ
	EN (DQ1)		Bit 1: DQ1 active as Timer DQ
	EN (DQ0)		Bit 0: DQ0 active as Timer DQ
Byte 23	Layout Property		Module-specific value
Bytes 24 to 25	ZSW	SSL	Bits 12...15: sign of life counter (SIave Sign of Life)
		—	Bits 10 to 11: Reserved
		SYNC	Bit 8: Module is synchronized with the user program
		Channel address	Bits 4 to 7 and 9: Number of the respective DI or DQ
		Channel mode	Bits 0 to 3: Operating mode of the respective DI or DQ

Notes on the feedback bits

Table 4- 7 Feedback bits with notes

Feedback bit	Notes
STS_DI (DIm)	This bit indicates the status of respective digital input DIm.
EN (DIm/DQm)	This bit indicates that • The respective digital input is active as Timer DI and, if required, is enabled, or • The respective digital output is active as Timer DQ and, if required, is enabled. For digital inputs and digital outputs with the operating modes "Counter", "Oversampling", "Pulse Width Modulation PWM" and for level-controlled hardware enable, this bit is permanently "0".
Layout Property	This value is a module-specific constant and used by the TIO instructions for the recognition of the technology module.
LEC (DIm)	This value indicates the number of edges at the respective digital input DIm for which no time stamp could be stored. The module can count a maximum of seven edges per application cycle. The counter is reset with each new application cycle.
QI (DIm)	This bit indicates that an error has occurred at the respective digital input. 0 means: Supply voltage L+ not present or too low. 1 means: Supply voltage is present and OK If the diagnostic interrupts are enabled, a diagnostic interrupt is triggered when there is a problem with the L+ supply voltage. Refer to the section Diagnostic alarms (Page 37) for details on the diagnostic interrupts.

Feedback bit	Notes
QI (DQm)	This bit indicates that an error has occurred at the respective digital output. 0 means: Short-circuit, overload or overtemperature 1 means: Supply voltage is present and OK If the diagnostic interrupts are enabled, a diagnostic interrupt is triggered when there is a fault at the digital output. Refer to the section Diagnostic alarms (Page 37) for details on the diagnostic interrupts.
TEC_IN (DIm)	If you use the time stamp function for the respective digital input DIm, this value returns the two input time stamps for the module. The input time stamps are read by the TIO instruction TIO_DI and converted to the TIO_Time. If you use the counting function for the respective digital input DIm, this value returns the current counter value. If you use the Oversampling function for the respective digital input DIm, this value returns the 32 states of the DIm.
ZSW	This value is controlled by the technology module and is used for communication with the TIO instruction TIO_SYNC.

Additional information

Detailed information about the time stamp function is available from Technical Support on request.

Interrupts/diagnostic messages

5

5.1 Status and error displays

LEDs

The figure below shows the LEDs (status and error displays) of the TM Timer DIDQ 10x24V.

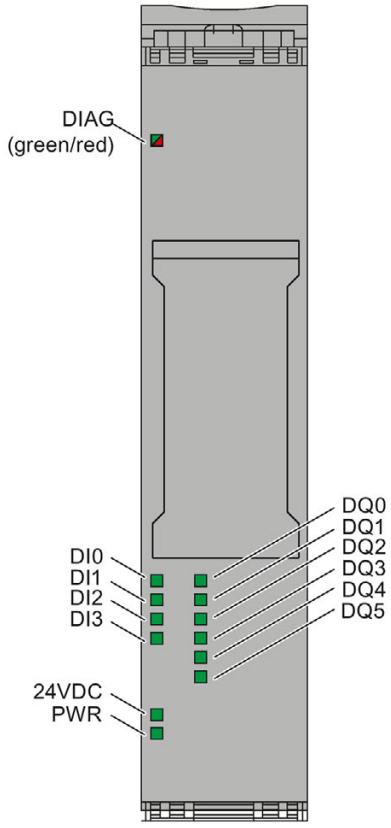


Figure 5-1 LEDs of the TM Timer DIDQ 10x24V

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic alarms (Page 37).

Table 5- 1 Status and error displays DIAG

LED DIAG	Meaning	To correct or avoid errors
Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the interface module or on the CPU.
Flashes	Technology module not configured	—
On	Technology module configured but no module diagnostics	
Flashes	Technology module configured and module diagnostics (at least one error pending)	Evaluate the diagnostic alarms and eliminate the error.

Table 5- 2 PWR/24VDC status displays

LEDs		Meaning	To correct or avoid errors
PWR	24VDC		
Off	Off	No supply voltage	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
On	On	Supply voltage is present and OK	—
On	Off	Short-circuit or overload at the encoder supply or supply voltage too low	• Check the encoder wiring. • Check the loads connected to the encoder supply. • Check the supply voltage.

ChannelLEDs

TheDIm LEDs indicate the current level of the associated signals. The LEDs of the digital outputs DQm indicate the desired state.

The flashing frequency of the channel LEDs is limited to approximately 14 Hz. If higher frequencies are present, the channel LEDs will flash at 14 Hz instead of indicating the current status.

Table 5- 3 Status displays DIm/DQm

LEDs DIm/DQm	Meaning
□ Off	Digital input / digital output at 0 level
■ On	Digital input / digital output at 1 level

5.2 Trigger a diagnostic interrupt

Enabling the diagnostic interrupts

You enable the diagnostic interrupts at the basic parameters.

The technology module can trigger the following diagnostic interrupts:

Table 5- 4 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• Error • Load voltage missing • Module temporarily unavailable • Short-circuit or overload at encoder supply • Error at the digital outputs • Supply voltage error • Overtemperature	Monitoring is always active. A detected error only triggers a diagnostic interrupt if "Enable diagnostic interrupts" has been enabled in the device parameters. The diagnostic interrupts are not enabled in the default setting.

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  Once you have remedied the error, the DIAG LED goes out.
- The S7-1500 CPU interrupts processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

Detailed information on the error event is available with the instruction "RALRM" (read additional interrupt information).

5.3 Diagnostic alarms

Diagnostic alarms

If a diagnostic alarm is pending, the DIAG LED flashes red.

The diagnostics are displayed as plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The technology module only has one channel as far as diagnostics is concerned. Channel number "0" is therefore displayed for each diagnostic with a few exceptions.

The following diagnostics can be signaled:

Table 5- 5 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Error	9_H	• Internal module error occurred • Possible cause: Technology module defective	Replace technology module
Load voltage missing*	11_H	• No technology module L+ supply voltage • Possible cause: BaseUnit type wrong	• Check BaseUnit type • Check the wiring of the supply voltage L+ on the BaseUnit
Module temporarily unavailable*	$1F_H$	• No normal operation of the technology module possible • Possible cause: Technology module is performing a firmware update	Wait until technology module is available again
Internal error	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	103_H	Firmware error	Run firmware update
		Technology module defective	Replace technology module
Short-circuit or overload at encoder supply	$10E_H$	• Error at encoder supply • Possible causes: – Short-circuit – Overload	• Check encoder wiring • Check consumers connected to encoder supply
Error at the digital outputs	$10F_H$	• Error at the digital outputs • Possible causes: – Short-circuit – Overload	• Check wiring at the digital outputs • Check consumers connected to the digital outputs

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Supply voltage error*	110_H	• Error at supply voltage L+ • Possible causes: – Low voltage – Wiring of L+ supply voltage defective	• Check the L+ supply voltage • Check the wiring of the supply voltage L+ on the BaseUnit
Overtemperature	506_H	• Short-circuit or overload at the digital outputs or outputs of the encoder supplies • Ambient temperature outside specifications	• Check process wiring • Improve cooling • Check connected loads

* This diagnostic alarm is displayed with the channel number "32768".

Technical specifications

6

	6ES7138-6CG00-0BA0
Product type designation	TM Timer DIDQ 10x24V
General information	
BaseUnits that can be used	BU type A0
Product function	
I&M data	Yes; I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 Update 3
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
Supply voltage	
Load voltage L+	
Rated value (DC)	24 V
Low limit of valid range (DC)	19.2 V
High limit of valid range (DC)	28.8 V
Reverse polarity protection	Yes; against destruction
Input current	
Current consumption, max.	50 mA; without load
Encoder supply	
Number of outputs	1
24 V encoder supply	
24 V	Yes; L+ (-0.8 V)
Short-circuit protection	Yes
Output current, max.	500 mA; note derating
Power loss	
Power loss, typ.	1.5 W
Address area	
Occupied address area	
Inputs	26 bytes
Outputs	32 bytes
Digital inputs	
Number of inputs	4
Digital inputs, configurable	Yes
Input characteristics to IEC 61131, Type 3	Yes

	6ES7138-6CG00-0BA0
Digital input functions, configurable	
Digital input with time stamp	Yes
• Number, max.	4
Counter	Yes
• Number, max.	3
Counter for incremental encoder	Yes
• Number, max.	1
Digital input with oversampling	Yes
• Number, max.	4
Hardware enable for digital input	Yes
• Number, max.	1
Hardware enable for digital output	Yes
• Number, max.	3
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
For signal "0"	-30 V to +5 V
For signal "1"	+11 V to +30 V
Permitted voltage at input, min.	-30 V
Permitted voltage at input, max.	30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (at rated value of input voltage)	
Minimum pulse width for program reaction	3 µs; with parameter assignment "none"
For standard inputs	
• Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 ms)
• at "0" to "1", min.	4 µs
• at "1" to "0", min.	4 µs
Cable length	
Cable length shielded, max.	1000 m; depending on sensor, cable quality and edge slope
Cable length unshielded, max.	600 m; depending on sensor, cable quality and edge slope

	6ES7138-6CG00-0BA0
Digital outputs	
Type of digital output	Transistor
Number of outputs	6
M switching	Yes; with high-speed output
Sourcing	Yes
Digital outputs, configurable	Yes
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	1.7 A with standard output; 0.5 A with high-speed output
Limiting of inductive shutdown voltage to	-0.8 V
Control of a digital input	Yes
Digital output functions, configurable	
Digital output with time stamp	Yes
• Number, max.	6
PWM output	Yes
• Number, max.	6
Digital output with oversampling	Yes
• Number, max.	6
Output switching capacity	
With resistive load, max.	0.5 A; 0.1 A with high-speed output
With lamp load, max.	5 W; 1 W with high-speed output
Load resistance range	
Low limit	48 Ω; 240 Ohm with high-speed output
High limit	12 kΩ
Output voltage	
Type of output voltage	DC
for signal "0", max.	1 V; with high-speed output
for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A; 0.1 A with high-speed output, note derating
for signal "1" permissible range, max.	0.6 A; 0.12 A with high-speed output, note derating
for signal "1" minimum load current	2 mA
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	1 µs; for high-speed output, 5 µs with standard output
"1" to "0", max.	1 µs; for high-speed output, 6 µs with standard output

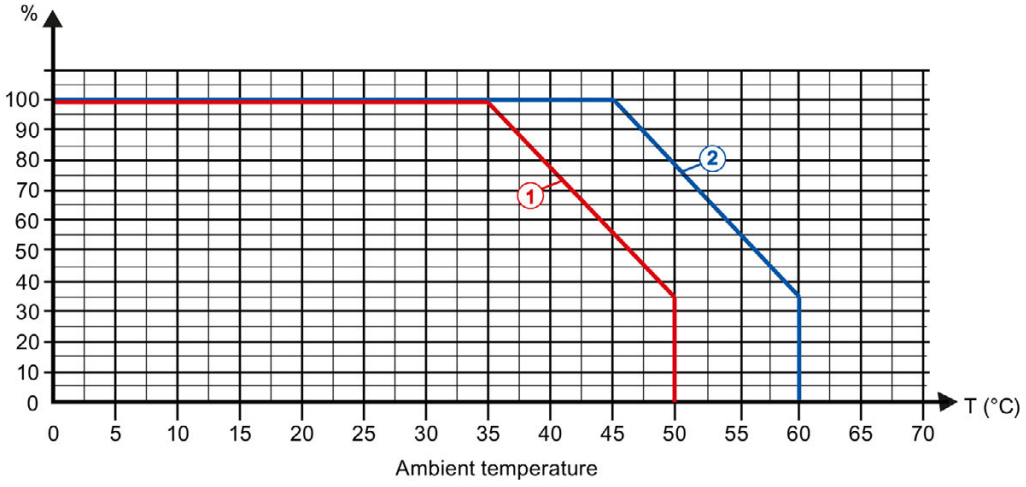
	6ES7138-6CG00-0BA0
Switching frequency	
With resistive load, max.	10 kHz
With lamp load, max.	10 Hz
Total current of outputs	
Max. current per module	3.5 A; note derating
Cable length	
Cable length shielded, max.	1000 m; depending on load and cable quality
Cable length unshielded, max.	600 m; depending on load and cable quality
Encoders	
Supported encoders	
Incremental encoder (asymmetric)	Yes
24 V initiator	Yes
2-wire sensor	Yes
• Permitted quiescent current (2-wire sensor), max.	1.5 mA
Encoder signals, incremental encoders (asymmetrical)	
Input voltage	24 V
Input frequency, max.	50 kHz
Counting frequency, max.	200 kHz; with quadruple evaluation
Cable length shielded, max.	600 m; depends on input frequency, encoder and cable quality; max. 200 m with 50 kHz
Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
Pulse encoder	Yes
24 V encoder signal	
• Permitted voltage at input, min.	-30 V
• Permitted voltage at input, max.	30 V
Interface hardware	
Input characteristics to IEC 61131, Type 3	Yes
Isochronous mode	
Isochronous mode (application synchronized until terminal)	Yes
Bus cycle time (TDP), min.	375 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Activation of substitute values	Yes
Interrupts	
Diagnostic interrupt	Yes
Diagnostic alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Short-circuit	Yes

	6ES7138-6CG00-0BA0
LED diagnostics display	
Monitoring of supply voltage (PWR LED)	Yes, green PWR LED
For module diagnostics	Yes; green / red DIAG LED
Integrated functions	
Number of counters	3
Counting frequency (counters), max.	200 kHz; with quadruple evaluation
Counting functions	
Continuous counting	Yes
Electrical isolation	
Electrical isolation channels	
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Operating temperature	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C; note derating
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; note derating
Distributed operation	
At SIMATIC S7-300	Yes
At SIMATIC S7-400	Yes
At SIMATIC S7-1500	Yes
Dimensions	
Width	15 mm
Weights	
Weight, approx.	45 g

Derating information for standardized total current of outputs

If the digital outputs of the TM Timer DIDQ 10x24V are operated with resistive loads, you should derate the standardized total current of the loads at the outputs of the technology module. The standardized total current is the standardized total of the mean output currents at all digital outputs and encoder supply related to its nominal current in each case.

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position:



① Vertical installation of the system

② Horizontal installation of the system

Figure 6-1 Standardized total current depending on ambient temperature and mounting position for resistive loads

Note

In the following cases, the voltage at the digital inputs and the load current supply L+ must not exceed DC 24 V + 5 %:

- When the system is mounted vertically, as of an ambient temperature of 35 °C
- When the system is mounted horizontally, as of an ambient temperature of 45 °C

Example

The following example shows the calculation of the standardized total current:

Table 6- 1 Calculation of the standardized total current

Digital output	High-speed output (0.1 A)	Output current		
		Nominal value according to parameter assignment	Mean value	Mean value in relation to the nominal value
DQ0	Yes	0.1 A	0.05 A	50 %
DQ1	Yes	0.1 A	0.08 A	80 %
DQ2	No	0.5 A	0.5 A	100 %
DQ3	No	0.5 A	0.1 A	20 %
DQ4	Yes	0.1 A	0.01 A	10 %
DQ5	No	0.5 A	0.15 A	30 %
Encoder supply	—	0.5 A	0.2 A	40 %
Total				330 %
Standardized total current = total / number of outputs = 330 % / 7 outputs				**47 %**

With a standardized total current of 47 % and horizontal mounting of the system, the ambient temperature according to the derating curve may amount to a maximum of approx. 57 °C.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Parameter data record

A

You may edit the module parameters in RUN. The WRREC instruction is used to transfer the parameters to the module using data record 128.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help (TIA Portal).

Structure of data record

The following table shows you the structure of data record 128 for TM Timer DIDQ 10x24V. The values in byte 0 to byte 3 are fixed and may not be changed.

Table A- 1 Parameter data record 128

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Reserved[2]		Major Version = 0		Minor Version = 1			
1	Length of the parameter data = 36							
2	Reserved[2]							
3								
4...7	**Basic parameters**							
4	Reserved[2]				PWM period for the digital outputs:			
					0000_B: 10 ms			
					0001_B: 5 ms			
					0010_B: 2 ms			
					0011_B: 1 ms			
					0100_B: 0.5 ms			
					0101_B: 0.2 ms			
					0110 to 1111_B: Reserved			
5	Reserved[2]					Enable diagnostic interrupt[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10 to 11_B: Reserved	
6	Reserved[2]							
7								

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
8...9	**Channel parameters for DI0**							
8	Reserved[2]		Invert input signal[1]	Reserved[2]	Operating mode of the digital input:			
					0000_B: Timer-DI			
					0001_B: Reserved			
					0010_B: Oversampling			
					0011_B: Counter			
					0100 to 1111_B: Reserved			
9	Reserved[2]				Input delay / Filter frequency:			
					0000_B: None			
					0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101 to 1110_B: Reserved			
					1111_B: 50 kHz			
10...11	**Channel parameters for DI1:** See bytes 8 and 9							
12...13	**Channel parameters for DI2**							
12	Reserved[2]		Invert input signal[1]	HW enable with DI3[1]	Operating mode of the digital input:			
					0000_B: Timer-DI			
					0001_B: Reserved			
					0010_B: Oversampling			
					0011_B: Counter			
					0100_B: Incremental encoder (A, B phase-shifted)			
					0101 to 1111_B: Reserved			
13	Reserved[2]				Input delay / Filter frequency:			
					0000_B: None			
					0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101 to 1110_B: Reserved			
					1111_B: 50 kHz			
14...15	**Channel parameters for DI3**							
14	Reserved[2]		Invert input signal[1]	Reserved[2]	Operating mode of the digital input:			
					0000_B: Timer-DI			
					0001_B: Reserved			
					0010_B: Oversampling			
					0011 to 1111_B: Reserved			

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
15	Reserved[2]				Input delay:			
					0000_B: None			
					0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101 to 1111_B: Reserved			
16...17	**Channel parameters for DQ0**							
16	High-speed output (0.1 A)[1]	Substitute value	Invert output signal[1]	HW enable with next digital input[1]	Operating mode of the digital output:			
					0000 to 0111_B: Reserved			
					1000_B: Timer DQ			
					1001_B: Reserved			
					1010_B: Oversampling			
					1011_B: PWM			
					1100 to 1111_B: Reserved			
17	Reserved[2]							
18...19	**Channel parameters for DQ1:** See bytes 16 and 17							
20...21	**Channel parameters for DQ2:** See bytes 16 and 17							
22...23	**Channel parameters for DQ3**							
22	High-speed output (0.1 A)[1]	Substitute value	Invert output signal[1]	Reserved[2]	Operating mode of the digital output:			
					0000 to 0111_B: Reserved			
					1000_B: Timer DQ			
					1001_B: Reserved			
					1010_B: Oversampling			
					1011_B: PWM			
					1100 to 1111_B: Reserved			
23	Reserved[2]							
24...25	**Channel parameters for DQ4:** See bytes 22 and 23							
26...27	**Channel parameters for DQ5:** See bytes 22 and 23							
28...39	Reserved[2]							

1) You enable a specific parameter by setting the corresponding bit to 1.

2) Must be set to 0.

Counting

The following table shows the properties for counting that you can set in the channel parameters of the respective digital input:

Operating mode for counting	Usable digital inputs	"Invert input signal" set to...	
		0	1
Counter (0011_B)	• DI0 • DI1 • DI2	Counting of **rising** edges	Counting of **falling** edges
Incremental encoder (A, B phase-shifted) (0100_B)	DI2 with DI3 (all bits of the channel parameters for DI3 are set to 0)	Counting direction **not inverted**	Counting direction **inverted**

Hardware enable (HW enable)

You can use a hardware enable by an enable input for the operating modes "Timer DI" and "Timer DQ". You set a hardware enable with bit 4 of the respective channel parameter.

You can set a hardware enable for the following inputs and outputs:

Digital input / digital output	Hardware enable by digital input...
DI2	DI3
DQ0	DI0
DQ1	DI1
DQ2	DI2

You set a hardware enable with the channel parameters of the enable input "Operating mode" and "Invert" signal input:

Operating mode	"Invert input signal" set to...	
	0	1
Oversampling (0010_B)	Hardware enable by **High** level	Hardware enable by **Low** level
Timer DI (0000_B)	When using the SIMOTION control system only	

Input filter

The following overview shows the input filters that can be set for specific operating modes of a digital input:

Table A- 2 Setting options for the input filter

Operating mode of the digital input	Type of input filter	Assignable values
• Timer DI (0000_B) • Oversampling (0010_B)	Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms
• Counter (0011_B) • Incremental encoder (A, B phase-shifted) (0100_B)	Filter frequency	50 kHz (cannot be changed)

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* @file splay_tree_.hpp
* Contains an implementation class for splay_tree_.
*/
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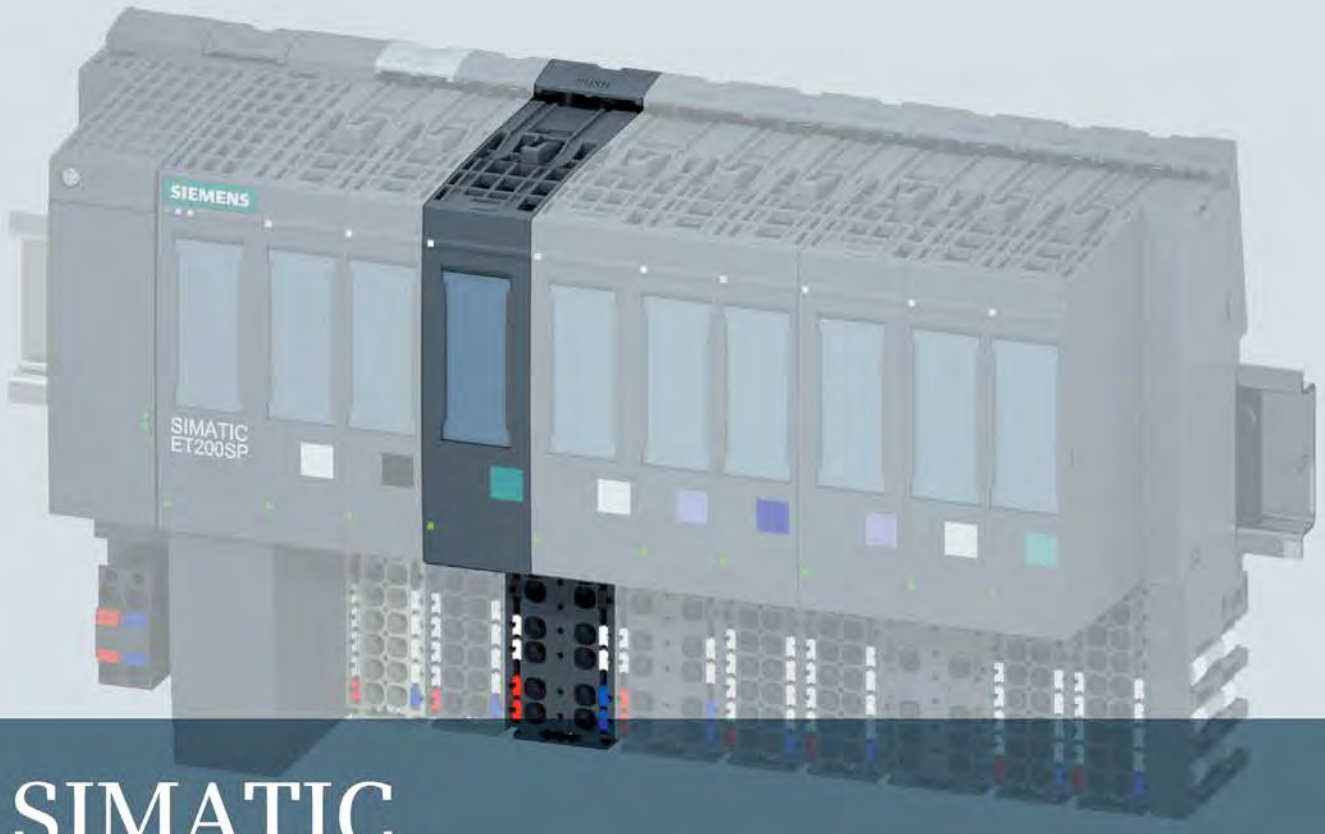

SIMATIC

ET 200SP

Technology Module TM Pulse 2x24V (6ES7138-6DB00-0BB1)

Manual

Version 09/2015

Answers for industry.

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ET 200SP
Technology module TM Pulse 2x24V (6ES7138-6DB00-0BB1)

Manual

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding the design and commissioning of the ET 200SP is available in the ET 200SP system manual.

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Documentation guide

1

Introduction

This modular documentation of a SIMATIC product covers automation system topics.

The complete documentation for the ET 200SP system consists of the respective system manuals, function manuals, and device manuals.

The STEP 7 information system (TIA Portal online Help) also helps you configure and program your automation system.

Overview of the documentation for TM Pulse 2x24V technology module

The following table lists further documentation that you will need when using the TM Pulse 2x24V technology module.

Table 1- 1 Documentation for TM Pulse 2x24V technology module

Topic	Documentation	Most important contents
System description	System manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/mdm/58649293?c=76156021003&t=1&s=BaseUnit&lc=en-US)	• Application planning • Installation • Connecting • Commissioning
	Device manuals Interface Module (https://support.industry.siemens.com/cs/products?dtp=Manual&pnid=14034&lc=en-US)	• Connecting • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimension drawing
	Device manual for the ET 200SP BaseUnit 6ES7-193-6B20-0BB1 compatible with the TM Pulse 2x24V module. ET 200SP BaseUnits (https://support.industry.siemens.com/cs/mdm/59753521?c=72851856267&t=1&s=ET 200SP BaseUnit&lc=en-US)	Technical specifications

Topic	Documentation	Most important contents
Configuring interference-free controllers	SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL Designing interference-free controllers (https://support.industry.siemens.com/cs/mdm/59193566?t=1&s=Designing interference free controllers function manual&lc=en-US) Function Manual	• Basics • Electromagnetic compatibility • Lightning protection
Isochronous mode	SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/mdm/49948856?c=73850691339&t=1&s=PROFINET with STEP 7 V13 SP1&lc=en-US) Function manual	• Benefits • Use • Parameter settings

SIMATIC manuals

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Product overview

2

2.1 Properties

Article number

6ES7138-6DB00-0BB1

View of the module

Figure 2-1 View of the TM Pulse 2x24V module

Properties

The TM Pulse 2x24V technology module has the following properties:

- 2 pulse output channels with up to 2 A output current per channel
  - One-channel operation: The two channels are merged together into one logical channel and are connected in parallel to generate pulse signals with up to 4 A output current.
  - Two-channel operation: The two channels can work independently of each other.
- Programmable pulse timing.

Pulse timing	Minimum		Maximum	
	High-speed disabled	High-speed enabled	High-speed disabled	High-speed enabled
Pulse duration	10 µs [1]	1.5 µs [1]	85,000,000 µs (85 s)	
Period duration	100 µs	10 µs		
On-delay	0 µs			
Off-delay				
Frequency	0.02 Hz		10 kHz	100 kHz

[1] A smaller value is possible but not guaranteed for Pulse train, PWM, On/Off-delay, and DC motor modes

Parallel mode	Maximum pulse output current	
	High-speed disabled	High-speed enabled
Disabled	2 A (two channels)	100 mA (two channels)
Enabled	4 A (one channel)	Not allowed

- You can configure DI0.0 (Channel 0) and DI1.0 (Channel 1) digital inputs as hardware enable inputs that start the output pulse sequence, or as inputs directly usable by your program and independent of the pulse generation. In DC motor mode, you can stop the motor by using the digital inputs for external stop control.
- If you configure one channel 4 A operation, the two output channels are connected in parallel. Only Channel 0 is parameterized to control the parallel connection and only DI0.0 is available as a digital input/hardware enable.
- Each channel's digital output provides two load connections:
  - All modes except DC motor mode use a single unipolar output connection (DQn.A).
  - In DC motor, connect a load between the bipolar output connections (DQn.A and DQn.B). For example, a channel output can drive a DC motor in both directions by reversing the voltage polarity. Note that not all functions are available in DC motor mode; for example, current measurement and current control are not allowed.
- Digital outputs have integrated protection diodes to prevent voltage overstress due to inductive kickback. No external protection diodes are required for inductive loads.

Operating modes

- Pulse output: output a single pulse with variable pulse duration and On-delay.
- Pulse width modulation (PWM):
  - Output a frequency with a defined period duration and variable ratio of pulse width to period duration (duty cycle).
  - PWM can vary current in the driven loads. You can use PWM mode to control temperature in a heating resistor or the force from a coil in a proportional valve.
- Pulse train: output a train of pulses with an assigned pulse quantity, period duration, ratio of pulse width to period duration (duty cycle), and On-delay.
- On/Off-delay: the pulse output follows the signal at the DIn.0 digital input after an assigned On-delay and Off-delay.
- Frequency output: output pulses at a variable frequency with a fixed pulse width to pulse period duty cycle of 50%.
- DC motor: drive a motor in both directions with a bipolar PWM output. You can assign a digital input as an "External stop" signal, for the motor.

Functions

- Sequence counter: count completed output sequences and provide a feedback signal. The sequence counter can count short output sequences that are too fast for your program to monitor. For example, the counter is useful when the output sequence is faster than your program's cycle time and the output sequence is triggered by the DI digital input. The sequence counter is limited to 4 bits (count range 0 to 15).
- The sequence counter is available only for:
  - Pulse output and Pulse train modes.
    Without hardware enable, the counter is set to 1 after completion of the output sequence.
    With hardware enable, the counter is incremented after every completed output sequence.
  - On/Off-delay mode.
    The counter is incremented with each positive and negative edge at the DQn.A digital output.
- Current measurement: for Pulse train and PWM modes.
- Current control: PID loop control for proportional current control in PWM mode.
- Dithering: superimpose a dither signal on the PWM output to prevent valve sticking and improve proportional valve control.
- Direct control of the digital output by your control program.

- Programmable output response to CPU/master STOP condition.
- Error detection and diagnostics:
  - Missing or under voltage L+ supply voltage
  - Short-circuit/overload of a digital output
  - Short-circuit/under voltage of a sensor power supply
  - Over temperature error
  - Parameterization fault
  - Module/firmware error

Configuration

TM Pulse 2x24V configuration software options:

- TIA Portal V13 + SP1 with HSP 0131 (Hardware Support Package from the Internet)
- STEP 7 version V5.5 + SP4 with HSP 0240
- GSD file links:
  - PROFIBUS GSD files (https://support.industry.siemens.com/cs/document/73016883?dti=0&lc=en-US)
  - PROFINET GSD files (https://support.industry.siemens.com/cs/document/57138621?dti=0&lc=en-US)

Firmware update

Firmware updates can be downloaded to the memory of the TM Pulse 2x24V module by means of the STEP 7 TIA Portal software or the HW Config software.

Accessories

The following accessories can be used with the module and are not included in the product package:

- Labeling strip
- Color identification labels
- Reference identification labels

A BaseUnit of the B1 type is required to operate the technology module. For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/document/73021864?dti=0&lc=en-US).

For detailed information on the installation procedure, refer to the system manual for the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/document/58649293?dti=0&lc=en-US).

Modes and Functions

3

3.1 Overview

Modes and functions

The TM Pulse 2x24V has two channels. You can assign a different mode for each channel.

Configuration of the operating mode is made using the TIA Portal or HW Config.

You can select one of six operating modes:

- Pulse output (single pulse)
- PWM
- Pulse train
- On/Off-delay
- Frequency output
- DC motor (PWM: forward and reverse rotation)

In addition to the operating mode, the TM Pulse 2x24V has the following functions:

- If enabled, the high-speed output option lets you generate a 1.5 µs minimum pulse duration at a current of 100 mA and a non-high-speed mode (high-speed mode disabled) with a minimum pulse duration of 10 µs and a maximum current of 2 A (two channels) or 4 A (one channel).
- The Sequence counter counts completed output sequences and provides a feedback signal.
- Current measurement for PWM and Pulse train modes
- Current control for the output current in PWM mode
- Dithering: superimpose a dithering signal on the PWM output to improve proportional valve control.
- You can directly control digital outputs with your control program, with separate control for each channel.
- Parallel connection of both channels creates one logical channel that can drive a 4 A output current.
- You can configure the response to CPU/master STOP. The outputs are put in the state that you assign for the control program STOP condition.

- The TM Pulse 2x24V provides module diagnostics and channel error detection.

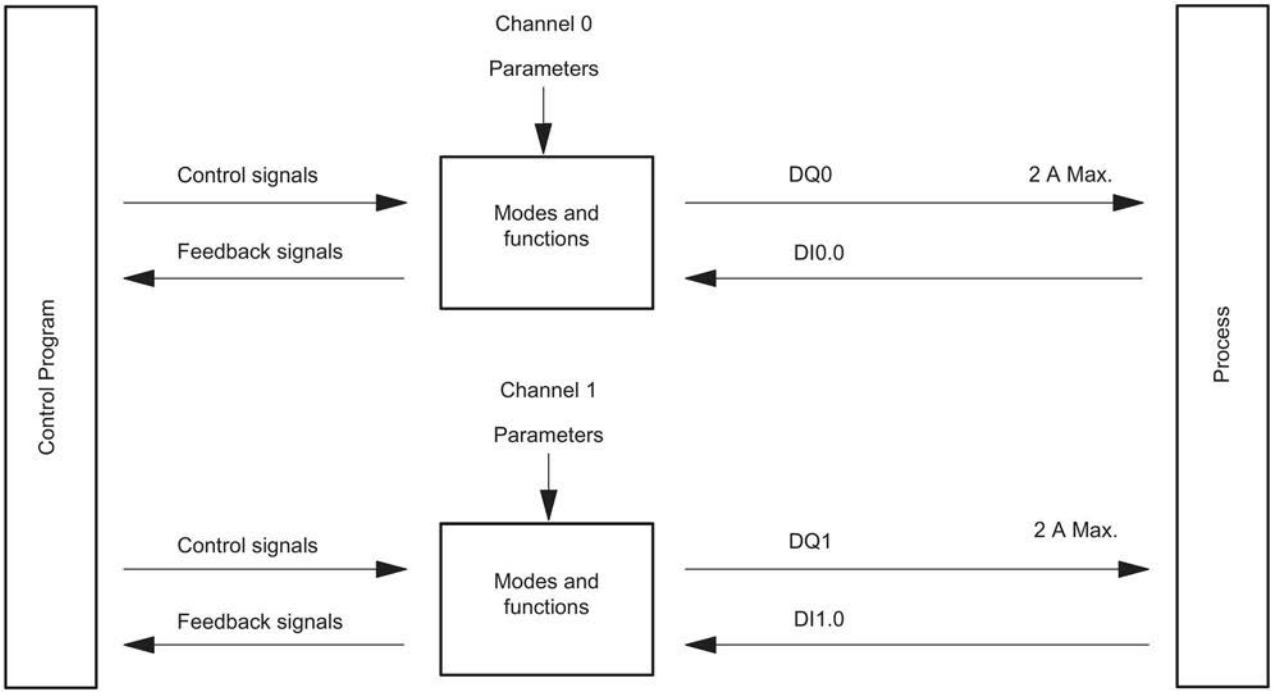


Figure 3-1 Dual channel operation

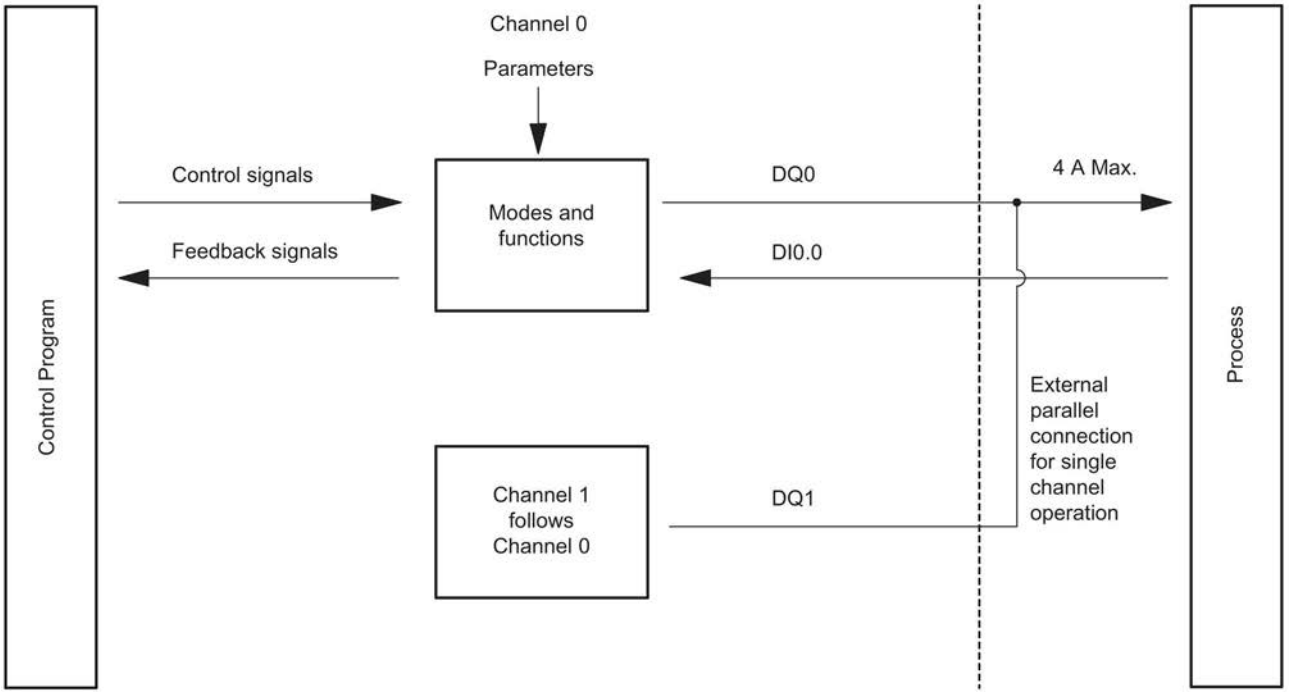


Figure 3-2 Single channel operation

Interfaces to the control program and the process under control

The TM Pulse 2x24V has the following I/O BaseUnit pin connections to the process under control:

Channel 0:

- DI0.0 (digital input 0)
- DQ0.A and DQ0.B (digital output 0)
  - Two connections are provided for each channel output (DQ0.A and DQ0.B). Load wiring depends on a channel's mode assignment.

Channel 1:

- DI1.0 (digital input 1)
- DQ1.A and DQ1.B (digital output 1)

You can find a table of configuration parameters in the "Parameter assignment and structure of the parameter data records (Page 138)" section.

You can modify and monitor the modes and functions with your control program using control and feedback signals. These parameters are listed in the "Control and feedback interface (Page 110)" section.

You will find the following in the "Modes and functions" section:

- Operation descriptions
- The relevant parameters
- The relevant control and feedback signals

The "Description of operations" for modes and functions applies to both channels. The terms DIn.0, DQn.A, and DQn.B are used in descriptions that are true for both channels.

3.2 Pulse output (single pulse) mode

Definition

After the assigned On-delay time expires, the TM Pulse 2x24V outputs a pulse at the DQn.A digital output (output sequence) for the pulse duration that you set.

Pulse diagram

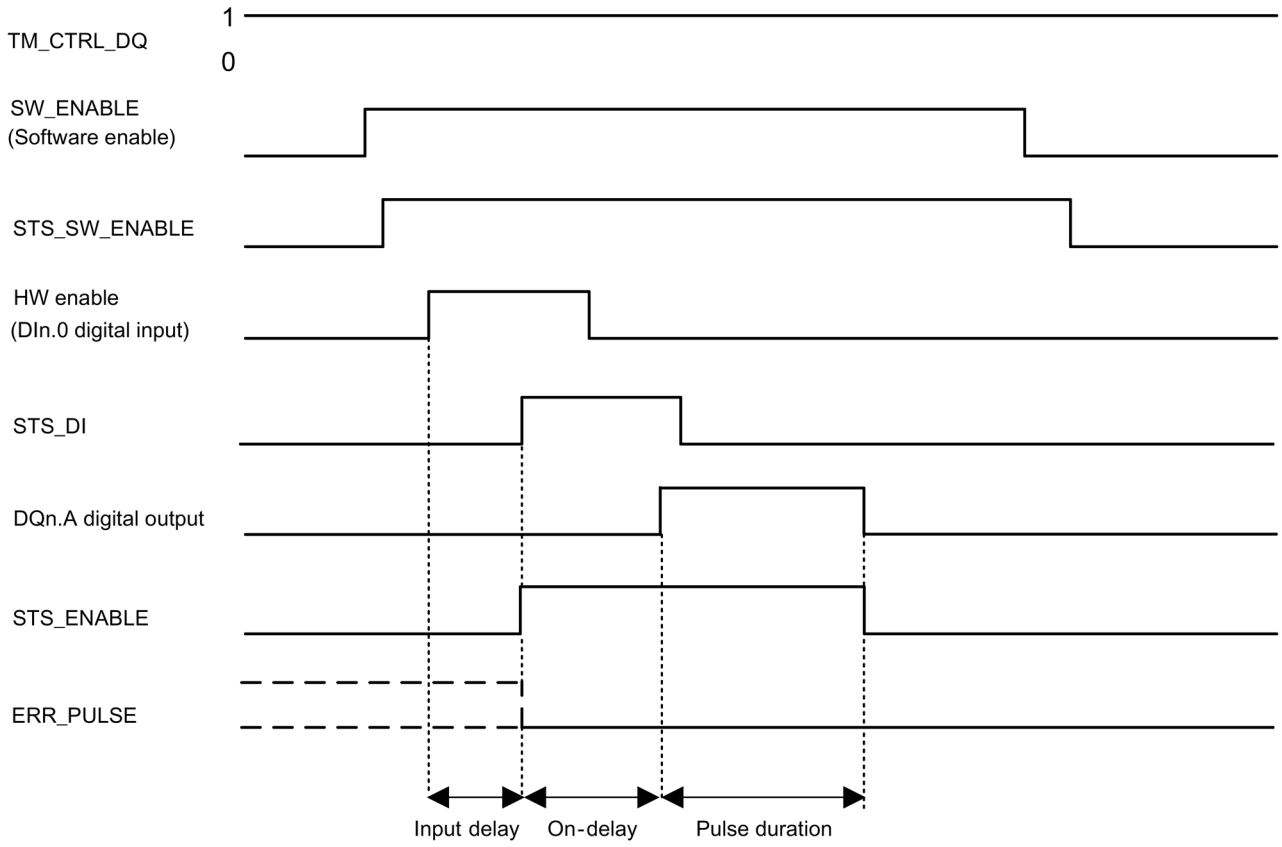


Figure 3-3 Pulse output mode output sequence using optional HW enable signal to start the output sequence

The timing diagram above has the "Function DI" parameter set to "HW enable". The other option is to set "Function DI" to "Input". If the "Function DI" parameter is set to "Input", then the On-delay phase starts at the rising edge of SW_ENABLE.

Starting the output sequence

Your control program must issue the enable for the output sequence, using the software enable (SW_ENABLE 0 → 1).

The STS_SW_ENABLE feedback bit indicates that a software enable is pending in the TM Pulse 2x24V.

You can also set the DIn.0 digital input of a TM Pulse 2x24V channel to be a hardware enable (HW enable) with the "Function DI" parameter. The input delay (noise filter) of the hardware enable can be set using the "Input delay" parameter.

If you want to use the hardware enable, it has to be combined with the software enable. When the software enable has been enabled, the output sequence starts at the first positive edge of the hardware enable. Further positive edges of the hardware enable during the current output sequence are ignored. When the HW enable goes high (positive edge) and remains high for the input delay time, the On-delay is started and the STS_ENABLE is set. After the On-delay expires, the pulse is output with the assigned pulse duration. The output sequence finishes with the end of the pulse and STS_ENABLE is cleared.

If you reduce the pulse duration to a time that has already expired, then the ERR_PULSE signal indicates a pulse output error and the output sequence stops. To resume the pulse output, you must restart the output sequence after an ERR_PULSE error occurs. The next time the output sequence starts, TM Pulse 2x24V clears the ERR_PULSE feedback bit.

Note

TM_CTRL_DQ technology module output control signal

- If TM_CTRL_DQ = 1, then the TM Pulse 2x24V module has control and produces pulse sequences at the DQn.A outputs.
- If TM_CTRL_DQ = 0, then the CPU has control and your program can set DQn.A/DQn.B outputs directly with the SET_DQA/SET_DQB control bits.

Canceling the output sequence

Disabling the software enable (SW_ENABLE = 1 → 0) cancels the current output sequence and the last period duration is not completed. STS_ENABLE and the DQn.A digital output are immediately reset to 0.

You must restart the output sequence to begin new pulse output.

Truth Table

Software enable SW_ENABLE	Function DI parameter	Hardware enable (DIn.0 digital input)	DQn.A digital output (when TM_CTRL_DQ = 1)	STS_ENABLE	Output Sequence
1	HW_ENABLE	0 → 1 and remains 1 during the input delay. Only active for the first positive edge, additional positive edges are ignored and no start occurs.	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0 → 1	Input	Not used	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0	HW_ENABLE or Input	Any status	0	0	Terminate
1	HW_ENABLE or Input	Any status	0, if On-delay is not expired or if the pulse duration is expired. 1, if On-delay is expired and pulse duration is not expired.		-
0 → 1	HW_ENABLE	0	0	0	-

Setting and changing the pulse duration

Your control program can set the pulse duration directly with the control interface field OUTPUT_VALUE as a DWord number value in microseconds:

- High-speed output enabled, from 2 µs to 85,000,000 µs
- High-speed output disabled, from 10 µs to 85,000,000 µs

If you change the pulse duration when an output sequence is running, the pulse time already elapsed is subtracted from the new pulse duration and the pulse output continues.

Reducing the pulse duration

If you have reduced the pulse duration to a time that is less than the pulse time already elapsed, then the output sequence is terminated. STS_ENABLE and the DQn.A digital output are cleared, and the ERR_PULSE status bit is set. At the next output sequence, the ERR_PULSE status bit is cleared.

Setting and changing the On-delay

- **Permanent update**

  The On-delay can be controlled permanently using the control interface. The MODE_SLOT bit has to be 1 (permanent-update); LD_SLOT must have the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the control interface field SLOT.

- **Single Update**

  Set the On-delay as a value between 0 µs and 85,000,000 µs in the configuration parameters. Alternatively, you can do a single update using the control interface. MODE_SLOT has to be 0 (single-update); LD_SLOT has to have the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the control interface field SLOT.

If you change the On-delay value during the output sequence, then the new On-delay is activated on the next output sequence.

For more details about the use of the SLOT value, see SLOT parameter handling (Page 113)

Using the Sequence counter

The Sequence counter counts completed pulse output sequences and provides the count value variable SEQ_CNT in the feedback interface. The sequence counter can count short output sequences that are too fast to be monitored by your program. See Sequence counter (Page 75) for details.

Isochronous mode

General information is available in Function: Isochronous mode (Page 86).

Isochronous mode does not have any influence on the functionality of Pulse output operating mode.

If you want to synchronize the output sequence with T_o, then set the Function DI parameter to "Input" and the Pulse output sequence starts at T_o.

Pulse output parameters

Pulse output parameter	Meaning	Value Range	Default
Mode	0 = Set the Pulse output operating mode.	0 = Pulse output 1 = Pulse width modulation 2 = Pulse train 3 = On/Off-delay 4 = Frequency output 5 = DC Motor	1
High-speed output [1]	The output supports higher frequencies at smaller loads when enabled.	0 = Disabled 1 = Enabled	Disabled
Function DI	You can use the DIn.0 digital input as an input or as a hardware enable. The signal at DIn.0 is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay, as the start of the output sequence.	0 = Input 1 = HW enable	Input
Input delay	DIn.0: a digital input must be stable over the delay time (signal noise suppression).	0 = Off (4 µs) 1 = 0.05 ms 2 = 0.1 ms 3 = 0.4 ms 4 = 0.8 ms 5 = 1.6 ms 6 = 3.2 ms 7 = 12.8 ms 8 = 20 ms	0.1 ms
On-delay	The time from the start of the output sequence to the output of the pulse. You can change the On-delay in your control program using the SLOT parameter.	0 µs to 85,000,000 µs	0 µs

[1] Only if the module is configured as "2 channels (2 A)"

Control and feedback signals for Pulse output mode

Control interface: Offset to the start address		**Parameter**	**Meaning**				
Channel 0	**Channel 1** [1]						
Bytes 0 to 3	Bytes 12 to 15	OUTPUT_VALUE (DWord)	Pulse duration: the time that the DQn.A digital output remains set after the On-delay time expires. If you violate the lower or upper limit of the range, then ERR_OUT_VAL is returned in the feedback interface and the last valid value is used.				
			High-speed output disabled:				**High-speed output enabled:**
			10 µs to 85,000,000 µs				2 µs to 85,000,000 µs
Bytes 4 to 7	Bytes 16 to 19	SLOT (DWord)	The On-delay can be changed before the start of the output sequence. See MODE_SLOT.				
			0 µs to 85,000,000 µs				
Byte 8	Byte 20	LD_SLOT	Interpretation of the value SLOT: all other values not listed below are invalid and produce the error ERR_LD (in single-update mode) or ERR_SLOT_VAL (in permanent-update mode).				
			Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
			0	0	0	0	Idle state; nothing is done with the value
			0	0	1	0	On-delay in µs
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT	**Bit 4**	Mode for use of the field SLOT.			
			0	Single-update mode			
			1	Permanent-update mode			
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE	**Bit 0**	Software enable: Start/enable and terminate/disable the output sequence.			
			0	Output disabled/terminated			
			0 → 1	Starts output sequence on positive edge when "Function DI" = "Input"			
			1	Enable output sequence, when start is dependent on HW enable with "Function DI" = "HW enable"			
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ	**Bit 1**	Set DQn.A output source: Select either CPU program or module's output sequence.			
			0	DQn.A and DQn.B are controlled by the CPU (your program logic) using the SET_DQA and SET_DQB control bits.			
			1	DQn.A is controlled by the module's pulse output sequence. DQn.B is always 0.			
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQA	**Bit 3**	Controls the value of the digital output DQn.A, if TM_CTRL_DQ is cleared.			
			0	0 on DQn.A			
			1	1 on DQn.A			
Byte 9: Bit 4	Byte 21: Bit 4	SET_DQB	**Bit 4**	Controls the value of the digital output DQn.B, if TM_CTRL_DQ and SET_DQA are cleared.			
			0	0 on DQn.B			
			1	1 on DQn.B			
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR	**Bit 0**	Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V).			
			0	Reset of errors is not active			
			1	Reset of errors is active			

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)".

Note: All bytes and bits not described in the table above are reserved and should be 0.

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1[1]			
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR	**Bit 0**	Indicates under voltage on the Power supply. Note that the bit is not set if the voltage is not present.
			0	PWR is not under voltage
			1	PWR is detected, but under voltage
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V	**Bit 1**	Indicates a short-circuit or overload on the output 24 V DC. You must set the RES_ERROR (control interface) to reset this error.
			0	No short-circuit on 24 V DC
			1	Short-circuit on 24 V DC
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD	**Bit 2**	Indicates an error while loading a value using the field SLOT (only in "single-update" SLOT mode).
			0	No load error pending.
			1	Load error pending: you must set the RES_ERROR (control interface) to reset this error and be able to use the SLOT again.
Byte 0: Bit 3	Byte 8: Bit 3	ERR_PULSE	**Bit 3**	Indicates a pulse output error.
			0	No pulse output error
			1	Pulse output error
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	**Bit 4**	Indicates a short-circuit on the output DQn.B. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.A
			1	Short-circuit on DQn.A
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	**Bit 5**	Indicates a short-circuit on the output DQn.B or an attempt to set both DQs manually using SET_DQA, SET_DQB, and TM_CTRL_DQ. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.B
			1	Short-circuit on DQn.B, or attempt to set both DQn.A and DQn.B
Byte 0: Bit 6	Byte 8: Bit 6	ERR_OUT_VAL	**Bit 6**	Indicates that an invalid value is detected in OUTPUT_VALUE.
			0	OUTPUT_VALUE is valid.
			1	OUTPUT_VALUE is not valid. This bit is reset automatically when a valid value is read by the module.
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL	**Bit 7**	Indicates that an invalid value is detected in SLOT (only in "permanent-update" SLOT mode).
			0	SLOT value is valid.
			0 → 1	SLOT value is not valid. This bit is reset automatically when a valid value is read by the module.
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT	**Bit 2**	Toggle acknowledge bit for each action of the SLOT in "single-update" SLOT mode. Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY	**Bit 4**	Indicates the module is ready and parameterized.
			0	Module is not parameterized
			1	Module is parameterized
Byte 1: Bit 5	Byte 9: Bit 5	STS_SW_ENABLE	**Bit 5**	Indicates the status of SW_ENABLE (control interface).
			0	SW_ENABLE cleared
			1	SW_ENABLE set
Byte 2: Bit 0	Byte 8: Bit 0	STS_ENABLE	**Bit 0**	Indicates an output sequence is running.
			0	Output sequence not running
			1	Output sequence running

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1[1]**			
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA	**Bit 1**	Indicates the signal level at the DQn.A digital output.
			0	0 on DQn.A digital output
			1	1 on DQn.A digital output
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB	**Bit 2**	Indicates the signal level at the DQn.B digital output.
			0	0 on DQn.B digital output
			1	1 on DQn.B digital output
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI	**Bit 3**	Indicates the signal level at the DIn.0 digital input.
			0	0 on DIn.0 digital input
			1	1 on DIn.0 digital input
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT	Sequence counter is incremented after completion of an output sequence	
			With SW_ENABLE: 0 to 1	
			With HW enable: 0 to 15	
Word 3	Word 7	Reserved	Read as 0	

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)".

Note: All bytes and bits not described in the table above are reserved and are read as 0.

Input and output signals for Pulse output mode

Input and output signals	Meaning	Value range	Channel 0 BaseUnit pin number	Channel 1 BaseUnit pin number
Input signal				
HW enable	You can select the HW enable with the "Function DI" parameter and select the input delay with the "Input delay" parameter. The signal at DIn.0 is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay, as the start of the output sequence.	0 = HW enable cleared 1 = HW enable issued 0 → 1 = Start of the output sequence after the input delay, dependent on the software enable (SW_ENABLE)	3	4
Output signal				
Pulse at the DQn.A digital output	A pulse is output at the DQn.A digital output for the set pulse duration.	0 = no pulse 1 = pulse	9	10

See also Pin assignment and load/sensor wiring (Page 91)

3.3 Pulse width modulation (PWM) mode

Definition

You control the pulse width duty cycle with the control interface field OUTPUT_VALUE. The TM Pulse 2x24V generates continuous pulses based on this value. The OUTPUT_VALUE control interface field determines the duty cycle (pulse duration/period duration) for PWM. The period duration can be adjusted.

After expiration of the assigned On-delay, the DQn.A output pulses begin (output sequence).

In PWM mode, you can enable current control using the internal PID loop function to control the output load current. When the current control option is enabled, the TM Pulse 2x24V control of the duty cycle and the OUTPUT_VALUE control interface field is used to assign the target current as the ratio of target current/reference current.

Pulse diagram

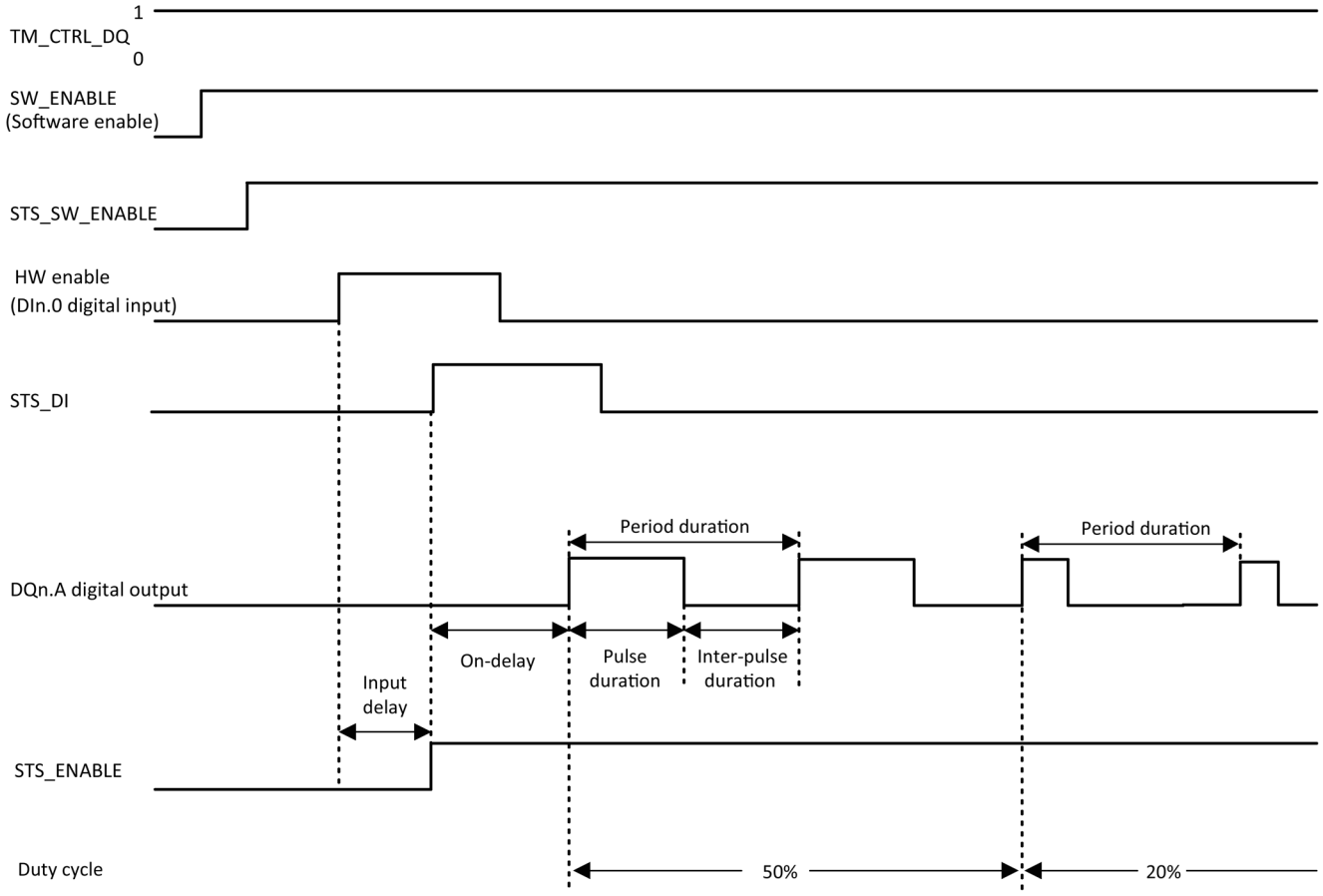


Figure 3-4 PWM output sequence

The timing diagram above has the "Function DI" parameter set to "HW_ENABLE". The other option is to set "Function DI" to "Input". If the "Function DI" parameter is set to "Input", then the On-delay phase starts at the rising edge of SW_ENABLE.

Starting the output sequence

Your control program must issue the enable for the output sequence, using the software enable (SW_ENABLE 0 → 1).

The STS_SW_ENABLE feedback bit indicates the software enable pending at the TM Pulse 2x24V.

You can also assign the DIn.0 digital input of the TM Pulse 2x24V as a HW enable with the "Function DI" parameter. The input delay (noise filter) of the hardware enable can be set using the parameter "Input Delay".

If you want to use the hardware enable, it has to be combined with the software enable. When the software enable has been enabled, the output sequence starts at the first positive edge of the hardware enable. Further positive edges of the hardware enable during the current output sequence are ignored by the TM Pulse 2x24V. The hardware enable option is not supported for isochronous mode.

When the enable is issued (positive edge) and remains high for the input delay time, the On-delay is started and the STS_ENABLE set. The PWM pulse train is output on expiration of the On-delay. The output sequence runs continuously as long as SW_ENABLE is set.

Note

Technology Module TM_CTRL output control signal

- If TM_CTRL_DQ = 1, then the TM Pulse 2x24V module has control and produces pulse sequences at the DQn.A outputs.
- If TM_CTRL_DQ = 0, then the CPU has control and your program can set DQn.A/DQn.B outputs directly with the SET_DQA/SET_DQB control bits.

Canceling the output sequence

Disabling the software enable (SW_ENABLE = 1 → 0) cancels the current output sequence and the last period duration is not completed. STS_ENABLE and the DQn.A digital output are immediately reset to 0.

You must restart the output sequence to begin new pulse output.

Truth table

Software enable SW_ENABLE	Function DI parameter	Hardware enable (DIn.0 digital input)	Digital output DQn.A (when TM_CTRL_DQ = 1)	STS_ENABLE	Output sequence
1	HW_ENABLE	0 → 1 and remains 1 during the input delay. Only active for the first positive edge, additional positive edges are ignored and no start occurs.	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0 → 1	Input	Not used	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0	HW_ENABLE or Input	Any state	0	0	Terminate

Software enable SW_ENABLE	Function DI parameter	Hardware enable (DIn.0 digital input)	Digital output DQn.A (when TM_CTRL_DQ = 1)	STS_ENABLE	Output sequence
1	HW_ENABLE or Input	Any state	0, if On-delay is not expired or you are in the interpulse time 1, if On-delay is expired and during the pulse duration		-
0 → 1	HW_ENABLE	0	0	0	-

Minimum pulse duration and minimum interpulse duration

The minimum pulse duration and minimum interpulse duration are superimposed on the proportional output characteristic.

You assign the minimum pulse duration and minimum interpulse duration using the "Minimum pulse duration" parameter; they always have the same value.

- A pulse duration calculated by the TM Pulse 2x24V that is shorter than the minimum pulse duration is suppressed.
- A pulse duration calculated by the TM Pulse 2x24V that is longer than the period duration minus the minimum interpulse duration is set to the period duration value (duty cycle 1,000‰).

Note

PWM current control and minimum pulse duration

If current control is activated by the current control bit in the parametrization record, then the parametrized minimum pulse duration and minimum interpulse period are ignored.

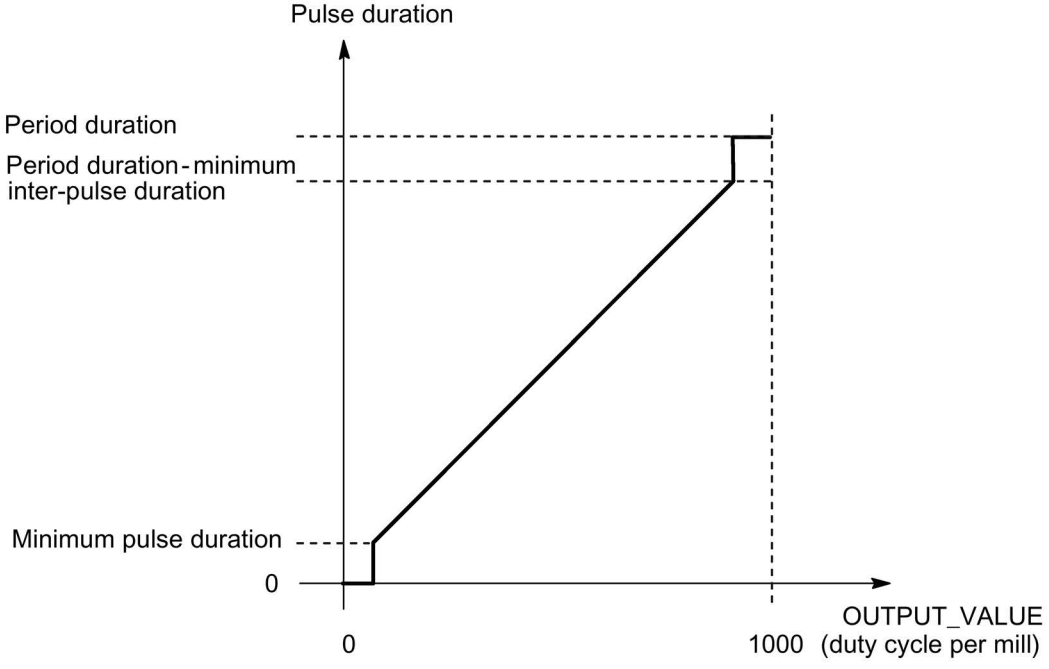


Figure 3-5 Modulation of the Pulse duration

Note

If Dithering is activated without current control, then the minimum pulse duration and minimum inter-pulse period are used by the module. In this case, the superimposed Dithering is reduced so the effective pulse duration fits in the allowed range.

Setting and changing the pulse duty cycle

OUTPUT_VALUE assigns the duty cycle for the current period duration. You select the range of the OUTPUT_VALUE control interface field with the "Output format" parameter.

- "Per 100 (%)" output format: Value range between 0 and 100
  Pulse duration = (OUTPUT_VALUE/100) x period duration.
- "Per 1,000 (‰)" output format: Value range between 0 and 1,000
  Pulse duration = (OUTPUT_VALUE/1,000) x period duration.
- "Per 10,000" output format: Value range between 0 and 10,000
  Pulse duration = (OUTPUT_VALUE/10,000) x period duration.
- "S7 analog output" output format: Value range between 0 and 27,648
  Pulse duration = (OUTPUT_VALUE/27,648) x period duration.

You assign OUTPUT_VALUE directly with your control program. A new OUTPUT_VALUE is applied at the next rising edge of the output.

When the current control option is enabled, the TM Pulse 2x24V module takes control of the duty cycle and the OUTPUT_VALUE control interface field is used to assign the target current as a ratio of target current/reference current. See the Current control (Page 78) function for details.

Setting and changing the period duration

- Permanent update
  The period duration is controlled permanently using the control interface. The MODE_SLOT bit has to be set ("1" means permanent update); LD_SLOT has to have the value 1 ("1" means Period duration).
  Set the period value in the field SLOT. The unit is always microseconds.
  - High-speed output **enabled**: between 10 µs and 85,000,000 µs in the field SLOT.
  - High- speed output **disabled**: between 100 µs and 85,000,000 µs in the field SLOT.
- Single Update
  Set the period duration in the configuration parameters. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared ("0" means single-update); LD_SLOT has to have the value 1 ('1' means Period duration). Set the period duration value in the field SLOT. The unit is always microseconds.
  - High-speed output **enabled**: between 10 µs and 85,000,000 µs in the parameters.
  - High-speed output **disabled**: between 100 µs and 85,000,000 µs in the parameters.

The new period duration is applied with the next rising edge of the output.

For more details about SLOT parameter handling, see "Slot parameter handling (control interface) (Page 113)".

Isochronous mode

General information is available in the "Function: Isochronous mode (Page 86)" topic.

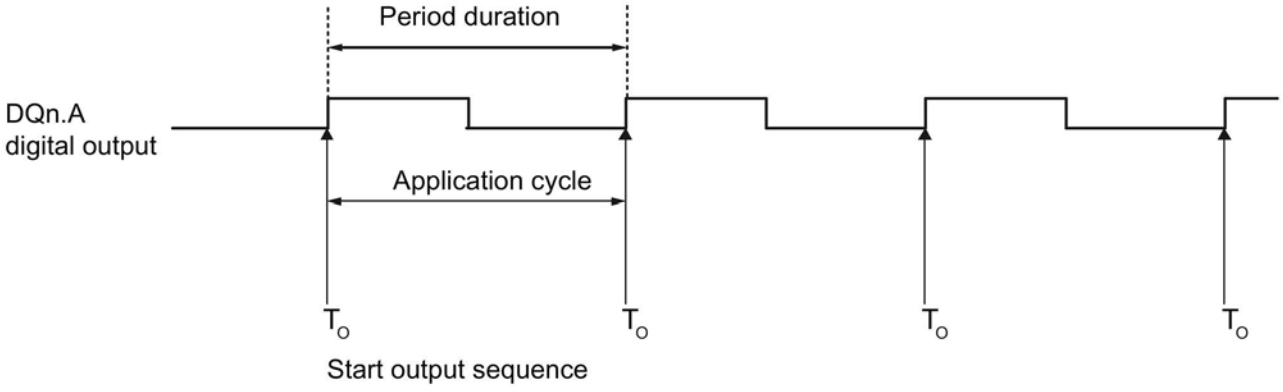
In isochronous mode, the output sequence is synchronized with the moment T_O. The period duration is coordinated to the application cycle (the synchronous cycle, a multiple of the PROFINET cycle). It is possible that your assigned period duration cannot be implemented exactly. The configured value of the period duration is adjusted by the TM Pulse 2x24V to the application cycle based on a calculation algorithm. The calculation is performed to minimize the difference between the assigned and calculated period duration. In the most unfavorable case, the deviation amounts to half the application cycle. The table below shows examples.

Application cycle T_{CAC} [1]	Assigned period duration $T_{Setpoint}$	$T_{CAC} \setminus T_{Actual}$	Calculated actual period duration T_{Actual} [1]	
10 ms (10000 µs)	5000 µs	2:1	5000 µs	
10 ms (10000 µs)	2000 µs	5:1	2000 µs	
10 ms (10000 µs)	3000 µs	3:1	3333 µs	Next possible value is used as actual value
10 ms (10000 µs)	1800 µs	6:1	1666 µs	Next possible value is used as actual value
10 ms (10000 µs)	6000 µs	2:1	5000 µs	Next possible value is used as actual value
10 ms (10000 µs)	12000 µs	1:1	10000 µs	Next possible value is used as actual value
10 ms (10000 µs)	16000 µs	1:2	20000 µs	Next possible value is used as actual value
10 ms (10000 µs)	26000 µs	1:3	30000 µs	Next possible value is used as actual value

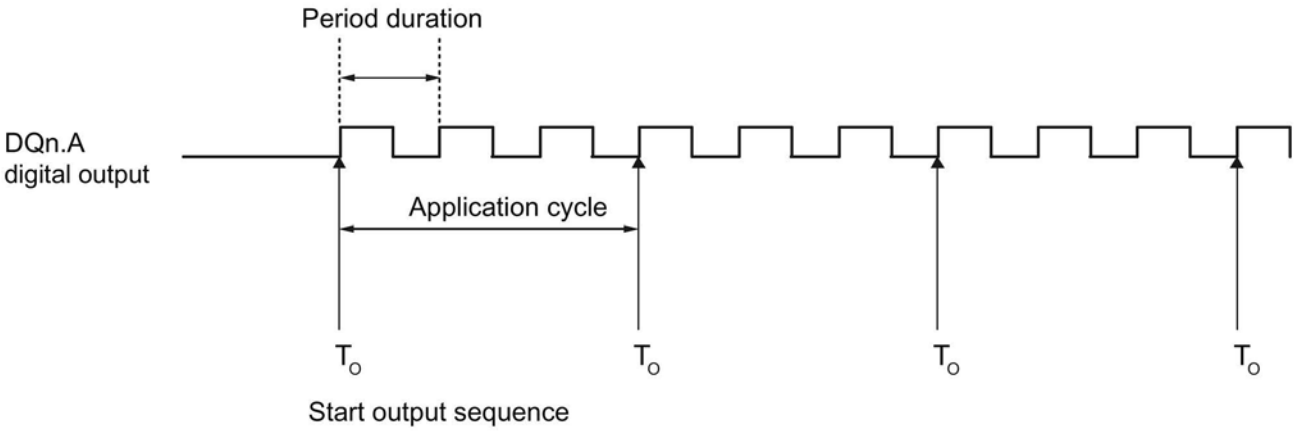
[1] The calculated actual period duration and the application cycle time always have an integer ratio (1:1, 1:2, 1:3, ..., 2:1, 3:1, ...) rounded down to the next possible value.

The timing between the digital output and the application cycle is shown below. The DQ duty cycle (On/Off) ratio is shown in the examples at 50%.

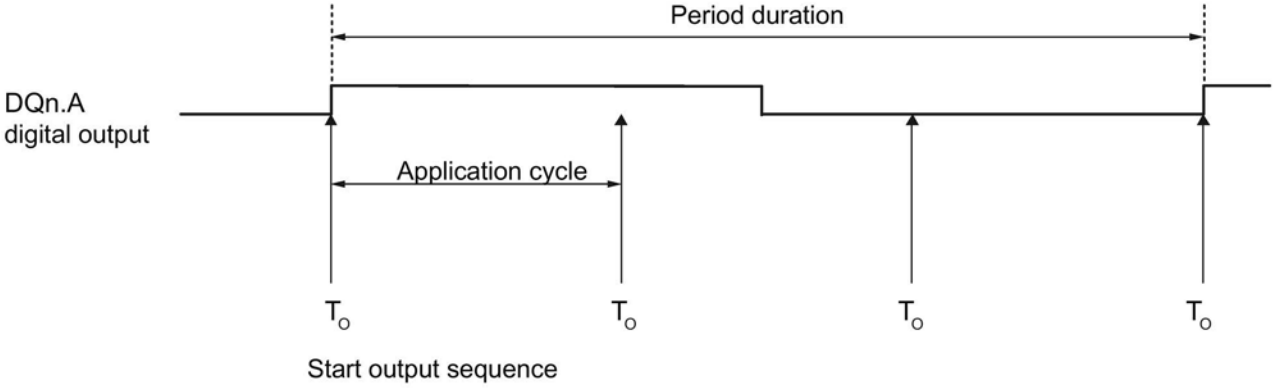
- Example 1: The period duration 10000 µs is equal to the application cycle time 10 ms (10000 µs).



- Example 2: The period duration 3333 µs is less than the application cycle time 10 ms (10000 µs).



- Example 3: The period duration 30000 µs is greater than the application cycle time 10 ms (10000 µs)



Note

Isochronous PWM operation

On-delay is not used by the module (always considered as zero) and the parameter "Function DI" is always "Input". Only the software-enable SW_ENABLE 0 → 1 is used to start the output sequence.

Setting the minimum pulse duration and minimum inter-pulse duration

You assign the minimum pulse duration and the minimum inter-pulse duration as a DWord number value between 0 and 85,000,000 µs using the "Minimum pulse duration" channel parameter configuration.

The unit is always microseconds. This value can only be changed using the configuration parameter record.

Setting and changing the On-delay

- Permanent update
  The On-delay can be controlled permanently using the control interface. The MODE_SLOT bit has to be set (permanent update); LD_SLOT must have the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the field SLOT. The unit is always microseconds.
- Single update
  Set the On-delay as a value between 0 µs and 85,000,000 µs in the configuration parameters. The unit is always microseconds. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared (single-update); LD_SLOT must have the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the field SLOT.

If you change the On-delay value during the output sequence, then the new On-delay is activated at the next output sequence. For more details about the use of the SLOT parameter see SLOT parameter handling (Page 113).

Current measurement

Current measurement is available in PWM mode. Your control program can use current measurement for control and diagnostic purposes.

For more information, refer to Function: Current measurement (Page 76).

Current control

Current measurement is available in PWM mode. Your control program can use current measurement for control and diagnostic purposes.

For more information, refer to Function: Current control (Page 78).

Parameters of PWM operating mode

Parameter	Meaning	Value range	Default
Operating mode	1 = Set the PWM operating mode.	0 = Pulse output 1 = Pulse width modulation 2 = Pulse train 3 = On/Off-delay 4 = Frequency output 5 = DC Motor	1
High-speed output [1]	The output supports higher frequencies.	0 = disabled 1 = enabled	Disabled
Function DI	You can use the DIn.0 digital input as an input or as a hardware enable. The signal at DIn.0 is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay, as the start of the output sequence.	0 = Input 1 = HW enable	Input
Output format	Defines the format of the ratio value (duty cycle).	0 = S7 analog format 1 = Per 100 (%) 2 = per 1,000 3 = Per 10,000	Per 100 (%)
Input delay	DIn.0 digital input must be stable over the delay time (signal noise suppression).	0 = Off (4 µs) 1 = 0.05 ms 2 = 0.1 ms 3 = 0.4 ms 4 = 0.8 ms 5 = 1.6 ms 6 = 3.2 ms 7 = 12.8 ms 8 = 20 ms	0.1 ms
Minimum pulse duration	Minimum pulse duration and minimum inter-pulse duration.	0 µs and 85,000,000 µs	0 µs
Period	Period duration of the output pulse cycle in µs. You can change the period duration in your control program with the control interface SLOT field.	• High-speed output disabled 100 µs to 85,000,000 µs • High-speed output enabled 10 µs to 85,000,000 µs	2,000,000 µs
On-delay	The time from the start of the output sequence to the output of the pulses. You can change the On-delay in your control program with the control interface SLOT field.	0 µs and 85,000,000 µs	0 µs

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)".

Control and feedback signals for PWM mode

Control interface Offset to the start address		Parameter	Meaning				
Channel 0	**Channel 1** [1]						
Bytes 0 to 3	Bytes 12 to 15	OUTPUT_VALUE (DWord)	The OUTPUT_VALUE determines the duty cycle (pulse duration/period duration ratio) within a period (pulse width modulation). The period duration can be adjusted. The new output value is applied at the next rising edge of the output. When the current control option is enabled, the TM Pulse 2x24V module takes control of the duty cycle and the OUTPUT_VALUE control interface field is used to assign the target current as a ratio of target current/reference current. See the Current control function for details. UDInt data type: Only 2 least significant bytes are used For channel 0: bytes 2 and 3 For channel 1: bytes 14 and 15				
			Output format	"Per 100": value range is 0 to 100			
				"Per 1000": value range is 0 to 1,000			
				"Per 10000": value range is 0 to 10,000			
				"S7 analog output": value range is 0 to 27,648			
Bytes 4 to 7	Bytes 16 to 19	SLOT (DWord)	Your program can change the parameters shown in the byte 8 LD_SLOT table below, before the start of the output sequence using the SLOT and MODE_SLOT parameters.				
			0 µs to 85,000,000 µs				
Byte 8	Byte 20	LD_SLOT	Interpretation of the value SLOT: all other values not listed below are invalid and produce the error ERR_LD (in single-update mode) or ERR_SLOT_VAL (in permanent-update mode).				
			Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	**Parameter**
			0	0	0	0	Idle state; nothing is done with the value
			0	0	0	1	Period in µs
			0	0	1	0	On-delay in µs
			0	1	0	1	Dither ramp in ms
			0	1	1	0	Dither amplitude in per mill
			0	1	1	1	Dither period in µs
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT	**Bit 4**	Mode for use of the field SLOT.			
			0	Single-update mode			
			1	Permanent-update mode			
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE	**Bit 0**	Software enable: start and terminate the output sequence.			
			0	Output canceled			
			0 → 1	Starts output sequence on positive edge when "Function DI" = "Input".			
			1	Enable output sequence, when start is dependent on HW enable with "Function DI" = "HW enable".			
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ	**Bit 1**	Set DQn.A output source: Selects either CPU program or module's output sequence.			
			0	DQn.A and DQn.B are controlled by the CPU (in your program) using the SET_DQA and SET_DQB control bits.			
			1	DQn.A is controlled by the module's pulse output sequence. DQn.B is always 0 for TM_CTRL_DQ = 1.			
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQA	**Bit 3**	Controls the value of the digital output DQn.A, if TM_CTRL_DQ = 0.			
			0	0 on DQn.A			
			1	1 on DQn.A			

Control interface Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1 [1]			
Byte 9: Bit 4	Byte 21: Bit 4	SET_DQB	**Bit 4**	Controls the value of the digital output DQn.B, if TM_CTRL_DQ = 0 and if SET_DQA is cleared.
			0	0 on DQn.B
			1	1 on DQn.B
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR	**Bit 0**	Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V).
			0	Reset of errors is not active
			1	Reset of errors is active

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and should be 0.

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1 [1]			
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR	**Bit 0**	Indicates under voltage on the Power supply. Note that the bit is not set if the voltage is not present.
			0	PWR is not under voltage
			1	PWR is detected, but under voltage
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V	**Bit 1**	Indicates a short-circuit or overload on the output 24 V DC. You must set the RES_ERROR (control interface), to reset this error.
			0	No short-circuit on 24 V DC
			1	Short-circuit on 24 V DC
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD	**Bit 2**	Indicates an error while loading a value using the field SLOT (only in "single-update" SLOT-mode).
			0	No load error pending
			1	Load error pending: you must set the RES_ERROR (control interface) to reset this error and be able to use SLOT again.
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	**Bit 4**	Indicates a short-circuit on the output DQn.A. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.A
			1	Short-circuit on DQn.A
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	**Bit 5**	Indicates a short-circuit on the output DQn.B or an attempt to set both DQn.A and DQn.B manually using SET_DQA, SET_DB, and TM_CTRL_DQ. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.B
			1	Short-circuit on DQn.B, or attempt to set both DQn.A and DQn.B
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL	**Bit 7**	Indicates that an invalid value is detected in SLOT (only in "permanent-update" SLOT-mode).
			0	SLOT value is valid
			0 → 1	SLOT value is not valid
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT	**Bit 2**	Toggle acknowledge bit for each action of SLOT in "single-update" SLOT-mode. Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY	**Bit 4**	Indicates the module is ready and parameterized.
			0	Module is not parameterized
			1	Module is parameterized

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1** [1]			
Byte 1: Bit 5	Byte 9: Bit 5	STS_SW_ENABLE	**Bit 5**	Indicates the status of SW_ENABLE (control interface).
			0	SW_ENABLE cleared
			1	SW_ENABLE set
Byte 2: Bit 0	Byte 8: Bit 0	STS_ENABLE	**Bit 0**	Indicates an output sequence is running.
			0	Output sequence not running
			1	Output sequence running
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA	**Bit 1**	Indicates the signal level at the DQn.A digital output.
			0	0 on DQn.A digital output
			1	1 on DQn.A digital output
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB	**Bit 2**	Indicates the signal level at the DQn.B digital output.
			0	0 on DQn.B digital output
			1	1 on DQn.B digital output
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI	**Bit 3**	Indicates the signal level at the DIn.0 digital input.
			0	0 on DIn.0 digital input
			1	1 on DIn.0 digital input
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT	Sequence counter = 0. The sequence counter is not used in pulse width modulation mode.	
Word 2	Word 6	MEASURED_CURRENT	S7 Analog format positive value 0 to 32,767: • 2 Ampere channel output: Full scale value 27,648; means 2,000 mA • 4 Ampere channel output: Full scale value 27,648; means 4,000 mA • 32,767 means no valid current measurement available; for example, during the very first PWM period.	
Word 3	Word 7	Reserved	Read as 0	

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and are read as 0.

Input and output signals for PWM operating mode

Input and output signal	Meaning	Value range	Channel 0 BaseUnit pin number	Channel 1 BaseUnit pin number
Input signal				
HW enable Note: HW enable not supported for PWM in isochronous mod	You can select the HW enable with the "Function DI" parameter and select the input delay with the "Input delay" parameter. The signal at the DIn.0 digital input is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay, as the start of the output sequence.	0 = HW enable cleared 1 = HW enable issued 0 → 1 = Start of the output sequence after the input delay; dependent on the software enable (SW_ENABLE)	3	4
Output signal				
Pulse at the DQn.A digital output	A pulse is output at the DQn.A digital output for the set duty cycle and period duration.	0 = no pulse 1 = pulse	9	10

See also Pin assignment and load/sensor wiring (Page 91)

3.4 Pulse train mode

Definition

On expiration of the assigned On-delay, the TM Pulse 2x24V outputs the number of pulses you assigned as a pulse train (output sequence). The period duration and pulse duration can be adjusted.

Pulse diagram

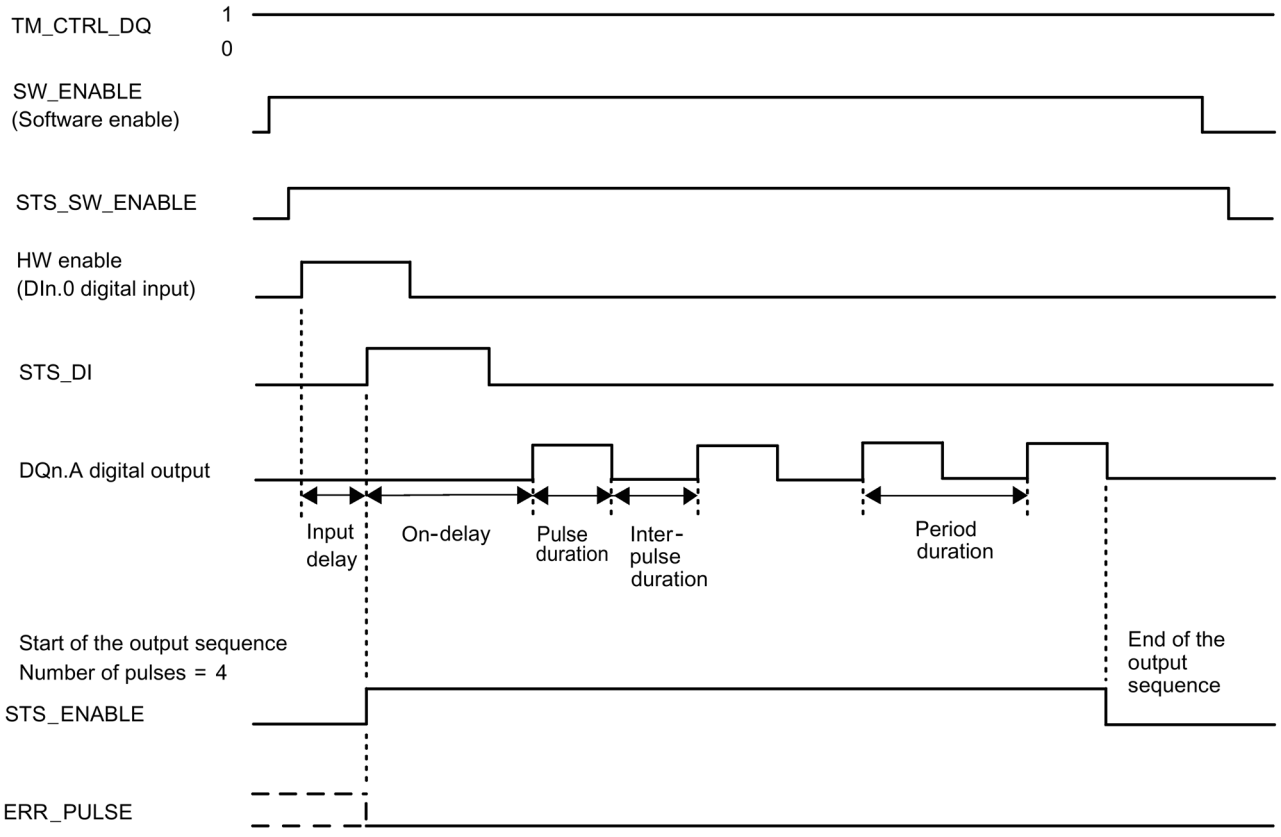


Figure 3-6 Output sequence of the pulse train

The timing diagram above has the "Function DI" parameter set to "HW enable". The other option is to set "Function DI" to "Input". If the "Function DI" parameter is set to "Input", then the On-delay phase starts at the rising edge of SW_ENABLE.

Starting the output sequence

Your control program must issue the enable for the output sequence, using the software enable (SW_ENABLE 0 → 1).

The STS_SW_ENABLE feedback bit indicates the software enable pending at the TM Pulse 2x24V.

You can also set the DIn.0 digital input of the TM Pulse 2x24V as a HW enable with the "Function DI" parameter. The input delay of the hardware enable can be set using the parameter "Input Delay".

If you want to use the hardware enable, it has to be combined with the software enable. When SW_ENABLE has been enabled, the output sequence starts at the first positive edge of the hardware enable. Further positive edges of the hardware enable during the current output sequence are ignored by the TM Pulse 2x24V. When the software enable has been issued, a positive edge of the hardware enable (detected after the input delay) starts the next output sequence.

When the enable is issued (positive edge) and remains high for the input delay (noise filter) time, the On-delay is started and STS_ENABLE is set. On expiration of the On-delay, the pulse train is output with the assigned pulse duration. The output sequence finishes with the end of the pulse and STS_ENABLE is cleared.

If you change the number of pulses during the output sequence to a value that has already been reached in the sequence, then the bit ERR_PULSE indicates a pulse output error

The next time the output sequence starts, the TM Pulse 2x24V clears the ERR_PULSE feedback bit.

Note

TM_CTRL_DQ technology module output control signal

- If TM_CTRL_DQ = 1, then the TM Pulse 2x24V module has control and produces pulse sequences at the DQn.A output.
- If TM_CTRL_DQ = 0, then the CPU has control and your program can set DQn.A/DQn.B outputs directly with the SET_DQA/SET_DQB control bits.

Canceling the output sequence

Disabling the software enable (SW_ENABLE = 1 → 0) during the On-delay or pulse train cancels the current output sequence and the last period duration is not completed. STS_ENABLE and the DQn.A digital output are immediately reset to 0.

You must restart the output sequence to begin a new pulse output.

Truth table

Software enable SW_ENABLE	Function DI parameter	Hardware enable (DIn.0 digital input)	Digital output DQn.1 (when TM_CTRL_DQ = 1)	STS_ENABLE	Output sequence
1	HW_ENABLE	0 → 1 and remains 1 during the input delay. Only active for the first positive edge, additional positive edges are ignored and no start occurs.	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0 → 1	Input	Not used	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0	HW_ENABLE or Input	Any status	0	0	Cancel
1	HW_ENABLE or Input	Any status	0, if On-delay is not expired or you are in the inter-pulse time or the output sequence is over 1, if On-delay is expired and during the pulse duration		-
0 → 1	HW_ENABLE	0	0	0	-

Setting and changing the number of pulses

Your control program can set the pulse count directly with the control interface parameter OUTPUT_VALUE.

Set the number of pulses directly as a DWord number value between 1 to 4,294,967,295 (2^{32}-1).

If you change the number of pulses, the new value takes effect immediately whether the On-delay is expired or not.

- If the new number of pulses has not yet been reached in the current output sequence, then the new number of pulses will be used in the current output sequence.
- If the number of pulses is reduced to a number that is less than the current number of pulses already output, then the output sequence is terminated, STS_ENABLE and the DQn.A digital output are cleared, ERR_PULSE is set. At the next start of an output sequence, ERR_PULSE is cleared.
- If the number of pulses is zero the output sequence is terminated, STS_ENABLE and the DQn.A digital output are cleared, and ERR_PULSE is set. At the next start of an output sequence, ERR_PULSE is cleared.

Setting and changing the period duration

- Permanent update
  The period duration can be controlled permanently using the control interface. The MODE_SLOT bit has to be set ('1' means permanent update); LD_SLOT has to have the value 1 (for Period duration). Set the period duration as a DWord number value of microseconds in the parameter field SLOT.
  - High-speed output **enabled** (see parameters): between 10 µs and 85,000,000 µs.
  - High-speed output **disabled** (see parameters): between 100 µs and 85,000,000 µs.
- Single update
  Set the period duration in the configuration parameters. Alternatively, you can do a single update using the control interface. MODE_SLOT has to be 0 (single-update); LD_SLOT has to have the value 1 (for Period duration). Set the period duration as a DWord number value of microseconds in the parameter field SLOT.
  - High-speed output **enabled** (see parameters): between 10 µs and 85,000,000 µs.
  - High-speed output **disabled** (see parameters): between 100 µs and 85,000,000 µs.

Setting and changing the On-delay

- Permanent update
  The On-delay can be controlled permanently using the control interface. MODE_SLOT bit has to be set ('1' means permanent update); LD_SLOT must be the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the parameter field SLOT.
- Single update
  Set the On-delay as a value between 0 µs and 85,000,000 µs in the configuration parameters. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared ("0" means single update); LD_SLOT must be the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the field SLOT.
- If you change the On-delay value during the output sequence, then the new On-delay is activated at the next output sequence.

For more details about the use of the SLOT parameter, see the SLOT parameter handling (Page 113).

Setting and changing the duty cycle

The range of the duty cycle parameter is selected using the "Output format" parameter. The TM Pulse 2x24V uses this assigned duty cycle value to calculate the pulse duration. If the number value you assign exceeds the upper limit, then a duty cycle of 100% of the period duration is used and this action does not cause an error.

- Output format "Per 100 (%)": Value range 0 to 100
  - Pulse duration = (duty cycle/100) x period duration.
- Output format "Per 1000": Value range 0 to 1,000
  - Pulse duration = (duty cycle/1,000) x period duration.
- Output format "Per 10000": Value range 0 to 10,000
  - Pulse duration = (duty cycle/10,000) x period duration.
- Output format "S7 analog output": Value range 0 to 27,648
  - Pulse duration = (duty cycle/27,648) x period duration.

Update the duty cycle

- Permanent update
  The duty cycle can be controlled permanently using the control interface. MODE_SLOT bit has to be set ("1" means permanent update); LD_SLOT must be the value 4 (for duty cycle). Set the duty cycle as a value in the control interface field SLOT. The unit depends on the assigned output format.
- Single update
  Set the duty cycle in the configuration parameters. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared ("0" means single update); LD_SLOT must be the value 4 (for duty cycle). Set the duty cycle as a value in the control interface field SLOT.
- The unit depends on the assigned output format. If you change the duty cycle value during the output sequence, then the new duty cycle is activated at the next output sequence.

For more details about the use of the SLOT parameter, see SLOT parameter handling (Page 113).

Isochronous mode

General information is available in Function: Isochronous mode (Page 86).

Isochronous mode does not have any influence on the functionality of Pulse train operating mode.

If you want to synchronize the output sequence with T_o, then set the Function DI parameter to "Input" and the Pulse train output sequence starts at T_o.

Current measurement

Current measurement is available in Pulse train mode. Your control program can use current measurement for control and diagnostic purposes.

For more information, refer to Function: Current measurement (Page 76).

Parameters for Pulse train operating mode

Parameter	Meaning	Value range	Default
Operating mode	2 = Set the "Pulse train" operating mode.	0 = Pulse output 1 = Pulse width modulation 2 = Pulse train 3 = On/Off-delay 4 = Frequency output 5 = DC motor	1
High-speed output [1]	The output supports higher frequencies (see pulse duration range).	0 = disabled 1 = enabled	Disabled
Function DI	You can use the DIn.0 digital input as an input or as a hardware enable. The signal at DIn.0 is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay, as the start of the output sequence.	• Input • HW enable	Input
Output format	Defines the format of the duty cycle ratio value.	0 = S7 analog format 1 = Per 100 (%) 2 = Per 1,000 3 = Per 10,000	Per 100 (%)
Input delay	DIn.0 digital input must be stable over the delay time (signal noise suppression).	0 = Off (4 µs) 1 = 0.05 ms 2 = 0.1 ms 3 = 0.4 ms 4 = 0.8 ms 5 = 1.6 ms 6 = 3.2 ms 7 = 12.8 ms 8 = 20 ms	0.1 ms
Period	Period duration of the output sequence: You can change the period duration in your control program using the control interface field SLOT.	• High-speed output disabled 100 µs to 85,000,000 µs • High-speed output enabled 10 µs to 85,000,000 µs	2,000,000 µs

Parameter	Meaning	Value range	Default
On-delay	The time from the start of the output sequence to the output of the pulse train. You can change the On-delay in your control program using the SLOT parameter.	0 µs to 85,000,000 µs	0 µs
Duty-cycle	The pulse duration results from the duty cycle and the period duration. The format of the duty cycle is determined by the parameter "Output format". You can change the duty-cycle in your control program using the control interface field SLOT.	Output format: minimum to maximum • Per 100: 0 to 100 • Per 1000: 0 to 1,000 • Per 10000: 0 to 10,000 • S7 analog output: 0 to 27,648	50%

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)".

Control and feedback signals for Pulse train operating mode

Control interface Offset to the start address		Parameter	Meaning				
Channel 0	**Channel 1** [1]						
Bytes 0 to 3	Bytes 12 to 15	OUTPUT_VALUE (DWord)	Assign the number of pulses to the OUTPUT_VALUE as a DWord number value 0 to 4,294,967,295 (2^{32}-1).				
Bytes 4 to 7	Bytes 16 to 19	SLOT (DWord)	The On-delay, period duration, and duty cycle can be changed before the start of the output sequence. See SLOT parameter handling (Page 113).				
			0 µs to 85,000,000 µs				
Byte 8	Byte 20	LD_SLOT	Interpretation of the value SLOT: All other values not listed below are invalid and produce the error ERR_LD (in single-update mode) or ERR_SLOT_VAL (in permanent-update mode).				
			Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
			0	0	0	0	Idle-state; nothing is done with the value
			0	0	0	1	Period duration in microseconds
			0	0	1	0	On-delay in microseconds
			0	1	0	0	Duty cycle in the format defined by the parameter "Output format"
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT	**Bit 4**	Mode for use of the field SLOT.			
			0	Single-update mode			
			1	Permanent-update mode			
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE	**Bit 0**	Software enable: Start/enable and terminate/disable the output sequence when "Function DI" = "Input".			
			0	Output disabled/terminated			
			0 → 1	Starts output sequence on positive edge when "Function DI" = "Input"			
			1	Enable output sequence, when start is dependent on HW enable with "Function DI" = "HW enable"			
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ	**Bit 1**	Set DQn.A output source: Selects either CPU program or module's output sequence.			
			0	DQn.A and DQn.B are controlled by the CPU (in your program) using the SET_DQA and SET_DQB control bits			
			1	DQn.A is controlled by the module's pulse output sequence. DQn.B is always 0			
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQA	**Bit 3**	Controls the value of the digital output DQn.A, if TM_CTRL_DQ is cleared.			
			0	0 on DQn.A			
			1	1 on DQn.A			
Byte 9: Bit 4	Byte 21: Bit 4	SET_DQB	**Bit 4**	Controls the value of the digital output DQn.B, if TM_CTRL_DQ is cleared and if SET_DQA is cleared.			
			0	0 on DQn.B			
			1	1 on DQn.B			
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR	**Bit 0**	Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V).			
			0	Reset of errors is not active			
			1	Reset of errors is active			

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and should be 0.

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1 [1]			
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR	**Bit 0**	Indicates under voltage on the Power supply. Note that the bit is not set if the voltage is not present.
			0	PWR is not under voltage
			1	PWR is detected, but under voltage
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V	**Bit 1**	Indicates a short-circuit or overload on the output 24 V DC. You must set the RES_ERROR (control interface) to reset this error.
			0	No short-circuit on 24 V DC
			1	Short-circuit on 24 V DC
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD	**Bit 2**	Indicates an error while loading a value using the field SLOT (only in "single-update" SLOT-mode).
			0	No load error pending
			1	Load error pending: you must set the RES_ERROR (control interface) to reset this error and be able to use the SLOT again.
Byte 0: Bit 3	Byte 8: Bit 3	ERR_PULSE	**Bit 3**	Indicates a pulse output error.
			0	No pulse output error
			1	Pulse output error
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	**Bit 4**	Indicates a short-circuit on the output DQn.A. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.A
			1	Short-circuit on DQn.A
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	**Bit 5**	Indicates a short-circuit on the output DQn.B or an attempt to set both DQs manually using SET_DQA, SET_DQB, and TM_CTRL_DQ. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.B
			1	Short-circuit on DQn.B, or attempt to set both DQn.A and DQn.B
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL	**Bit 7**	Indicates that an invalid value is detected in SLOT (only in "permanent-update" SLOT-mode).
			0	SLOT value is valid
			1	SLOT value is not valid
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT	**Bit 2**	Toggle acknowledge bit for each action of the SLOT in "single-update" SLOT-mode. Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY	**Bit 4**	Indicates the module is ready and parameterized.
			0	Module is not parameterized
			1	Module is parameterized
Byte 1: Bit 5	Byte 9: Bit 5	STS_SW_ENABLE	**Bit 5**	Indicates the status of SW_ENABLE (control interface).
			0	SW_ENABLE cleared
			1	SW_ENABLE set
Byte 2: Bit 0	Byte 8: Bit 0	STS_ENABLE	**Bit 0**	Indicates an output sequence is running.
			0	Output sequence not running
			1	Output sequence running
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA	**Bit 1**	Indicates the signal level at the DQn.A digital output.
			0	0 at the DQn.A digital output
			1	1 at the DQn.A digital output

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1** [1]			
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB	**Bit 2**	Indicates the signal level at the DQn.B digital output.
			0	0 at the DQn.B digital output
			1	1 at the DQn.B digital output
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI	**Bit 3**	Indicates the signal level at the DIn.0 digital input.
			0	Signal 0 at the DIn.0 digital input
			1	Signal 1 at the DIn.0 digital input
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT	Sequence counter: is incremented after completion of an output sequence.	
			With SW_ENABLE: 0 to 1	
			With HW enable: 0 to 15	
Word 2	Word 6	MEASURED_CURRENT	S7 Analog format positive value 0 to 32,767: • 2 Ampere output: Full scale value 27,648, means 2,000 mA • 4 Ampere output: Full scale value 27,648, means 4,000 mA • 32,767 means no valid current measurement available; for example, during the very first period	
Word 3	Word 7	Reserved	Read as 0	

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and are read as 0.

Input and output signals for Pulse train operating mode

Input and output signal	Meaning	Value range	Channel 0 BaseUnit pin number	Channel 1 BaseUnit pin number
Input signal				
HW enable	You can select the HW enable with the "Function DI" parameter and select the input delay with the "Input delay" parameter. The signal of the DIn.0 digital input is interpreted by the TM Pulse 2x24V, after filtering by the input delay, as the start of the output sequence.	0 = HW enable cleared 1 = HW enable issued 0 → 1 = Start of the output sequence; dependent on the software enable (SW_ENABLE)	3	4
Output Signal				
Pulse train at the DQn.A digital output	Pulses are output at the DQn.A digital output for the set pulse duration.	0 = no pulse 1 = pulse	9	10

See also Pin assignment and load/sensor wiring (Page 91)

3.5 On/Off-delay mode

Definition

The signal pending at the TM Pulse 2x24V DIn.0 digital input is output with an assigned On/Off-delay at the DQn.A digital output.

Pulse diagram

SW_ENABLE is set, while DIn.0 digital input = 0:

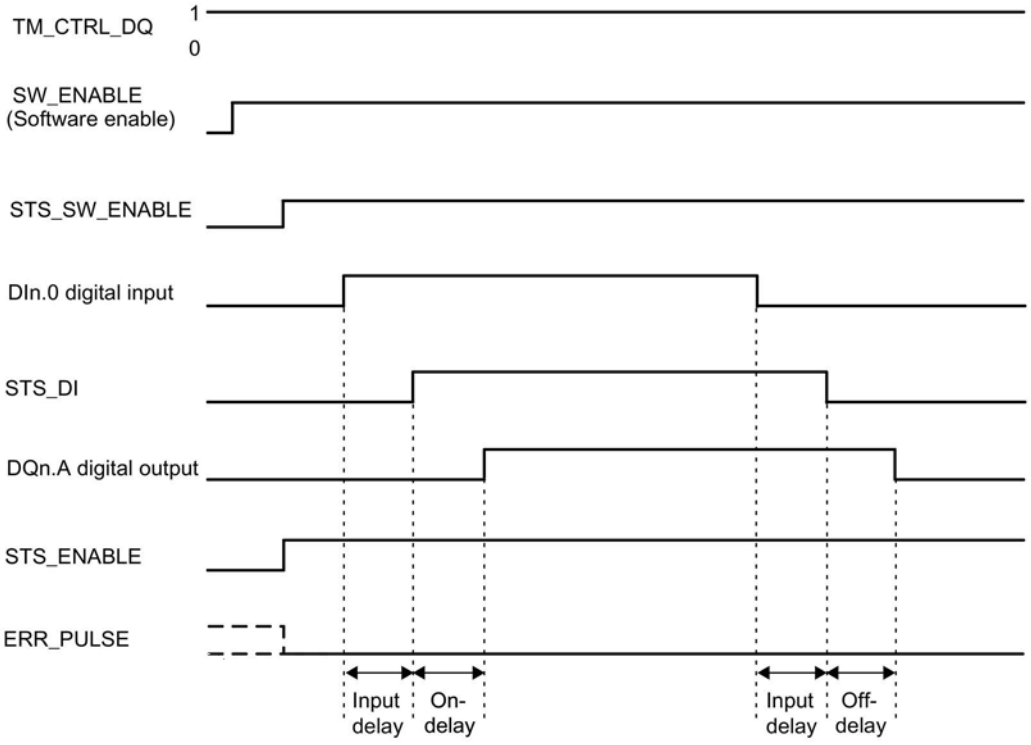


Figure 3-7 Output sequence On/Off-delay (at the start DIn.0 digital input = 0)

SW_ENABLE is set, while DIn.0 digital input = 1:

If SW_ENABLE is set while DIn.0 digital input = 1, the first edge of a digital input (falling edge) is ignored.

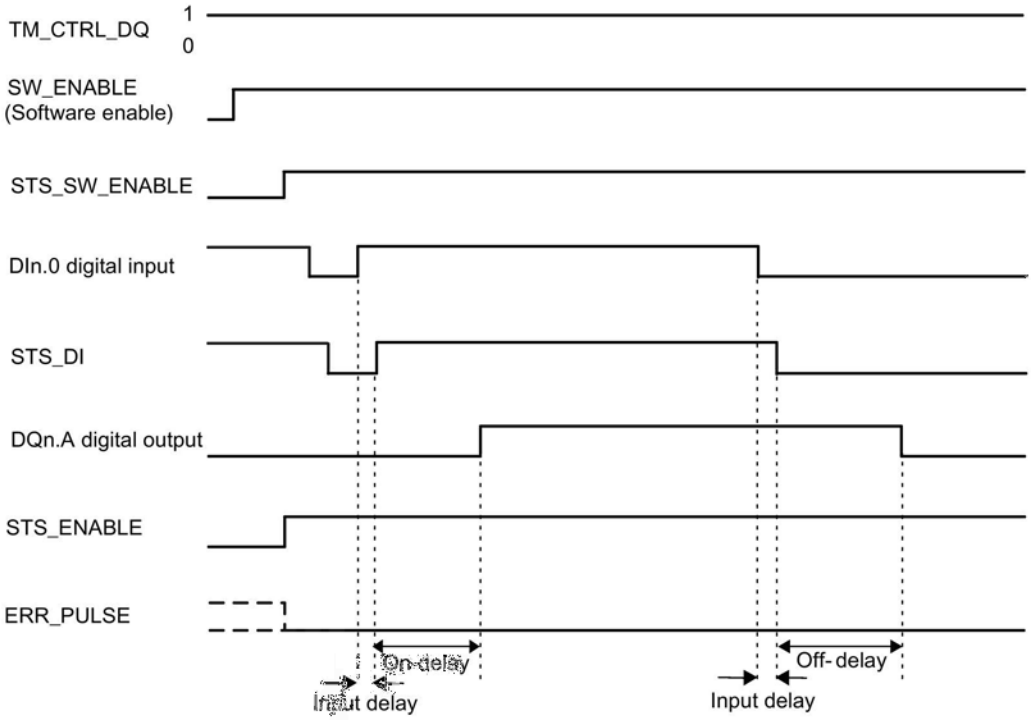


Figure 3-8 Output sequence On/Off-delay (at the start DIn.0 digital input = 1)

Starting the output sequence

Your control program must issue the enable for the output sequence, using the software enable (SW_ENABLE 0 → 1).

The STS_SW_ENABLE feedback bit indicates the software enable pending at the TM Pulse 2x24V.

- When the DIn.0 digital input goes high (positive edge) and remains high for the input delay time, the On-delay is started. After the On-delay expires, the DQn.A digital output is set.
- When the DIn.0 digital input goes low for the input delay time, the Off-delay is started. After the Off-delay expires, the DQn.A digital output is cleared.
- If the TM Pulse 2x24V recognizes a pulse duration or inter-pulse duration at the DIn.0 digital input shorter than the input delay time, then the input is ignored and the DQn.A digital output is unchanged.
- If the TM Pulse 2x24V recognizes a pulse duration or inter-pulse duration at the DIn.0 digital input longer than the input delay time, but too short to produce the parameterized pulse duration or inter-pulse duration, then the ERR_PULSE bit is set and the DQn.A digital output is unchanged.
- At the next edge of the DIn.0 digital input, the TM Pulse 2x24V clears the ERR_PULSE feedback bit

Note

TM_CTRL_DQ technology module output control signal

- If TM_CTRL_DQ = 1, then the TM Pulse 2x24V module has control and produces pulse sequences at the DQn.A output.
- If TM_CTRL_DQ = 0, then the CPU has control and your program can set DQn.A/DQn.B outputs directly with the SET_DQA/SET_DQB control bits.

Canceling the output sequence

Disabling the software enable (SW_ENABLE = 1 → 0) during the On-delay or pulse cancels the current output sequence and the last period duration is not completed. STS_ENABLE and the DQn.A digital output are immediately reset to 0.

You must restart the output sequence to begin new pulse output.

Truth Table

Software enable SW_ENABLE	DIn.0 digital input	DQn.A digital output (when TM_CTRL_DQ = 1)	STS_ENABLE	Output sequence
1	0 → 1 and remains 1 during the input delay	0, if On-delay > 0 1, if On-delay = 0	1	Start
1	1 → 0	1, if Off-delay > 0 0, if Off-delay = 0	1	Start
0	Any status	0	0	Cancel
1	Any status	0, if On-delay is not expired or if Off-delay is expired 1, if On-delay is expired and Off-delay is not expired	1	-
0 → 1	0	0	1	-

Minimum pulse duration/minimum interpulse duration of the DQn.A digital output

The minimum pulse duration/minimum interpulse duration of the DQn.A digital output is 1.5 µs (high-speed active) and 10 µs (high-speed inactive). Note that lower values are possible but not guaranteed because this is hardware dependent.

Make sure you take this into consideration when you set the On/Off-delay and the pulse duration/interpulse duration of the DIn.0 digital input. Otherwise, the response at the DQn.A digital output is not guaranteed.

The pulse duration of the DIn.0 digital input is too short

Case 1: The DIn.0 pulse duration < input delay time: The DIn.0 pulse is filtered out and ignored (no error occurs).

Case 2: The TM Pulse 2x24V detects a DIn.0 pulse duration that is too short if: DIn.0 pulse duration + Off-delay time ≤ On-delay (error is set)

Case 3: The TM Pulse 2x24V detects a DIn.0 pulse duration that is too short if: DIn.0 pulse duration + Off-delay time + minimum DQ pulse duration < On-delay time (error is set) .

Response of the TM Pulse 2x24V to a pulse duration that is too short:

- ERR_PULSE is set.
- The current On-delay is cleared.
- The Off-delay is not started.
- The signal level at the DQn.A digital output remains at 0.

ERR_PULSE is cleared at the next positive edge on the DIn.0 digital input.

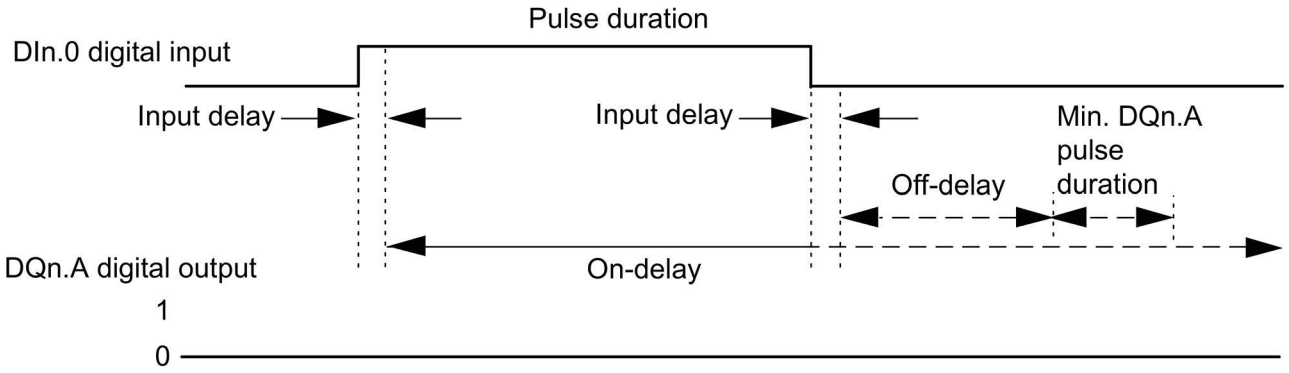


Figure 3-9 DIn.0 pulse duration too short

The interpulse duration of the DIn.0 digital input is too short

The TM Pulse 2x24V detects an interpulse duration that is too short on the positive edge on the DIn.0 digital input if:

Interpulse duration + On-delay ≤ Off-delay.

- Case 1: Interpulse duration < input delay time: The DIn.0 input interpulse is filtered out and ignored (no error occurs).
- Case 2: Interpulse duration + On-delay time ≤ Off-delay time (error is set).
- Case 3: Interpulse duration + On-delay time < Off-delay time + minimum inter-pulse duration (error is set).

Response of the TM Pulse 2x24V to an interpulse duration that is too short:

- ERR_PULSE is set.
- The current Off-delay is cleared.
- The On-delay is not started.
- The signal level at the DQn.A digital output remains at 1.

ERR_PULSE is cleared with the next negative edge on the DIn.0 digital input.

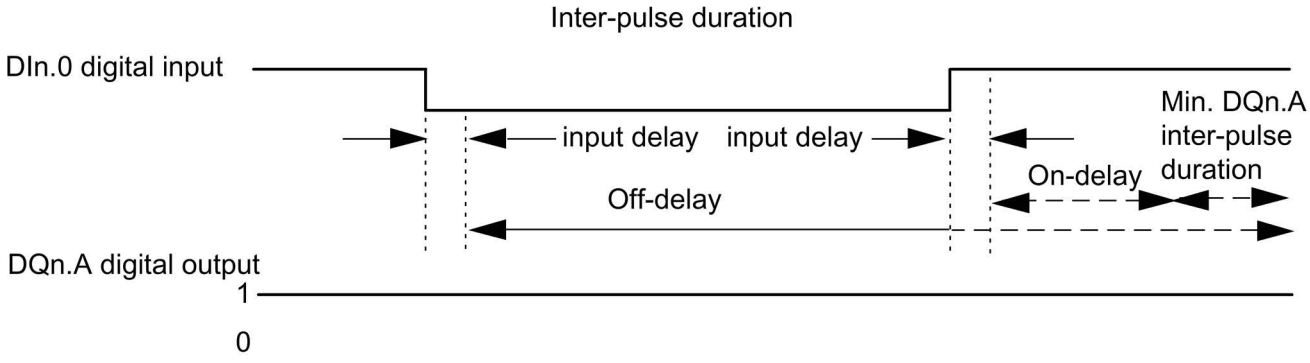


Figure 3-10 DIn.0 inter-pulse duration too short

Retriggering the current On-delay

The TM Pulse 2x24V starts a new On-delay on the positive edge on the DIn.0 digital input if:

On-delay > pulse duration + inter-pulse duration

This clears the current Off-delay.

The DQn.A digital output is only set if signal level 1 is present on the DIn.0 digital input longer than the On-delay. This enables you to filter rapid pulses.

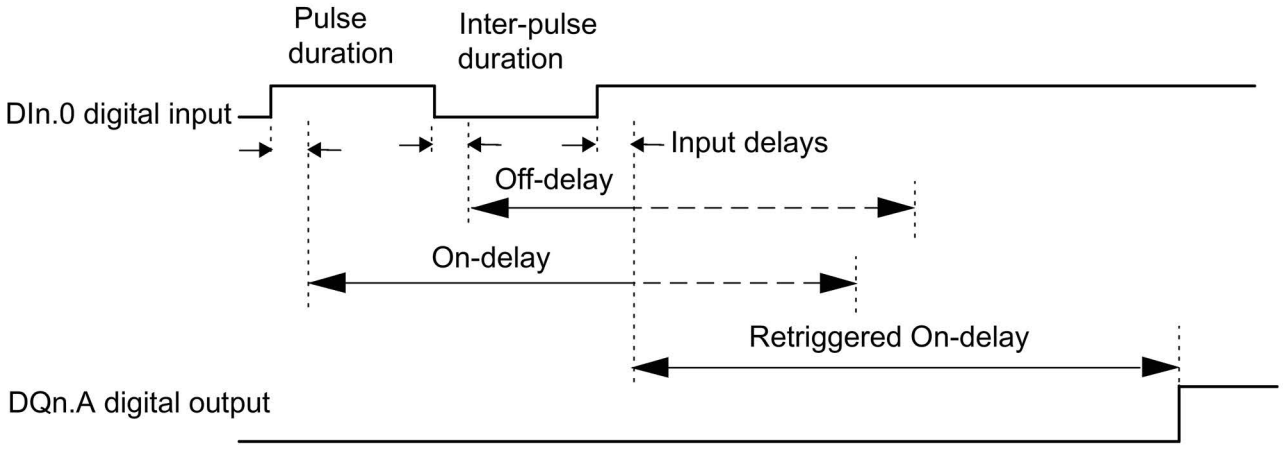


Figure 3-11 DIn.0 retriggering the current On-delay

Retriggering the current Off-delay

The TM Pulse 2x24V starts a new Off-delay on the negative edge on the DIn.0 digital input if:

Off-delay > pulse duration + inter-pulse duration

The DQn.A digital output is only cleared if signal level 0 is present on the Dn.0I digital input longer than the Off-delay.

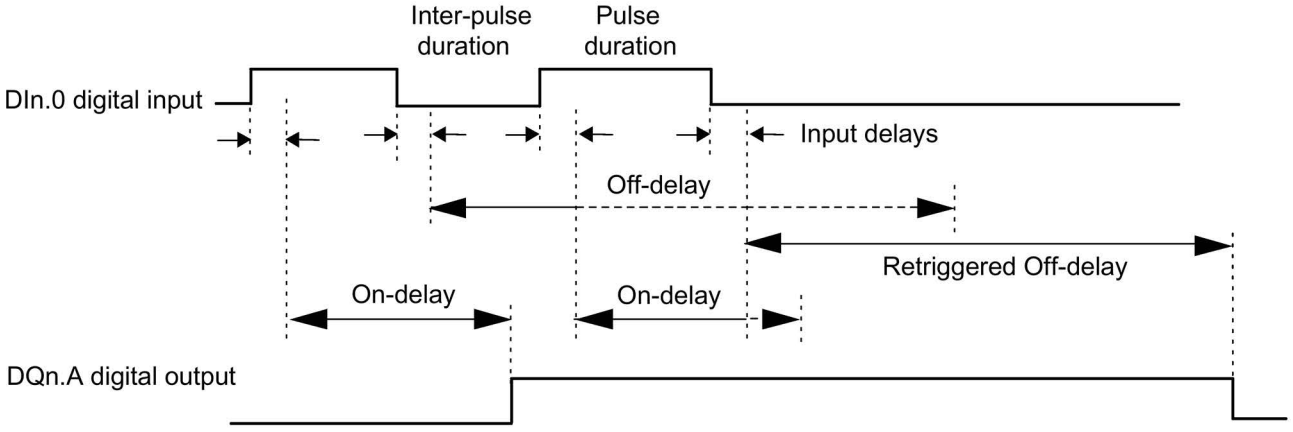


Figure 3-12 Retriggering the current Off-delay

Setting and changing the OUTPUT_VALUE (On-delay)

- You set the On-delay OUTPUT_VALUE directly using your control program to assign a value.
- The unit is always microseconds. Possible range: between 0 µs and 85,000,000 µs. If an invalid value is assigned by your program, the module will send back error ERR_OUT_VAL in the feedback interface and continue using the last valid value.
- The new On-delay value is activated with the next positive edge on the DIn.0 digital input.

Setting and changing the Off-delay

- Permanent update
  The Off-delay can be controlled permanently using the control interface. MODE_SLOT bit has to be set (permanent update); LD_SLOT must be the value 3 (for Off-delay). Set the Off-delay as a value between 0 µs and 85,000,000 µs in the field SLOT. The unit is always microseconds.
- Single update
  Set the Off-delay as a value between 0 µs and 85,000,000 µs in the configuration parameters. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared (single-update); LD_SLOT must be the value 3 (for Off-delay). Set the Off-delay as a value between 0 µs and 85,000,000 µs in the field SLOT.

If you change the Off-delay value during the output sequence, the new Off-delay is activated at the next negative edge on the DIn.0 digital input.
For more details about the use of the SLOT parameter, see SLOT parameter handling (Page 113).

Isochronous mode

General information is available in Function: Isochronous mode (Page 86).

Isochronous mode does not have any influence on the functionality of On/Off-delay operating mode.

Parameters for On/Off-delay operating mode

Parameter	Meaning	Value Range	Default
Mode	3 = Set the "On/Off-delay" operating mode.	0 = Pulse output 1 = Pulse width modulation 2 = Pulse train 3 = On/Off-delay 4 = Frequency output 5 = DC-Motor	1
High Speed Output [1]	The output supports higher frequencies.	0 = disabled 1 = enabled	Disabled
Function DI	You can only use the DIn.0 digital input as an input.	0 = Input 1 = reserved (do not use)	Input
Input Delay	DI digital input must be stable over the delay time (signal noise suppression).	0 = Off (4 µs) 1 = 0.05 ms 2 = 0.1 ms 3 = 0.4 ms 4 = 0.8 ms 5 = 1.6 ms 6 = 3.2 ms 7 = 12.8 ms 8 = 20 ms	0.1 ms
Off-delay	The time from the falling edge of the DIn.0 digital input to the falling edge of the DQn.A. You can change the Off-delay in your control program using the SLOT parameter.	0 µs to 85,000,000 µs	0 µs

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)".

Control and feedback signals for On/Off-delay operating mode

Control interface Offset to the start address		Parameter	Meaning				
Channel 0	**Channel 1** [1]						
Bytes 0 to 3	Bytes 12 to 15	OUTPUT_VALUE (DWord)	On-delay				
			0 µs to 85,000,000 µs				
Bytes 4 to 7	Bytes 16 to 19	SLOT (DWord)	The Off-delay can be changed anytime, but only takes effect on the next falling edge of the DIn.0 digital input.				
			0 µs to 85,000,000 µs				
Byte 8	Byte 20	LD_SLOT	Interpretation of the value SLOT: All other values not listed below are invalid and produce the error ERR_LD (in single-update mode) or ERR_SLOT_VAL (in permanent-update mode).				
			Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
			0	0	0	0	Idle-state; nothing is done with the value
			0	0	1	1	Off-delay in microseconds
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT	**Bit 4**	Mode for use of the field SLOT.			
			0	Single-update mode			
			1	Permanent-update mode			
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE	**Bit 0**	Software enable: Start and terminate the output sequence.			
			0	Output canceled			
			0 → 1	Starts output sequence on positive edge			
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ	**Bit 1**	Set DQn.A output source: Selects either CPU program or module's output sequence.			
			0	DQn.A and DQn.B are controlled by the CPU (in your program) using the SET_DQA and SET_DQB control bits.			
			1	DQn.A is controlled by the module's pulse output sequence. DQn.B is always 0 for TM_CTRL = 1.			
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQA	**Bit 3**	Controls the value of the digital output DQn.A, if TM_CTRL_DQ is cleared.			
			0	0 on DQn.A			
			1	1 on DQn.A			
Byte 9: Bit 4	Byte 21: Bit 4	SET_DQB	**Bit 4**	Controls the value of the digital output DQn.B, if TM_CTRL_DQ is cleared and if SET_DQA is cleared.			
			0	0 on DQn.B			
			1	1 on DQn.B			
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR	**Bit 0**	Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V).			
			0	Reset of errors is not active			
			1	Reset of errors is active			

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and should be 0.

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1 [1]			
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR	**Bit 0**	Indicates under voltage on the Power supply. Note that the bit is not set if the voltage is not present.
			0	PWR is not under voltage.
			1	PWR is detected, but under voltage.
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V	**Bit 1**	Indicates a short-circuit or overload on the output 24 V DC. You must set the RES_ERROR (control interface), to reset this error and be able to use the SLOT again.
			0	No short-circuit on 24 V DC
			1	Short-circuit on 24 V DC
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD	**Bit 2**	Indicates an error while loading a value using the field SLOT (only in "single-update" SLOT-mode).
			0	No load error pending.
			1	Load error pending: you must set the RES_ERROR (control interface) to reset this error and be able to use the SLOT again.
Byte 0: Bit 3	Byte 8: Bit 3	ERR_PULSE	**Bit 3**	Indicates a pulse output error.
			0	No pulse output error
			1	Pulse output error
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	**Bit 4**	Indicates a short-circuit on the output DQn.A. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.A
			1	Short-circuit on DQn.A
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	**Bit 5**	Indicates a short-circuit on the output DQn.B or an attempt to set both DQn.A and DQn.B manually using SET_DQA, SET_DB, and TM_CTRL_DQ. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.B
			1	Short-circuit on DQn.B or attempt to set both DQn.A and DQn.B
Byte 0: Bit 6	Byte 8: Bit 6	ERR_OUT_VAL	**Bit 6**	Indicates that an invalid value is detected in OUTPUT_VALUE.
			0	OUTPUT_VALUE is valid
			1	OUTPUT_VALUE is not valid
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL	**Bit 7**	Indicates that an invalid value is detected in SLOT (only in "permanent-update" SLOT-mode).
			0	SLOT value is valid
			0 → 1	SLOT value is not valid
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT	**Bit 2**	Toggle acknowledge bit for each action of the SLOT in "single-update" SLOT-mode. Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY	**Bit 4**	Indicates the module is ready and parameterized.
			0	Module is not parameterized
			1	Module is parameterized
Byte 1: Bit 5	Byte 9: Bit 5	STS_SW_ENABLE	**Bit 5**	Indicates the status of SW_ENABLE (control interface).
			0	SW_ENABLE cleared
			1	SW_ENABLE set

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1** [1]			
Byte 2: Bit 0	Byte 8: Bit 0	STS_ENABLE	**Bit 0**	Indicates an output sequence is running.
			0	Pulse output is not running
			1	Pulse output is running
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA	**Bit 1**	Indicates the signal level at the DQn.A digital output.
			0	0 at the DQn.A digital output
			1	1 at the DQn.A digital output
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB	**Bit 2**	Indicates the signal level at the DQn.B digital output.
			0	0 at the DQn.B digital output
			1	1 at the DQn.B digital output
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI	**Bit 3**	Indicates the signal level at the DIn.0 digital input.
			0	0 at the DIn.0 digital input
			1	1 at the DIn.0 digital input
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT	Counts rising and falling edges of DQn.A output	
Word 3	Word 7	Reserved	Read as 0	

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and are read as 0.

Input and output signals for On/Off-delay operating mode

Input and Output Signals	Meaning	Value Range	Channel 0 BaseUnit pin number	Channel 1 BaseUnit pin number
Input signal				
DIn.0 Digital input	The signal of the DIn.0 digital input is output with an On/Off-delay on DQn.A digital output.	0 = no pulse 1 = pulse	3	4
Output signal				
Pulse at the DQn.A digital output	The signal of the DIn.0 digital input is output with an On/Off-delay on the DQn.A digital output.	0 = no signal 1 = signal	9	10

See also Pin assignment and load/sensor wiring (Page 91)

3.6 Frequency output mode

Definition

This mode allows you to assign a frequency value at high frequencies more precisely than PWM period and Period duration.

A square wave signal with an assigned frequency and a constant duty cycle of 50% is produced at the digital output of the TM Pulse 2x24V.

The output sequence is started after expiration of the configured On-delay on the DQn.A digital output.

Pulse diagram

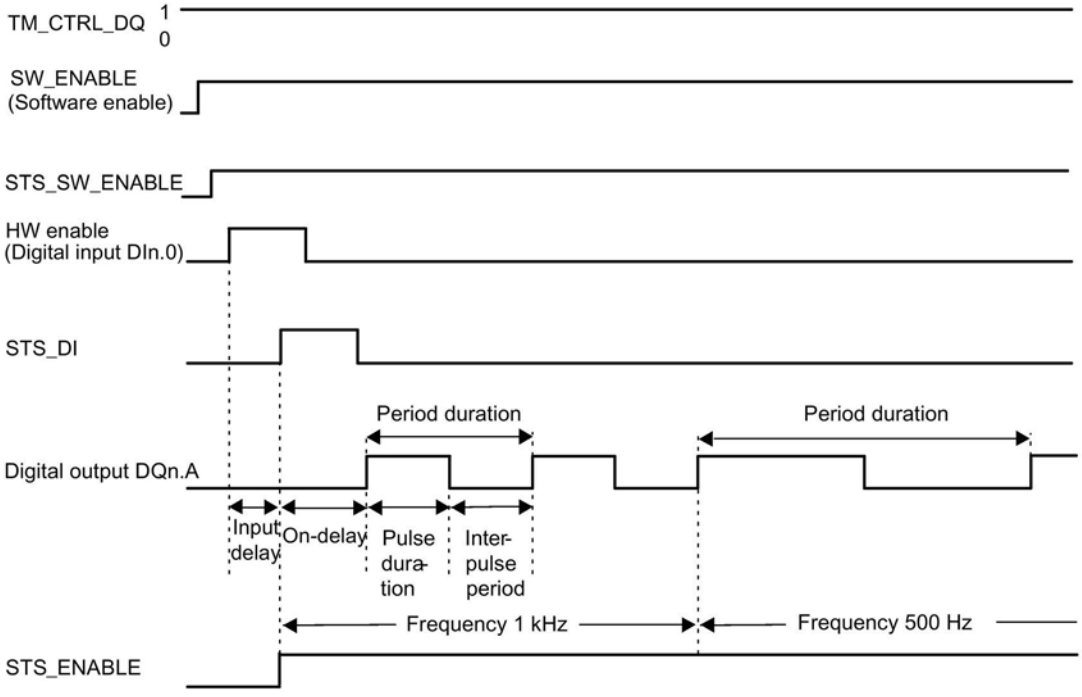


Figure 3-13 Frequency output - output sequence

The timing diagram above has the "Function DI" parameter set to "HW enable". The other option is to set "Function DI" to "Input". If the "Function DI" parameter is set to "Input", then the On-delay phase starts at the rising edge of SW_ENABLE.

Starting the output sequence

Your control program must issue the enable for the output sequence, using the software enable (SW_ENABLE 0 → 1).

The STS_SW_ENABLE feedback bit indicates the software enable pending at the TM Pulse 2x24V.

You can also set the DIn.0 digital input of the TM Pulse 2x24V as a HW enable with the "Function DI" parameter.

If you want to use the hardware enable, it has to be combined with the software enable. When SW_ENABLE has been enabled, the output sequence starts at the first positive edge of the hardware enable. Further positive edges of the hardware enable during the current output sequence are ignored by the TM Pulse 2x24V.

When the enable is issued (positive edge) and remains high for the time of the input delay (noise filter), the On-delay is started and the STS_ENABLE set. The frequency sequence is output on expiration of the On-delay. The output sequence runs continuously as long as SW_ENABLE is set.

Note

TM_CTRL_DQ technology module output control signal

- If TM_CTRL_DQ = 1, then the TM Pulse 2x24V module has control and produces pulse sequences at the DQn.A output.
- If TM_CTRL_DQ = 0, then the CPU has control and your program can set DQn.A/DQn.B outputs directly with the SET_DQA/SET_DQB control bits.

Canceling the output sequence

Disabling the software enable (SW_ENABLE = 1 → 0) during the On-delay or frequency output cancels the current output sequence and the last period duration is not completed. STS_ENABLE and the DQn.A digital output are immediately reset to 0.

You must restart the output sequence to begin new pulse output.

Truth table

Software enable SW_ENABLE	Function DI parameter	Hardware enable (DIn.0 digital input)	DQn.A digital output (when TM_CTRL_DQ = 1)	STS_ENABLE	Output sequence
1	HW_ENABLE	0 → 1 and remains 1 during the input delay. Only active for the first positive edge, additional positive edges are ignored and no start occurs.	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0 → 1	Input	Not used	0, if On-delay > 0 1, if On-delay = 0	0 → 1	Start
0	HW_ENABLE or Input	Any status	0	0	Cancel
1	HW_ENABLE or Input	Any status	0, if On-delay is not expired or you are in the inter-pulse time 1, if On-delay is expired and during the pulse duration		-
0 → 1	HW_ENABLE	0	0	0	-

Setting and changing the output value (Frequency)

You set the OUTPUT_VALUE directly using your control program in the control interface. The value is in real format and the unit is always "Hz". The possible range is dependent on the parameter "High Speed Output" as follows:

- High Speed Output disabled
  - Frequency (OUTPUT_VALUE): 0.02 Hz to 10,000 Hz
- High Speed Output enabled
  - Frequency (OUTPUT_VALUE): 0.02 Hz to 100,000 Hz

The new frequency value is applied at the next rising edge of the output.

Output frequency accuracy

The configured output frequency is output with an accuracy of +/- 100 ppm at the DQn.A digital output.

Setting and changing the On-delay

- Permanent update
  The On-delay can be controlled permanently using the control interface. MODE_SLOT bit has to be set (permanent-update); LD_SLOT must be the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the field SLOT. The unit is always microseconds.
- Single update
  Set the On-delay as a value between 0 µs and 85,000,000 µs in the configuration parameters, the unit is always microseconds. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared (single-update); LD_SLOT must be the value 2 (for On-Delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the field SLOT.

If you change the On-delay value during the output sequence, the new On-delay is activated at the next output sequence.

For more details about the use of the SLOT parameter, see Slot parameter handling (Page 113).

Isochronous mode

General information is available in the "Function: Isochronous mode (Page 86)" topic.

Isochronous mode does not have any influence on the functionality of Frequency output operating mode.

If you want to synchronize the output sequence with T_o , then set the Function DI parameter to "Input" and the frequency output sequence starts at T_o.

Parameters of Frequency output operating mode

Parameter	Meaning	Value range	Default
Mode	4 = Set the Frequency output operating mode.	0 = Pulse output 1 = Pulse width modulation 2 = Pulse train 3 = On/Off-delay 4 = Frequency output 5 = DC Motor	1
High Speed Output [1]	The output supports higher frequencies.	0 = disabled 1 = enabled	Disabled
Function DI	You can use the DIn.0 digital input as an input or as a hardware enable.	0 = Input 1 = HW enable	Input
Input delay	DIn.0 digital input must be stable over the delay time (signal noise suppression).	0 = Off (4 µs) 1 = 0.05 ms 2 = 0.1 ms 3 = 0.4 ms 4 = 0.8 ms 5 = 1.6 ms 6 = 3.2 ms 7 = 12.8 ms 8 = 20 ms	0.1 ms
On-delay	The time from the start of the output sequence to the output of the pulses. You can change the On-delay in your control program using SLOT parameter.	0 µs to 85,000,000 µs	0 µs

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)".

Control and feedback signals for Frequency output operating mode

<table>
<tr><th colspan="2">Control interface
Offset to the start address</th><th rowspan="2">Parameter</th><th colspan="5" rowspan="2">Meaning</th></tr>
<tr><th>Channel 0</th><th>Channel 1 [1]</th></tr>
<tr><td rowspan="3">Bytes 0 to 3</td><td rowspan="3">Bytes 12 to 15</td><td rowspan="3">OUTPUT_VALUE
(Real)</td><td colspan="5">DQn.A digital output frequency as a real number. The unit is always Hz.
If you violate the lower or upper limit of the range, the TM Pulse 2x24V will work with the last valid value and the error ERR_OUT_VAL is activated.</td></tr>
<tr><td colspan="3">High-speed output disabled</td><td colspan="2">High-speed output enabled</td></tr>
<tr><td colspan="3">0.02 Hz to 10,000 Hz</td><td colspan="2">0.02 Hz to 100,000 Hz</td></tr>
<tr><td rowspan="2">Bytes 4 to 7</td><td rowspan="2">Bytes 16 to 19</td><td rowspan="2">SLOT
(DWord)</td><td colspan="5">The On-delay can be changed before the start of the output sequence. See MODE_SLOT.</td></tr>
<tr><td colspan="5">0 µs to 85,000,000 µs</td></tr>
<tr><td rowspan="4">Byte 8</td><td rowspan="4">Byte 20</td><td rowspan="4">LD_SLOT</td><td colspan="5">Interpretation of the value SLOT: All other values not listed below are invalid and produce the error ERR_LD (in single-update mode) or ERR_SLOT_VAL (in permanent-update mode).</td></tr>
<tr><td>Bit 3</td><td>Bit 2</td><td>Bit 1</td><td>Bit 0</td><td></td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Idle-state; nothing is done with the value</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>On-delay in microseconds</td></tr>
</table>

Control interface Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1** [1]			
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT	**Bit 4**	Mode for use of the field SLOT.
			0	Single-update mode
			1	Permanent-update mode
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE	**Bit 0**	Software enable: Start/enable and terminate/disable the output sequence.
			0	Output disabled/terminated
			0 → 1	Starts output sequence on positive edge when "Function DI" = "Input"
			1	Enable output sequence, when start is dependent on HW enable with "Function DI" = "HW enable"
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ	**Bit 1**	Set DQn.A output source: Selects either CPU program or module's output sequence.
			0	DQn.A and DQn.B are controlled by the CPU (in your program) using the SET_DQA and SET_DQB control bits.
			1	DQn.A is controlled by the module's pulse output sequence. DQn.B is always 0.
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQA	**Bit 3**	Controls the value of the digital output DQn.A, if TM_CTRL_DQ is cleared.
			0	0 on DQn.A
			1	1 on DQn.A
Byte 9: Bit 4	Byte 21: Bit 4	SET_DQB	**Bit 4**	Controls the value of the digital output DQn.B, if TM_CTRL_DQ is cleared and if SET_DQA is cleared.
			0	0 on DQn.B
			1	1 on DQn.B
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR	**Bit 0**	Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V).
			0	Reset of errors is not active
			1	Reset of errors is active

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and should be 0.

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1[1]**			
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR	**Bit 0**	Indicates under voltage on the Power supply. Note that the bit is not set if the voltage is not present.
			0	PWR is not under voltage
			1	PWR is detected, but under voltage
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V	**Bit 1**	Indicates a short-circuit or overload on the output 24 V DC. You must set the RES_ERROR (control interface), to reset this error.
			0	No short-circuit on 24 V DC
			1	Short-circuit on 24 V DC
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD	**Bit 2**	Indicates an error while loading a value using the field SLOT (only in "single-update" SLOT-mode).
			0	No load error pending
			1	Load error pending; you must set the RES_ERROR (control interface) to reset this error and be able to SLOT again.
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	**Bit 4**	Indicates a short-circuit on the output DQn.A. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.A
			1	Short-circuit on DQn.A
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	**Bit 5**	Indicates a short-circuit on the output DQn.B or an attempt to set both DQn.A and DQn.B manually using SET_DQA,SET_DB, and TM_CTRL_DQ. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.B
			1	Short-circuit on DQn.B or attempt to set both DQn.A and DQn.B
Byte 0: Bit 6	Byte 8: Bit 6	ERR_OUT_VAL	**Bit 6**	Indicates that an invalid value is detected in OUTPUT_VALUE.
			0	OUTPUT_VALUE is valid
			1	OUTPUT_VALUE is not valid
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL	**Bit 7**	Indicates that an invalid value is detected in SLOT (only in "permanent-update" SLOT-mode).
			0	SLOT value is valid
			0 → 1	SLOT value is not valid
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT	**Bit 2**	Toggle acknowledge bit for each action of the SLOT in "single-update" SLOT-mode. Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY	**Bit 4**	Indicates the module is ready and parameterized.
			0	Module is not parameterized
			1	Module is parameterized
Byte 1: Bit 5	Byte 9: Bit 5	STS_SW_ENABLE	**Bit 5**	Indicates the status of SW_ENABLE (control interface).
			0	SW_ENABLE cleared
			1	SW_ENABLE set
Byte 2: Bit 0	Byte 8: Bit 0	STS_ENABLE	**Bit 0**	Indicates an output sequence is running
			0	Pulse output is not running
			1	Pulse output is running
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA	**Bit 1**	Indicates the signal level at the DQn.A digital output.
			0	0 at the DQn.A digital output
			1	1 at the DQn.A digital output

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1[1]**			
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB	**Bit 2**	Indicates the signal level at the DQn.B digital output.
			0	0 on DQn.B digital output
			1	1 on DQn.B digital output
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI	**Bit 3**	Indicates the signal level at the DIn.0 digital input.
			0	0 on DIn.0 digital input
			1	1 on DIn.0 digital input
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT	Sequence counter = 0. The sequence counter is not used in frequency output mode.	
Word 3	Word 7	Reserved	Read as 0	

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and are read as 0.

Input and output signals for Frequency output operating mode

Input and Output Signals	Meaning	Value Range	Channel 0 BaseUnit pin number	Channel 1 BaseUnit pin number
Input signal				
HW enable	You can select the HW enable with the "Function DI" parameter and select the input delay with the "Input delay" parameter. The signal of the DIn.0 digital input is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay, as the start of the output sequence.	0 = HW enable cleared 1 = HW enable issued 0 → 1 = Start of the output sequence after the input delay; dependent on the software enable (SW_ENABLE)	3	4
Output signal				
Pulse at the DQn.A digital output	A pulse is output at the DQn.A digital output for the assigned frequency.	0 = no pulse 1 = pulse	9	10

See also Pin assignment and load/sensor wiring (Page 91)

3.7 DC motor mode

Definition

Each channel has an A and a B output for connection to your DC motor load. The bipolar output switch and pulse width modulation lets your assign rotation direction and output voltage duty cycle.

You can use the two channels for 2 A per channel maximum or use a parallel connection that provides a single channel 4 A maximum.

Two channel motor load connection:

- Channel 0: motor connected between DQ0.A and DQ0.B
- Channel 1: motor connected between DQ1.A and DQ1.B

Single channel motor load connection

- 4 A Channel 0: motor connected between DQ0.A and DQ0.B.
  DQ0.A and DQ1.A are connected together; DQ0.B and DQ1.B are connected together.

For more details concerning the connection, see the Connecting chapter (Page 91)of this manual.

Motor rotate

Rotation direction

- Forward during high phase of the PWM signal: DQn.A is 1 and DQn.B is 0.
- Backward during high phase of the PWM signal: DQn.A is 0 and DQn.B is 1.
- Forward/Backward during low phase of the PWM signal: DQn.A is 0 and DQn.B is 0.

Motor stop

The motor can be stopped using an external signal connected to the DIn.0 digital input or using the signal SW_ENABLE in the control interface. Configure the "Function DI" accordingly.

Function DI setting:

- "HW enable" starts the motor on the rising edge of DI and stops the motor on the falling edge of DI.
- "External stop" starts the motor on the rising edge on SW_ENABLE and stops the motor on the rising edge on DI, or the falling edge of SW_ENABLE.
- "Input" starts the motor on the rising edge of SW_ENABLE and stops the motor on the falling edge of SW_ENABLE (DI has no effect on the control of the motor).

You control the output pulse width duty cycle with the control interface field OUTPUT_VALUE. The TM Pulse 2x24V generates continuous pulses based on this value. The OUTPUT_VALUE determines the duty cycle (pulse duration/period duration) within a period for pulse width modulation. The period duration can be adjusted.

After expiration of the assigned On-delay, the DQn.A and DQn.B output pulses begin (output sequence).

High-speed mode, current measurement, and current control are not available in DC motor mode.

Starting the output sequence

Your control program must issue the enable for the output sequence, using the software enable (SW_ENABLE 0 → 1).

The STS_SW_ENABLE feedback bit indicates the software enable pending at the TM Pulse 2x24V.

You can also assign the DIn.0 digital input of the TM Pulse 2x24V as a HW enable with the "Function DI" parameter. The input delay (noise filter) of the hardware enable can be set using the parameter "Input Delay".

If you want to use the hardware enable, it has to be combined with the software enable. When SW_ENABLE has been enabled, the output sequence starts at the first positive edge of the hardware enable. Further positive edges of the hardware enable during the current output sequence are ignored by the TM Pulse 2x24V. The hardware enable option is not supported for isochronous mode.

When the enable is issued (positive edge) and remains high for the input delay time, the On-delay is started and the STS_ENABLE set. The PWM pulse train is output on expiration of the On-delay. The output sequence runs continuously as long as SW_ENABLE is set.

Canceling the output sequence

- Using the SW_ENABLE signal: Disabling the software enable (SW_ENABLE = 1→0) cancels the current output sequence and the last period duration is not completed. STS_ENABLE and the DQn.A and DQn.B digital outputs are immediately set to 1 (motor stop).

You must restart the output sequence to begin new pulse output.

- Using the digital input DIn.0:
  - If "Function DI" is parameterized as "HW_ENABLE": a falling edge on DIn.0 will stop the output sequence with the same behavior as using the SW_ENABLE.
  - If "Function DI" is parameterized as "External stop": a rising edge on DIn.0 will stop the sequence with the same behavior as using the SW_ENABLE.

Truth table

Software enable SW_ENABLE	Function DI parameter	Hardware enable (DIn.0 digital input)	Digital output DQn.A and DQn.B	STS_ENABLE	Output sequence
1	HW_ENABLE	0 → 1 and remains 1 during the input delay. Only active for the first positive edge, additional positive edges are ignored and no start occurs.	If On-delay > 0: DQn.A: 0 DQn.B: 0	0 → 1	Start
			If On-delay = 0: Forward: DQn.A: 1 DQn.B: 0 Backward: DQn.A: 0 DQn.B: 1		
0 → 1	Input or External stop	Any state	If On-delay > 0 DQn.A: 0 DQn.B: 0	0 → 1	Start
			If On-delay = 0 Forward: DQn.A: 1 DQn.B: 0 Backward: DQn.A: 0 DQn.B: 1		
0	HW_ENABLE or Input or External stop	Any state	DQn.A: Tri-state DQn.B: Tri-state	0	Cancel
1	Input	Any state	If On-delay is not expired or during interpulse time: DQn.A: 0 DQn.B: 0		-
			If On-delay is expired and during the pulse duration: Forward: DQn.A: 1 DQn.B: 0 Backward: DQn.A: 0 DQn.B: 1		
1	HW_ENABLE	0	DQn.A: Tri-state DQn.B: Tri-state	1 → 0	Stop
1	External stop	0 → 1	DQn.A: Tri-state DQn.B: Tri-state	1 → 0	Stop
0 → 1	HW_ENABLE	0	DQn.A: Tri-state DQn.B: Tri-state	0	-

Setting and changing the pulse duty cycle and rotation direction

OUTPUT_VALUE assigns the duty cycle and the direction for the current period duration.

OUTPUT_VALUE is given as an S7 analog value, the sign gives the direction of the motor rotation ("+" means forward, "-" means backwards). The possible range is -27648 to +27648.

Only the two least significant bytes of OUTPUT_VALUE are used, the two other bytes are ignored. A value of the two least significant bytes higher than +27648 will be interpreted as a value of +27648 (100% forward). A value of the two least significant bytes below -27648 will be interpreted as a value of -27648 (100% backward).

Before changing the rotation direction, it is recommended that the OUTPUT_VALUE is first set to 0 long enough, to first stop the motor. Note that the TM Pulse 2x24V module does not override our duty cycle assignment in order to protect the motor. If a ramp-up or ramp-down is required by the motor, this ramp has to be implemented in the automation program and transmitted to the module by controlling the value of the field OUTPUT_VALUE accordingly.

- "S7 analog output" output format: Value range between -27,648 and +27,648. The sign determines the motor rotation direction.
- Pulse duration = (OUTPUT_VALUE/27,648) x period duration.

You assign OUTPUT_VALUE directly with your control program. A new OUTPUT_VALUE is applied at the next rising edge of the output.

Setting and changing the period duration

- Permanent update
  The period duration is controlled permanently using the control interface. The MODE_SLOT bit has to be set ("1" means permanent update); LD_SLOT has to have the value 1 ("1" means Period duration).
  Set the period duration value in the field SLOT between 100 µs and 85,000,000 µs.
- Single update
  Set the period duration in the configuration parameters. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared ("0" means single-update); LD_SLOT has to have the value 1 ('1' means Period duration).
  Set the period duration value in the field SLOT between 100 µs and 85,000,000 µs.

The new period duration is applied with the next rising edge of the output.

For more details about SLOT parameter handling, see "Slot parameter handling (control interface)".

Isochronous mode

General information is available in the "Function: Isochronous mode" topic.

In isochronous mode, the output sequence is synchronized with the moment T_O. The period duration is coordinated to the application cycle (the synchronous cycle, a multiple of the PROFINET cycle). The behavior in the DC-motor mode is the same than the behavior in the operating mode PWM. Please refer to the corresponding chapter in this manual. Only the differences are listed below:

- During the "pulse duration phase" (high phase), the status of the outputs is as follows:
  - In forward direction: DQn.A is 1 and DQn.B is 0
  - In backward direction: DQn.A is 0 and DQn.B is 1
- During the "interpulse duration phase" (low phase), the status of the outputs is as follows:
  - DQn.A is 0 and DQn.B is 0
- The parameter "Function DI" can be parameterized as "External stop" in isochronous mode to use the rising edges on the DIn.0 to stop the motor. Note that if "Function DI" is parameterized as "HW_ENABLE" in isochronous mode which is not supported, it will be interpreted as "External stop" by the TM Pulse 2x24V module.

Setting and changing the On-delay

- Permanent update
  The On-delay can be controlled permanently using the control interface. The MODE_SLOT bit has to be set (permanent update); LD_SLOT must have the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the field SLOT. The unit is always microseconds.
- Single update
  Set the On-delay as a value between 0 µs and 85,000,000 µs in the configuration parameters. The unit is always microseconds. Alternatively, perform a single update using the control interface. MODE_SLOT has to be cleared (single-update); LD_SLOT must have the value 2 (for On-delay). Set the On-delay as a value between 0 µs and 85,000,000 µs in the field SLOT.

If you change the On-delay value during the output sequence, then the new On-delay is activated at the next output sequence. For more details about the use of the SLOT parameter see SLOT parameter handling.

Parameters for DC motor operating mode

Parameter	Meaning	Value range	Default
Operating mode	5 = Set the DC motor operating mode.	0 = Pulse output 1 = Pulse width modulation 2 = Pulse train 3 = On/Off-delay 4 = Frequency output 5 = DC Motor	1
Function DI	You can use the DIn.0 digital input as an input, for HW_ENABLE, or External stop signal. The signal at DIn.0 is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay. If HW_ENABLE is used in non-isochronous mode, a rising edge on DIn.0 starts the output sequence (If SW_ENABLE is set) and a falling edge on DIn.0 stops the output sequence. If HW_ENABLE is used in isochronous mode, it will be interpreted by the module as External stop. If External Stop is used, the output sequence starts with the rising edge of SW_ENABLE and stops with the rising edge of DIn.0.	0 = Input 1 = HW enable 2 = External stop	Input
Output format	Defines the format of the ratio value (duty cycle).	0 = S7 analog format	S7 analog format
Input delay	DIn.0 digital input must be stable over the delay time (signal noise suppression).	0 = Off (4 µs) 1 = 0.05 ms 2 = 0.1 ms 3 = 0.4 ms 4 = 0.8 ms 5 = 1.6 ms 6 = 3.2 ms 7 = 12.8 ms 8 = 20 ms	0.1 ms
Period	Period duration of the output pulse cycle in µs. You can change the period duration in your control program with the control interface SLOT field.	100 µs to 85,000,000 µs	1000 µs
On-delay	The time from the start of the output sequence to the output of the pulses. You can change the On-delay in your control program with the control interface SLOT field.	0 µs to 85,000,000 us	0 µs

Control and feedback signals for DC motor mode

Control interface Offset to the start address		**Parameter**	**Meaning**				
Channel 0	**Channel 1** [1]						
Bytes 0 to 3	Bytes 12 to 15	OUTPUT_VALUE (DWord)	The OUTPUT_VALUE determines the duty cycle (pulse duration/period duration ratio) within a period (PWM). The period duration can be adjusted. The new output value is applied at the next rising edge of the output. The OUTPUT_VALUE sign indicates direction of rotation (positive for forward) and (negative for backward). S7 analog output format: value range is -27,648 to +27,648 DInt data type: Only 2 least significant bytes are used For channel 0: bytes 2 and 3 For channel 1: bytes 14 and 15				
Bytes 4 to 7	Bytes 16 to 19	SLOT (DWord)	Your program can change the On-delay and Period duration before the start of the output sequence using the SLOT and MODE_SLOT parameters.				
			0 µs to 85,000,000 µs				
Byte 8	Byte 20	LD_SLOT	Interpretation of the value SLOT: All other values not listed below are invalid and produce the error ERR_LD (in single-update mode) or ERR_SLOT_VAL (in permanent-update mode).				
			Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
			0	0	0	0	Idle-state; nothing is done with the value
			0	0	0	1	Period in µs
			0	0	1	0	On-delay in µs
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT	**Bit 4**	Mode for use of the field SLOT.			
			0	Single-update mode			
			1	Permanent-update mode			
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE	**Bit 0**	Software enable: Start and terminate the output sequence.			
			0	Output canceled			
			0 → 1	Starts output sequence on positive edge when "Function DI" = "Input" or "Function DI" = "External stop".			
			1	Enable output sequence, when start is dependent on HW enable with "Function DI" = "HW enable"			
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ	**Bit 1**	The outputs are always controlled by the module in DC-motor mode. This bit is ignored.			
			X	Don't care: No effect on the outputs.			
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQA	**Bit 3**	Controls the value of the digital output DQn.A, if TM_CTRL_DQ = 0.			
			X	Don't care: No effect on the outputs.			
Byte 9: Bit 4	Byte 21: Bit 4	SET_DQB	**Bit 4**	Controls the value of the digital output DQn.B, if TM_CTRL_DQ = 0.			
			X	Don't care: No effect on the outputs.			
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR	**Bit 0**	Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V).			
			0	Reset of errors is not active			
			1	Reset of errors is active			

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and should be 0.

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1 [1]			
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR	**Bit 0**	Indicates under voltage on the Power supply. Note that the bit is not set if the voltage is not present.
			0	PWR is not under voltage
			1	PWR is detected, but under voltage
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V	**Bit 1**	Indicates a short-circuit or overload on the output 24 V DC. You must set the RES_ERROR (control interface), to reset this error.
			0	No short-circuit on 24 V DC
			1	Short-circuit on 24 V DC
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD	**Bit 2**	Indicates an error while loading a value using the field SLOT (only in "single-update" SLOT-mode).
			0	No load error pending
			1	Load error pending: you must set the RES_ERROR (control interface) to reset this error and be able to use SLOT again.
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	**Bit 4**	Indicates a short-circuit on the output DQn.A. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.A
			1	Short-circuit on DQn.A
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	**Bit 5**	Indicates a short-circuit on the output DQn.B. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.B
			1	Short-circuit on DQn.B
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL	**Bit 7**	Indicates that an invalid value is detected in SLOT (only in "permanent-update" SLOT-mode).
			0	SLOT value is valid
			0 → 1	SLOT value is not valid
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT	**Bit 2**	Toggle acknowledge bit for each action of SLOT in "single-update" SLOT-mode. Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY	**Bit 4**	Indicates the module is ready and parameterized.
			0	Module is not parameterized
			1	Module is parameterized
Byte 1: Bit 5	Byte 9: Bit 5	STS_SW_ENABLE	**Bit 5**	Indicates the status of SW_ENABLE (control interface).
			0	SW_ENABLE cleared
			1	SW_ENABLE set
Byte 2: Bit 0	Byte 8: Bit 0	STS_ENABLE	**Bit 0**	Indicates an output sequence is running.
			0	Output sequence not running
			1	Output sequence running
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA	**Bit 1**	Indicates the signal level at the DQn.A digital output.
			0	0 on DQn.A digital output
			1	1 on DQn.A digital output
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB	**Bit 2**	Indicates the signal level at the DQn.B digital output.
			0	0 on DQn.B digital output
			1	1 on DQn.B digital output

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	**Channel 1** [1]			
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI	**Bit 3**	Indicates the signal level at the DIn.0 digital input.
			0	0 on DIn.0 digital input
			1	1 on DIn.0 digital input
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT	Sequence counter = 0. The sequence counter is not used in PWM mode.	
Word 3	Word 7	Reserved	Read as 0	

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note: All bytes and bits not described in the table above are reserved and are read as 0.

Input and output signals for DC motor operating mode

Input and output signal	Meaning	Value range	Channel 0 BaseUnit pin number	Channel 1 BaseUnit pin number
Input signal				
HW enable /External stop Note: HW enable not supported for PWM in isochronous mode	You can select the interpretation of the digital input signal on the output sequence with the "Function DI" parameter and select the input delay with the "Input delay" parameter. The signal at the DIn.0 digital input is interpreted by the TM Pulse 2x24V, after noise filtering by the input delay, as the start of the output sequence.	Function DI = "HW_ENABLE": 0 = HW enable cleared 1 = HW enable issued 0→1 = Start of the output sequence after the input delay, dependent on the software enable (SW_ENABLE) 1→0 = Stop of the output sequence after the input delay, dependent on the software enable (SW_ENABLE). Function DI = External stop: 0→1 = Stop of the output sequence after the input delay; dependent on the software enable (SW_ENABLE)	3	4
Output signal				
Pulse at the DQn.A and DQn.B digital outputs	A pulse is output at the DQn.A and DQn.B digital outputs for the assigned duty cycle and period duration.	**No pulse or interpulse period:** DQn.A is 0 V and DQn.B is 0 V **Pulse duration in forward direction:** DQn.A is 24 V and DQn.B is 0 V **Pulse duration in backward direction:** DQn.A is 0 V and DQn.B is 24 V	9 (DQ0.A) 11 (DQ0.B)	10 (DQ1.A) 12 (DQ1.B)

See also Pin assignment and load/sensor wiring

3.8 Function: High-speed output

High-speed mode improves the signal timing of the DQ digital outputs. The switching edges have less delay, variation, jitter, and smaller rise/fall times.

High-speed mode is designed to produce more precise timing for pulse signals, but provides less maximum load current.

High-speed output is only available in dual channel operation; it is not available in single channel operation.

You can use the STEP 7 (TIA Portal) or STEP 7 hardware configuration to select "High-speed output (0.1 A)" option for each channel separately. Also, you can change the parameter assignment at runtime with your program using data record 128 (Page 138).

STEP 7 (TIA Portal) and STEP 7 assist you during parameter assignment, by disabling keyboard input for invalid parameters and range checking your value assignments. Depending on previous parameter selections, other options will be disabled. For example, if you select the single channel operation (the parallel connection of the two output channels), then the parameter options for Channel 1 and high-speed output are disabled.

High-speed output option is available for these operation modes:

- Pulse output
- PWM
- Pulse train
- On/Off-delay
- Frequency output

High-speed output is not available in DC motor mode.

High-speed output option

Pulse timing	Minimum		Maximum	
	High-speed disabled	High-speed enabled	High-speed disabled	High-speed enabled
Pulse duration	10 µs	1.5 µs	85,000,000 µs	
Period duration	100 µs	10 µs		
On-delay	0 µs			
Off-delay				
Frequency	0.02 Hz		10 kHz	100 kHz

High-speed output load current

Parallel mode (single channel operation)	Maximum pulse output load current	
	High-speed disabled	High-speed enabled
Disabled	2 A (Two channels)	100 mA (Two channels)
Enabled	4 A (One channel)	Not allowed

3.9 Function: Sequence counter

The TM Pulse 2x24V has a sequence counter for each channel that counts completed output sequences. Successfully completed and unsuccessfully completed output sequences are counted.
You can monitor the completion of an output sequence with the sequence counter SEQ_CNT variable in the feedback interface (Page 115).

The counter has a width of 4 bits. After a count overflow, the counter jumps back to 0.

Function of the sequence counter

The sequence counter has the following function in the individual operating modes:

- Pulse output and pulse train
  - Function DI configuration is set to "Input": the counter is set to 1 after completion of the output sequence (range 0 to 1).
  - Function DI configuration is set to "HW enable": the counter is incremented after every completed output sequence (range 0 to 15).
- On/Off-delay
  - The counter is incremented, with each edge (positive and negative) at the DQ output (range 0 to 15).
- PWM, frequency output, and DC motor
  - The counter does not have any function.

When the software enable (SW_ENABLE = 0) occurs, the counter is reset to 0.

Application options

The sequence counter can be used for:

- Detecting (counting) very short pulse sequences
- Counting of output sequences controlled with the hardware enable

3.10 Function: Current measurement

Principle of operation

Your program logic can use load current measurements with a control loop for proportional control of the energy transferred to an inductive or resistive load. The current measurements are provided in the feedback interface (Page 115) MEASURED_CURRENT value in SIMATIC S7 analog value format.

Current measurement is possible:

- For PWM and Pulse train operating modes and if the high-speed output option is inactive
  - When there is no pulse output (at STS_ENABLE = 0), 7FFFH is supplied as the measured value.
  - The measured value is valid at (STS_ENABLE = 1) after the first period duration. The returned current measurement value is a mean value of measured values sampled over the duration of at least one period. If Dithering is active, then the mean value is sampled over the duration of the entire Dither period.

Current measurement is not possible and returns a MEASURED_CURRENT value of 0:

- For all other operating modes or if the high-speed output option is active.

Note

In order for the current measurement to work correctly, do not connect a freewheeling diode (snubber/suppressor diode) to the output load.

Measuring range and measured value

- **Channel configuration is 2 channels (2 A)** (the parallel channel connection is deactivated).
  - A measured mean current of 2 A corresponds to the SIMATIC S7 analog value of 27,648 ($6C00_H$).
  - Measurements of current are possible up to a SIMATIC S7 analog value of 32,511 ($7EFF_H$) which corresponds to a current of 2.37 A.
  - Currents exceeding 2 A may only occur briefly.
- **Channel configuration is 1 channel (4 A)** (the parallel channel connection is activated).
  - A measured mean current of 4 A corresponds to the SIMATIC S7 analog value of 27,648.
  - Measurements of current are possible up to a SIMATIC S7 analog value of 32,511 which corresponds to a current of 4.74 A.
  - Currents exceeding 4 A may only occur briefly.

Output current limit diagnostic message

If diagnostics are enabled and the module is in PWM or PTO mode, then an over current diagnostic error will be reported when the module senses the current to be higher 2.37 A (4.74 A in single channel mode).

Current measurement accuracy

Current measurement accuracy is ±2% of the full scale 27,648 measuring range

- ±40 mA in dual channel mode
- ±80 mA in single channel mode

The current measurement accuracy degrades above 3 kHz pulse frequency to -2% +5% accuracy, when driving resistive loads at a frequency of 10 kHz.

Note

2% current measurement accuracy is only possible, if the period duration is not changed during the measurement process.

3.11 Function: Current control

Current control (PWM mode only)

In PWM mode, the TM Pulse 2x24V module can use a proportional-integral-derivative (PID) algorithm to control output current. The target value of the current (set point) is determined by your program and the module controls the duty cycle of the PWM output to follow the set point, with a response that is based on the assigned PID parameters.

The set point and the measured value of the load current are compared by the PID controller. If the resulting difference (error) is outside a symmetrical dead band, a reaction is calculated by adding the selected proportional, integral and/or derivative parts. The manipulated value is limited by the defined high/low limits and finally the output pulse duration time (duty cycle) is modified, depending on the PWM period duration.

Assign the reference current value to the current measured in the channel's DQn.A output load when the output is continuously in the high (On) state.

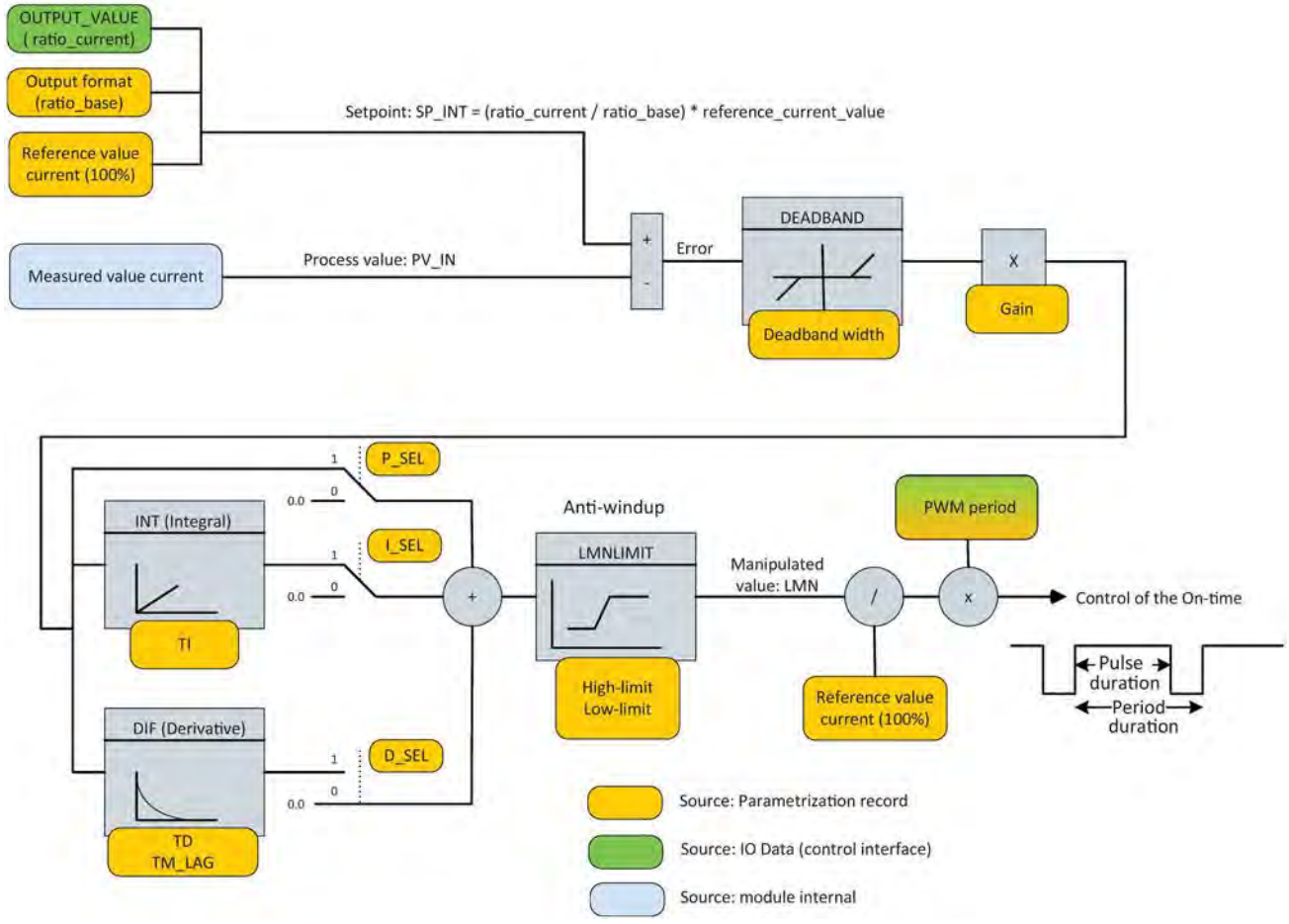


Figure 3-14 Current control PID function

For more information about this PID control method, refer to the CONT_C instruction topic in TIA Portal online help.

Setting up current control

In order to use the current control feature, the module must be parametrized correctly and the set point (target value of the current) must to be controlled by the user program. In addition, your program can also read the limit-reached flags.

PID parameters

The PID parameters can be set in TIA Portal device configuration or by your program writing parametrization record (record 128) in the module. See the parametrization record description (Page 138) for details.

- Current Control: "1" activates the PID controller. Limitations: Current control can only be activated if the selected mode of operation is PWM and the high-speed output is disabled.
  All the following parameters have no effect, if current control is disabled.
- P_Sel, I_Sel, D_Sel: defines the PID control calculation. The proportional, integral, and derivative parts can be enabled ("1") or disabled ("0") in the device configuration.
- Reference value current (mA): The reference value is used to define the maximum set point and the high and low limits of the controlled current. Typically, the maximum current can be measured in PWM mode with current control disabled and a duty cycle set to 100%. The value measured can be set as a reference for the current control. The maximum value is 4000 mA for single channel operation (parallel channel connection enabled) and 2000 mA per channel for dual channel operation (parallel connection disabled).
- Dead band width (µA): A dead band is applied to the output current deviation from the set point current. The "Dead band width" is half of the size of the dead band. The dead band is symmetrical: For example, if the dead band width = 1500 µA, then the dead band is from -1500 µA to +1500 µA .
- High limit (S7 analog value): The manipulated value is always restricted to a high limit and low limit. The "High limit" parameter assigns the high limit in S7 analog format, relative to the reference value current. A value higher or equal than 27648 means 100% of the reference value current. The High limit value must be higher than the Low limit.

  High limit example:

  – The reference current is set to 1000 mA which should be the load current measured with 100% duty cycle.
  – If the high limit is 20000, this means the maximum current the controller will drive is 20000/27648 * 1000 mA = 723.4 mA that is equivalent to a duty cycle of 72.34%.
  – If the controller calculates a control value higher than 72.34%, it will drive 72.34% and never go higher than that value.

- **Low limit (S7 analog value):** The manipulated value is always restricted to a high limit and low limit. The "Low limit" parameter assigns the low limit in S7 analog format, relative to the reference value of the current. A value higher or equal to 27648 is not allowed. The Low limit value must be lower than the High limit.
  Low limit example:
  - The reference current is set to 1000 mA which should be the load current measured with 100% duty cycle.
  - If the low limit is 100, this means the minimum current the controller will drive is 100/27648 * 1000 mA = 3.6 mA that is equivalent to a duty cycle of 0.36%.
  - If the controller calculates a control value below 0.36%, it will drive 0.36% and never go lower than that value.
- **Gain:** The proportional gain parameter assigns the amplification factor for the P part of the PID algorithm.
- **TI (s)**: The integration time parameter determines the time interval of the integral action. If TI is smaller than the controller cycle time, TI will be set internally to the controller cycle time.
- **TD (s)**: The derivative time parameter determines the time interval of the derivative action. If TD is smaller than the controller cycle time, TI will be set internally to the controller cycle time.
- **TM_LAG (s)**: Time lag of the derivative action. The algorithm of the D-action contains a delay of TM_LAG. If TM_LAG is smaller than half the controller cycle time, TI will be set internally to half the controller cycle time.

Set point control

Your program controls the target value of the output current by setting the control interface field OUTPUT_VALUE. The output format is selected in the parametrization record (see parameter "output format"). For example, if the output format "per 100" is selected, writing the value 60 in OUTPUT_VALUE means the target current value is 60% of the reference current value (see parameter "reference value current").

Limit reached flags

The limit reached flags are available in the feedback interface.

QLMN_HLM: "1" means the manipulated value is at the high limit.

QLMN_LLM: "1" means the manipulated value is at the low limit.

For more information about the PID control parameters, refer to the CONT_C instruction topic in TIA portal online help.

Controller cycle time

The internal controller cycle time depends on the configured automation system and on the PWM period. The controller cannot control the current faster than the parametrized PWM period, as the measured current is averaged over an entire PWM period.

If Dithering is active simultaneously with current control, the PID controller uses the Dither period duration as the internal controller cycle time.

Resetting the PID current controller

The internal data of the current controller are reset in the following cases:

- SW_ENABLE (see control interface) is low.
- A new parametrization record is sent to the module.

See also

TM Pulse 2x24V feedback interface (Page 115)

3.12 Function: Dither PWM output

Dither overview

The Dither function creates a vibration in a proportional valve when the desired valve position is controlled with current supplied from the PWM output. The vibration is induced by superimposing the dither current fluctuation around the target current, in a PWM output load (valve coil).

The dither vibration improves the accuracy and linearity of proportional control valves. You can enable and configure the Dither function to minimize valve control problems caused by static friction, stiction, and hysteresis.

Dither parameters

The dither parameters can be set in the TIA Portal device configuration or in the parameterization record (record 128) sent by the program to the module. See the Parameterization record (Page 138) description for details. Some dither parameters can be changed during operation by using the slot mechanism in the control interface for calibration purposes. It is recommended to restart the PWM output sequence after such a parameter change.

- Dither: "1" enables the dither feature. In addition to enabling "Dither" in the module's PWM configuration, you must set the DITHER bit in the Control interface (Page 110) to start the Dither signal.
- Dither amplitude (‰): Assign the amplitude ratio of the superimposed dither signal in a per mill ratio. The allowed range is 0 to 500‰ duty cycle. If a higher value is assigned, then 500‰ is used by the module.

  For example: if the dither amplitude is set to 100‰ and the duty cycle in PWM mode is set to 50%, then the effective duty cycle of the signal will vary periodically between 40% and 60%.

  The dither amplitude is adapted (reduced) dynamically by the module if the calculated effective duty cycle is higher than 100% or lower than 0%, so that the dither signal remains symmetrical.

  For example, if the dither amplitude is set to 100‰ and the duty cycle in PWM mode is set to 95%, the effective duty cycle of the signal will vary periodically between 90% and 100%. The dither amplitude is always corrected to remain symmetrical. The dither amplitude will return to the assigned value, as soon as the output signal allows enough duty cycle margin for the superimposed Dither duty cycle variation to be symmetrical.

- **Dither period (µs)**: Assign the period duration in microseconds for the superimposed dither signal. The allowed range is from (4 x PWM period) to 100,000 µs. Also, the Dither period must be greater than 2 ms. If a value less than 2 ms or less than (4 x PWM period) is parametrized, then an error occurs (see parameter validation (Page 120) for ERR_SLOT_VAL and ERR_LD). If a Dither period higher than 100 ms is assigned, the module will use the value 100 ms. The Dither period used by the module can only be an even multiple of the PWM period. The module will use the nearest possible value to the assigned Dither period.
- **Dither ramps**: The dither ramp parameter is one double-word made of two different words. The low word is the dither ramp-up time and the high word is the dither ramp-down time.
  - **Dither ramp-up time (ms):** Assign the time in milliseconds for the duty cycle to rise from 0% to 100%. The allowed range is 0 ms to 30,000 ms. If a higher value is assigned, then 30,000 ms is used by the module.
    The effective ramp-up time is dependent on the dither amplitude and the nominal value of the duty cycle.
    For example: if your nominal value of the duty cycle is 50% and the dither amplitude is 100‰, the effective duty cycle will vary between 40% and 60%, the ramp-up time from 50% to 60% will be 100‰ x Dither ramp-up time.
  - **Dither ramp-down time (ms):** Assign the time in milliseconds for the duty cycle to fall from 100% to 0%. The allowed range is 0 ms to 30,000 ms. If a higher value is assigned, then 30,000 ms is used by the module.
    The effective ramp-down time is dependent on the Dither amplitude and the nominal value of the duty cycle.
    For example: if your nominal value of the duty cycle is 50% and the dither amplitude is 100‰, the effective duty cycle will vary between 40% and 60%, the ramp-down time from 50% to 40% will be 100‰ x Dither ramp-down time.

Note

Changing parameters during Dither output

If the PWM period is changed during operation using the slot mechanism, so that the dither period is less than (4 x PWM period), then dither current is deactivated and feedback bit STS_DITHER = 0, until a valid combination of Dither and PWM periods is assigned.

If you change parameter values using the SLOT mechanism during dither output, then you should restart the output sequence.

Note

PWM with dithering in isochronous mode

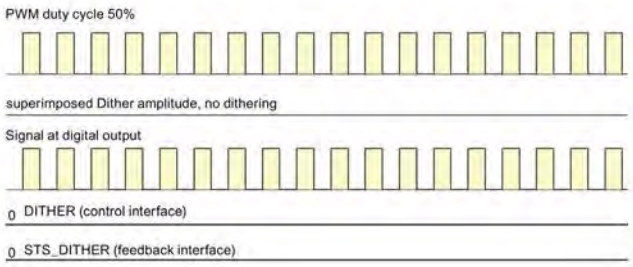
For best results, set the dither period duration to an integral even-numbered multiple of the application cycle.

Example: If the application cycle is 1ms, then the minimal optimal dither period is 2ms. The next optimal values are 4ms, 6ms, ...

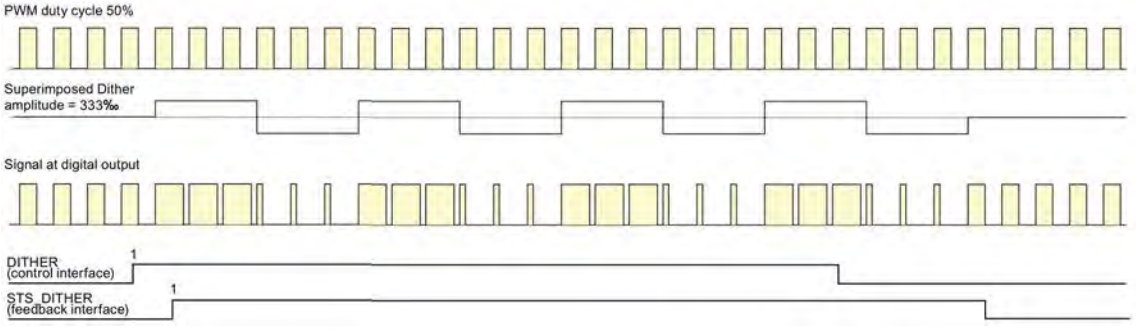
Dither starting and stopping

The ramp-up of the dither current starts as soon as the bit DITHER is set in the control interface and the current Dither period has ended and a new Dither period starts. The feedback interface provides an acknowledge bit STS_DITHER in the feedback interface that goes high when the ramp-up phase is started (by setting the DITHER bit when the output sequence is running) and goes low when the ramp-down phase is over or the output sequence is stopped. The ramp-down starts when the bit DITHER is cleared in the control interface and the current Dither period has ended and a new Dither period starts.

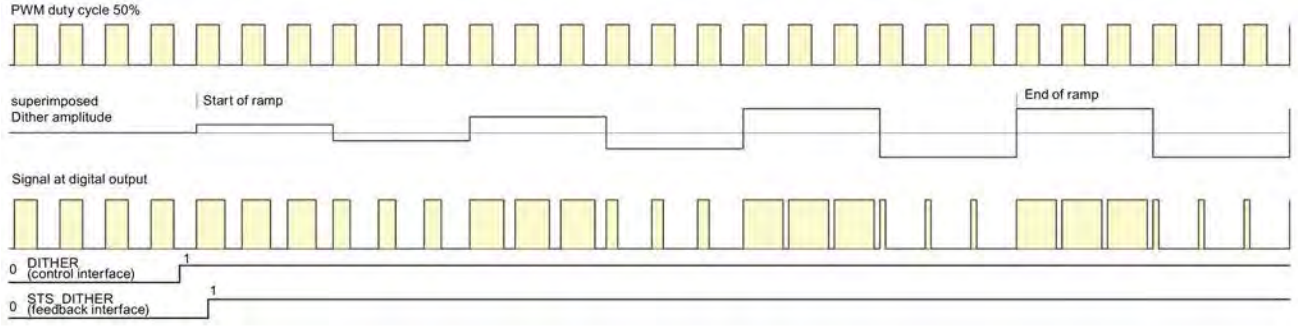
Example 1: No dither (Dither bit = 0)



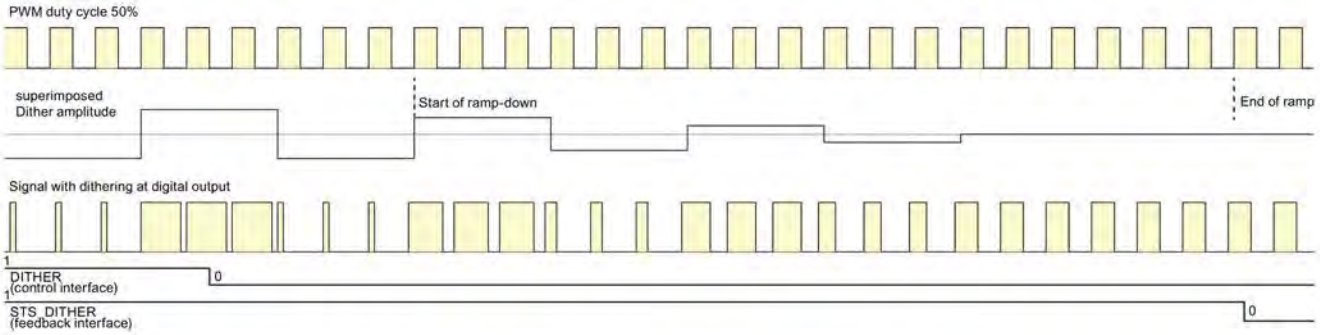
Example 2: Dither with no ramp (Dither period = 6 x PWM period)



Example 3: Dither with ramp-up



Example 4: Dither with ramp-down



3.13 Function: Isochronous mode

Note

For basic information on isochronous mode, refer to the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/mdm/49948856?c=73850691339&t=1&s=PROFINET in STEP 7&lc=en-US) manual.

Requirements

You will require the following for the TM Pulse 2x24V in isochronous mode:

- A CPU that supports isochronous mode
- An IM (interface module) that supports isochronous mode
- Engineering software, such as TIA portal or STEP 7, to parameterize isochronous mode

Response of the TM Pulse 2x24V

Depending on the system parameter assignment, the TM Pulse 2x24V works in either non-isochronous or isochronous mode.

In isochronous mode

- The output sequences are started at the moment T_O, when only the software enable is used.
- Data communication between the PROFINET controller and TM Pulse 2x24V is isochronous to the cycle.
- All 12 bytes of a channel's control interface are consistent (24 bytes for both channels).
- All 8 bytes of a channel's feedback interface are consistent (16 bytes for both channels).
- In the PWM operating mode, the period duration is synchronized to the application cycle time (PROFINET). See the PWM chapter (Page 25) for details.

3.14 Function: Direct control of DQ digital outputs

Definition

You can directly set the TM Pulse 2x24V DQ digital outputs with your control program. Select the DQ direct control function, by clearing the Technology Module output control bit (TM_CTRL_DQ = 0), in the control interface.

Direct control of a digital output can support you when commissioning an automation control system.

If you select direct control of the DQ during a pulse output sequence, the sequence will continue to run in the background, so that when the module gets control again (by setting TM_CTRL_DQ = 1), the output sequence continues.

You assign the state of a digital output DQn.A and DQn.B with the SET_DQA and SET_DQB control bits.

You cannot use the Direct control function to set both DQn.A and DQn.B outputs high on the same channel. If an attempt to do so occurs, then error ERR_DQB is set in the feedback interface and only the DQn.A output is set high.

When you set TM_CTRL_DQ = 1, you deselect the direct control of digital output function. If the output sequence is still running (STS_ENABLE still active), then the TM Pulse 2x24V module regains control of a channel's DQn.A and DQn.B outputs.

Note

TM_CTRL_DQ technology module output control signal

- If TM_CTRL_DQ = 1, then the TM Pulse 2x24V module has control and produces pulse sequences at the DQn.A and DQn.B outputs. DQn.B is always 0 except in DC motor mode.
- If TM_CTRL_DQ = 0, then the CPU has control and your program can set DQ outputs directly with the SET_DQA/SET_DQB control bits. In DC motor mode, it is not possible to control the DQn.A and DQn.B outputs manually; TM_CTRL_DQ, SET_DQA, and SET_DQB have no effect.

Pulse diagram

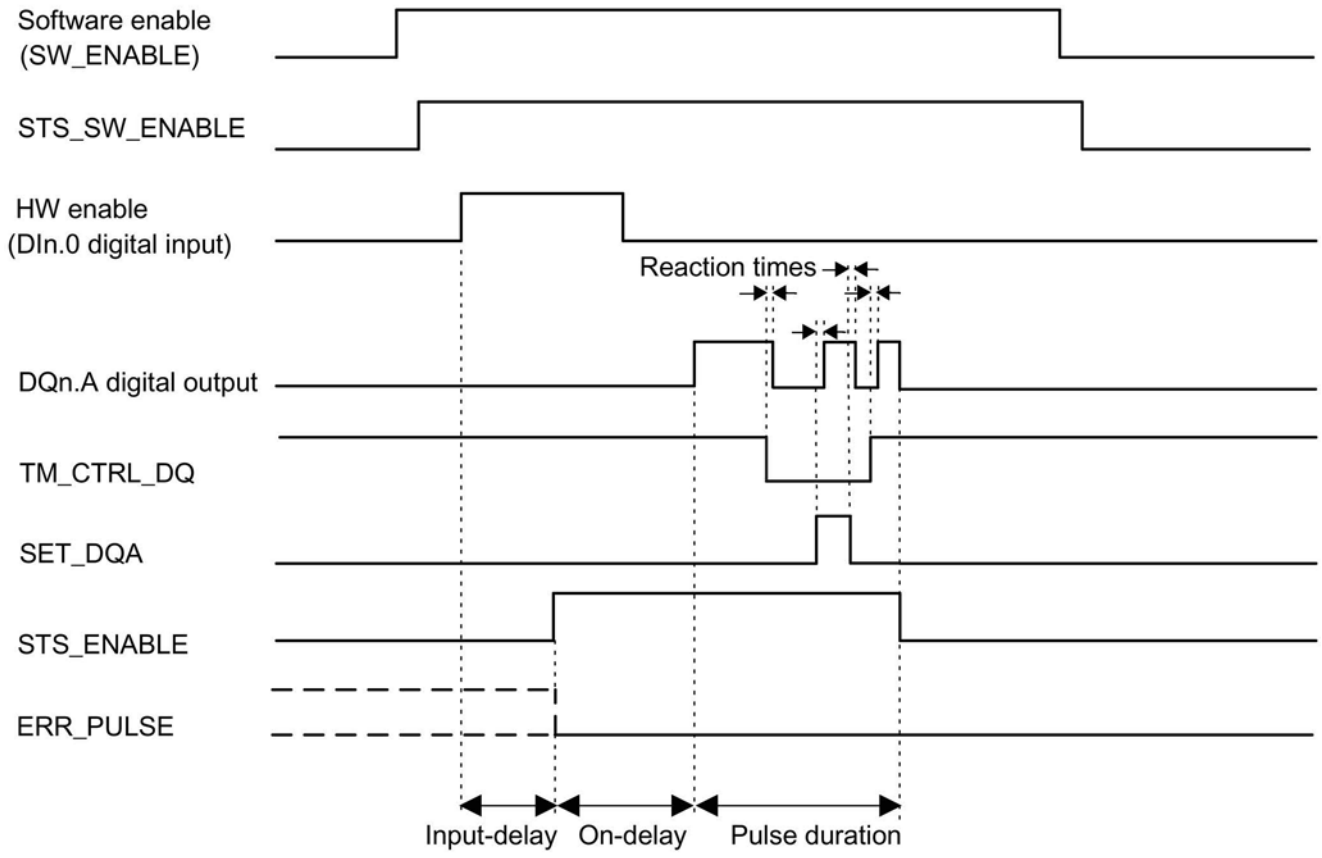


Figure 3-15 Direct control of DQ timing during Pulse output mode

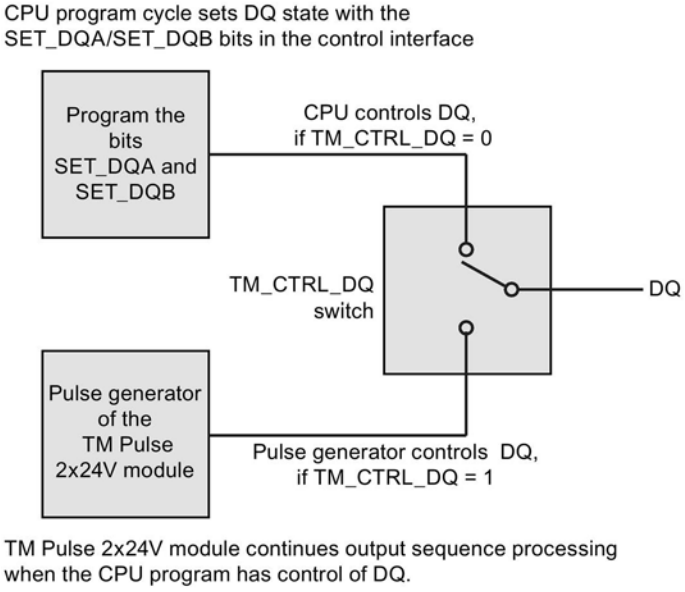


Figure 3-16 TM_CTRL_DQ output switch

Control and feedback signals

Control interface Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1			
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE	**Bit 0**	Software enable: Start and terminate the output sequence.
			0	Output canceled.
			0 → 1 1	Starts output sequence on positive edge; may be dependent on the hardware enable.
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ	**Bit 1**	Set DQ output source: Selects either PLC program or module's output sequence.
			0	DQn.A and DQn.B are controlled by the PLC program using SET_DQA and SET_DQB.
			1	DQn.A is controlled by the module's pulse output sequence.
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQA	**Bit 3**	Controls the value of the digital output DQn.A, if TM_CTRL_DQ is cleared.
			0	0V on DQn.A
			1	24V on DQn.A
Byte 9: Bit 4	Byte 21: Bit 4	SET_DQB	**Bit 4**	Controls the value of the digital output DQn.B, if TM_CTRL_DQ is cleared and if SET_DQA is cleared.
			0	0V on DQn.B
			1	24V on DQn.B

Feedback interface: Offset to the start address		Parameter	Meaning	
Channel 0	Channel 1			
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	**Bit 4**	Indicates a short-circuit on the output DQn.A. You must set RES_ERROR (control interface) to reset this error.
			0	No short- circuit on DQn.A
			1	Short-circuit on DQn.A
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	**Bit 5**	Indicates a short-circuit on the output DQn.B or an attempt to set both DQn.A and DQn.B manually using SET_DQA,SET_DB, and TM_CTRL_DQ. You must set RES_ERROR (control interface) to reset this error.
			0	No short-circuit on DQn.B
			1	Short-circuit on DQn.B or attempt to set both DQn.A and DQn.B
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA	**Bit 1**	Indicates the signal level at the DQn.A digital output.
			0	Signal 0 at the DQn.A digital output
			1	Signal 1 at the DQn.A digital output
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB	**Bit 2**	Indicates the signal level at the DQn.B digital output.
			0	Signal 0 at the DQn.B digital output
			1	Signal 1 at the DQn.B digital output

States of DQ bits				
TM_CTRL_DQ	**SET_DQA**	**SET_DQB**	**Reaction at DQn.A**	**Reaction at DQn.B**
0	0	0	0	0
0	1	0	1	0
0	1	1	1	0 (ERR_DQB is set)
0	0	1	0	1
1	Don't care	Don't care	State controlled by pulse processing	State controlled by pulse processing

Note

Setting both DQn.A and DQn.B to the 1 state not allowed

You cannot set both DQn.A and DQn.B to 1 at the same time. If SET_DQA and SET_DQB are set high and TM_CTRL_DQ is low, only output DQn.A will go high and an error bit ERR_DQB is set in the feedback interface. This error must be acknowledged in the control interface by using the RES_ERROR bit.

Connecting

4

4.1 Pin assignment, sensor, load, and power wiring

The TM Pulse 2x24V must use the B1 type BaseUnit.

Digital inputs, digital outputs, 24 V DC sensor power outputs and an external 24 V DC power source are connected to the BaseUnit of the technology module.

BaseUnit

The BaseUnit is not included in the TM Pulse 2x24V product package and must be ordered separately.

For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) device manual.

Pin assignment of the BaseUnit

The table below shows the pin assignment, using the BaseUnit BU20-P12+A0+4B (6ES7193-6BP20-0BB1). For this BaseUnit, the TM Pulse module's L+ pins are always isolated from adjacent modules. The L+ voltage from adjacent modules are connected together through a bypass in the BaseUnit.

Table 4- 1 Pin assignment of the BaseUnit BU20-P12+A0+4B

Designation	Pin name		View	Pin name		Designation
24 V DC supply output for sensor power	24VDC	1		2	24VDC	24VDC supply output for sensor power
Channel 0 digital input	DI0.0	3		4	DI1.0	Channel 1 digital input
Channel 0 ground for digital inputs	M	5		6	M	Channel 1 ground for digital inputs
Channel 0 ground for digital outputs	M	7		8	M	Channel1 ground for digital outputs
Channel 0 digital output A	DQ0.A	9		10	DQ1.A	Channel 1 digital output A
Channel 0 digital output B	DQ0.B	11		12	DQ1.B	Channel 1 digital output B
External 24VDC supply input for digital output and sensor power	L+	13		14	M	Ground for supply voltage
External 24VDC supply input for digital output and sensor power. Pins 13 and 15 are connected internally.	L+	15		16	M	Ground for supply voltage Pins 14 and 16 are connected internally.

24 V DC sensor power output

To power digital input sensors, the technology module supplies 24 V DC with reference to M. The 24 V DC supply is monitored for short-circuits and overload conditions.

L+ external power supply

Connect an external 24 V DC power to the L+ and M connections to supply power for the TM Pulse 2x24V module, output loads, and sensors. An internal protection circuit protects the technology module against damage due to reversed polarity of the supply voltage.

Unexpected conditions can occur at the digital outputs when L+ is connected to the supply voltage and M is disconnected from the supply voltage return, due to a wire break. The technology module monitors the connection of the supply voltage.

⚠ WARNING

Supply voltage M connections

Connect both the M potential pins to the power supply return with separate wires. If one wire breaks, then the other wire maintains the electrical connection from M to the power supply return

If the electrical connection between the M potential and the power supply return is broken, then unexpected conditions can occur and the digital outputs may go high even though your program is not setting a high state.

Note

L+ and M isolation on TM Pulse 2x24V module using BaseUnit type B1

The L+ and M connections on the type B1 BaseUnit are electrically isolated, from adjacent BaseUnits plugged in on the left-side or right-side. The L+ and M power bus passes through the type B1 BaseUnit (with no connections) and extends the power bus to connect left-side and right-side BaseUnits.

DI0.0 and DI1.0 digital inputs

The digital inputs are not electrically isolated from each other or from the digital outputs. The digital inputs are electrically isolated from the ET 200SP system bus.

When you connect input signals, depending on the configured input delay and the potential effect of interference, ground the shield on both ends of a cable that connects sensor to BaseUnit pin.

Note

Electromagnetic interference shielding for inputs

Input connections on the type B1 BaseUnit used by the TM Pulse 2x24V module do not have shield ground connections. You must connect cable shields to electrical ground at the DIN rail or the system cabinet.

Input noise filter for digital inputs

You can configure an input delay for each digital input to suppress interference. Signals must have a steady state during the configured input delay before a signal is accepted as a valid input state.

You can assign the following values for the input delay:

- Off (means input delay of 4 µs and requires a minimum pulse width of 3 µs)
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

The input delay that you assign affects the detection time of input signals. The detected state change is always offset in time by the assigned input delay time.

Note

For input delay settings of "Off" or "0.05 ms" and longer wire lengths, use shielded cables at digital input connections. Shielding improves input response accuracy.

Digital outputs of channel 0 (DQ0.A, DQ0.B) and channel 1 (DQ1.A, DQ1.B)

- The digital outputs are not electrically isolated from each other or from the digital inputs. The digital outputs are electrically isolated from the ET 200SP system bus.
- The digital outputs are protected from overload and short-circuit.
- DQ0.B and DQ1.B are only used in DC motor mode or directly controlled by a SET_DQB bit in the control interface.
- Digital outputs have integrated protection diodes to prevent voltage overstress due to inductive kickback. No external protection diodes are required for inductive loads.

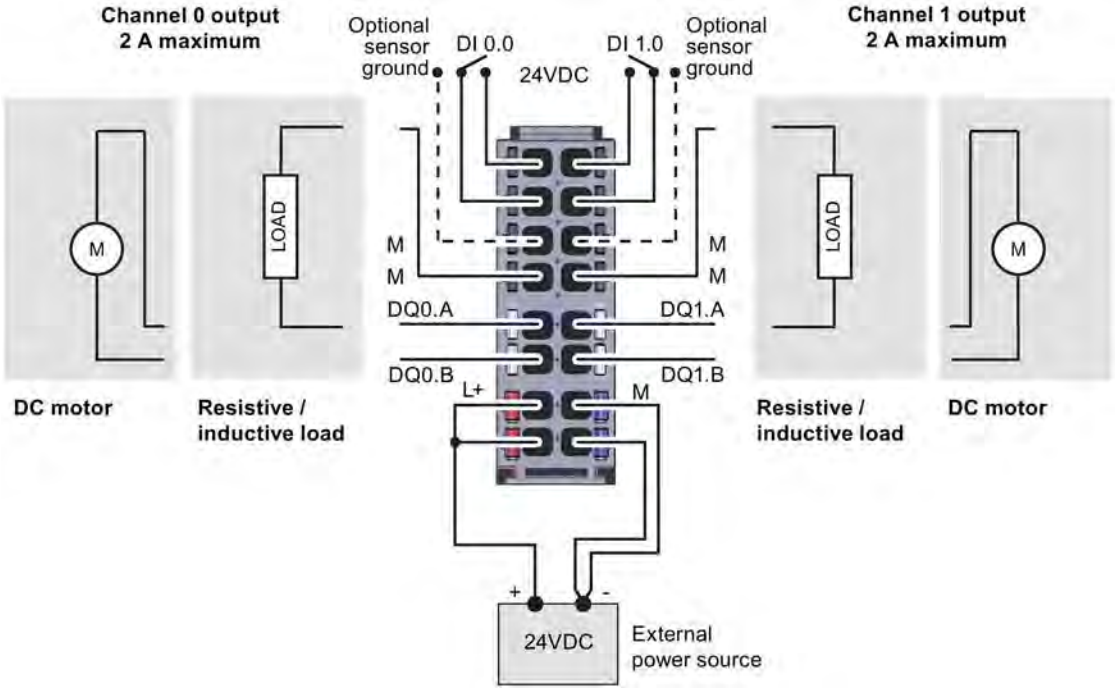


Figure 4-1 Dual channel wiring

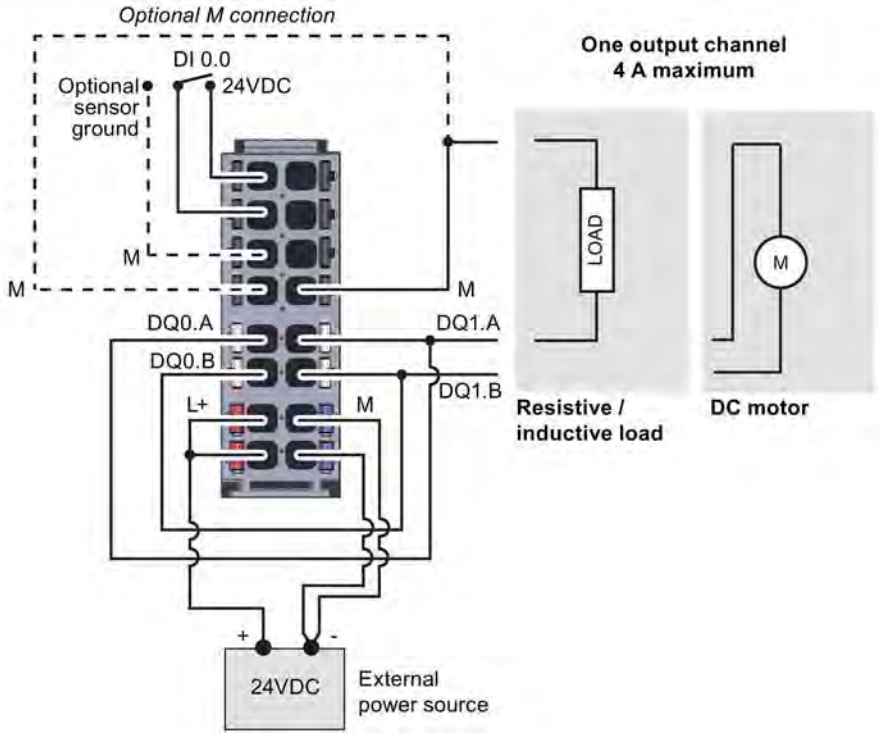


Figure 4-2 Single channel with parallel connection wiring

WARNING

Supply voltage M connections

Connect both the M potential pins to the power supply return with separate wires. If one wire breaks, then the other wire maintains the electrical connection from M to the power supply return

If the electrical connection between the M potential and the power supply return is broken, then unexpected conditions can occur at the digital outputs.

Note

Load wiring resistance

In single channel mode with parallel connected wiring, the wires from DQ0.A and DQ1.A must have equal resistance (length and size) for proper current sharing between the two outputs. Also, the wiring for DQ0.B and DQ1.B must have equal resistance when using DC motor mode.

Maximum current is limited and current measurement errors occur if the wiring does not have equal resistance.

Note

Excessive temperature from unsuitable loads

A high-speed output generates edges that are very steep. This creates very powerful charge reversals for the connected load, which can overheat the load at very high switching frequencies.

The connected load must therefore be approved for high input frequencies. See Function: High-speed output (Page 74) topic for details.

Note

The digital output switch-off response / switch-off edge depends on the load. Thus, it is possible that very short pulses cannot be output correctly.

Note

Relays and contactors can be connected direct without external circuitry.

Configuring

5

5.1 Configuration software

Introduction

The TM Pulse 2x24V module is configured and assigned parameters with the configuration software.

The module's pulse output sequences are controlled and monitored by your program.

System environment

The technology module can be used in the following system environments:

Table 5- 1 Applications of the technology module with PROFINET I/O

Applications	Components required	Configuration software	In your program
Decentralized operation in an S7-1500 system	• S7-1500 automation system • ET 200SP decentralized I/O system • TM Pulse 2x24v	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN)	Direct access to the control and feedback interface (Page 110) of the TM Pulse 2x24V in the I/O data
Centralized or decentralized operation in an ET 200SP system	• ET 200SP automation system • TM Pulse 2x24v	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN)	Direct access to the control and feedback interface of the TM Pulse 2x24V in the I/O data
Decentralized operation in an S7-300/400 system	• S7-300/400 automation system • ET 200SP decentralized I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN) STEP 7: Device configuration and parameter settings with HSP	Direct access to the control and feedback interface of the TM Pulse 2x24V in the I/O data
Decentralized operation in a PROFINET controller or PROFIBUS master	PROFINET controller • ET 200SP decentralized I/O system • TM Pulse 2x24V	Engineering system with GSD file	Direct access to the control and feedback interface of the TM Pulse 2x24V in the I/O data

5.2 Configuration overview

You can use the STEP 7 (TIA Portal) or STEP 7 hardware configuration to set these parameters. Also, you can change the parameter assignment at runtime with your program using data record 128.

STEP 7 (TIA Portal) and STEP 7 assist you during parameter assignment by disabling keyboard input for invalid parameters and range checking your value assignments. Depending on previous parameter selections, other options will be disabled. For example, if you select the one channel operation (the parallel connection of the two output channels), then the parameter options for channel two and high-speed output are disabled.

When you make a runtime parameter assignment that uses the WRREC (Write Record) instruction to modify data record 128, you must ensure that you do not attempt to write an invalid record data. WRREC execution with invalid data fails and returns error code. For example, if you are using one channel operation and include parameter data for two channels, then the record length is too long and WRREC execution fails. In addition, you must follow the parameter validation rules (Page 120).

If you use STEP 7 (TIA Portal), you can find the module in the Hardware catalog under "Technology Modules". If you use STEP 7, you can find the module following installation of the corresponding HSP file in the Hardware catalog.

STEP 7 has two entries for Technology Module - Pulse output, with one entry for "TM Pulse 2x24V 2x2A" and one entry for "TM Pulse 2x24V 1x4A.

The following table shows how a channel's "Parameter" group is affected by mode selection.

Table 5- 2 Channel parameters and mode selection: ✓ means the parameter is available for configuration

Channel "Parameter" group	Pulse output mode	PWM mode	Pulse train mode	On/Off delay mode	Frequency output mode	DC motor mode
[1] High-speed output (.1 A)	✓	✓	✓	✓	✓	
HW enable option on DIn.0 input	✓	✓[3]	✓		✓	✓[3]
Input delay	✓	✓	✓	✓	✓	✓
Output format	✓	✓	✓	✓	✓	✓
Minimum pulse duration		✓[4]				
Period duration		✓	✓			✓
On delay	✓	✓[3]	✓		✓	✓[3]
Off delay				✓		
Duty cycle			✓			
[2] Current control		✓				
Activate P (Proportional)		✓				
Activate I (Integral)		✓				
Activate D (Derivative)		✓				
Reference value current		✓				
Dead band width		✓				
High limit S7 analog		✓				
Low limit S7 analog		✓				
Gain		✓				
Integration time		✓				
Derivative action time		✓				

Channel "Parameter" group	Pulse output mode	PWM mode	Pulse train mode	On/Off delay mode	Frequency output mode	DC motor mode
Time lag		✓				
Dithering		✓				
Dither ramp up time		✓				
Dither ramp down time		✓				
Dither amplitude		✓				
Dither period		✓				

1 High speed output is not available for the one channel (4 A) configuration that uses a parallel connection of the two (2 A) channels.

2 In PWM mode, you can enable either High-speed or Current control, but not both options at once.

3 Parameter is disabled in isochronous mode.

4 Parameter is disabled when current control is active

5.3 Required I/O address space

Address space of the technology module

Table 5- 3 TM Pulse 2x24V I/O address space usage

Function	Bytes per channel	Total I/O bytes Single channel (4 A)	Total I/O bytes Dual channel (2 A)
Program control of module operation	12 output bytes (Q addresses)	12 output bytes	24 output bytes
Feedback module status to control program	8 input bytes (I addresses)	8 input bytes	16 input bytes

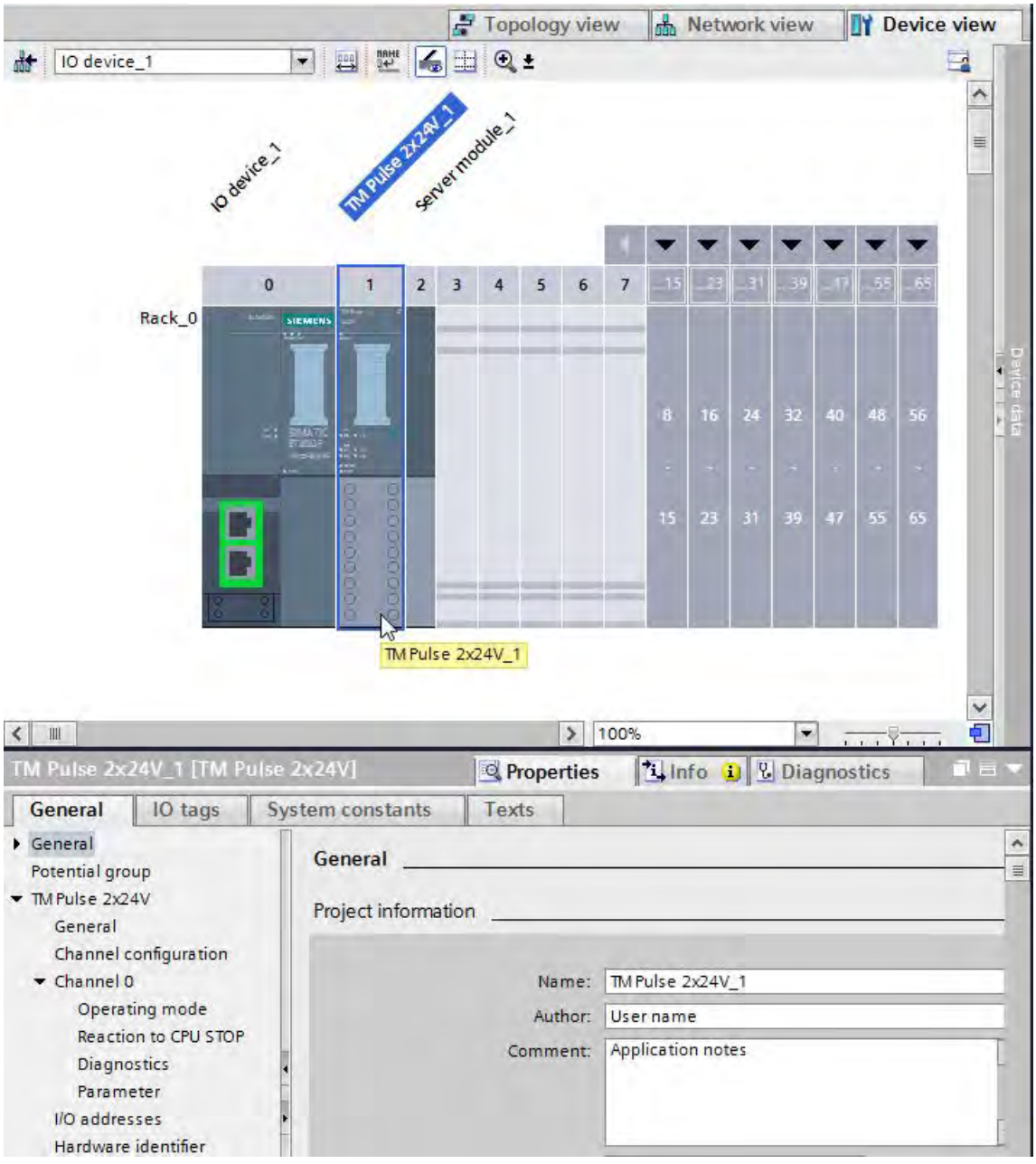
Additional information

A description on how to use the control and feedback interface of TM Pulse 2x24V can be found in the chapter Program control and feedback interface (Page 110).

5.4 TIA portal Device configuration

5.4.1 TIA Portal Device configuration

Drag the TM Pulse 2x24V module from the hardware catalog and drop it in a rack image. The example rack below uses the TM Pulse 2x24V module in a decentralized I/O system where it is possible to enable and configure isochronous mode. When you click on the TM Pulse 2x24V image in a rack, a blue line highlights the module and you can set parameters that appear on the Properties tab.



5.4.2 General information

Enter the general project and identification & maintenance information.

5.4.3 Potential group

The Potential group parameters are disabled for the type B1 BaseUnit used by the TM Pulse 2x24V. The TM Pulse 2x24V module is isolated from the other BaseUnit potential groups on the right and on the left of the TM Pulse 2x24V module. Therefore, the TM Pulse 2x24V requires an external supply.

5.4.4 Channel configuration: (4 A) single or (2 A) dual channel operation

Select the channel configuration:

- Two separate channels with 2 ampere maximum output current per channel. The high-speed option (100mA maximum current) is allowed.
- One logical channel where the two output channels connected in parallel to provide 4 ampere maximum output current. The high-speed option is not allowed.

1 channel (4 A) operation

If the "1 channel (4 A)" option is selected, then the TM Pulse 2x24V operates as a single-channel module. All parameter assignments and operations using the control interface must use Channel 0 addresses. Feedback signals are only provided for Channel 0.

The control and feedback interface is reduced to only one channel. Channel 1 cannot be configured or operated.

The current measurement adds the measured values of both channels together. This results in a measuring range up to 4 A.

The measured value of the current is supplied as a SIMATIC S7 analog value in the feedback interface. A current of 4 A corresponds to the SIMATIC S7 analog value of 27,648.

See also Pin assignment and load/sensor wiring (Page 91)

5.4.5 Channel parameters

5.4.5.1 Operating mode

Select an operating mode.

- Pulse output (single pulse)
- Pulse width modulation PWM
- Pulse train
- On/Off-delay
- Frequency output
- DC motor

5.4.5.2 Reaction to CPU STOP

You can configure the reaction of the TM Pulse 2x24V to the failure of a higher-level controller differently for each channel.

Table 5- 4 Reaction to CPU/Master STOP options for all modes except DC motor

Response to CPU/master STOP	Channel-specific response and status of the TM Pulse 2x24V
DQ substitute a value	• Output of the channel-specific, substitute value that you assigned. • STS_ENABLE goes to the 0 state. • Terminate the current output sequence.
Continue working mode	The current output sequence is continued.

Reaction to CPU/Master STOP options for DC motor mode

For DC motor mode, there are no configuration options for the reaction to CPU STOP. The outputs always behave as follows.

Both DQs (DQn.A and Dn.B) go to tri-state (high impedance state) when the CPU goes to STOP.

Substitute values

If you select the "DQ substitute a value" option as a reaction to CPU STOP, then you must configure the substitute value (0 or 1) for the DQn.A and DQn.B outputs.

Each channel has two outputs (A and B). A resistive or inductive load is wired to a channel's A output, so you must assign a substitute value to the DQn.A output. A reversible direction DC motor load is wired to a channel's A and B outputs, so you must assign substitute values to the DQn.A and DQn.B outputs.

You cannot set both substitute values of one channel to the high state (DQn.A and DQn.B). If you do so, an error code is returned to the parameterization attempt. See the Parameter validation errors (Page 120) topic for details.

Startup

To start a new output sequence after CPU/master STOP with STS_SW_ENABLE set, first reset SW_ENABLE. Keep SW_ENABLE reset until STS_SW_ENABLE is also reset.

If the "Continue working mode" option is used, then during a change from CPU-/Master-STOP to RUN (startup), the CPU/Master cannot clear the outputs.

Possible solution: In the part of your program that is executed during startup, set the "Software enable" (SW_ENABLE = 1) control bit.

Modified parameter assignment

The status assumed by the TM Pulse 2x24V at CPU/master STOP remains even in the case of parameter assignment or configuration of the ET 200SP station. This occurs, for example, at POWER ON of the CPU/master, or the IM 155-6, or at the resumption of DP transfer.

In "Continue working mode", however, and after loading changed parameters or configuration of the ET 200SP station to the CPU/master, the TM Pulse 2x24V terminates the process. As a result, the TM Pulse 2x24V does the following:

- Resets the DQ digital output.
- Resets STS_ENABLE
- Terminates the current output sequence.

5.4.5.3 Diagnostics

Module monitoring is always active. A detected error only triggers a diagnostic alarm if the diagnostics type is enabled in the Diagnostics check boxes.

TM Pulse 2x24V diagnostics

Diagnostic type	TM Pulse 2x24V module error	Default option
Group diagnostics	• Supply voltage error • Short-circuit on 24 V DC sensor supply	Disabled
Diagnostics DQA	Short-circuit of DQn.A digital output	Disabled
Diagnostics DQB	Short-circuit of DQn.B digital output	Disabled

When a TM Pulse 2x24V error event triggers a diagnostic alarm, the following happens:

- The DIAG light flashes red when a diagnostics alarm is pending. Once you have remedied the error, the DIAG light goes out.
- The diagnostics are displayed as plain text in the STEP 7 (TIA Portal) online and diagnostics view.
- Options for the reaction of a CPU running your control program
  - CPU goes to STOP and interrupts processing of your program. The diagnostic interrupt OB (for example, OB 82) is called. The event that triggered the interrupt is written in the start information of the diagnostic interrupt OB.
  - CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible, while the error exists.
- Detailed information on the error event is available through execution of the RALRM (read alarm information) program instruction.

Note

Error message details

The Diagnostics information provided through OB 82 and RALRM does not indicate which channel has an error.

The alternative error information provided by the feedback interface ERR_xxx bits does indicate which channel has an error.

See also Error detection and diagnostics (Page 122)

5.4.5.4 Parameter (Channel parameters)

The different operating modes restrict the configuration to a subset of these parameters and options.

Channel parameters

High-speed output

- Enabled
  - High-speed (0.1 A) option single channel output limit is 0.1 A.
  - 1 channel (4 A) parallel channel connection is not possible.
  - PWM mode current control is not possible.
- Disabled
  - Single channel output limit is 2 A

Function DI (digital input)

- Input: DIn.0 functions as a digital input
- HW enable: DIn.0 functions as a Hardware enable for the pulse output sequence. The HW enable option is available for these modes.
  - Pulse output
  - PWM (not available for isochronous mode)
  - Pulse train
  - Frequency output
  - DC motor (not available for isochronous mode)
- External stop (DC motor only)

See also Function: High-speed output (Page 74)

Input delay

A digital input state change must remain stable over the input delay time, before the state change is accepted and processed. The input delay time provides noise filtering for the input wiring.

- Off (4 µs)
- 0.05 ms
- 0.1 ms (default value)
- 0.4 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Output format

Set the format and value range for ratio variables like duty cycle.

Output format options	Value range
• S7 analog output	0 to 27,648 -27648 to 27648 (in DC motor mode)
• Per 100	0 to 100
• Per 1000	0 to 1000
• Per 10000	0 to 10000

Minimum pulse duration

Assign the minimum pulse duration that you allow in µs.

Period duration

Assign the period duration in µs.

Actual period duration

This read-only field is displayed only when isochronous mode is enabled. The period duration value that is displayed is the actual isochronous compatible period duration that is calculated from the value you entered in the Period duration parameter.

On-delay

Assign the On-delay in µs

Pulse timing	Minimum		Maximum	
	High-speed disabled	High-speed enabled	High-speed disabled	High-speed enabled
Pulse duration	10 µs	1.5 µs	85,000,000 µs	
Period duration	100 µs	10 µs		
On-delay	0 µs	0 µs		

Dither parameters

- Dither ramp-up time: 0 ms to 30,000 ms.
- Dither ramp-down time: 0 ms to 30,000 ms.
- Dither amplitude: 0 to 500‰
- Dither period: From (4 x PWM period) to 100,000 µs. Also, the Dither period must be greater than 2 ms.

Current control

- Enabled
- Disabled

Current control parameters

If current control is enabled, then the following parameters are available for modification.

- **Activate P**: Enable/disable the proportional part in the PID algorithm
- **Activate I**: Enable/disable the integral part in the PID algorithm
- **Activate D**: Enable/disable the derivative part in the PID algorithm
- **Reference value current**: The reference value is used to define the maximum set point and the high and low limits of the controlled current. Typically, the maximum current can be measured in PWM mode with current control disabled and a duty cycle set to 100%. The value measured can be set as a reference for the current control. The maximum value is 4000mA for single channel operation (parallel channel connection enabled) and 2000mA per channel for dual channel operation (parallel connection disabled).
- **Deadband width**: A dead band is applied to the output current deviation from the set point current. The "Deadband width" determines the size of the dead band. The dead band is symmetrical: Actual dead band value range = -Deadband width to +Deadband width.
- **High limit S7 analog**: The manipulated value is always restricted to a high limit and low limit. The "High limit" parameter assigns the high limit in S7 analog format, relative to the reference value current. A value higher or equal than 27648 means 100% of the reference value current. The High limit value must be higher than the Low limit.
- **Low limit S7 analog**: The manipulated value is always restricted to a high limit and low limit. The "Low limit" parameter assigns the low limit in S7 analog format, relative to the reference value of the current. A value higher or equal than 27648 is not allowed. The Low limit value must be lower than the High limit.
- **Gain**: The proportional gain parameter assigns the amplification factor for the P part of the PID algorithm.
- **Integration time**: The proportional gain parameter assigns the amplification factor for the P part of the PID algorithm.
- **Derivative action time**: The derivative time parameter determines the time interval of the derivative action. If TD is smaller than the controller cycle time, TI will be set internally to the controller cycle time.
- **Time lag**: Time lag of the derivative action. The algorithm of the D-action contains a delay of TM_LAG. If TM_LAG is smaller than half the controller cycle time, TI will be set internally to half the controller cycle time.

5.4.6 I/O addresses

You can assign the base addresses for the control interface (12 output Q byte addresses/channel) and the feedback interface (8 input I byte addresses/channel). Your program logic uses the values stored in these addresses to control the TM Pulse 2x24V output and read feedback signals from the module.

I/O addresses

Output addresses

Start address: Assign a starting address to 12 bytes (Q addresses) for a channel's control interface.

End address: The control interface end address is a calculated read-only field.

Input addresses

Start address: Assign a starting address to 8 bytes (I addresses) for a channel's feedback interface.

End address: The feedback interface end address is a calculated read-only field.

Isochronous mode

The Isochronous mode checkbox is only displayed if your system hardware supports isochronous mode.

Organization block

Accept the default OB assignment or select a different OB. If isochronous mode is enabled and the Organization block (OB 61) "Synchronous cycle" is assigned, then TM Pulse 2x24V PWM operation in a decentralized I/O system becomes coordinated with bus master PROFINET cycles.

In isochronous mode, the PWM output sequence is synchronized with the moment T_o. The period duration is coordinated to the application cycle (the synchronous cycle, a multiple of the PROFINET cycle).

Process image

Accept the default assignment or assign a different Process image partition.

Program control and feedback interface

6

6.1 TM Pulse 2x24V control interface

Your program uses this interface to control the behavior of the technology module.

Control interface

The following table shows control interface assignment for one channel:

Bit → / Byte↓	7	6	5	4	3	2	1	0
00	OUTPUT_VALUE							
01								
02								
03								
04	SLOT							
05								
06								
07								
08	Reserved[1)]			MODE_SLOT	LD_SLOT			
09	Reserved[1)]		DITHER	SET_DQB	SET_DQA	Reserved[1)]	TM_CTRL_DQ	SW_ENABLE
10	Reserved[1)]							RES_ERROR
11	Reserved[1)]							

[1)] Must be set to 0

Control interface parameters

Two use cases are possible while using TM Pulse 2x24V module.

Case 1: Only the main parameter OUTPUT_VALUE is controlled every program scan cycle by your program logic. All the other parameters required for the output sequence are fixed.

Case 2: The main parameter OUTPUT_VALUE and another parameter SLOT are controlled every program scan cycle by your program logic. All other parameters required for the output sequence are fixed.

Other parameters required for the output sequence are defined prior to the start of an output sequence using one of two possible methods.

- TIA portal device configuration, STEP 7 hardware configuration, or WRREC execution modifies the parameterization data record.
- Use the Control interface in single-update mode and before switching to the permanent-update mode (case 2 only) with the assigned LD_SLOT value selecting the control parameter.

OUTPUT_VALUE

The interpretation of the value in OUTPUT_VALUE depends on the mode setting. The OUTPUT_VALUE is always updated. If an invalid value is detected (outside the allowed range), then the error flag ERR_OUT_VAL is set until a valid value is detected. During the error condition, the invalid value is ignored and the module continues with the last valid OUTPUT_VALUE.

Note that PWM ratio values are not checked. If a ratio value is higher than the format allows, then a ratio of 100% is used by the module.

When the PWM current control option is activated, the TM Pulse 2x24V module takes control of the duty cycle and the OUTPUT_VALUE control interface field is used to assign the target current as a ratio of target current/reference current.

Mode	OUTPUT_VALUE meaning	Data type
Pulse output	Pulse duration High-speed disabled: 10 µs to 85,000,000 µs High-speed enabled: 2 µs to 85,000,000 µs	UDInt
PWM	Current control disabled: Duty cycle Current control enabled: Ratio current	UDInt: Only 2 least significant bytes are used For channel 0: bytes 2 and 3 For channel 1: bytes 14 and 15
Pulse train	Number of pulses	UDInt
On/Off delay	On-delay in microseconds	UDInt
Frequency output	Frequency in Hz	Real
DC motor	Duty cycle	DInt: Only 2 least significant bytes are used For channel 0: bytes 2 and 3 For channel 1: bytes 14 and 15

SLOT, MODE_SLOT, and LD_SLOT

The TM Pulse 2x24V module has a SLOT field in the control interface for each channel that allows several parameters to be single-updated, or one parameter to be permanently controlled (in addition to OUTPUT_VALUE). The interaction of SLOT, MODE_SLOT, and LD_SLOT is described in the SLOT parameter handling (Page 113) topic.

SW_ENABLE

If 0 → 1, then activate the output sequence. For some output modes, you can configure HW_ENABLE (hardware enable) to combine with SW_ENABLE (software enable) and trigger an output sequence with a hardware signal.

TM_CTRL_DQ

- If 1, then outputs are controlled by the module and produce the pulse sequences.
- If 0, then the outputs are controlled directly by your program through SET_DQA and SET_DQB assignments
  Note: This bit has no effect in DC motor mode

SET_DQA

- If 1, then set the output A to 1, when TM_CTRL_DQ is inactive.
- If 0, then set the output A to 0, when TM_CTRL_DQ is inactive.
  Note: This bit has no effect in DC motor mode.

SET_DQB

- If 1, then set output B to 1, when TM_CTRL_DQ is inactive and SET_DQA is 0.
- If 0, then set the output B to 0, when TM_CTRL_DQ is inactive.
  Note: This bit has no effect in DC motor mode

DITHER

- Activates the start (rising edge on DITHER) of the dithering function and begins dithering ramp-up, if a ramp-up is configured.
- Activates the end (falling edge on DITHER) of the superimposed dithering and begins dithering ramp-down, if a ramp-down is configured.

RES_ERROR

Resets the error flags ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V in the feedback interface.

See also

Parameter data record (Page 138)

6.2 SLOT parameter handling (control interface)

SLOT and MODE_SLOT

SLOT has the following modes.

- **Single-update mode** (MODE_SLOT = 0)
  Use this mode if some parameters have to be changed sometimes, prior to starting the output sequence. Using the SLOT parameter is an alternative to sending a new parameterization record to the module. A pulse operation change made with the SLOT parameter does not reset the module. A pulse operation change made by sending a new parameterization record does reset the module.
  - The value in SLOT is used each time the value in LD_SLOT changes.
  - An acknowledge bit is toggled in the feedback interface STS_LD_SLOT.
  - The interpretation of the SLOT is defined by the value of LD_SLOT (see the following table).
  - If the LD_SLOT value is invalid, a parameter error is triggered ERR_LD, and the user has to reset the error using the RES_ERROR control bit to reactivate SLOT.
  - The changes done in this mode can be read back from the module in the parameterization record.
  - The changes done in this mode are not permanently stored in the CPU. A restart of the CPU resets the parameters to the values specified in the hardware configuration.
- **Permanent-update mode** (MODE_SLOT = 1)
  Use this mode, if in addition to the main controlled parameter, another parameter has to be controlled continuously by the program.
  - The value in SLOT is transferred each module cycle.
  - No acknowledge bit is available.
  - The interpretation of SLOT is defined by the value of LD_SLOT (see the following table).
  - If the value in SLOT is not valid, then the error ERR_SLOT_VAL occurs. The error is automatically reset once a valid value is loaded. Note that the ratio values are not checked, if the value is higher than the format allows, a ratio of 100% will be used by the module.
  - Using this mode, the value is not updated in the parameterization record. If LD_SLOT is changed in this mode, the last valid value controlled previously is retained.
  - The permanent update mode can be stopped by setting LD_SLOT to 0 and MODE_SLOT to 0. By stopping permanent update mode, changes made to parameters during permanent update mode are retained.

Interpretation of SLOT parameter value

The value written to the SLOT parameter is interpreted as shown in the following table, depending on the LD_SLOT value and operating mode.

LD_SLOT	SLOT value meaning	Valid modes for SLOT value use	SLOT Data type
0	No action / idle state	All modes	
1	Period duration	PWM Pulse train DC motor	UDInt
2	On-delay	Pulse output PWM Pulse train Frequency output DC motor	UDInt
3	Off-delay	On/Off-delay	UDInt
4	Duty cycle (On-ratio)	Pulse train	UDInt: Only 2 least significant bytes are used. For channel 0: bytes 6 and 7 For channel 1: bytes 18 and 19
5	Dither ramp (includes ramp-up time and ramp-down time)	PWM	UDInt
6	Dither amplitude	PWM	UDInt
7	Dither period	PWM	UDInt

6.3 TM Pulse 2x24V feedback interface

Your program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface for one channel

Bit → / Byte ↓	7	6	5	4	3	2	1	0
00	ERR_SLOT_VAL	ERR_OUT_VAL	ERR_DQB	ERR_DQA	ERR_PULSE	ERR_LD	ERR_24V	ERR_PWR
01	Reserved		STS_SW_ENABLE	STS_READY	Reserved	STS_LD_SLOT	Reserved	
02	Reserved			STS_DITHER	STS_DI	STS_DQB	STS_DQA	STS_ENABLE
03	Reserved				SEQ_CNT			
04	MEASURED_CURRENT							
05								
06	Reserved						QLMN_HLM	QLMN_LLM
07	Reserved							

Feedback parameters

Table 6- 1 Status feedback

Feedback parameter	Meaning	Value range
STS_READY	Module is parameterized correctly, running, and delivering valid data.	0: Not ready 1: Ready
STS_SW_ENABLE	Current state of the software enable	0: SW_ENABLE is not active 1: Recognized SW_ENABLE
STS_LD_SLOT	Toggle acknowledge bit for each action of the SLOT in single-update SLOT-mode.	Each toggle of this bit indicates a successful LD_SLOT action.
STS_ENABLE	Output sequence is active.	0: No output sequence running 1: Output sequence running
STS_DQA	State of digital output DQn.A	0: DQn.A is not active 1: DQn.A is active
STS_DQB	State of digital output DQn.B	0: DQn.B is not active 1: DQn.B is active
STS_DI	DIn.0: State of digital input	0: DIn.0 is not active 1: DIn.0 is active
STS_DITHER	Dithering state	0: Dithering inactive 1: Dithering active with ramp-up phase started and ramp-down not complete.
SEQ_CNT	Counts completed output sequences	0 to 15

Feedback parameter	Meaning	Value range
MEASURED_CURRENT	S7 analog value	0 to 32,767 27,648 means 4 A for "1 channel (4 A)" 27,648 means 2 A for "2 channels (2 A)"
QLMN_LLM	The low limit of the manipulated value has been reached.	0: Low limit not reached 1: Low limit reached
QLMN_HLM	The high limit of the manipulated value has been reached.	0: High limit not reached 1: High limit reached

Table 6- 2 Error feedback

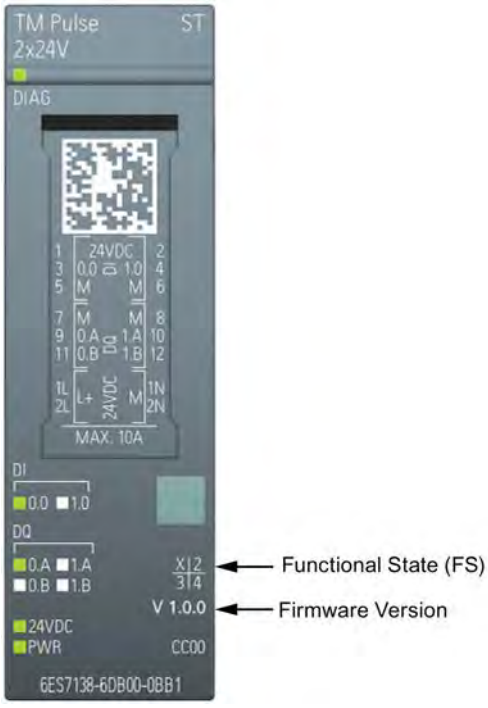
Feedback parameter	Meaning	Value range
ERR_PWR	24 V DC present, but is not in the correct range.	0: No error 1: Error
ERR_24V	Short-circuit/overload, in the 24 V DC sensor supply output.	0: No error 1: Error
ERR_LD	Error while loading a parameter value using single-update mode.	0: No error 1: Error
ERR_PULSE	Pulse duration reduced to smaller than the minimum allowed value during operation.	0: No error 1: Error
ERR_DQA	Short-circuit/overload on the digital output DQn.A detected	0: No error 1: Error
ERR_DQB	Short-circuit/overload on the digital output DQn.B or attempt to manually set both DQn.A and DQn.B high.	0: No error 1: Error
ERR_OUT_VAL	The value in OUTPUT_VALUE is not valid.	0: No error 1: Error
ERR_SLOT_VAL	The value in SLOT is not valid where MODE_SLOT = 1 (permanent update)	0: No error 1: Error

Interrupts/diagnostic messages

7

7.1 Status and error displays

TM Pulse 2x24V front view



LED status display

The following tables explain the meaning of the status and error displays. Refer to Error correction and diagnostics (Page 122) for details.

Table 7- 1 DIAG LED

DIAG LED	Meaning	To correct or avoid errors
Off	Backplane bus supply of the ET 200SP not OK	Check or switch On the supply voltage of the head station. Ensure the TM Pulse2x24V is correctly inserted in the BaseUnit.
Flashes green	Technology Module not configured	
On green	Technology Module configured and no module error exists	
Flashes red	Technology Module configured and module diagnostics (at least one error pending) Note:	Evaluate the diagnostic alarms and eliminate the error.

Note

The DIAG LED only shows an error if the Diagnostic alarm is activated during device configuration. By default, the Diagnostic alarm is not activated.

Table 7- 2 PWR and 24 V DC LED status

LEDs		Meaning	To correct or avoid errors
PWR	24 V DC		
Off	Off	No supply voltage	• Check the external 24 V DC power supply voltage connected between L+ and M.
On green	On green	Supply voltage is present and OK	
On green	Off	Short-circuit or overload at the sensor supply or supply voltage too low	• Check sensor wiring. • Check the loads connected to the sensor supply. • Check the supply voltage.

Channel status LEDs

The LEDs for DI digital inputs and DQ digital outputs indicate the digital state of the associated channel signals.
The LEDs of the digital outputs DQ indicate the desired state.

- DIn.0 digital inputs
  - 0.0 - Channel 0 input
  - 1.0 - Channel 1 input
- DQn.A and DQn.B digital outputs
  - 0.A and 0.B - Channel 0 outputs
  - 1.A and 1.B - Channel 1 outputs

The flashing frequency of the channel LEDs is limited to approximately 12 Hz. If higher frequencies are present, the channel LEDs will flash at 12 Hz instead of indicating the actual status.

Table 7- 3 Status displays DI digital inputs and DQ digital outputs

LED status	Meaning
□ Off	Digital input / digital output is at 0 level.
■ On green	Digital input / digital output is at 1 level.

7.2 Parameter validation errors

If the TM Pulse 2x24V parameter record is modified with an incorrect parameter value, then the module returns the error codes shown in the following table.

During TIA Portal Device configuration, parameter values are verified before transfer to the module. This prevents parameter errors during the static TIA Portal Device configuration.

You can modify the parameter data record during runtime with the WRREC (Write Record) program instruction.

For example, an illegal mode value is written to the module by WRREC execution. After execution the WRREC STATUS output is an ARRAY[1..4] of BYTE data with the value 16#DF80E111.

Example WRREC STATUS data	Address	Meaning
DF_H	STATUS[1]	Write data record error
80_H	STATUS[2]	Error according to IEC 61158-6
$E1_H$	STATUS[3]	Module specific error
11_H	STATUS[4]	Module error code from row 1 in the following table: Mode parameter has an incorrect reserved value.

Error code	Parameter	Validation criteria	Mode
11_H	Mode	Reserved value	All modes
12_H	Reaction to CPU STOP	Reserved value	All modes
$1A_H$	Input delay	Reserved value	All modes
$1B_H$	Period duration	Greater than maximum	PWM Pulse train DC motor
$1C_H$	On-delay	Greater than maximum	Pulse output PWM Frequency output DC motor
$1D_H$	Minimum pulse duration	Greater than maximum	PWM
$1E_H$	Off-delay	Greater than maximum	On/Off-delay
20_H	Reference value current	Greater than maximum	PWM
21_H	Period duration	Lower than minimum	PWM Pulse train DC motor
22_H	Dithering	Not disabled	Pulse output Pulse train On/Off-delay Frequency output DC motor
23_H	High-speed output	Not disabled	DC motor All modes with parallel connection
24_H	Current control	Not disabled	Pulse output Pulse train On/Off-delay Frequency output DC motor
25_H	Current control and high-speed output	Both enabled	PWM

Error code	Parameter	Validation criteria	Mode
26_H	Function DI	HW enable activated	On/Off-delay
27_H	Low limit and High limit	High limit <= Low limit	PWM with current control
28_H	Dithering period	Period is lower than 4 times the PWM period or lower than 2 ms.	PWM with dithering
29_H	Substitue values DQA and DQB	Substitute values DQA and DQB are both 1.	All modes

7.3 Error detection and diagnostics

Feedback interface ERR bits

Your program can access power supply error and output load status directly, through a channel's feedback interface.

Channel 0 address	Channel 1 address	Feedback bit	Meaning	Value range
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR	Indicates under voltage on the power supply. Note that the bit is not set, if the voltage is not present.	0 = PWR is not in under voltage 1 = PWR is detected but in under voltage
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V	Indicates a short-circuit or under voltage condition on the 24V sensor power supply.	0 = 24 V DC sensor supply working normally 1 = 24 V DC sensor supply short-circuit or under voltage
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD	Indicates an error occurred when loading a parameter value through the SLOT field using the single-update method.	0 = No SLOT single-update error 1 = SLOT single-update error
Byte 0: Bit 3	Byte 8: Bit 3	ERR_PULSE	Indicates a pulse output error in the Pulse output, On/Off-delay, and Pulse train modes	0 = No pulse output error 1 = Pulse output error
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA	Indicates a short-circuit or overload of DQn.A digital output.	0 = No DQn.A digital output short-circuit or overload 1 = DQn.A digital output short-circuit or overload
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB	Indicates a short-circuit, overload of DQn.B digital output. Also, indicates an attempt to set one channel's DQn.A and DQn.B to the high state (using SET_DQA, SET_DQB, and TM_CTRL_DQ).	0 = No DQn.B digital output short-circuit or overload 1 = DQn.B digital output short-circuit, overload, or attempt to set DQn.A and DQn.B high.
Byte 0: Bit 6	Byte 8: Bit 6	ERR_OUT_VAL	Indicates the value in OUTPUT_VALUE is not valid	0 = No OUTPUT_VALUE error 1 = Error in OUTPUT_VALUE
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL	The value in SLOT is not valid (when MODE_SLOT = permanent update)	0 = No SLOT value error 1 = SLOT value error

Note

If an output short-circuit occurs, the digital output is able to briefly supply a current substantially higher than the rated value.

Diagnostic alarms

When a TM Pulse 2x24V error event triggers a diagnostic alarm, the following happens:

- The DIAG light flashes red when a diagnostics alarm is pending. Once you have remedied the error, the DIAG light changes to green.
- The diagnostics are displayed as plain text in the STEP 7 (TIA Portal) online and diagnostics view.
- Options for the reaction of a CPU running your control program
  - CPU goes to STOP and interrupts processing of the user program. The diagnostic interrupt OB (for example, OB 82) is called. The event that triggered the interrupt is written in the start information of the diagnostic interrupt OB.
  - CPU remains in RUN even if no diagnostic interrupt in present in the CPU. The technology module continues working unchanged if this is possible, while the error exists.
- Detailed information on the error event is available through execution of the RALRM (read alarm information) program instruction

Diagnostic configuration options

If a short-circuit or overload occurs on the 24 V DC sensor supply or digital output, the TM Pulse 2x24V generates a diagnostic message for the connected CPU/master. During the TM Pulse 2x24V device configuration, you must enable a channel's Group diagnostics and Diagnostics DQA / Diagnostics DQB parameters to enable the corresponding diagnostic messages.

See also TIA portal Diagnostics configuration (Page 105)

Configuration parameter	Meaning	Default
Group diagnostics	When Group diagnostics is enabled, the TM Pulse 2x24V generates a diagnostic message for the CPU/master in the following cases: • Supply voltage error • Short-circuit on 24 V DC sensor supply • Over-temperature	Disabled
Diagnostics DQA	The TM Pulse 2x24V detects a short-circuit/overload on the DQn.A digital output when Diagnostics DQA is enabled.	Enabled
Diagnostics DQB	The TM Pulse 2x24V detects a short-circuit/overload of the DQn.B digital output when Diagnostics DQB is enabled.	Enabled

Diagnostic alarms

Diagnostic alarm	Error Code	Meaning	To correct or avoid errors
Class A diagnostics (cannot be deactivated by user)			
Internal error	100_H	Technology Module is defective	Replace Technology Module
Watchdog tripped	103_H	Firmware Error, Technology Module is defective.	Run firmware update. If the problem remains, replace Technology Module.
Parametrization Fault	010_H	Possible causes: • The received parametrization record is not valid. • The configured BaseUnit is not the actual BaseUnit.	• Check the parametrization record. • Check the BaseUnit.
Module temporarily not available	$01F_H$	Possible causes: • Firmware-update is currently running. • Firmware-update has been interrupted.	• Wait for the end of the firmware update • Retry firmware update
Class B diagnostics (can be deactivated by user)			
No supply voltage	011_H	No L+ supply voltage for the technology module	Connect L+ supply voltage to the Technology Module.
Short-circuit or overload at the 24 V DC sensor supply	$10E_H$	Error on 24 V DC sensor supply Possible causes: • Short-circuit • Overload	• Correct wiring to 24 V DC. • Check loads connected to 24 V DC.
Error at the digital outputs	$10F_H$	Error at the digital outputs Possible causes: • Short-circuit • Overload	• Correct wiring at the digital outputs. • Check loads connected to the digital outputs.
Supply voltage error	110_H	Error at L+ supply voltage Possible causes: • Low voltage • Wiring of L+ supply voltage defective	• Check the L+ supply voltage. • Check the wiring of L+ supply voltage.
Over temperature	506_H	Possible causes: • Short-circuit or overload at the digital outputs • Ambient temperature outside specifications	• Correct process wiring • Improve cooling • Check connected loads

Technical specifications

8

	6ES7138-6DB00-0BB1
Product type designation	TM Pulse 2x24 V
General information	
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type B1
Color code for module-specific color identification plate	CC40
Product function	
I&M data	Yes; I&M 0
Isochronous mode	Yes
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V13 SP1
STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
PROFIBUS as of GSD version/GSD revision	GSD Revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.31
Supply voltage	
Load voltage L+	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19,2 V
permissible range, upper limit (DC)	28,8 V
Short-circuit protection	Yes
Reverse polarity protection	Yes; against destruction
Input current	
Current consumption, max.	70 mA; without load
Encoder supply	
Number of outputs	2; A common 24V encoder supply for both channels
24 V encoder supply	
24 V	Yes; L+ (-0.8 V)
Short-circuit protection	Yes; per module, electronic
Output current, max.	300 mA
Power loss	
Power loss, typ.	1,7 W

	6ES7138-6DB00-0BB1
Address area	
Occupied address area	
Inputs	16 byte; 8 per channel
Outputs	24 byte; 12 per channel
Digital inputs	
Number of digital inputs	2; 1 per channel
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Digital input functions, parameterizable	
Freely usable digital input	Yes
HW enable for digital output	Yes
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
for signal "0"	-30 to +5V
for signal "1"	+11 to +30V
permissible voltage at input, min.	-30 V
permissible voltage at input, max.	30 V
Input current	
for signal "1", typ.	2,5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
• parameterizable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
• at "0" to "1", min.	4 µs; for parameterization "none"
• at "1" to "0", min.	4 µs; for parameterization "none"
Cable length	
shielded, max.	1000 m; Depending on load and cable quality
unshielded, max.	600 m; Depending on load and cable quality
Digital outputs	
Type of digital output	P- and M-switching
Number of digital outputs	2; 1 per channel
Current-sinking	Yes
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	6.8 A with Standard output, 2 A with High Speed output

	6ES7138-6DB00-0BB1
Limitation of inductive shutdown voltage to	-0.8 V
Controlling a digital input	Yes
Accuracy of pulse duration	±100 ppm ±0.5 µs with High Speed output, ±100 ±100 ppm ±9 µs with Standard output
minimum pulse duration	1,5 µs; With High Speed output, 10 µs with Standard output
Digital output functions, parameterizable	
Freely usable digital output	Yes
PWM output	Yes
• Number, max.	2; 1 per channel
• Cycle duration, parameterizable	Yes; Max. 85 s
• ON period, min.	0 %
• ON period, max.	100 %
• Resolution of the duty cycle	0,0036 %; For S7 analog format, min. 20 ns
Connection of a proportional valve	Yes
Dithering	Yes
• Frequency adjustable	Yes
• Amplitude adjustable	Yes
Current measurement	Yes
Current control	Yes
Connection of a DC motor	Yes
ON-delay	Yes
OFF-delay	Yes
Frequency output	Yes
Pulse train	Yes
Pulse output	Yes
Switching capacity of the outputs	
with resistive load, max.	2 A
on lamp load, max.	10 W; 1 W with High Speed output
Load resistance range	
lower limit	12 Ω; 240 ohm with High Speed output
upper limit	12 kΩ
Output voltage	
Type of output voltage	DC
for signal "0", max.	1 V
for signal "1", min.	23,2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	2 A; 0.1 A with High Speed output, observe derating

	6ES7138-6DB00-0BB1
Output delay with resistive load	
"0" to "1", typ.	0 µs; With High Speed output, 4.5 µs with Standard output
"0" to "1", max.	0,8 µs; With High Speed output, 9 µs with Standard output
"1" to "0", typ.	0 µs; With High Speed output, 4.5 µs with Standard output
"1" to "0", max.	0,8 µs; With High Speed output, 9 µs with Standard output
Parallel switching of 2 outputs	
for uprating	Yes
Switching frequency	
with resistive load, max.	100 kHz; With High Speed output, 10 kHz with standard output
with inductive load, max.	100 kHz; With High Speed output, 10 kHz with standard output
on lamp load, max.	10 Hz
Total current of the outputs	
Current per channel, max.	2 A
Current per group, max.	4 A
Current per module, max.	4 A
Cable length	
shielded, max.	1000 m; Depending on load and cable quality
unshielded, max.	600 m; Depending on load and cable quality
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes
Bus cycle time (TDP), min.	250 µs; with 1 channel configuration, 375 µs with 2 channel configuration
Jitter, max.	1 µs; typically ±
Interrupts/diagnostics/status information	
Substitute values connectable	Yes; Parameterizable
Alarms	
Diagnostic alarm	Yes
Diagnostic messages	
Diagnostics	Yes
Monitoring the supply voltage	Yes
Short-circuit	Yes
Diagnostics indication LED	
Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
Channel status display	Yes
for module diagnostics	Yes; green/red DIAG LED

	6ES7138-6DB00-0BB1
Potential separation	
Potential separation digital inputs	
between the channels and backplane bus	Yes
Potential separation digital outputs	
between the channels and backplane bus	Yes
Potential separation channels	
between the channels	No
between the channels and backplane bus	Yes
Permissible potential difference	
between different circuits	75 V DC/60 V AC (base isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
horizontal installation, max.	60 °C; Observe derating
vertical installation, max.	50 °C; Observe derating
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	20 mm
Weights	
Weight, approx.	50 g

Ambient temperature output current derating information

Use the following graphs to find the maximum output current, when operating at higher loads and temperatures.

The output current derating for single channel (4 A) is twice (2x) the derating of the dual channel (2 A per channel) values shown in the derating graphs.

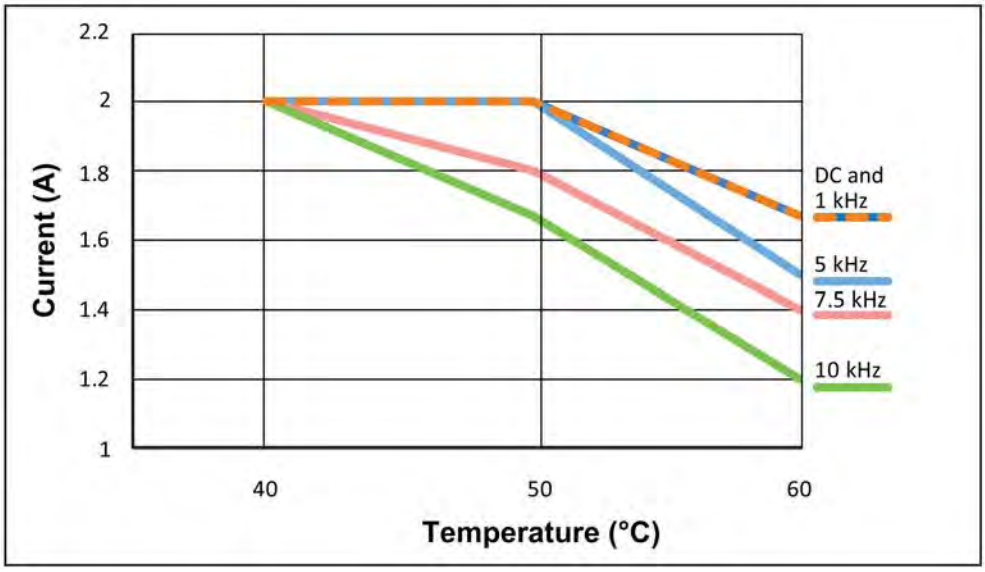


Figure 8-1 Maximum output current temperature derating for DC and 90%/10% duty cycle

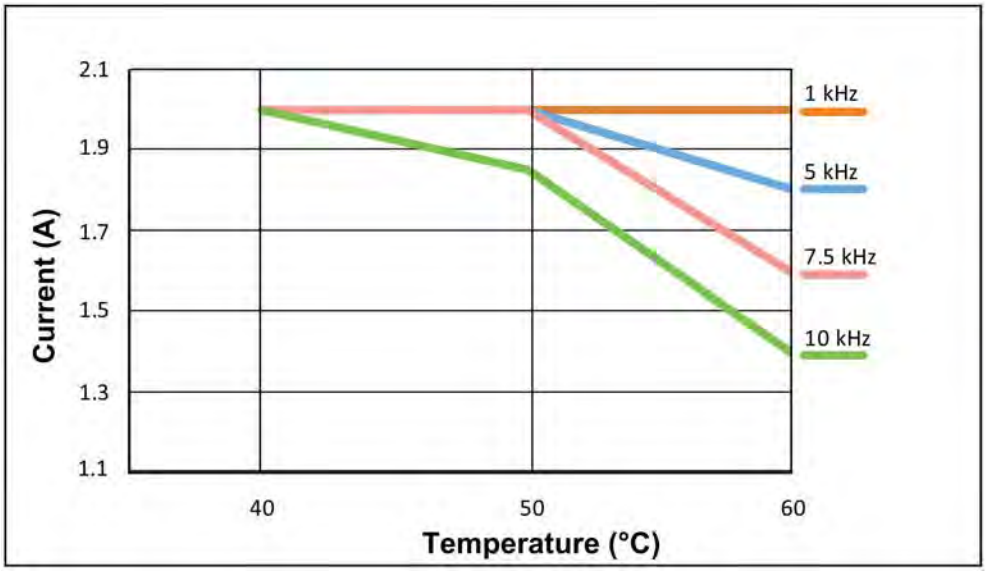


Figure 8-2 Maximum output current temperature derating for 50% duty cycle

BaseUnit technical specifications

Refer to the user manual for ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

8.1 Programming reference

Control interface: 2 channels, 24 output bytes (Q addresses)

CPU input address		Description
Channel 0	Channel 1[1]	
DWord 0	DWord 12	Depending on the mode: • Pulse output mode: Pulse duration in µs • PWM mode: Duty cycle On-ratio (Number range set by Output format configuration) – "Per 100": 0 to 100 – "Per 1000": 0 to 1,000 – "Per 10000": 0 to 10,000 – "S7 analog output": 0 to 27,648 • PWM mode with current control: Target current is assigned as a ratio of target current/reference current • Pulse train mode: Number of pulses to output as a DWord number value between 1 to 4,294,967,295 (2^{32}-1) • On/Off-delay mode: Off-delay in µs • Frequency output mode: Output frequency in Hz
DWord 4	DWord 16	SLOT value: Behavior depends on operating mode, MODE_SLOT(1 bit), and LD_SLOT (four bits).
Byte 8: Bits 0 to 3	Byte 20: Bits 0 to 3	LD_SLOT value controls interpretation of SLOT value. • 0 = No action / idle state • 1 = Period duration µs (PWM, Pulse train, and DC motor) • 2 = On-delay µs (Pulse output, PWM, Pulse train, Frequency output, and DC motor) • 3 = Off-delay µs (On/Off-delay) • 4 = Duty cycle On-ratio (Pulse train) • 5 = Dither ramp-up time and ramp-down time (PWM) • 6 = Dither amplitude (PWM) • 7 = Dither period (PWM)
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT value controls the SLOT update process. • 0 = single update (SLOT changed sometimes, prior to output sequence) • 1= permanent update (SLOT controlled continuously)

CPU input address		Description
Channel 0	**Channel 1[1]**	
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE: Transition from 0 → 1 and remaining 1 during the input delay starts the output sequence. Only active for the first positive edge, additional positive edges are ignored and no start occurs.
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ: Set DQ output source: Selects either CPU program or module's output sequence. • 0 = DQn.A and DQn.B are controlled by the CPU (in your program) using the SET_DQA and SET_DQB control bits. • 1 = DQn.A and DQn.B are controlled by the module's output sequence.
Byte 9: Bit 2	Byte 21: Bit 2	SET_DQA: Controls the value of the digital output DQn.A, if TM_CTRL_DQ = 0 • 0 = 0V on DQn.A • 1 = 24V on DQn.A
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQB: Controls the value of the digital output DQn.B, if TM_CTRL_DQ = 0 • 0 = 0V on DQn.B • 1 = 24V on DQn.B
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR: Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V). • 0 = Reset of errors is not active. • 1 = Reset of errors is active.

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Feedback Interface: 2 channels, 16 input bytes (I addresses)

CPU output address		Description
Channel 0	**Channel 1[1]**	
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR: 1 = 24 V DC present, but is not in the correct range. 0 = no error
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V: 1 = Short-circuit/overload, in the 24 V DC sensor supply output. 0 = no error
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD: 1 = Error while loading a parameter value using single-update mode. 0 = no error
Byte 0: Bit 3	Byte 8: Bit 3	ERR_PULSE: 1 = Pulse duration reduced to smaller than the minimum allowed during operation. 0 = No error
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA: 1 = Short-circuit/overload on the digital output DQn.A. 0 = no error
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB: 1 = Short-circuit/overload on the digital output DQn.B or attempt to set both DQn.A and DQn.B to high. 0 = no error
Byte 0: Bit 6	Byte 8: Bit 6	ERR_OUT_VAL: 1 = The value in OUTPUT_VALUE is not valid. 0 = no error
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL: 1 = The value in SLOT is not valid where MODE_SLOT = 1 (permanent update). 0 = no error
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT: Toggle acknowledge bit for each action of the SLOT in single-update SLOT-mode Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY: 1 = Module is parameterized correctly, running, and delivering valid data. 0 = not ready
Byte 1: Bit 5	Byte 9: Bit 5	ST_SW_ENABLE: 1 = SW_ENABLE active. 0 = SW_ENABLE not active
Byte 2: Bit 0	Byte 10: Bit 0	STS_ENABLE: 1 = Output sequence running. 0 = No output sequence running
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA: 1 = DQn.A output active. 0 = DQn.A output not active.
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB: 1 = DQn.B output active. 0 = DQn.B output not active.
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI: 1 = DIn.0 digital input active. 0 = DIn.0 digital input not active.

CPU output address		Description
Channel 0	Channel 1[1]	
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT: Sequence counter: Is incremented after completion of an output sequence (Range 0 to 15)
Word 4	Word 12	MEASURED_CURRENT: Current measurement uses a SIMATIC S7 analog value. Full-scale value depends on module configuration, as 2 channel (2 A) or 1 channel (4 A). • 2 channel (2 A): 0 to 32767 corresponds with 0 to 2.4 A • 1 channel (4 A): 0 to 32767 corresponds with 0 to 4.8 A
Byte 6: Bit 0	Byte 14: Bit 0	QLMN_LLM: The low limit of the manipulated value has been reached.
Byte 6: Bit 1	Byte 14: Bit 1	QLMN_HLM: The high limit of the manipulated value has been reached.

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Note

If the TM Pulse 2x24V external supply voltage is interrupted, then, 16#00000000 is returned as feedback value (substitute value).

Controlling the different operating modes

You select an output channel's operating mode during device configuration. Configuration data is stored in parameter data record 128.
The following table shows the program variables that the different operating modes use.

Program control variable	Notes
Software enable	
SW_ENABLE	Transition from 0 → 1 and remaining 1 during the input delay starts the output sequence. Only active for the first positive edge, additional positive edges are ignored and no start occurs. You must always issue the software enable in your control program. If you don't use a HW enable, the output sequence will be started by the positive edge of the software enable. If you reset the software enable, the current output sequence will be terminated.
Direct control of the digital output	
TM_CTRL_DQ	• If TM_CTRL_DQ = 1, then the TM Pulse 2x24V module has control and produces pulse sequences at the DQ outputs. • If TM_CTRL_DQ = 0, then the CPU has control and your program can set outputs DQn.A and DQn.B directly with the SET_DQA and SET_DQB control bits
SET_DQA SET_DQB	These control bits set/reset a channel's DQn.A and DQn.B outputs while TM_CTRL_DQ = 0. Note: You cannot set a channel's DQn.A and DQn.B to high at the same time. Otherwise, error ERR_DQB is set and only DQn.A is set high.
Pulse output operating mode	
Pulse duration	Assign the pulse duration directly with the control interface parameter OUTPUT_VALUE, as a DWord number value in µs.
On-delay	The time from the start of the output sequence to the start of the DQ output pulse. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.

Program control variable	Notes
PWM operating mode	
Duty cycle or Target current (current control enabled)	**Current control disabled**: PWM: OUTPUT_VALUE assigns the duty cycle (On/Off ratio) for the current period duration. You select the range of the OUTPUT_VALUE control interface field with the "Output format" configuration. • Output format "Per 100 (%)": Value range between 0 and 100 Pulse duration = (OUTPUT_VALUE/100) x period duration. • Output format "Per 1,000": Value range between 0 and 1,000 Pulse duration = (OUTPUT_VALUE/1,000) x period duration. • Output format "Per 10,000": Value range between 0 and 10,000 Pulse duration = (OUTPUT_VALUE/10,000) x period duration. • "S7 analog output" output format: Value range between 0 and 27,648 Pulse duration = (OUTPUT_VALUE/27,648) x period duration. **Current control enabled:** OUTPUT_VALUE assigns the target current as a ratio of target current/reference current. The reference current value is used to define the maximum set point and the high and low limits of the controlled current. Typically, the maximum current can be measured in PWM mode with current control disabled and a duty cycle set to 100%. The value measured can be set as a reference for the current control. The maximum value is 4000 mA for single channel operation (parallel channel connection enabled) and 2000 mA per channel for dual channel operation (parallel connection disabled).
Period duration	The Period duration of an output PWM cycle. Assign the period duration value in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 1. When you assign the period duration, take into account the minimum pulse duration configuration and the response time of the control element connected to the DQ digital output.
On-delay	The time from the start of the output sequence to the start of the DQ output pulse. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.
Pulse train operating mode	
Number of pulses	Number of pulses that are output at the DQ digital output on expiration of the On-delay. Your control program can set the pulse count directly with the control interface parameter (OUTPUT_VALUE). Set the number of pulses directly as a DWord number value between 0 to 4,294,967,295 (2^{32}-1).
Period duration	The Period duration of an output pulse cycle. Assign the period duration in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 1. When you assign the period duration take into account the minimum pulse duration configuration and the response time of the control element connected to the DQ digital output.
Duty cycle	Assign the duty cycle with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 4. The range of the duty cycle parameter is selected using the "Output format" configuration. If the number value you assign exceeds the upper limit, then a duty cycle of 100% of the period duration is used and this action does not cause an error. • Output format "Per 100 (%)": Value range 0 to 100 Pulse duration = (duty cycle/100) x period duration. • Output format "Per 1000": Value range 0 to 1,000 Pulse duration = (duty cycle/1,000) x period duration. • Output format "Per 10000": Value range 0 to 10,000 Pulse duration = (duty cycle/10,000) x period duration. • Output format "S7 analog output": Value range 0 to 27,648 Pulse duration = (duty cycle/27,648) x period duration.

Program control variable	Notes
On/Off-delay operating mode	
On-delay	The time between a positive edge of the DIn.0 digital input and DQn.A digital output (DQ follows DI state). Assign the On-delay in µs directly using the OUTPUT_VALUE control interface field.
Off-delay	The time between a negative edge of the DIn.0 digital input and its output on the DQn.A digital output (DQ follows DI state). Assign the Off-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 3.
Frequency output operating mode	
Output frequency	Frequency output at the digital output DQ. Assign the frequency in real format as Hz using the OUTPUT_VALUE control interface field. The possible range is dependent on the "High Speed Output" configuration. • High Speed Output disabled Frequency (OUTPUT_VALUE): 0.02 Hz to 10,000 Hz • High Speed Output enabled Frequency (OUTPUT_VALUE): 0.02Hz to 100,000Hz
On-delay	The time from the start of the output sequence to the output of the frequency. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.
DC motor operating mode	
OUTPUT_VALUE	The OUTPUT_VALUE determines the duty cycle (pulse duration/period duration ratio) within a period (PWM). The period duration can be adjusted. The new output value is applied at the next rising edge of the output. The sign indicates direction of rotation (positive for forward) and (negative for backward). S7 analog output format: value range is -27,648 to +27,648 DInt data type: Only 2 least significant bytes are used For channel 0: bytes 2 and 3 For channel 1: bytes 14 and 15
On-delay	The time from the start of the output sequence to the output of the frequency. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.
If "Function DI" is parameterized as "External stop":	A rising edge on DIn.0 will stop the output sequence and stop the DC motor.

Device configuration (Assignments stored in parameter data record 128)

Parameters	Value Range	Default
Channel configuration	• 2 channels (2 A) • 1 channel (4 A)	2 channels (2 A)
Channel (0 and 1)		
Reaction to CPU STOP	• Continue working mode • DQ substitute a value	DQ substitute a value
Substitute value DQA	0 or 1	0
Substitute value DQB	0 or 1	0
Group diagnostics	Disable/enable	Disabled
Diagnostics DQA		Disabled
Diagnostics DQB		Disabled
Operating mode	• Pulse output • PWM • Pulse train • On/Off-delay • Frequency output • DC motor	PWM
High-speed output (0.1 A)	Disable/enable	Disabled
Current control (for PWM mode only)	Disable/enable	Disabled
Function DI HW enable option available for Pulse output, Pulse train, Frequency output and DC motor modes.	• Input • HW enable • External stop (DC motor only)	Input
Activate P	P-SEL: Add Proportional term for current control	Enabled
Activate I	I-SEL: Add Integral term for current control	Enabled
Activate D	D-SEL: Add Derivative term for current control	Disabled
Input delay	• Off (4µs) • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	0.1 ms
Output format: PWM and Pulse train modes DC motor mode, (only S7 analog output format is possible)	• S7 analog output format • Per 100 • Per 1000 • Per 10000	Per 100

Parameters	Value Range			Default
Output format (in the "Frequency output" operating mode)	1 Hz			1 Hz
Dithering (PWM mode only): Superimpose dithering waveform on PWM output sequence.	Disable/enable			Disabled
	Minimum		Maximum	
	High-speed **disabled**	High-speed **enabled**		
DWord: Minimum pulse duration for PWM and DC motor modes	10 µs	1.5 µs	85,000,000 µs	0
DWord: Period duration for PWM, Pulse train, and DC motor modes	100 µs	10 µs		2,000,000 µs
DWord: On-delay for all modes except On/Off-delay	0 µs	0 µs		0
DWord: Value depends on mode				
PWM: Dither ramp	Low word: Dither ramp-up time 0 to 30000 ms High word: Dither ramp-down 0 to 30000 ms			0 ms 0 ms
Pulse train: Duty cycle	S7 analog output format: 0 to 27648			13824 (50%)
	Per 100 format: 0 to100			50 (50%)
	Per 1000 format: 0 to 1000			500 (50%)
	Per 10000 format: 0 to 10000			5000 (50%)
On/Off delay: Off delay	0 to 85,000,000 µs			0
DWord: Dither amplitude for PWM only	0 to 500 ‰ (per mill)			50 ‰
DWord: Dither period for PWM only	From (4 times the PWM period µs) to 100000 µs (must be higher than 2000 µs)			50000 µs
Word: Reference value current for PWM with current control only	• 0 mA to 2000 mA for "2 channels (2 A)" operation • 0 mA to 4000 mA for "1 channel (4 A)" operation to 4000 mA for "1 channel (4 A)" operation			0 mA
Word: Dead band width (µA) for current control	0 µA to 65535 µA			0 µA
Word: High current limit for current control	S7-analog value relative to the reference value current: Range is 1 to 65535 (>= 27648 means 100%)			27648
Word: Low current limit for current control	S7-analog value relative to the reference value current: Range 0 to 27647 (Low limit must be less than the High limit)			0
Gain for current control	Real value (DWord size)			2.0 s
TI: Integration time (s) for current control	Real value (DWord size)			20.0 s
TD: Derivative action time (s) for current control	Real value (DWord size)			10 .0 s
TM LAG: Time lag of the derivative action (s)	Real value (DWord size)			2.0 s

Parameter data record

A

The TM Pulse 2x24V parameter data record is modified and stored for you by the TIA portal when you perform a Device configuration, successful configuration block compilation, and download a new configuration block to the system hardware.

You may also directly edit the module parameters with the CPU in RUN mode. The WRREC instruction is used to transfer parameters to the module using data record 128.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the data actually transferred.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help (TIA Portal).

Structure of data record 128

The following table shows you the structure of data record 128 for the TM Pulse 2x24V. The values in byte 0 to byte 3 are fixed and may not be changed. Default values are indicated in bold font.

- A total of 108 bytes (4 header bytes + 2(52 channel bytes) is required for the 2 channel configuration (parallel connection disabled).
- A total of 56 byes (4 header bytes + 52 channel bytes) is required for the 1 channel configuration (parallel connection enabled).
- Bytes 4 to 55 are the channel 0 parameters
- Bytes 56 to 107 are the channel 1 parameters.
- Channel 1 parameters use the same data structure as channel 0. Add a 52 byte offset to the channel 0 byte numbers, to determine the channel 1 byte numbers.

Table A- 1 Header and channel 0 basic configuration

Bit → / Byte ↓	7	6	5	4	3	2	1	0
0 to 3	**Header**							
0	Reserved[1]		Major version = 0		Minor version = 1			
1	Channel parameter data length = 52 bytes							
2	Reserved[1]							
3								
4 to 55	**Channel 0 parameters**							
4	Current control	Dithering	High-speed output		Mode			
	0$_B$: Disabled	**0**$_B$: Disabled	**00**$_B$: Disabled					
	1$_B$: Enabled (not if High-speed mode is enabled)	1$_B$: Enabled	01$_B$: Enabled Not allowed for "1 channel (4A)" configuration that connects the two channels in parallel.					
			10$_B$-11$_B$: Reserved					
					0: Pulse output			
					1: PWM (Pulse width modulation)			
					2: Pulse train			
					3: On/Off-delay			
					4: Frequency output			
					5: DC motor			
5	PID loop calculation for current control			Reserved[1]		Diagnostic interrupt	Reaction to CPU STOP	
	P-SEL: Add Proportional term	I-SEL: Add Integral term	D-SEL: Add Derivative term			**0**$_B$: Disabled	**00**$_B$: DQ substitute a value	
						1$_B$: Enabled	01$_B$: Reserved	
	0$_B$: Disabled	0$_B$: Disabled	**0**$_B$: Disabled				10$_B$: Continue working mode	
	1$_B$: Enabled	**1**$_B$: Enabled	1$_B$: Enabled				11$_B$: Reserved	
6	Reserved[1]		Input delay				Function DI	
			0$_H$: Off (4 µs)				**00**$_B$: Input	
			1$_H$: 0.05 ms00				01$_B$:HW enable	
			2$_H$: 0.1 ms				10$_B$:External stop (DC motor mode only)	
			3$_H$: 0.4 ms					
			4$_H$: 0.8 ms					
			5$_H$: 1.6 ms					
			6$_H$: 3.2 ms					
			7$_H$: 12.8 ms					
			8$_H$: 20 ms					
			9$_H$ to F$_H$ Reserved					

Bit → / Byte ↓	7	6	5	4	3	2	1	0
7	Reserved[1]		Output format		Diagnostics DQB	Diagnostics DQA	Substitute value DQB	Substitute value DQA
			Bits 5 and 4	PWM or Pulse train	Frequency output	DC motor	**0_B**: Disable	**0_B**: Disable	**0_B**: 0 V	**0_B**: 0 V
							1_B: Enable	1_B: Enable	1_B: 24V	1_B: 24V
			00_B	S7 Analog format	Reserved	**S7 Analog format**				
			01_B	**Per 100** (%)	**1 Hz**	Reserved				
			10_B	Per 1,000	Reserved	Reserved				
			11_B	Per 10,000	Reserved	Reserved				

[1] Must be set to 0.

Table A- 2 Channel 0 Word, DWord, and Real values configuration

Byte	Channel 0 mode and variable usage	Value range
8 to 11	**Minimum pulse duration DWord**	
	PWM (only if current-control is inactive)	Minimum pulse duration: Default value = **0 µs**
	Pulse output, Pulse train, On/Off-delay, and Frequency output	Reserved
12 to 15	**Period duration DWord**	
	PWM, Pulse train	Period duration: High-speed disabled: 100 µs to 85,000,000 µs High-speed enabled: 10 µs to 85,000,000 µs Default value = **2,000,000 µs**
	DC motor	Period duration: 100 µs to 85,000,000 µs Default value = 1000 µs
	Pulse output, On/Off-delay, and Frequency output	Reserved
16 to19	**On-delay DWord**	
	Pulse output, PWM, Pulse Train, Frequency output, and DC motor	On-delay: **0 µs** to 85,000,000 µs
	On/Off-delay	Reserved
20 to 23	**Value DWord**	
	PWM	Dithering ramp times (2 bytes each): • Ramp-up time (low word): **0 ms** to 30,000 ms • Ramp-down time (high word): **0 ms** to 30,000 ms
	Pulse train	Duty cycle %: 0 to 27648, Default = **50** (50%)
	On/Off-delay	Off-delay: **0 µs** to 85,000,000 µs
	Pulse output, Frequency output, and DC motor	Reserved

Byte	Channel 0 mode and variable usage	Value range
24 to 27	**Dither amplitude DWord**	
	PWM	Dither amplitude (per mil): 0 to 500 the default value is **50**.
	Pulse output, Pulse train, On/Off-delay, Frequency output, and DC motor	Reserved
28 to 31	**Dither period DWord**	
	PWM	Dither period: Valid from ((4 x PWM period) AND (> 2000)) µs to 100,000 µs. The default value is **50,000 µs**.
	Pulse output, Pulse train, On/Off-delay, Frequency output, and DC motor	Reserved
32 to 55	**PWM mode only: Current control parameters**	
32 to 33	Reference value current (mA)	Word size: **0 mA** to 2000 mA for "2 channels (2 A)" operation **0 mA** to 4000 mA for "1 channel (4 A)" operation
34 to 35	Dead band width (µA)	Word size: **0 µA** to 65535 µA
36 to 37	High limit - S7-analog value relative to the reference value current	Word size: 1 to 65535 (>= **27648** means 100%)
38 to 39	Low limit - S7-analog value relative to the reference value current	Word size: **0** to 27647 (because Low limit must be less than the High limit)
40 to 43	Gain	Real (DWord size): Default value = **2.0 s**
44 to 47	TI: Integration time (s)	Real (DWord size): Default value = **20.0 s**
48 to 51	TD: Derivative action time (s)	Real (DWord size): Default value = **10.0 s**
52 to 55	TM LAG: Time lag of the derivative action (s)	Real (DWord size): Default value = **2.0 s**

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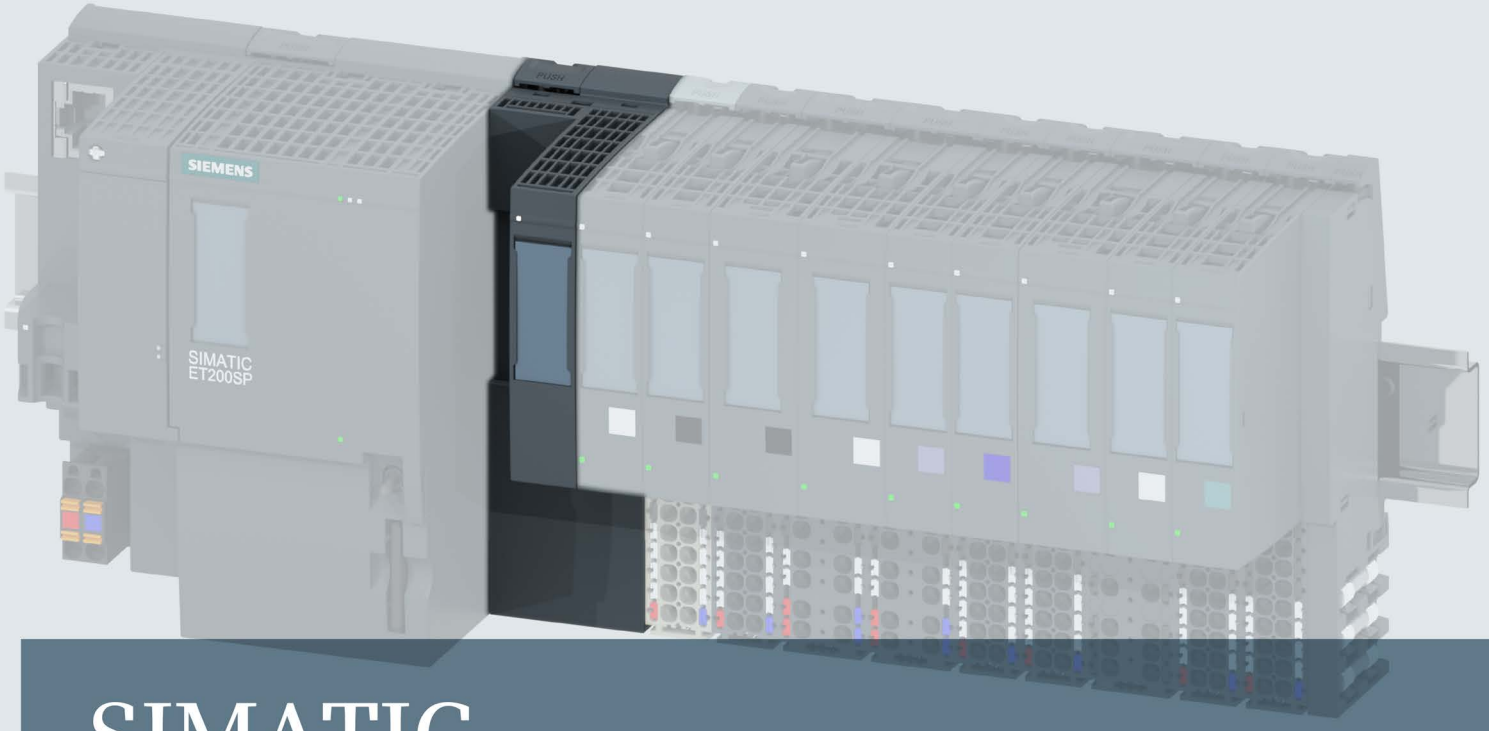

SIMATIC

ET 200SP

Communication module CM DP (6ES7545-5DA00-0AB0)

Manual

Edition 12/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Communication module CM DP
(6ES7545-5DA00-0AB0)

Manual

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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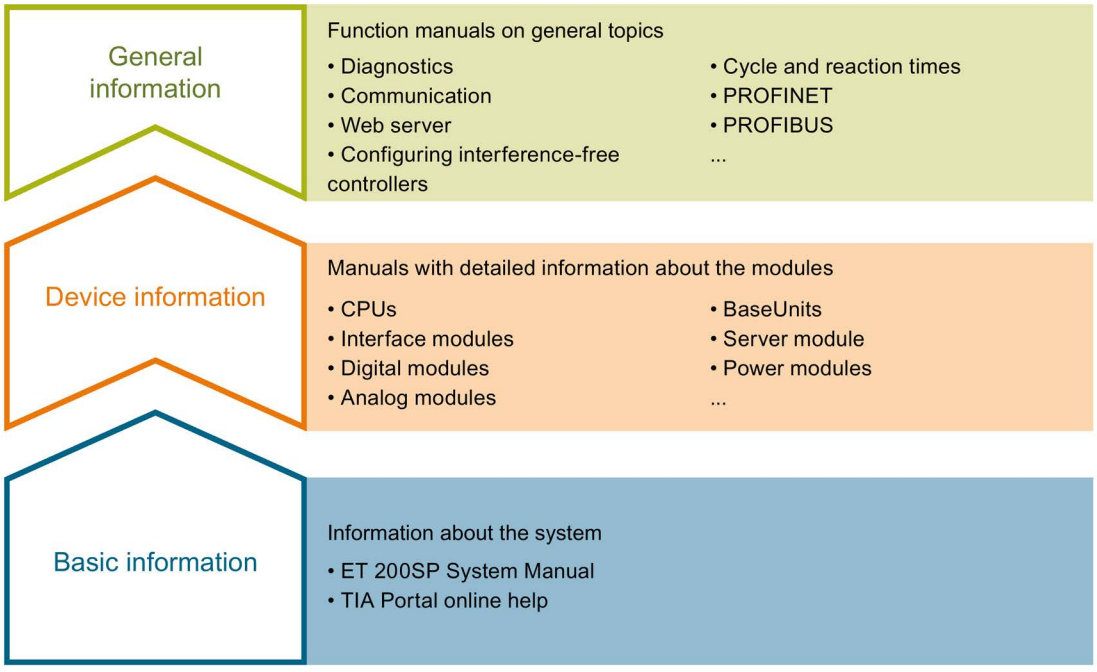
ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

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CAx Download Manager

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You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7545-5DA00-0AB0

View of the module

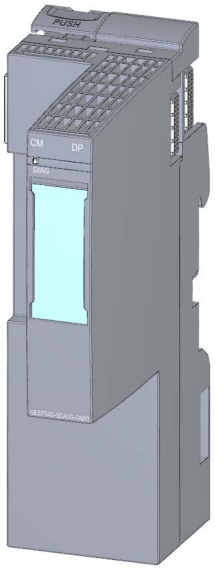


Figure 2-1 View of the CM DP communication module

Properties

The communication module CM DP can be used with the ET 200SP CPUs. You insert the communication module to the right next to the CPU.

The communication module has the following properties:

- Technical properties
  - Connects the CPU of the ET 200SP distributed I/O system with PROFIBUS DP
  - Bus connection via RS485 interface
- Supported functions
  - Operation as DP master or DP slave
  - Enable/disable DP slave
  - Diagnostics requirements
  - Identify the bus topology in a DP master system
  - Identification data I&M 0
  - Time-of-day synchronization
  - Line diagnostics
  - S7 services

Supported communication services

The communication module supports the following communication services:

- PROFIBUS DP-Master, as of STEP 7 V13, Update 3
  - PROFIBUS DP according to IEC 61158 and 61784 DPV1, DP master for DP slaves according to PROFIBUS DP and DPV1 standard
- PROFIBUS DP slave, as of STEP 7 V13, SP1
  - PROFIBUS DP according to IEC 61158 and 61784 DPV1, DP slave and I-slave

Note

DP master or DP slave

Note however: The CM DP only supports alternative operation as DP master or DP slave.

Maximum configuration as DP Master

Table 2- 1 General characteristics of DP mode

Feature	Explanation/values
Number of operable DP slaves	125
Max. size of the input area over all DP slaves	8 KB
Max. size of the output area via all DP slaves	8 KB
Maximum number of inputs per DP slave	244 bytes
Maximum number of outputs per DP slave	244 bytes
Max. size of the consistency area for a module	128 bytes

Note

Setting the PROFIBUS DP address on the communication module CM DP

The communication module CM DP does not have a DIP switch. You set the PROFIBUS DP address via STEP 7 (TIA Portal). You can find more information on this topic in the STEP 7 online help.

Accessories

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

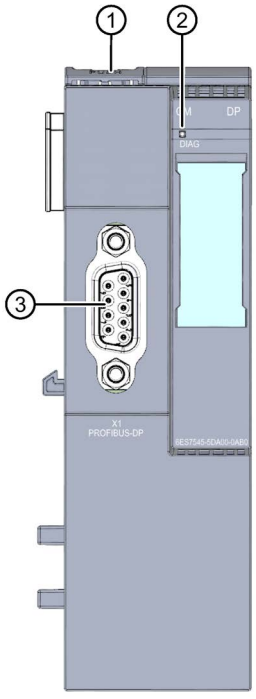
Additional information

You can obtain detailed information on the topic of PROFIBUS in the function manual PROFIBUS (http://support.automation.siemens.com/WW/view/de/59193579/0/en)

2.2 Operating and display elements

Operating and connection elements

The following figure shows the operating and connection elements of the CM DP communication module.



① Mounting rail release
② DIAG LED
③ DP interface

Figure 2-2 Operating and display elements of the communication module CM DP

Wiring

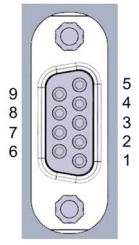
3

3.1 Pin assignment

PROFIBUS DP with RS485 interface

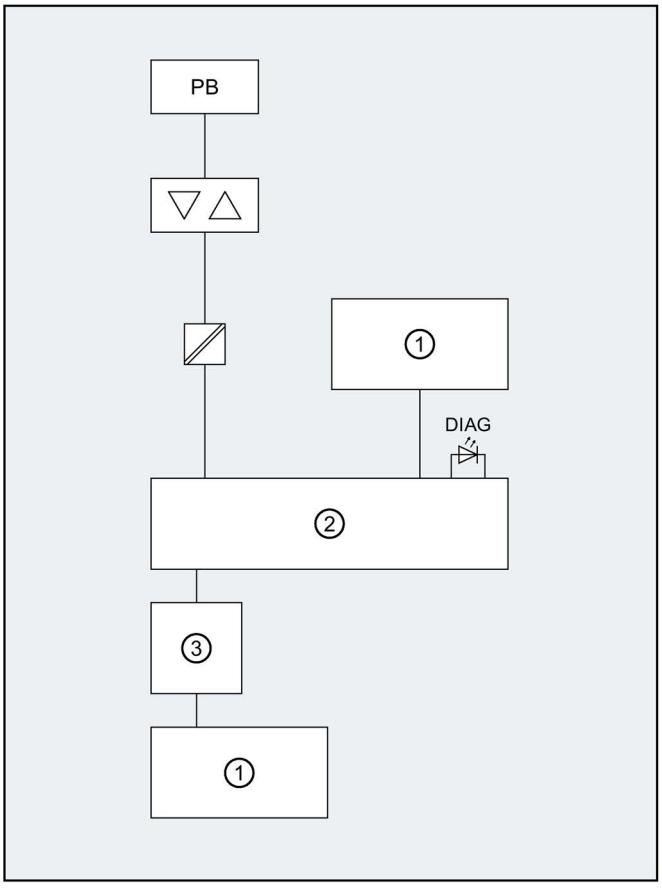
The following table shows the signal names and the designations of the pin assignment for the PROFIBUS DP interface.

Table 3- 1 Pin assignment PROFIBUS DP with RS485 interface

View	Signal name		Designation
	1	-	-
	2	-	-
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	DP data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	-	-
	8	RxD/TxD-N	Data line A
	9	-	-

3.2 Block diagram

The following figure shows the block diagram of the CM DP communication module.



①	Backplane bus	PB	PROFIBUS interface
②	ET 200SP PROFIBUS interface and backplane bus transmission	DIAG	LED diagnostics (green/red)
③	Internal power supply		

Figure 3-1 Block diagram of the CM DP

Programming

4

Instructions

Pre-written instructions are available as an interface in your STEP 7 user program for communication services.

Table 4- 1 Instructions for PROFIBUS DP

Instructions	Meaning when used with CM DP	
	DP master	DP slave (I-slave)
DPSYC_FR	Synchronize DP slaves/Freeze inputs (SYNC/FREEZE instruction)	-
DPNRM_DG	Read diagnostics data of a DP slave	-
DP_TOPOL	Determine topology for DP master system	-
WRREC	Write data record of a DP slave	-
RDREC	Read data record of a DP slave	-
GETIO	Read process image of a DP standard slave	Read process image
SETIO	Transfer process image of a DP standard slave	Transfer process image
GETIO_PART	Read process image area of a DP standard slave	Read process image area
SETIO_PART	Transfer process image area of a DP standard slave	Transfer process image area
D_ACT_DP	Enable/disable DP slaves	-
DPRD_DAT	Read consistent data of a module (user data)	
DPWR_DAT	Write consistent data of a module	
RALRM	Event-driven reading of alarm information (diagnostics, pull/plug, hardware interrupt) as well as DPV1-specific interrupts (update, status, vendor-specific interrupt)	Event-driven reading of interrupt information (diagnostic interrupt)

Read the documentation for the instructions in the STEP 7 online help

Calling instructions for distributed I/O

Multiple calls are required for the instructions of the distributed I/O.

The duration of the call processing is dependent on the load, bus cycle time and transmission rate. Timeouts may occur if these instructions are called in a loop within a cycle.

Exceptions:

- Only one call is necessary for the RALRM instruction "Receive interrupt".

Program blocks for DPV1 (according to PNO standard) [1]:

- "Read data record from a DP slave" RDREC instruction is functionally equivalent to SFC59 (write record)
- "Write data record to a DP slave" WRREC instruction is functionally equivalent to SFC58 (read record)
- "Read interrupt information from a DP slave" RALRM instruction call is made within an interrupt OB

[1] PNO: PROFIBUS user organization

Diagnostics, error and system alarms

5

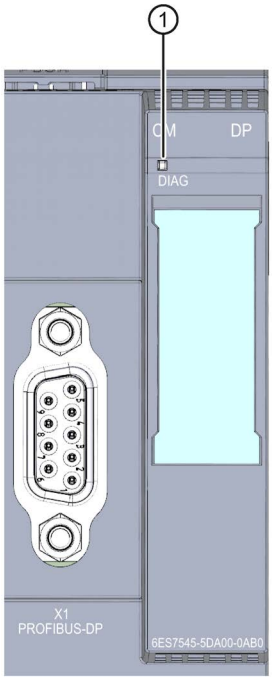
5.1 Status and error displays

Introduction

Diagnostics by means of LEDs is an initial tool for error localization. In order to localize errors still further, you usually evaluate the display of the module status in STEP 7 or the diagnostics buffer of the CPU. The buffer contains plain text information on the error that has occurred. For example, you will find the number of the relevant error OB in the plain text information.

LED display

The figure below shows the LED display on the CM DP communication module.



① DIAG (green/red)

Figure 5-1 LED display on the CM DP communication module

Meaning of the DIAG LED display on the communication module

The CM DP communication module has an LED for monitoring the diagnostics.

DIAG LED

Table 5- 1 DIAG LED fault display

DIAG LED	Meaning
Flashes	Module parameters not assigned
On	Module parameters assigned and no diagnostics
Flashes	Diagnostics of subordinate modules (as of firmware version V1.7)

Additional information

You can find more information on diagnostics in the Diagnostics function manual (http://support.automation.siemens.com/WW/view/de/59192926/0/en) for diagnostic options that are available for SIMATIC systems S7-1500, ET 200MP, ET 200SP and ET 200AL.

5.2 DP slave diagnostics

DP V1 slave: Diagnostic interrupt

Transmission of diagnostic data is made as a diagnostic interrupt. Diagnostic interrupts must be acknowledged by the DP master.

Supported diagnostic functions

The CM DP supports the following blocks of the DP diagnostics:

- Standard diagnostics (6 bytes)
- Identifier-related diagnostics (2...17 bytes depending on the number of configured transfer areas)
- Module status (5...35 bytes depending on the number of configured transfer areas)
- Diagnostic interrupt (8 bytes, if any)

User program (DP master)

The "DPNRM_DG" instruction is used to read the diagnostic data of a DP slave (DP single diagnostics) in the DP master.

The diagnostic interrupts for DP V1 slaves are periodically evaluated in the user program of the master via the "RALRM" instruction.

You can find the required parameter assignment for the instruction in the STEP 7 online help.

The following is a structural overview of the diagnostic data.

Overview of standard diagnostics

Standard diagnostics	
Byte	**Meaning**
0	Station status 1
1	Station status 2
2	Station status 3
3	Master address
4...5	Manufacturer ID of the slave

Overview of device-specific diagnostics

The device-specific diagnostics data depends on the protocol variant in which the DP slave is operated:

- **DP-V1 slave**

Table 5- 2 Overview of device-specific diagnostics of the CM DP for DP V1 slaves

Device-specific diagnostics		
Byte	**Meaning**	
0	Header	
1	Variant Interrupt type	Variant Status type
2	Slot number	
3	Variant Interrupt specifier	Variant Status specifier
4...62	Module-specific diagnostic data	

5.3 Standard diagnostics

Standard diagnostics

The coding of the standard diagnostic bytes is explained below.

Byte 0: Station status 1

Table 5- 3 Structure of station status byte 1

Bit no.	Name	Explanation
7	Master_Lock	The DP slave was configured by a different DP master. The DP slave can only be accessed read-only by the DP master configured as productive. This bit is set by the DP master when its bus address does not match the configured address.
6	Parameter_Fault	The most recently received parameter frame was corrupt or not permitted. This bit is set by the DP slave. Remedy: Check the parameter assignment with respect to invalid parameters.
5	Invalid_Slave_Response	This bit is set by the DP master if an implausible response has been received by the DP slave.
4	Service_Not_Supported	This bit is set by the DP master if a function is called by the master that is not supported by the DP slave. Remedy: Disable the parameter assignment of the required function at the master.
3	Ext_Diag	This bit is set by the slave. • Bit =1: Diagnostic data is available in the diagnostic area specific to the slave. The diagnostic data can be evaluated in the user program of the master. • Bit =0: A status message can be available in the diagnostic area specific to the slave. The status message can be evaluated in the user program of the master.
2	Slave_Config_Check_Fault	The configuration data sent by the DP master is rejected by the DP slave. Cause: Configuration error. Remedy: Change the configuration.
1	Station_Not_Ready	The DP slave is not yet ready for productive data exchange. This is a temporary condition and cannot be influenced by the DP master.
0	Station_Non_Existent	The DP slave is not responding on the bus. This bit is set by the DP master 1 (the slave permanently sets this bit to 0). If the bit is set, the diagnostic bits contain the status of the last diagnostic alarm or the initial value.

Byte 1: Station status 2

Table 5- 4 Structure of station status byte 2

Bit no.	Name	Explanation
7	Deactivated	The DP slave was shown as inactive in the local parameter set and will not be cyclically queried.
6	Reserved	- Reserved -
5	Sync_Mode	The DP slave is in SYNC mode. The bit is set by the slave.
4	Freeze_Mode	The DP slave is in FREEZE mode. The bit is set by the slave.
3	Watchdog_On	The watchdog is activated on the DP slave. The bit is set by the slave.
2	Status_From_Slave	Bit =1: The diagnostics comes from the DP slave. The bit is permanently set by the slave to 1.
1	Static_Diag	Static diagnostics If the DP slave sets this bit, the DP master must fetch the diagnostic data from the DP slave until the DP slave resets this bit. The DP slave sets this bit, for example, if it cannot perform data transfer.
0	Parameter_Request	The DP slave sets this bit when it has to be re-parameterized and configured. If bit 0 and bit 1 are both set, bit 0 has the higher priority.

Byte 2: Station status 3

Table 5- 5 Structure of station status byte 3

Bit no.	Name	Explanation
7	Ext_Data_Overflow	If this bit is set, there is more diagnostic information than is specified in the diagnostics data. This data cannot be viewed.
6...0	Reserved	- Reserved -

Byte 3: Master address

The address of the DP master that has configured this DP slave is entered in the "Master_Add" byte.

If the DP slave was not configured by a DP master, the DP slave sets address 255 in this byte.

Bytes 4 and 5: Manufacturer ID of the slave ("Ident_Number")

The manufacturer ID ("Ident_Number") for the DP slave type is entered in the bytes 4 and 5. This identifier can be used to identify the slave.

The most significant part of the value is in byte 5.

5.4 Device-specific diagnostics with DP-V1

Device-specific diagnostics

The device-specific diagnostics of DP V1 slaves is available in two variants:

- Interrupt type
- Status type

The two variants differ in the coding of byte 1, bit 7 of the device-specific diagnostic data. The distinction is component-specific.

Byte 0: Header

The two most significant bits have the value 00. This identifies the "Module-specific diagnostic data" block as a whole (see bytes 4...62).

The remaining six bits indicate the length of the data block including byte 0.

Byte 1: "Interrupt type" variant

Table 5- 6 Structure of byte 1 of the device-specific diagnostics ("Interrupt type" variant)

Bit no.	Meaning	
7	Value	Meaning
	0	**Interrupt**
6...0	**Alarm_Type**	
	0	- Reserved -
	1	Diagnostic interrupt
	2	Process interrupt
	3	Pull interrupt
	4	Plug interrupt
	5	Status interrupt
	6	Update interrupt
	7...31	- Reserved -
	32...126	Manufacturer-specific
	127	- Reserved -

Older status interrupts can be overwritten by newer ones when status interrupts occur in rapid succession.

Byte 1: "Status type" variant

Table 5- 7 Structure of byte 1 of the device-specific diagnostics ("Status type" variant)

Bit no.	Meaning	
7	Value	Meaning
	1	**Status message**
6...0	**Status_Type**	
	0	- Reserved -
	1	Status message
	2	Module_Status (see also bytes 4...62)
	3...31	- Reserved -
	32...126	Vendor-specific
	127	- Reserved -

Byte 2: Slot number

Slot number (1...n) of the slave module

0 is the placeholder for the overall device.

Byte 3: "Interrupt specifier" variant

Table 5- 8 Structure of byte 3 of the device-specific diagnostics ("Interrupt specifier" variant)

Bit no.	Meaning	
7...3	Seq_No	Unique identification of an alarm message
2	Add_Ack	If this bit is set, the DP V1 master indicates that this interrupt expects an acknowledgment in the form of a WRITE job.
1...0	Alarm_Specifier	
	0	No further distinction
	1	Interrupt appears, slot is disrupted The slot generates an interrupt due to an error.
	2	Interrupt disappears, slot is OK The slot generates an interrupt and indicates that there is no other error.
	3	Interrupt disappears, slot is still disrupted The slot generates an interrupt and indicates that errors remain.

Byte 3: "Status specifier" variant

Table 5- 9 Structure of byte 3 of the device-specific diagnostics ("Status specifier" variant)

Bit no.	Meaning	
7...2	- Reserved -	
1...0	Status_Specifier	
	0	No further distinction
	1	Status appears
	2	Status disappears
	3	- Reserved -

Bytes 4...62: Module-specific diagnostic data: General coding

This byte contains data with module-specific information that is described in the respective module documentation. The particular module is identified by the slot (byte 2).

Bytes 4...62: Module-specific diagnostics for "Status type" and "Modul_Status"

In the case of the "Status type" variant of device-specific diagnostics from DP V1 slaves (see byte 1, bit 7) and the "Module_Status" setting (see byte 1, bits 0...6) two status bits are provided here for each slot (= module). Unneeded bits are set to 0.

Table 5- 10 Structure of the bytes for the module-specific diagnostic data

Byte	Bit assignment							
Bit	7	6	5	4	3	2	1	0
4	Module status 4		Module status 3		Module status 2		Module status 1	
5	Module status 8		Module status 7		Module status 6		Module status 5	
...	...		...		...		...	
62	Module status 236		Module status 235		Module status 234		Module status 233	

The respective status bits are coded as follows:

Table 5- 11 Meaning of the values of the status bits

Value	Meaning
00	Data valid
01	Data invalid - error (e.g. short-circuit)
10	Data invalid - wrong module
11	Data invalid - no module plugged

Technical specifications

6

6.1 Technical specifications

Technical specifications of the CM DP (6ES7545-5DA00-0AB0) communication module

	6ES7545-5DA00-0AB0
Product type designation	ET 200SP, CM DP
General information	
Hardware version	FS01
HW functional status	FS01
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 Update 3
Installation type/mounting	
Rack mounting possible	No
Rail mounting possible	Yes; standard DIN rail
Supply voltage	
Type of supply voltage	24 VDC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Interfaces	
Number of interfaces PROFIBUS	1
1. interface	
Interface hardware	
• RS 485	Yes
Protocols	
• SIMATIC communication	Yes
• PROFIBUS DP master	Yes
• PROFIBUS DP slave	Yes
Interface hardware	
RS 485	
Transmission rate, max.	12 Mbps
Max. cable length	100 m

	6ES7545-5DA00-0AB0
Protocols	
PROFIBUS DP master	
Services	
• PG/OP communication	Yes
• S7 routing	Yes
• Data record routing	Yes
• Isochronous mode	No
• Constant bus cycle time	No
• Number of DP slaves	125
• Activation/deactivation of DP slaves	Yes
PROFIBUS DP slave	
Transmission rate, max.	12 Mbps
Automatic baud rate search	Yes
Address area, max.	120
User data per address area, max.	128 bytes
Services	
• PG/OP communication	Yes, only with active interface
• Routing	Yes, only with active interface
• S7 communication	Yes, only with active interface
• Direct data exchange (data exchange broadcast)	Yes, no subscriber possible - only passive publisher
• DPV1	Yes
Transfer memory	
• Inputs	244 bytes
• Outputs	244 bytes
Interrupts/diagnostics/status information	
Diagnostic alarms	
Diagnostics	Yes
Diagnostic indicator LED	
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Between backplane bus and interface	Yes
Ambient conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C

	6ES7545-5DA00-0AB0
Dimensions	
Width	35 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	80 g

Dimension drawing

A

A.1 Dimension drawing of the CM DP communication module

This section contains a dimension drawing of the module mounted on a mounting rail. Observe the dimensions when installing in cabinets, control rooms, etc.

Dimension drawing of the CM DP communication module

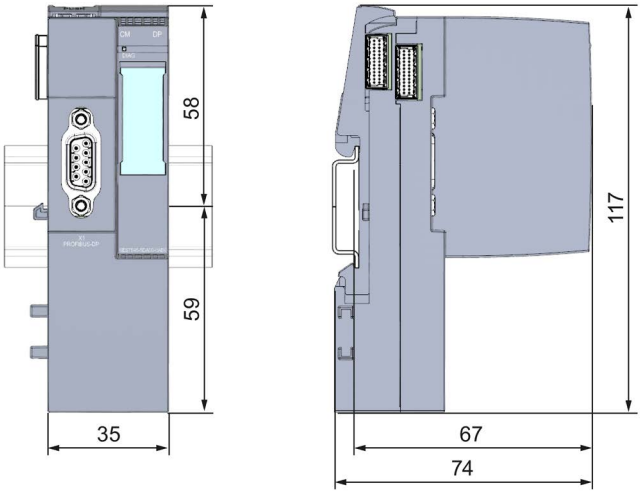


Figure A-1 Dimension drawing CM DP

SIEMENS

SIMATIC

ET 200SP
CM PtP communication module (6ES7137-6AA00-0BA0)

Manual

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Dimensional drawing A

01/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Preface

Purpose of the documentation

This documentation provides important information on installing, wiring and commissioning the ET 200SP point-to-point communications module.

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Conventions

This documentation contains figures of the described device. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contain important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Note on IT security

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You can register for a product-specific newsletter here.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-1500 and ET 200SP automation systems consists of system manuals, function manuals and manuals.

The STEP 7 information system (Online Help) also helps you configure and program your automation system.

Overview of the documentation provided for the CM PtP communication module (ET 200SP)

The following table lists additional references that you will need when using the CM PtP communication module.

Table 1- 1 Documentation for the CM PtP communication module

Topic	Documentation	Key content
System description	System Manual S7 -1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Addressing • Commissioning • Maintenance
	Device manual Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300)	• Connecting • Interrupt, error and system messages • Technical specifications • Dimensional drawing
	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
Point-to-point communication	Function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093)	• Basic information • Data transmission functions • Diagnostics functions

SIMATIC Manuals

All current manuals for the SIMATIC products are available for download free of charge on the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Order number

6ES7137-6AA00-0BA0

View of the module

Figure 2-1 View of CM PtP (without BaseUnit)

Properties

The communication module has the following properties:

- Technical properties
  - RS232 interface (via BaseUnit)
  - RS422/485 interface (via BaseUnit)
  - short-circuit proof
  - electrically disconnected
  - Protocols: 3964(R), Modbus master (RTU), Modbus slave (RTU), Freeport and USS with instructions
- Supported system functions
  - Firmware update
  - Identification data I&M0
  - Parameter re-assignment in CPU RUN mode (using instructions)
  - Diagnostic interrupts

Additional information

Additional information on the properties of the CM PtP can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

You can find additional information on the design of the ET 200SP and the associated modules in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

2.2 Accessories

ET 200SP accessories

Accessories and spare parts for ET 200SP can be found in the System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Online catalog

Additional order numbers for ET 200SP can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and online ordering system.

2.3 Functions

Introduction

The communication module allows you to exchange data between your own and other programmable controllers or computers by means of a point-to-point connection, and to connect various devices from a variety of manufacturers.

Functionality of the CM PtP

The CM PtP communication module offers the following functionality:

- RS232 and RS422/485 interface
- Data transmission rate: 300 to 115200 bps
- Maximum frame length: 2 kbyte
- Transmission protocols: Freeport, 3964(R) and Modbus

Note

The USS protocol can be implemented with instructions included in STEP 7 (TIA Portal).

Hardware components of a point-to-point connection

You require certain hardware components for a point-to-point connection with the CM PtP.

Components	Function
Automation system	... contains the CPU and PROFINET interface, and the central I/O, if applicable, and executes the user program.
ET 200SP Distributed I/O System	... contains the distributed I/O.
Interface module (IM)	... connects the distributed I/O system ET 200SP to PROFINET IO and supports all ET 200SP I/O modules.
CM PtP communication module	... communicates with a communication partner (point-to-point) by means of the interface.
BaseUnit (6ES7193-6BP00-0xA0)	... connects the communication module with the I/O system and the supply voltage.
Server module	... completes the setup of the ET 200SP

System environment

The communication module can be used in the following system environments:

Applications	Components required	Configuration
Distributed operation in an S7-1500 system	• CPU 151x • IM 155-6 • CM PtP • Power supply (optional)	STEP 7 (TIA Portal)
Distributed operation in an S7-300/400 system	• CPU 31x / CPU 41x • IM 155-6 • CM PtP • BaseUnit	STEP 7 (TIA Portal) STEP 7 with integration of a GSD file
Distributed operation in a third-party automation system	• Third-party automation system • IM 155-6 • CM PtP	GSD file imported to/installed in the engineering system [1]

[1] Information on using the communication module in a third-party system is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

Additional information

Information on configuration and programming of the CM PtP communications module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and in the information system of the TIA Portal.

2.4 Properties of the interfaces

Interfaces of the CM PtP

The CM PtP has the following interfaces, which are connected by means of the associated BaseUnit (see RS232 and RS422/485 interface of the communication module (Page 17) for assignment):

- RS232 interface
- RS422/485 interface

2.4.1 Properties of the RS232 interface

Definition - RS232 interface

The RS232 interface is a voltage interface used for serial data transmission.

Properties - RS232 interface

The RS232 interface has the following properties and meets the following requirements:

Type	Voltage interface
BaseUnit terminals	Terminals connected to the electronics module (see RS232 and RS422/485 interface of the communication module (Page 17) for assignment)
RS232 signals	TXD, RXD, RTS, CTS, DTR, DSR, RI, DCD, GND; all signals isolated against the backplane bus and load voltage
Max. data transmission rate	115.2 kbps
max. cable length	15 m, cable type LIYCY 9 x 0.14
Standard	DIN 66020, DIN 66259, EIA-RS 232C, CCITT V.24/V.28

RS232 signals

The table below shows the meaning of the individual RS232 accompanying signals.

Table 2- 1 Signals of the RS232 interface

Signal	Designation	Meaning
TXD	Transmit Data	Transmit data; transmit cable logically held to "1" by communication module in idle state.
RXD	Receive Data	Receive data; receive cable logically held to "1" by communication partner in idle state.
RTS	Request To Send	Request to send RTS set to "ON": Communication module ready to send; signals to the communication partner that there is data ready to send RTS set to "OFF": Communication module does not send
CTS	Clear To Send	Clear to send CTS set to "ON": Signals "clear to send" to the communication partner CTS set to "OFF": Signals "Not clear to send" to the communication partner
DTR	Data Terminal Ready	DTR set to "ON": Communications module switched on, ready for operation DTR set to "OFF": Communications module not switched on, not ready for operation
DSR	Data Set Ready	DSR set to "ON": Communication partner signals "ready for operation" DSR set to "OFF": Communication partner not switched on, not ready for operation
RI	Ring Indicator	Incoming call when connecting a modem
DCD	Data Carrier Detect	Carrier signal when connecting a modem. The communication partner signals with a high level that it detects incoming data on the cable.

2.4.2 Properties of the RS422/485 interface

Definition - RS422/485 interface

The RS422/485 (X27) interface is a differential voltage interface for serial data transmission.

Properties - RS422/485 interface

The RS422/485 (X27) interface has the following properties and meets the following requirements:

Type	Differential voltage interface
BaseUnit terminals	Terminals connected to the electronics module (see RS232 and RS422/485 interface of the communication module (Page 17) for assignment)
RS422 signals:	T (A), R (A), T (B), R (B), GND; all signals are isolated against the backplane bus and the load voltage
RS485 signals:	R/T (A), R/T (B), GND; all signals isolated against backplane bus and load voltage
Max. data transmission rate:	115.2 kbps
Max. cable length:	1200 m; cable type LIYCY 3 x 2 x 0.14. T(A)/T(B) and R(A)/R(B) twisted in pairs.
Standard:	DIN 66259 Parts 1 and 3, EIA-RS422/485, CCITT V.11

Connecting

3

3.1 RS232 and RS422/485 interface of the communication module

Pin assignment

Table 3- 1 RS232 connection

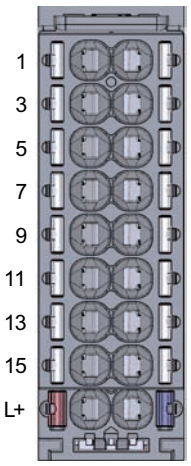
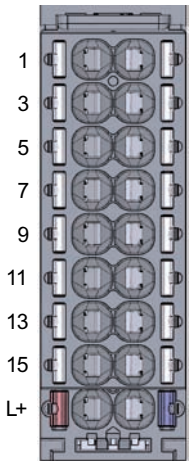
Terminal assignment of the communication module BaseUnit	Pin	Designation	Input/output	Meaning
	1	TXD Transmit Data	Output	Transmit data
	2	RXD Receive Data	Input	Receive data
	3	RTS Request To Send	Output	Request to send
	4	CTS Clear To Send	Input	Clear to send
	5	DTR Data Terminal Ready	Output	Data terminal ready
	6	DSR Data Set Ready	Input	Data set ready
	7	DCD Data Carrier Detect	Input	Received signal level
	8	RI Ring Indicator	Input	Incoming call
	9+10	PE Ground	-	GND functional ground (isolated)
Front view				

Table 3- 2 RS422/485 connection

Terminal assignment of the communication module BaseUnit	Pin	Designation	Input/output	Meaning
	11	T (A) -	Output	Send data (four-wire mode)
	12	R (A) - T(A)/R(A)	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	13	T (B) +	Output	Send data (four-wire mode)
	14	R (B) + T(B)/R(B)	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	15+16	PE Ground	-	GND functional ground (isolated)
Front view				

Note

Ensure the power supply is disconnected before you wire the communication module.

Additional information

Information on connecting the modules can be found in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Installation guidelines

To take into consideration

The general installation guidelines must be taken into consideration (see function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)).

The cable shield must be installed on a grounding rail to maintain the EMC values (electromagnetic compatibility).

Parameters/address space 4

4.1 Parameter assignment

Introduction

You configure and assign the parameters of the communication module with STEP 7 (TIA Portal V12 or later) or with STEP 7 with integration of a GSD file.

Additional information

The device manual of the communication module is supplemented by the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and the TIA Portal information system.

There you will find information on the following topics:

- Operating modes
- Receive buffer
- Data flow control
- Transmission integrity
- Data transmission - protocol specific
- Programming/configuring in STEP 7 (TIA Portal)
- Module-specific instructions
- Diagnostics

4.2 Reaction to CPU STOP

Ongoing transmissions are aborted when the higher-level control (CPU) goes to STOP.

Frames in the receive buffer are retained. With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

4.3 Address space

Address space of the communication module

The input addresses of the communications module total 8 bytes. The input addresses are automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal). Output addresses are not required.

Hardware identification (not freely configurable)

The hardware identification (HW ID) is automatically assigned for each communications module when you specify the device configuration in STEP 7 (TIA Portal).

The hardware ID is issued along with the diagnostic messages to localize the module. In addition, the HW identification is required for S7-1500 at the communication instructions in order to identify the communication module. For S7-300/400, the communication module is identified by the start address of the input data.

Programming

5

Overview of the instructions

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules. The instructions process the exchange of data between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place asynchronously across several cycles.

The transmission protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Instruction	Meaning
Port_Config	You use the Port_Config instruction to dynamically assign basic interface parameters.
Send_Config	You use the Send_Config (send configuration) instruction to dynamically assign serial send parameters of a protocol.
Receive_Config	You use the Receive_Config (receive configuration) instruction to dynamically assign serial receive parameters of a protocol.
P3964_Config	You use the P3964_Config (protocol configuration) instruction to dynamically assign the parameters of the 3964(R) procedure.
Send_P2P	You use the Send_P2P instruction to send data to a communication partner.
Receive_P2P	You use the Receive_P2P instruction to receive data from a communication partner.
Receive_Reset	You use the Receive_Reset instruction to delete the receive buffer of the communication module.
Signal_Get	You use the Signal_Get instruction to read the RS232 accompanying signals.
Signal_Set	You use the Signal_Set instruction to set the RS232 accompanying signals.
Get_Features	You use the Get_Features instruction to read expanded functions supported by the communication module.
Set_Features	You use the Set_Features instruction to set expanded functions supported by the communication module.
USS_Port_Scan	You use the USS_Port_Scan instruction to communicate using the USS.
USS_Drive_Control	You use the USS_Drive_Control instruction to exchange data with a drive.
USS_Read_Param	You use the USS_Read_Param instruction to read parameters from the drive.
USS_Write_Param	You use the USS_Write_Param instruction to change parameters in the drive.
Modbus_Comm_Load	The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU.

Instruction	Meaning
Modbus_Master	The instruction Modbus_Master allows you to communicate as Modbus master by means of the PtP port.
Modbus_Slave	The instruction Modbus_Slave allows you to communicate as Modbus slave by means of the PtP port.

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor.

Additional information

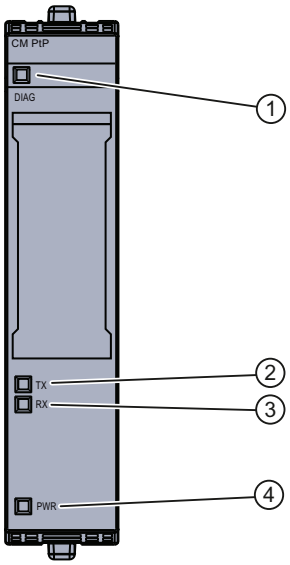
Additional information on programming the communication modules can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

Error and system messages

6

LED displays of the communication module

The figure below shows the LED displays of the CM PtP communication module.



① LED display DIAG
② LED display TX
③ LED display RX
④ LED display PWR

Figure 6-1 View of CM PtP (without BaseUnit)

Meaning of DIAG LED display

LED DIAG	Meaning	Solution
■ On	CM configured and ready for operation	---
☼ Flashes	CM in startup, parameters not assigned yet	---
☼ Flashes	Error information; diagnostic interrupt (break)	Evaluate the diagnostics data and eliminate the error. [1)]

1) Information on communication module startup and diagnostics is available in the CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) function manual

Meaning of the TXD/RXD LED displays

LED		Meaning	Solution
TX	RX		
☼ Flashes	□ Off	Interface is transmitting	---
□ Off	☼ Flashes	Interface is receiving	---

Meaning of PWR LED display

LED PWR	Meaning	Solution
■ On	Power ON (supply voltage present)	---
□ Off	Power OFF (supply voltage missing)	Check the voltage supply of the load group

Additional information

Information on communication module startup and diagnostics is available in the CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) function manual.

Technical specifications

7

Technical specifications of the CM PtP communication module

	6ES7137-6AA00-0BA0
Product type designation	ET 200SP CM PtP
General information	
• I&M data	Yes: I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V12.0 / V12.0
STEP 7 can be configured/integrated as of version	V5.5 SP2 or higher with a GSD file
PROFIBUS as of GSD version/GSD revision	- / -
PROFINET as of GSD version/GSD revision	V2.3
Installation type/mounting	
• Rail mounting possible	Yes; standard - DIN rail
Supply voltage	
Voltage type of supply voltage	24 V DC
• Rated value (DC)	24 V
• Low limit of valid range (DC)	19.2 V
• High limit of valid range (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
• Current consumption (rated value)	29 mA
Power loss	
• Power loss, typ.	0.7 W
Address area	
Occupied address area	
• Inputs	8 bytes

	6ES7137-6AA00-0BA0
Interfaces	
1. Interface	
Interface hardware	
• RS 232	Yes
• RS 422	Yes
• RS 485	Yes
Interface hardware	
RS 232	
• Transmission rate, max.	115.2 kbps
• Max. cable length	15 m
RS-232 accompanying signals	RTS, CTS, DTR, DSR, RI, DCD
RS 485	
• Transmission rate, max.	115.2 kbps
• Max. cable length	1200 m
RS 422	
• Transmission rate, max.	115.2 kbps
• Max. cable length	1200 m
• 4-wire full duplex connection	Yes
• 4-wire multipoint connection	Yes
Protocols	
Integrated protocols	
Freeport	
• Frame length, max.	2 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
3964 (R)	
• Frame length, max.	2 kbyte
• Bits per character	7 or 8
• Number of stop bits	1 or 2 bits
• Parity	None, even, odd, always 1, always 0, any
Modbus RTU master	
Address area	1 to 247, extended 1 to 65,535
• Max. number of slaves	32

	6ES7137-6AA00-0BA0
Modbus RTU slave	
Address area	1 to 247, extended 1 to 65,535
Frame buffer	
• Buffer memory for frames	4 kbyte
• Number of frames which can be buffered	255
Interrupts/diagnostics/status information	
Interrupts	
• Diagnostic interrupt	Yes
• Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes
• Wire break	Yes
Diagnostics display LED	
• Monitoring of supply voltage	Yes; green PWR-LED
• For module diagnostics	Yes; green/red DIAG-LED
• Receive RxD	Yes; green LED
• Send TxD	Yes; green LED
Electrical isolation	
• between backplane bus and interface	Yes
Permitted potential difference	
Between the different circuits	75 V DC / 60 V AC (Basic insulation)
Insulation	
Insulation tested with	707 V DC (Type Test)
Ambient conditions	
Operating temperature	
• Horizontal installation, min.	0 °C
• Horizontal installation, max.	60 °C
• Vertical installation, min.	0 °C
• Vertical installation, max.	50 °C
Distributed operation	
• At SIMATIC S7-300	Yes
• At SIMATIC S7-400	Yes
• At SIMATIC S7-1200	No
• At SIMATIC S7-1500	Yes
• At Standard Profinet Controller	Yes

	6ES7137-6AA00-0BA0
Dimensions	
• Width	15 mm
• Height	73 mm
• Depth	58 mm
Weights	
• Weight, approx.	30 g

Additional general technical specifications for SIMATIC ET 200SP can be found in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Dimensional drawing

A

In this appendix, you will find the dimensional drawing of the communication module, inserted into a BaseUnit and mounted on a DIN rail. You have to consider the dimensions during installation in control cabinets, control rooms, etc (BaseUnit: 6ES7193-6BP00-0xA0).

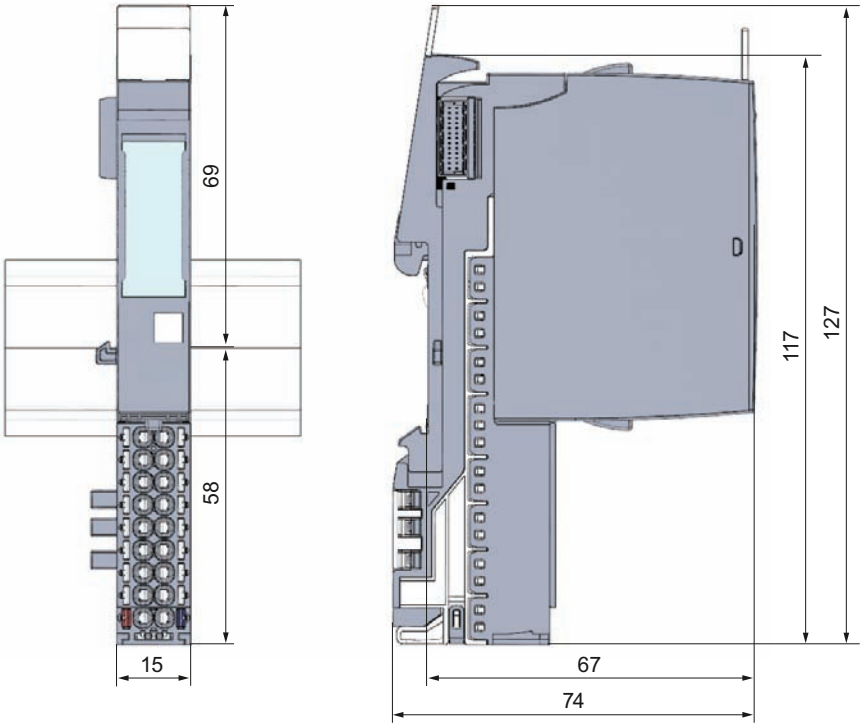


Figure A-1 Dimensional drawing of the CM PtP communication module

SIEMENS

SIMATIC NET

ET 200SP - Industrial Ethernet CP 1542SP-1, CP 1542SP-1 IRC, CP 1543SP-1

Operating Instructions

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C79000-G8976-C426-01

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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C79000-G8976-C426-01
℗ 08/2016 Subject to change

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Preface

Validity of this manual

This document contains information on the following modules:

- **CP 1542SP-1**
  Article number **6GK7542-6UX00-0XE0**
  Hardware version 1
  Firmware version V1.0
  Communications processor for connecting a SIMATIC ET 200SP CPU to Industrial Ethernet
- **CP 1542SP-1 IRC**
  Article number **6GK7542-6VX00-0XE0**
  Hardware version 1
  Firmware version V1.0
  Communications processor for connecting a SIMATIC ET 200SP CPU via Industrial Ethernet to a control room (TCSB, DNP3, IEC 60870-5-104)
- **CP 1543SP-1**
  Article number **6GK7543-6WX00-0XE0**
  Hardware version 1
  Firmware version V1.0
  Communications processor for connecting a SIMATIC ET 200SP CPU to Industrial Ethernet, Security

Figure 1 CP 1542SP-1 with plugged in bus adapter (here 2xRJ-45)

On the front of the module at the right edge, the hardware version is printed as a placeholder "X". If the printed text is, for example, "X 2 3 4", "X" would be the placeholder for hardware product version 1.

Directly below, you will find the firmware version of the CP as it shipped.

The MAC address is printed on the front at the bottom left, above the connectors for the power supply.

Product names, terms and abbreviations/acronyms

Below you will find terms and abbreviations/acronyms used often in this manual.

- **CP**

  When the property being described is valid in the current context for all three CP types or if the CP type being used is clear from the context, the abbreviation "CP" will be used instead of the three following product designations

  – CP 1542SP-1

  – CP 1542SP-1 IRC

  – CP 1543SP-1

  If information applies only to a certain product variant. the full module name is specified.

- **TCSB**

  Control center software "TeleControl Server Basic"

- **Telecontrol server**

  PC with installed software "TeleControl Server Basic"

Purpose of the manual

This manual describes the properties of this module and supports you when installing and commissioning it.

The required configuration steps are described as an overview and there are explanations of the relationship between firmware functions and configuration.

You will also find information about the diagnostics options of the device.

Required experience

To install, commission and operate the CP, you require experience in the following areas:

- Automation engineering
- Setting up the SIMATIC ET 200SP
- SIMATIC STEP 7 Professional

Cross references

In this manual there are often cross references to other sections.

To be able to return to the initial page after jumping to a cross reference, some PDF readers support the command <Alt>+<Left arrow>.

Current manual release on the Internet

You will also find the current version of this manual on the Internet pages of Siemens Industry Online Support under at the following addresses:

- CP 1542SP-1 / CP 1543SP-1
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/man)
- CP 1542SP-1 IRC
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man)

Sources of information and other documentation

You will find an overview of further reading and references in the Appendix of this manual.

License conditions

Note

Open source software

Read the license conditions for open source software carefully before using the product.

You will find license conditions in the following document on the supplied data medium:

- DOC_OSS-CP154xSP_74.pdf

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit
Link: (http://www.siemens.com/industrialsecurity)

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
Link: (http://www.siemens.com/industrialsecurity).

Firmware

The firmware is signed and encrypted. This ensures that only firmware created by Siemens can be downloaded to the device.

SIMATIC NET glossary

Explanations of many of the specialist terms used in this documentation can be found in the SIMATIC NET glossary.

You will find the SIMATIC NET glossary here:

- SIMATIC NET Manual Collection or product DVD

  The DVD ships with certain SIMATIC NET products.

- On the Internet under the following address:

  Link: (https://support.industry.siemens.com/cs/ww/en/view/50305045)

Training, Service & Support

You will find information on training, service and support in the multilanguage document "DC_support_99.pdf" on the Internet pages of Siemens Industry Online Support:

Link: (https://support.industry.siemens.com/cs/ww/en/view/38652101)

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Application and functions

1

1.1 Components of the product

The following components are supplied with the product:

- CP 154xSP-1
- Plug for the socket of the power supply (24VDC) of the CP
- DVD with documentation and license texts

A BusAdapter for the Ethernet connection of the CP does not ship with the product.

1.2 Application

Application of the CP variants

The CP is used to connect the ET 200SP to Industrial Ethernet via a copper cable or fiber-optic cable. It can be used as an additional Ethernet interface of the CPU for S7 communication.

For the Ethernet connection, the CP requires a bus adapter that does not ship with the product.

The three CP variants are intended for the following communication tasks:

- **CP 1542SP-1**

  The CP 1542SP-1 allows the ET 200SP a further Ethernet connection.

- **CP 1542SP-1 IRC**

  The CP 1542SP-1 IRC supports telecontrol communication for connecting the ET 200SP CPU to a control center. The following telecontrol protocols can be used as alternatives:

  – TeleControl Basic

    For connection of the ET 200SP to a master station with telecontrol server (TCSB V3 SP3)

  – DNP3

    For connection of the ET 200SP to a master station with DNP3 masters

  – IEC 60870-5-104

    For connection of the ET 200SP to a master station with IEC masters

- **CP 1543SP-1**

  The CP 1543SP-1 has Security functions for network security, such as a firewall and VPN. This makes protected access to the ET 200SP possible.

1.3 Communications services

Communications services

The following communications services are supported:

- **S7 communication and PG/OP communication with the following functions:**
  - PUT/GET as client and server for data exchange with S7 stations
  - PG functions
  - Operator control and monitoring functions (HMI)

  For S7 communication, the CP requires a fixed IP address.
- **S7 routing**
  - Routing of S7 connections via the backplane bus and the CPU to other S7 stations
- **Open User Communication (OUC)**

  OUC via program blocks with the following protocols:
  - TCP/IP
  - ISO-on-TCP
  - UDP

  The CP 1543SP-1 supports Secure OUC.

  You will find the program blocks supported by the three CP types in the section Programming (OUC) (Page 93).
- **E-mail using program blocks**
- **HTTP / HTTPS**

  Via HTTP / HTTPS you can access the Web server of the CPU.

For telecontrol communication of the CP 1542SP-1 IRC, see section Telecontrol communication of the CP 1542SP-1 IRC (Page 13).

For information on the Security functions of the CP 1543SP-1, refer to the section Security functions (CP 1542SP-1 IRC, CP 1543SP-1) (Page 15).

1.4 Telecontrol communication of the CP 1542SP-1 IRC

Telecontrol protocols

In addition to the communications services named above, the CP 1542SP-1 IRC supports the following telecontrol protocols for communication with a master station:

- **TeleControl Basic**

  This is a proprietary protocol of Siemens for telecontrol applications. The IP-based protocol is used to connect the CP to the application TCSB.

  TCSB is installed on a PC in the master station, the telecontrol server. Via the OPC-DA or OPC-UA server of TCSB, an OPC client can access the process data of the CP.

  TCSb is supported as of the following version: V3.0 + SP3

  For the TCSB manual, see /3/ (Page 118).

- **DNP3**

  The CP functions as a DNP3 station (Outstation).

  Communication is based on the DNP3 SPECIFICATION Version 2.11 (2007/2009).

  You will find a detailed overview of the attributes and properties specified in the DNP3 protocol and supported by the CP in the DNP3 device profile, see Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man).

  You will find the supported object groups and variations in the section Datapoint types (Page 58).

  Communications partner (DNP3) can be:

  – SIMATIC PCS7 TeleControl
  – SIMATIC WinCC TeleControl
  – SIMATIC WinCC OA
  – A TIM module with DNP3 capability (TIM 3V IE DNP3 / TIM 4R IE DNP3)

    For the manual of the TIM module see /5/ (Page 118).
  – Third-party systems that support the DNP3 specification named above.

- **IEC 60870-5-104**

  The CP functions as a substation (slave).

  Communication is based on the specification IEC 60870-5 Part 104 (2006).

  You will find a detailed overview of the attributes and properties specified in the IEC specification and supported by the CP in the IEC device profile, see Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man).

  You will find the supported IEC type identifiers as in the section Datapoint types (Page 58).

  Communications partner (IEC master) can be:

  – SIMATIC PCS7 TeleControl
  – SIMATIC WinCC TeleControl

- SIMATIC WinCC OA
- Third-party systems that support the DNP3 specification named above.

Properties of the telecontrol CP

- **Data point configuration**

  The process values are configured as data points for the communication. The data points access PLC tags in the CPU. The data points can be processed one-to-one in the control system.

- **Messages / e-mail**

  With configurable events in the process image of the CPU, the CP 1542SP-1 IRC can send messages as e-mails. The data sent by e-mail is configured using PLC tags.

- **Storage of events**

  The CP 1542SP-1 IRC can store events of different classes and transfer them together to the communications partner.

- **Analog value processing**

  Analog values can be preprocessed on the CP 1542SP-1 IRC according to various methods.

1.5 Other services and properties

Further services and properties of the CP

- **IP configuration**
  - Address types

    The CP supports IP addresses according to IPv4 and IPv6.
  - Addressing

    The IP address, the subnet mask and the address of a gateway can be set manually in the configuration. As an alternative, the IP address can be obtained using program blocks.
  - DHCP: As an alternative, the IP address can be obtained from a DHCP server.
  - DCP (Discovery and Configuration Protocol) is supported.
- **Time-of-day synchronization**
  - NTP

    On the Ethernet interface, the CP can synchronize its time of day via NTP.

– Only CP 1542SP-1 IRC

When telecontrol communication is enabled, the CP always obtains its local time of day as UTC time from the communications partner. The time of day of the CP can be read by the CPU using a PLC tag. For information on the format of the time stamp of the data frames, refer to the section Datapoint types (Page 58).

if telecontrol communication is disabled, the CP can synchronize its time of day via NTP.

– Only CP 1543SP-1

If the Security functions are enabled, the secure method NTP (secure) can be used.

For more information, refer to the section Time-of-day synchronization (Page 41).

- **SNMP**

  As SNMP agent, the CP supports queries via SNMPv1.

  The CP 1543SP-1 also supports SNMPv3.

  For more detailed information, refer to section SNMP (Page 43).

1.6 Security functions (CP 1542SP-1 IRC, CP 1543SP-1)

The Security functions described below are enabled in the configuration for the relevant CP.

For information on the Securityfunctions of Open User Communication, refer to the section Programming (OUC) (Page 93).

Note

Recommendation for critical security plants

Refer to the information in the section Security recommendations (Page 37).

Security functions of the CP 1542SP-1 IRC

- **E-mail**

  For secure transfer of information with encrypted e-mails you have the alternative of using:

  – SSL/TLS

  – STARTTLS

  For information on the configuration, refer to the section Security > E-mail configuration (Page 84).

- **Certificates**

  For the secure authentication of the communications partners, certificates are used.

- **Secure telecontrol communication**

  The telecontrol protocols provide the following Security functions:

  – TeleControl Basic

    As an integrated security function, the telecontrol protocol encrypts the data for transfer between the CP and telecontrol server. The interval for the key exchange between CP and telecontrol server is set to 1 hour.

    The telecontrol password is used to authenticate the CP with the telecontrol server

  – DNP3

    The CP supports the Security mechanisms listed in the specification.

Security functions of the CP 1543SP-1

With Industrial Ethernet Security, individual devices, automation cells or network segments of an Ethernet network can be protected. The data transfer via the CP 1543SP-1 can be protected from the following attacks by a combination of different security measures:

- Data espionage
- Data manipulation
- Unauthorized access

Secure underlying networks can be operated via additional Ethernet/PROFINET interfaces of the CPU.

As a result of using the CP, as a security module, the following security functions are accessible to the ET 200SP station on the interface to the Ethernet network:

- **Firewall**

  The firewall protects the device with:

  – IP firewall with stateful packet inspection (layer 3 and 4)

  – Firewall also for "non-IP" Ethernet frames according to IEEE 802.3 (layer 2)

  – Limitation of the transmission speed ("Bandwidth limitation")

- **Certificates**

  For the secure authentication of the communications partners, certificates are used.

- **Communication made secure by IPsec tunnels (VPN)**

  VPN tunnel communication allows the establishment of secure IPsec tunnels for communication with one or more security modules. The CP can be put together with other modules to form VPN groups during configuration. IPsec tunnels (VPN) are created between all security modules of a VPN group.

- **Logging**

  To allow monitoring, events can be stored in log files that can be read out using the configuration tool or can be sent automatically to a Syslog server.

- **NTP (secure)**

  For secure transfer during time-of-day synchronization

- **SNMPv3**

  For secure transmission of network analysis information safe from eavesdropping

For information on configuring the security functions, refer to the section Security configuration(CP 1543SP-1) (Page 84).

You will find further information on the functionality and configuration of the security functions in the information system of STEP 7 and in the manual /4/ (Page 118).

1.7 Configuration limits and performance data

Number of CPs per station

In each ET 200SP station, up to three special modules can be plugged in and configured; this allows a maximum of two CP 154xSP-1 modules.

For details of the permitted special modules and the slot rules, refer to section Installing the CP (Page 32).

Connection resources

Number of connections via Industrial Ethernet in total maximum of 32,
of which:

- S7: Max. 16
- TCP/IP: Max. 32
- ISO-on-TCP: Max. 32
- UDP: Max. 32

Also:

- Online connections of the engineering station (STEP 7): Max. 2
- TCP connections for HTTP

  For HTTP access upp to 12 TCP connection resources are available that are used by one or more Web browsers to display data of the CP.
- PG/OP connections (HMI): In total maximum of 16,
  of which:
  - Connection resources for PG connections: Max. 16
  - Connection resources for OP connections: Max. 16

Frame memory (send buffer)

Only CP 1542SP-1 IRC

The CP has a frame memory (send buffer) for the values of data points configured as an event.

The volume of the send buffer is divided equally among all configured communications partners.

The size of the send buffer can be configured in STEP 7, refer to the section Communication with the CPU (Page 55).

The maximum size of the send buffer depends on the telecontrol protocol being used and is as follows:

- TeleControl Basic

  64000 events

- DNP3

  100000 events

- IEC 60870-5-104

  100000 events

You will find details of how the send buffer works such as storing events as well as the options for transferring the data in the section Process image, types of transmission, event classes, triggers (Page 62).

E-mail (via message editor)

Only CP 1542SP-1 IRC

With telecontrol communication enabled, up to 10 messages can be configured in STEP 7. The messages are sent as e-mails.

Telecontrol connections and data points

Only CP 1542SP-1 IRC

- **Telecontrol connections**
  - TeleControl Basic

    A connection can be established to a single or redundant telecontrol server.
  - DNP3

    Connections to up to four masters can be established.
  - IEC 60870-5-104

    Connections to up to four masters can be established.
- **Data points**

  The data to be transferred by the CP is assigned to various data points in the STEP 7 configuration. The size of the user data per data point depends on the data type of the relevant data point. You will find details in the section Datapoint types (Page 58).

  The maximum number of configurable data points is 500.

  In the allocation of the internal CP memory for data points, the length of the data point name is also included. See also the note in section Configuring the data points (Page 56).

Security functions

Only CP 1543SP-1

- **VPN tunnel**

  A maximum of four VPN tunnels can be established for secure communication with other Security modules.

- **Firewall rules**

  The maximum number of firewall rules in advanced firewall mode is limited to 256. The firewall rules are divided up as follows:

  – Maximum 226 rules with individual addresses

  – Maximum 30 rules with address ranges or network addresses (e.g. 140.90.120.1 - 140.90.120.20 or 140.90.120.0/16)

  – Maximum 128 rules with limitation of the transmission speed ("Bandwidth limitation")

1.8 Requirements for use

1.8.1 Hardware requirements

Bus adapter

To connect to the Ethernet network, the CP requires a BusAdapter. A BusAdapter does not ship with the CP.

The CP supports the following BusAdapter:

- BA 2xRJ45
- BA 2xFC
- BA 2xSCRJ
- BA SCRJ/RJ45
- BA SCRJ/FC
- BA 2xLC
- BA LC/RJ45
- BA LC/FC

For more detailed information on the bus adapters, refer to the section BusAdapter (Page 115) and the manual /2/ (Page 117).

CPUs and other components of the ET 200SP

The CP supports operation in stations that contain one of the following CPUs:

- CPU 1510SP-1 PN

  Article number: 6ES7510-1DJ01-0AB0
- CPU 1510SP F-1 PN

  Article number: 6ES7510-1SJ01-0AB0
- CPU 1512SP-1 PN

  Article number: 6ES7512-1DK01-0AB0
- CPU 1512SP F-1 PN

  Article number: 6ES7512-1SK01-0AB0

Further parts and modules that are also required to set up the ET 200SP station, such as rails, I/O modules or cabling are not listed here. See also /2/ (Page 117) for information on this.

Components of the communications partner

Components required by the communications partners of the CP 1542SP-1 IRC are not listed here. You will find references to other products (e.g. TCSB) in the list of references in the appendix of the manual.

1.8.2 Software requirements

Configuration software

To configure the CP, the following configuration tool is required:

- STEP 7 Professional as of version 14.

Software for online functions

To use the online functions, the following software is required:

- STEP 7 in the version specified above

CPU firmware

To use the CP, a CPU 151xSP with a firmware version ≥ V2.0 is required.

Telecontrol protocols (CP 1542SP-1 IRC)

You will find telecontrol protocols supported by the CP in the section Telecontrol communication of the CP 1542SP-1 IRC (Page 13).

1.9 Configuration examples

Below you will find configuration examples for the use of the three CP variants.

CP 1542SP-1 - Network separation

The CP is used in the ET 200SP to operate lower-level networks separately or to achieve separation from the higher-level network.

The ET 200SP can be expanded flexibly with further Ethernet interfaces via the CP. The network separation allows the setting up of identical machines with the same IP address. The CP takes over the communication and relieves the CPU.

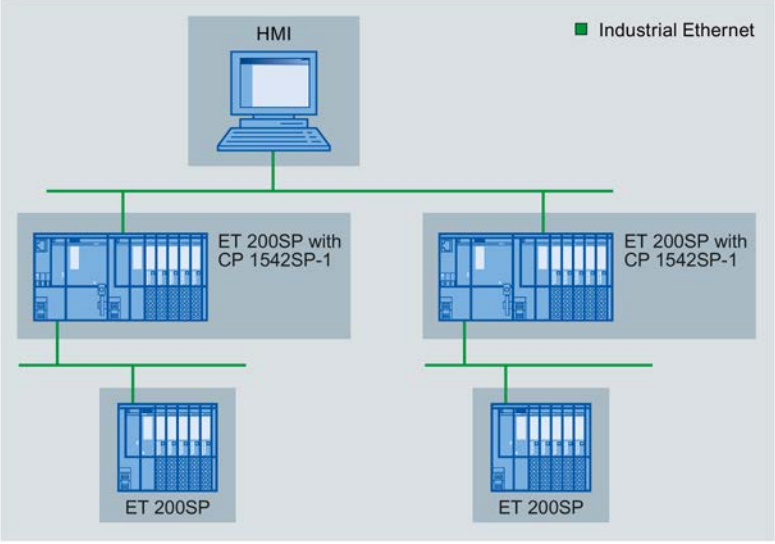


Figure 1-1 Configuration example of an ET 200SP with CP 1542SP-1

CP 1543SP-1 - Cell protection with Security functions

The CP communicates encrypted with communications partners in the connected network. The firewall monitors the access to the ET 200SP and therefore protects lower-level networks. This avoids data loss, disruptions of production and damage to machines.

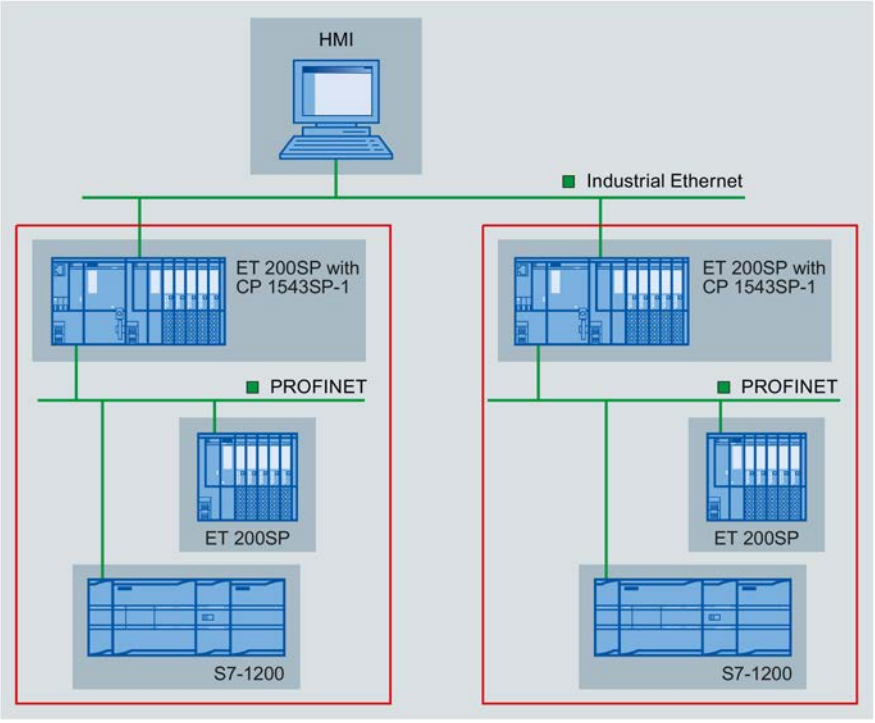


Figure 1-2 Configuration example of an ET 200SP with CP 1543SP-1

CP 1542SP-1 IRC - Connection to control centers

By using the CP the ET 200SP can be used as a remote terminal unit. For the communication, the following telecontrol protocols can be used:

- TeleControl Basic

  The Siemens telecontrol protocol for connection to master stations with TCSB
- IEC 60870-5-104
- DNP3

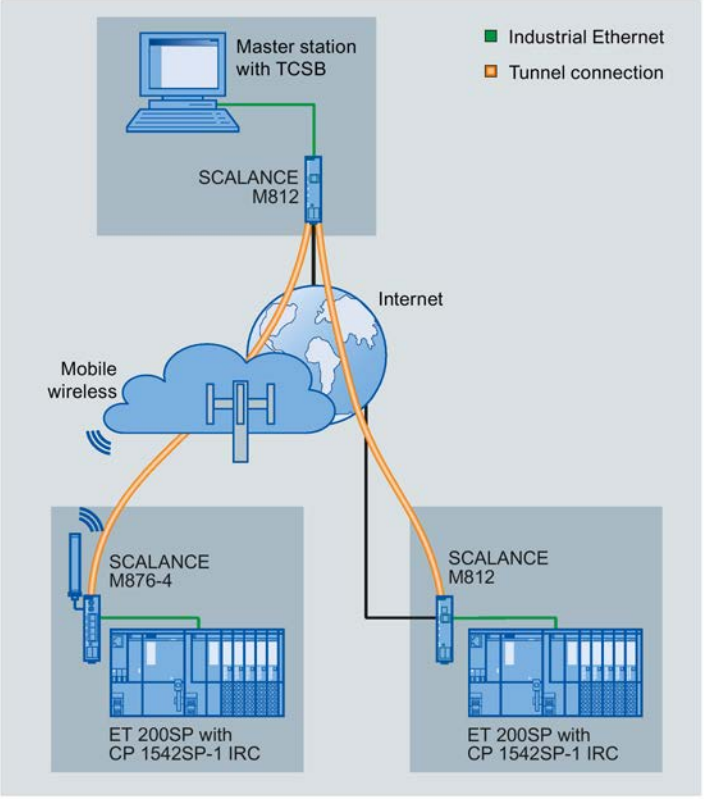


Figure 1-3 Configuration example of an ET 200SP with CP 1542SP-1 IRC; protocol: TeleControl Basic

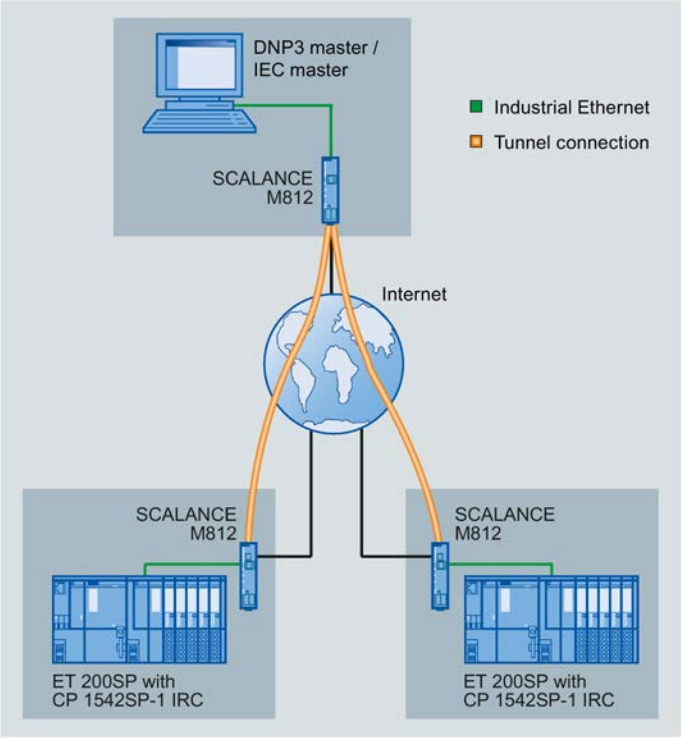


Figure 1-4 Configuration example of an ET 200SP with CP 1542SP-1 IRC; protocol: DNP3 or IEC 60870-5-104

LEDs and connectors

2

2.1 LEDs

Meaning of the LED displays of the CP

The CP has the following light emitting diodes (LEDs) on the front:

LED name	Meaning
PWR	Power supply
RN	Operating mode
ER	Error
MT	Maintenance

Table 2- 1 Legend for the following tables

Symbol				-
Meaning / LED status	ON (LED lit)	OFF	LED flashes	Any

Table 2- 2 Meaning of the LED displays of the CP

PWR (green)	RN (green)	ER (red)	MT (yellow)	Meaning
				No supply voltage on the CP or supply voltage too low
				CP startup
				CP in RUN mode
	-			Error. LED display with the following events: • Duplicate IP address • Bus adapter not plugged in or pulled • No telecontrol connection (CP 1542SP-1 IRC)
				Error: CP defective
				Missing configuration data
				Firmware update running
				There is a maintenance request from the CP. Example: • End of the firmware update

LEDs of the bus adapter

Every port of a bus adapter has an LED "LKx" that informs about the connection status with Ethernet and the frame traffic of the port.

Table 2- 3 Meaning of the LED displays of the bus adapters

LK (green)	Meaning
○	No Ethernet connection. Possible causes: • No physical connection to the network • Port disabled in the configuration
☼	LED flashing test
●	There is an Ethernet connection between the port and communications partner.

2.2 Power supply

External power supply required

The connector for the external 24 VDC power supply is located on the front of the CP.

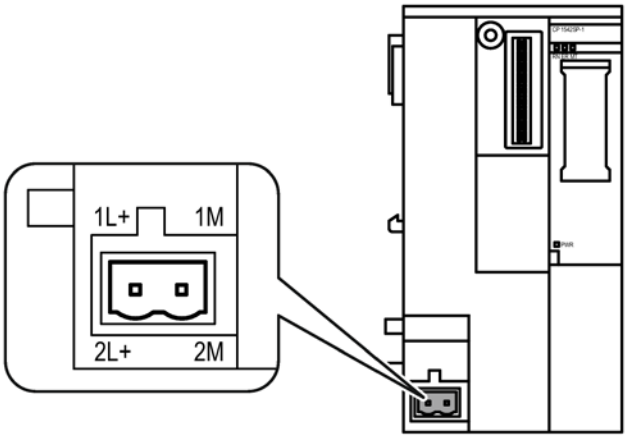


Figure 2-1 Power supply of the CP

Connector X80 is intended for connection to a single or redundant power supply. The power supply is connected to the CP with the supplied plug-in terminal block. The terminal block is plugged in to the socket X80 of the CP.

For information on installing and connecting up, refer to the sections Installing the CP (Page 32) and Connecting the CP (Page 36).

Reverse polarity protection

The plug-in terminal block for connector X80 is designed so that it can only be plugged in in one position. This provides constructional reverse polarity protection.

The connector X80 also has electronic reverse polarity protection.

You will find further data on the power supply in section Technical specifications (Page 107).

2.3 Connector for the BusAdapter

Operation of the device only with BusAdapter

For connecting to Ethernet the CP requires a BusAdapter. A BusAdapter does not ship with the CP.

The slot is on the front of the device:

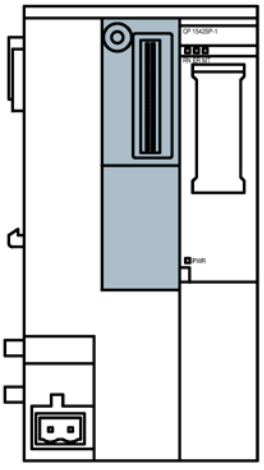


Figure 2-2 Front of the CP, the slot for the bus adapter is marked gray.

You will find the bus adapters supported by the CP in section BusAdapter (Page 115).

For information on installing and connecting up, refer to the sections Installing the CP (Page 32) and Connecting the CP (Page 36).

You will find the pinout of the Ethernet interface in section Assignment of the Ethernet interface of the bus adapter (Page 116). You will find further technical specifications of the bus adapter in the manual /2/ (Page 117).

Installation and connecting up

3

3.1 Important notes on using the device

Safety notices on the use of the device

Note the following safety notices when setting up and operating the device and during all associated work such as installation, connecting up or replacing the device.

Overvoltage protection

NOTICE
Protection of the external power supply If power is supplied to the module or station over longer power cables or networks, the coupling in of strong electromagnetic pulses onto the power supply cables is possible. This can be caused, for example by lightning strikes or switching of higher loads. The connector of the external power supply is not protected from strong electromagnetic pulses. To protect it, an external overvoltage protection module is necessary. The requirements of EN61000-4-5, surge immunity tests on power supply lines, are met only when a suitable protective element is used. A suitable device is, for example, the Dehn Blitzductor BVT AVD 24, article number 918 422 or a comparable protective element. Manufacturer: DEHN+SOEHNE GmbH+Co.KG Hans Dehn Str.1 Postfach 1640 D-92306 Neumarkt, Germany

3.1.1 Notes on use in hazardous areas

⚠ WARNING
EXPLOSION HAZARD DO NOT OPEN WHEN ENERGIZED.

⚠ WARNING
The device may only be operated in an environment with pollution degree 1 or 2 (see IEC 60664-1).

WARNING

The equipment is designed for operation with Safety Extra-Low Voltage (SELV) by a Limited Power Source (LPS).

This means that only SELV / LPS complying with IEC 60950-1 / EN 60950-1 / VDE 0805-1 must be connected to the power supply terminals. The power supply unit for the equipment power supply must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

WARNING

EXPLOSION HAZARD

Do not connect or disconnect cables to or from the device when a flammable or combustible atmosphere is present.

WARNING

EXPLOSION HAZARD

Replacing components may impair suitability for Class 1, Division 2 or Zone 2.

WARNING

When used in hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or a suitable enclosure.

WARNING

DIN rail

In the ATEX and IECEx area of application only the Siemens DIN rail 6ES5 710-8MA11 may be used to mount the modules.

3.1.2 Notes on use in hazardous areas according to ATEX / IECEx

WARNING

Requirements for the cabinet/enclosure

To comply with EU Directive 94/9 (ATEX95), the enclosure or cabinet must meet the requirements of at least IP54 in compliance with EN 60529.

WARNING

If the cable or conduit entry point exceeds 70 °C or the branching point of conductors exceeds 80 °C, special precautions must be taken. If the equipment is operated in an air ambient in excess of 50 °C, only use cables with admitted maximum operating temperature of at least 80 °C.

WARNING

Take measures to prevent transient voltage surges of more than 40% of the rated voltage. This is the case if you only operate devices with SELV (safety extra-low voltage).

3.1.3 Notes on use in hazardous areas according to UL HazLoc

WARNING

EXPLOSION HAZARD

DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS.

This equipment is suitable for use in Class I, Division 2, Groups A, B, C and D or non-hazardous locations only.

This equipment is suitable for use in Class I, Zone 2, Group IIC or non-hazardous locations only.

3.2 Installing the CP

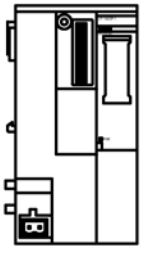
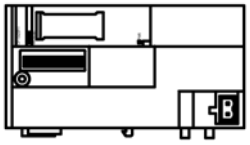
NOTICE
Install and remove the CP only when the power is off Switch off the power supply of the ET 200SP and the CP before you install or remove modules. Installing and removing modules with the power supply on can lead to damage to the modules and to loss of data.

Note

Note the installation guidelines

When installing and connecting up the CP note the instructions in the manual /2/ (Page 117).

NOTICE
Installation location - Dependency of the temperature range The module must be installed so that its upper and lower ventilation slits are not covered, allowing adequate ventilation. Above and below the modules, there must be a clearance of 25 mm to allow air to circulate and prevent overheating. Note the dependency of the permitted temperature range of the installation location. • Horizontal installation of the rack (DIN rail) means vertical position of the CP. • Vertical installation of the rack (DIN rail) means horizontal position of the CP. You will find the permitted temperature ranges in the section Technical specifications (Page 107).

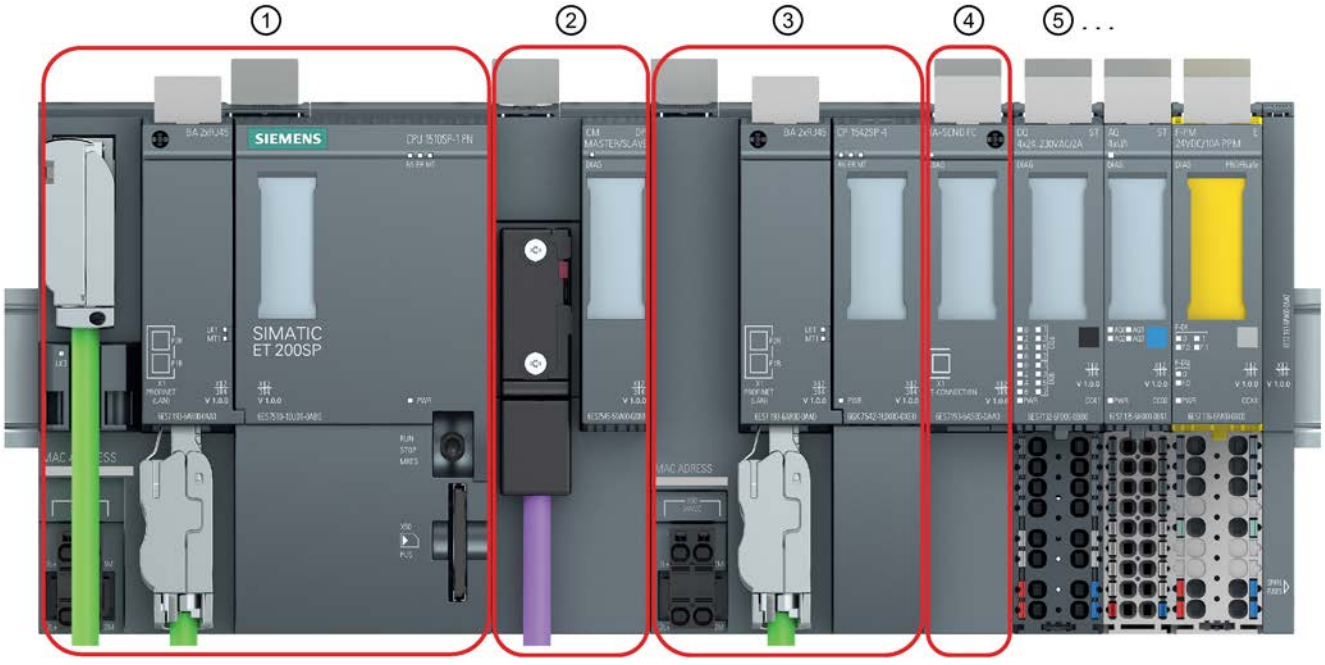
Installation of the rack	Installation position of the CP
Horizontal installation of the rack	
Vertical installation of the rack	

Slot rules

The CPU always occupies slot 1. In an ET 200SP you can plug in up to three of the following modules in slots 1 ... 4 (see figure) to the right of the CPU:

- CMs
- CPs
- BusAdapter Send

Of these three modules, up to two CP 154xSP-1 modules can be plugged in. These two CPs can be of the same type or different.



① Slot 1 - only permitted for the CPU.

② Slot 2 - for CM / CP / BusAdapter Send *
If you use a PROFIBUS CM, you must plug this in directly beside the CPU in slot 1.

③ Slot 3 - for CM / CP / BusAdapter Send *

④ Slot 4 - for CM / CP / BusAdapter Send *

⑤ Slot 5 ff for IO modules

* If you use a BusAdapter Send, this must be plugged in to the slot directly beside the IO modules.

Figure 3-1 Slots of the ET 200SP

Installation on a DIN rail

Note

Protecting the modules from slipping on the DIN rail

If you install the modules in an area with mechanical load, use suitable clamping devices at both ends of the device group to secure the modules on the DIN rail, e.g. Siemens and retainer 8WA1808.

The end retainers prevent the modules separating under mechanical load.

When using the device in the areas of application ATEX or IECEx, note the information on the DIN rai in section Notes on use in hazardous areas (Page 29).

The ET 200SP system is suitable for installation on a mounting rail according to EN 60715 (35 × 7.5 mm or 35 × 15 mm)

1. Hang the CPU / the interface module on the mounting rail.
2. Tilt the CPU / the interface module to the back until the mounting rail release audibly locks in place.
3. Hang the CP to the right next to the CPU.
4. Tilt the CP to the back until the mounting rail release audibly locks in place.
5. Move the CP to the left until it audibly locks in place in the CPU.
6. Mount the other base units and modules accordingly.

   See manual /2/ (Page 117) for information on this.

Plugging in the bus adapter

NOTICE
Touching the plug-in contacts
Do not touch the plug-in contacts when no bus adapter is plugged in.

1. Connect the appropriate cable to the bus adapter if you use a bus adapter with optical or direct electrical or optical connection (without plug).

2. Plug the bus adapter into the slot of the CP.

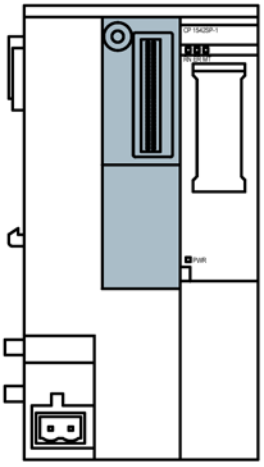


Figure 3-2 Front of the CP, the slot for the bus adapter is marked gray.

3. Screw the bus adapter to the CP.

   The securing screw is located at the top left on the front of the bus adapter.

   To do this use a screwdriver with 3 to 3.5 mm blade width or a suitable Torx screwdriver (T15).

   The maximum tightening torque is 0.25 Nm.

4. Plug the connector of the connecting cable into the socket of the bus adapter if you use a bus adapter with plug.

For information on plugging in the bus adapter and fitting cables see also the manual /2/ (Page 117).

Removal from the DIN rail

Follow the steps below to remove a CP from the DIN rail:

1. Turn off the power supply to the entire station including the CP and CPU.
2. Activate the mounting rail release of the modules to be moved (CPU, CPs) and move them parallel to the left until they are released from the remaining module group (free space approx. 16 mm).

   Press the locking slide marked "PUSH" on the top of a module down to be able to move the module in the DIN rail.
3. Activate the mounting rail release on the CP and move it to the right until it is released from the CPU (free space approx. 8 mm).
4. While holding the mounting rail release on the CP, swing the CP out of the mounting rail.

3.3 Connecting the CP

Order of the work

NOTICE
Connection only with power off Connect the CP only when the power is off. Refer to the information in the system manual, see /2/ (Page 117).

The bus adapter is already connected to the relevant cable, see section Installing the CP (Page 32).

1. Connect the external power supply to the terminal block of connector X80.

   Use the same power supply as the CPU.

2. Turn the power supply on only after the CP has been completely wired and connected.

Power supply at connector X80

You will find the location of the connector X80 four the power supply to the CP in section Power supply (Page 26). There, you will also find notes on reverse polarity protection..

The 2-terminal plug-in terminal block has the following pin assignment for the socket:

Terminal	Assignment
1L+ / 2L+	24 VDC
1M / 2M	Ground

The two terminals 1L+/L2+ and 1M/2m of the terminal block are each bridged internally so that you can connect either a single or a redundant power supply.

Connectable cable cross-section

- Without wire end ferrule 0.2 .. 2.5 mm^2 / AWG 24 .. 13
- With wire end ferrule 0.25 .. 1.5 mm^2 / AWG 24 .. 16
- With TWIN wire end ferrule: 0.5 .. 1.0 mm^2 / AWG 20 .. 17

You will find information about the power consumption and further technical details of the connectors in section Technical specifications (Page 107).

Configuration and operation 4

4.1 Security recommendations

Keep to the following Security recommendations to prevent unauthorized access to the system.

Note

Security functions of the CP types

Depending on the supported function - the following notes do not apply to every CP type described in this manual.

General

- You should make regular checks to make sure that the device meets these recommendations and other internal security guidelines if applicable.
- Evaluate your plant as a whole in terms of security. Use a cell protection concept with suitable products.
- Do not connect the device directly to the Internet. Operate the device within a protected network area.
- Keep the firmware up to date. Check regularly for security updates of the firmware and use them.
- Check regularly for new features on the Siemens Internet pages.
  - Here you will find information on network security:

    Link: (http://www.siemens.com/industrialsecurity)
  - Here you will find information on Industrial Ethernet security:

    Link: (http://w3.siemens.com/mcms/industrial-communication/en/ie/industrial-ethernet-security/Seiten/industrial-security.aspx)
  - You will find an introduction to the topic of industrial security in the following publication:

    Link: (http://w3app.siemens.com/mcms/infocenter/dokumentencenter/sc/ic/InfocenterLanguagePacks/Netzwerksicherheit/6ZB5530-1AP02-0BA4_BR_Network_Security_en_112015.pdf)

Physical access

Restrict physical access to the device to qualified personnel.

Network attachment

Do not connect the PC directly to the Internet. If a connection from the CP to the Internet is required, arrange for suitable protection before the CP, for example a SCALANCE S with firewall or use the CP 1543SP-1.

Security functions of the product

Use the options for security settings in the configuration of the product. These includes among others:

- Protection levels

  Configure a protection level of the CPU.

  You will find information on this in the information system of STEP 7.

- Disabling the bus adapter ports

  In the configuration disable a port of the bus adapter being used that is not required.

- Security function of the communication
  - Enable the Security functions of the CP and set up the firewall.

    If you connect to public networks, you should use the firewall. Think about the services you want to allow access to the station via public networks. By using the "bandwidth limitation" of the firewall, you can restrict the possibility of flooding and DoS attacks.
  - Use the secure protocol variants NTP (secure) and SNMPv3.
  - Use the Security functions of the telecontrol protocols. e.g. the DNP3 Security options.
  - Use the secure Open User Communication (Secure OUC) via the appropriate program blocks.
  - Leave access to the Web server of the CPU (CPU configuration) and to the Web server of the CP disabled.

- Protection of the passwords for access to program blocks

  Protect the passwords stored in data blocks for the program blocks from being viewed. You will find information on the procedure in the STEP 7 information system in the topic "Know-how protection".

- Logging function

  Enable the function in the Security configuration and check the logged events regularly for unauthorized access.

Passwords

- Define rules for the use of devices and assignment of passwords.
- Regularly update the passwords to increase security.
- Only use passwords with a high password strength. Avoid weak passwords for example "password1", "123456789" or similar.

- Make sure that all passwords are protected and inaccessible to unauthorized personnel.

  See also the preceding section for information on this.
- Do not use one password for different users and systems.

Protocols

Secure and non-secure protocols

- Only activate protocols that you require to use the system.
- Use secure protocols when access to the device is not prevented by physical protection measures.

  The NTP protocol provides a secure alternative with NTP (secure).

Table: Meaning of the column titles and entries

The following table provides you with an overview of the open ports on this device.

- **Protocol / function**

  Protocols that the device supports.
- **Port number (protocol)**

  Port number assigned to the protocol.
- **Default of the port**
  - Open

    The port is open at the start of the configuration.
  - Closed

    The port is closed at the start of the configuration.
- **Port status**
  - Open

    The port is always open and cannot be closed.
  - Open according to configuration

    The port is open if it has been configured.
  - Open (login, when configured)

    As default the port is open. After configuring the port, the communications partner needs to log in.
  - Closed after configuration

    The port is closed because the CP is always client for this service.
- **Authentication**

  Specifies whether or not the protocol authenticates the communications partner during access.

Protocol / function	Port number (protocol)	Default of the port	Port status	Authentication
DHCP	68 (UDP)	Closed	Open after configuration (while the CP obtains a new address)	No
S7 and online connections	102 (TCP)	Open	Open after configuration	No
Online diagnostics (CP 1543SP-1)	8448 (TCP)	Closed	Open after configuration	No
DNP3 listener port	20000 (TCP/UDP) can be set	Closed	Open after configuration	Yes, when Security is enabled.
IEC listener port	2404 (TCP) can be set	Closed	Open after configuration	No
SMTP	25 (TCP) can be set	Closed	Closed after configuration	No
SSL/TLS	587 (TCP) can be set	Closed	Closed after configuration	No
NTP	123 (TCP)	Closed	Closed after configuration	No
HTTP	80 (TCP)	Closed	Open after configuration	Yes
HTTPS	443 (TCP)	Closed	Open after configuration	Yes
SNMP	161 (UDP)	Open	Open after configuration	Yes (with SNMPv3)

4.2 Configuration in STEP 7

Configuration in STEP 7

You configure the modules and networks in SIMATIC STEP 7. You will find the required version in the section Software requirements (Page 20). You can configure a maximum of two CP 154xSP-1 for an ET 200SP.

You will find comprehensive information on configuration in the Information system of STEP 7 and in the following sections.

Overview of configuration of the CP

Follow the steps below when configuring:

1. Create a STEP 7 project.
2. Insert the required SIMATIC stations.
3. Insert the CPs and the required input and output modules in the stations.
4. Create an Ethernet network.
5. Connect the stations to the Ethernet subnet.
6. Configure the inserted CPs.

7. Optional: Create the program blocks for the Open User Communication.
8. Save and compile the project.

Here you will find information on individual parameter groups in the following sections. You will find information on parameters not described in this manual in the information system of STEP 7.

Details on the parameters of the telecontrol communication of the CP 1542SP-1 IRC can be found in the section Telecontrol communication (CP 1542SP-1 IRC) (Page 44).

Details on the parameters of the security functions can be found in the section Security configuration(CP 1543SP-1) (Page 84).

Loading and saving the configuration data

When you load the station, the project data of the station including the configuration data of the CP is stored on the CPU. You will find information on loading the station in the STEP 7 information system.

4.3 Ethernet interface

4.3.1 IPv6

Configuring the Ethernet addresses

You will find information on configuration in the information system of STEP 7.

Note

Communication via IPv6

If you want to use IPv6 addresses and connect the CP to the Internet, make sure that the router connected to the Internet and the providers of the Internet services used (e.g. e-mail) also support IPv6 addresses.

4.3.2 Time-of-day synchronization

Procedure for time-of-day synchronization

You will find the parameter group for time-of-day synchronization under the Ethernet interface.

If the Security functions are enabled, the parameter group is displayed below "Security".

Note

Recommendation for setting the time

Synchronization with a external clock at intervals of approximately 10 seconds is recommended. This achieves as small a deviation as possible between the internal time and the absolute time.

Note

No forwarding of the time of day with NTP / NTP (secure)

Both the CPU and CP can have the time of day synchronized using NTP. If you enable time-of-day synchronization for both modules, it is recommended that you use the same NTP server to retain a consistent time-of-day within the station.

The CP supports the following time-of-day synchronization method:

- **NTP**

  You configure the addresses of the NTP server(s), the synchronization interval and the "Accept time from non-synchronized NTP servers" option

CP 1542SP-1 IRC

With telecontrol communication enabled (parameter group "Communication types" the time of day is normally taken from the partner:

- **Time from partner**

  The CP sets its clock using the time of day that it receives in frames from the communications partner.

The CP 1542SP-1 IRC provides the CPU with the option of it taking its time from the CP using a PLC tag. See section Auto-Hotspot for information on this.

Note

No time-of-day synchronization of the CPU when the time is taken from the CP

When the CPU takes the time from the CP using a PLC tag, disable the CPU's own time-of-day synchronization.

CP 1543SP-1

Note

Ensuring a valid time of day

If you use security functions, a valid time of day is extremely important. It is recommended to use the NTP (secure)NTP (secure) method.

The CP supports the following time-of-day synchronization methods:

- **NTP**
- **NTP (secure)**

  The secure method NTP (secure) uses authentication with symmetrical keys according to the hash algorithms MD5 or SHA-1.

  In the global security settings, you can create and manage additional NTP servers also of the type NTP (secure).

See also

Communication with the CPU (Page 55)

4.4 SNMP

"SNMP" parameter group

- "**Enable SNMP**" parameter group

  Releases the function of the SNMP agent on the CP.

Note

If the security functions are enabled for the CP 1543SP-1 you will find the parameter group "SNMP" in "Security".

Scope of performance of the CPs

The CPs support the following SNMP version:

- **CP 1542SP-1, CP 1542SP-1 IRC**
  - SNMPv1
- **CP 1543SP-1**
  - SNMPv1
  - SNMPv3 (with activated Security functions)

Traps are not supported by the CP.

You will find detailed information about the supported functions in the section Diagnostics with SNMP (Page 98).

4.5 Telecontrol communication (CP 1542SP-1 IRC)

4.5.1 Configuration

Data points for telecontrol communication

No program blocks need to be programmed for the CP 1542SP-1 IRC to transfer user data between the station and communications partner.

The data areas in the memory of the CPU intended for communication with the partner are configured data point-related on the CP. Each data point is linked to a PLC tag or element in a data block on the CPU.

The individual data points can be transferred to the control system and processed there.

To transfer the process data and for some options of the parameter groups "Partner stations" and "Communication with the CPU" configured data points are required.

For further information, refer to section Data point configuration (Page 56).

4.5.2 Communication types

In this parameter group, you enable the communication types you want to use for the particular CP..

To minimize the risk of unauthorized access to the station via Ethernet, you need to enable the communications services that the CP will execute individually.

The Open User Communication does not exist in the parameter group because these communications services are not configured but programmed using program blocks.

The parameter group does not exist for the CP 1542SP-1, since the communications services supported by this CP are always enabled.

"Communication types" parameter group

- **Enable telecontrol communication**

  Only with the CP 1542SP-1 IRC

  Enables telecontrol communication on the CP. The following protocols can be used as alternatives:

  – **TeleControl Basic**

    Enables communication with the telecontrol server

  – **DNP3**

    Enables communication with up to four DNP3 masters

  – **IEC 60870-5-104**

    Enables communication with up to four IEC masters

Note

Full telecontrol functionality only when Security functions are enabled

For the following functions, you need to enable the Security functions:

- Send messages (e-mails) using the telecontrol functionality
- Use of the "TeleControl Basic" protocol (general)
- Use of the DNP3 Security functions
- Use of certificates

Note

Loss of configuration data when changing the telecontrol protocol

If you change the protocol on a configured CP, protocol-specific configuration data is lost, for example, the data point configuration, the partner configuration and the messages (e-mails).

- **Activate online functions**

  Enables access to the CPU for the online functions via the CP (diagnostics, loading project data etc.). If the function is enabled, the engineering station can access the CPU via the CP.

  If the option is disabled, you have no access to the CPU via the CP with the online functions. Online diagnostics of the CPU with a direct connection to the interface of the CPU however remains possible.

- **Enabling S7 communication**

  Enables the functions of S7 communication with a SIMATIC S7 and S7 routing on the CP.

  If you configure S7 connections to the relevant station, and these run via the CP, you will need to enable this option.

4.5.3 Address and authentication information

Address and authentication information for telecontrol communication

Depending on the telecontrol protocol the news, the communications partners of the CP require the following address and authentication information of the CP that needs to be configured for the CP:

- **TeleControl Basic**

  The telecontrol server requires:

  – Project number

  – Station number

  – Telecontrol password (for authentication)

  You will find the parameters in the parameter group "CP idenfication" under "Security".

  – IP address (in the "Ethernet interface“ parameter group)

    Since the CP always establishes the connection to the telecontrol server, the IP address of the CP does not need to be configured in TCSB.

- **DNP3**

  The master requires:

  – Station number (in the "CP identification" parameter group)

  – IP address (in the "Ethernet interface“ parameter group)

  – Port number of the CP

- **IEC**

  The master requires:

  – Station number (in the "CP identification" parameter group)

  – IP address (in the "Ethernet interface“ parameter group)

  – Port number of the CP

Address information required by the CP

You will find information about the address information of the communications partner required by the CP in section Partner stations (Page 50).

4.5.4 Ethernet interface (X1) > Advanced options

Configure the generally available parameters just as for every other Ethernet interface:

- General data (name etc.)
- Addresses and possibly routers

- Port settings
- Access to the Web server

Below you will find only the description of the specific parameters for telecontrol communication.

TCP connection monitoring

The setting made here applies globally to all TCP connections of the CP. Note the option of overwriting the value configured here for individual communications partners, see below.

- **TCP connection monitoring time**

  If there is no data traffic within the connection monitoring time, the CP sends a keepalive to the communications partner.

  Permitted range: 1 ... 65535 s. Default setting: 180

  The monitoring time is configured for the Ethernet interface as the default for all TCP connections. The default value can be adapted individually for each connection in "Partner stations", compare section Partner stations (Page 50). The function can only be disabled by entering 0 (zero) for the partners.

- **TCP keepalive monitoring time**

  After sending a keepalive, the CP expects a reply from the communications partner within the keepalive monitoring time. If the CP does not receive a reply within the configured time, it terminates the connection.

  Permitted range: 1 ... 65535 s. Default setting: 10

  The monitoring time is configured for the Ethernet interface as the default for all TCP connections. The default value can be adapted individually for each connection in "Partner stations". The function can only be disabled by entering 0 (zero) for the partners.

Transmission settings - TeleControl Basic

- **Connection establishment delay**

  Basic value for the wait time until the next connection establishment following an unsuccessful attempt to establish a connection. After every 3 attempts, the basic value is doubled up to a maximum of 900 s.

  Permitted range: 10 ... 300. Default setting: 10

  Example: The basic value 20 results in the following wait times: 3 x 20 s, 3 x 40 s, 3 x 80 s etc. up to max. 3 x 900 s.

- **Send monitoring time**

  Time (seconds) for the arrival of the acknowledgment from the communications partner (Telecontrol server) after sending spontaneous frames. The time is started after sending an unsolicited frame. If no acknowledgement has been received from the partner when the connection monitoring time elapses, the frame is repeated up to three times. After three unsuccessful attempts, the connection is terminated and re-established.

  Permitted range: 1 ... 65535. Default setting: 5

- **Key exchange interval**

  Here, you enter the interval in hours after which the key is exchanged again between the CP and the communications partner (TCSB V3). The key is a security function of the telecontrol protocol used by the CP and TCSB V3.

  Permitted range: 0 ... 65535. Default setting: 8

  If you enter 0 (zero), the function is disabled.

Transmission settings - DNP3

You will find information on the permitted ranges of the functions and defaults in the tooltips of STEP 7.

- **Disturbance bit**

  The disturbance bit can be used as bit 1.6 (IIN1.6) of the "Internal Indication Bytes" to indicate to the master when the CPU is in STOP mode.

- **Max. time between Select and Operate**
- **Frame repetitions**
- **Connection confirmation**
- **Connection monitoring time**
- **Transfer mode "Unsolicited"**
- **Max. number of unsolicited frames**
- **Monitoring time for unsolicited frames**
- **Buffer for class 1 / 2 / 3 events**

  Here, for each of the three event classes you specify the number of events after which the stored events are sent to the communications partner.

  Permitted range: 1 ... 255.

- **Delay time class 1 / 2 / 3 events**

  Here, for each of the three event classes you specify the maximum time in seconds the events can be stored in the send buffer before they are sent to the communications partner.

  Permitted range: 0 ... 255.

  If you enter 0 (zero), the function is disabled.

You will find details of how the send buffer works (storing and sending events) as well as the options for transferring data in the section Process image, types of transmission, event classes, triggers (Page 62).

Transmission settings - IEC

Note

Settings on the master

When configuring the monitoring times t_1 and t_2 make sure that you make the corresponding settings on the master so that there are no unwanted error messages or connection aborts.

You will find information on the permitted ranges of the functions and defaults in the tooltips of STEP 7.

- **Max. time between Select and Operate**
- **Monitoring time for connection establishment (t_0)**
- **Frame monitoring time (t_1)**

  Monitoring time for the acknowledgement of frames sent by the CP by the communications partner. The monitoring time applies to all frames sent by the CP in I, S and U format.

  If the partner does not send an acknowledgment during the monitoring time, the CP terminates the connection to the partner.

- **Monitoring time for S and U frames (t_2)**

  Monitoring time for the acknowledgment of data frames of the master by the CP.

  After receiving data from the master, the CP acknowledges the received data alternatively:

  – If the CP sends data to the master itself within t_2, it acknowledges the data frames received from the master during t_2 at the same time along with the sent data frame (I format).

  – The CP sends an acknowledgment frame (S format) to the master at the latest when t_2 elapses.

  The value of t_2 should be less than that of t_1.

- **Idle time for test frames (t_3)**

  Monitoring time during which the CP has not received any frames from the master.

  When t_3 elapses, the CP sends a test/control frame (U format) to the master.

  This parameter is intended for longer times without data traffic.

- **Difference between send sequence number N(S) and receive sequence number N(R)**

  Maximum number of unacknowledged data frames (I-APDUs) as maximum difference between send sequence number N(S) and receive sequence number N(R).

  When k is reached and t_1 has not yet elapsed, the CP does not send any frames until all the frames sent have been acknowledged by the master.

  When k is reached and t_1 has elapsed, the TCP connection is terminated.

- **Max. number of unacknowledged data frames**

  Maximum number of received data frames (I-APDUs), after which the oldest frame received from the master must be acknowledged.

Acknowledgment mechanism for the IEC protocol

With each sent data frame, the CP sends a continuous send sequence number. The data frame remains initially stored in the send buffer.

When it receives the data frame, the master sends the send sequence number from this or (if several frames are received) the last frame as an acknowledgement to the CP. The CP saves the send sequence number returned by the master as a receive sequence number and uses it as an acknowledgement.

Frames whose send sequence number is equal to or lower than the current receive sequence number are evaluated as having been successfully transferred and are deleted from the send buffer of the CP.

Recommendations of the specification:

- w should not be higher than 2/3 of k.
- Recommended value for k: 12
- Recommended value for w: 8

Port [X1 Px]

If you do not want to use both ports of the bus adapter, you can disable one of the two ports.

You will find information on the other parameters in the information system of STEP 7.

4.5.5 Partner stations

4.5.5.1 Partner configuration

The STEP 7 configuration of the communications partners of the CP (telecontrol server, DNP3 or IEC master) and the connections to the partners is not possible and not necessary.

Address information of the communications partners

For the communications partners of the CP, the following information is required during the configuration of the CP:

- TeleControl Basic
  - Partner IP address

    See section Auto-Hotspot for information on this.
  - Partner port (port number of the listener port of TCSB)

- DNP3 / IEC
  - Master station address

    Station address specified on the master

    With the IEC protocol the Master station address is not evaluated.
  - Partner IP address

    IP address of the master

    For the addressing of redundant partners, see section Addressing of single and redundant communications partners (Page 53).
  - Partner port

"Partner stations" (only with DNP3 / IEC)

- **Listener port**

  CP's own listener port

"Telecontrol server" / "Partner"

- **Activate partner**

  Enable the option to be able to use the partners configured later for the communication.

  In "TeleControl Basic" the telecontrol server is always enabled as a partner.
- **Partner number**

  The partner number is always signed by STEP 7.
- **Station address / Master station address**

  The station address of the telecontrol server is assigned automatically by the system if telecontrol communication is enabled.

"Connection to partner"

You will find information on the permitted ranges and defaults in the tooltips of STEP 7.

- **Partner IP address**

  IP address or host name (FQDN) of the telecontrol server. This can, for example, also be the FQDN of a DynDNS service.
- **Connection monitoring**

  When the function is enabled, the connection to the communications partner is monitored by sending keepalive frames.

  The TCP connection monitoring time is set for all TCP connections of the CP in the parameter group of the Ethernet interface, see also the section Ethernet interface (X1) > Advanced options (Page 46). These settings apply to all TCP connections of the CP.

  Here in the parameter group "Partner stations" the globally set monitoring time can also be set separately for this partner. The value set here overwrites the global value for this partner that was set in the "Ethernet interface (X1) > Advanced options > TCP connection monitoring" parameter group.

- **TCP connection monitoring time**

  Only with TCP: If there is no data traffic within the connection monitoring time, the CP sends a keepalive to the communications partner.

  The monitoring time is configured for the Ethernet interface as the default for all TCP connections. The default value can be adapted individually for each connection in "Partner stations" and this overwrites the global value for this partner that was set in the parameter group "Ethernet interface".

  The function can be disabled by entering 0 (zero) for the individual partners.

- **TCP keepalive monitoring time**

  Only with TCP: After sending a keepalive, the CP expects a reply from the communications partner within the keepalive monitoring time. If the CP does not receive a reply within the configured time, it terminates the connection.

  The monitoring time is configured for the Ethernet interface as the default for all TCP connections. The default value can be adapted individually for each connection in "Partner stations".

  The function can be disabled by entering 0 (zero) for the individual partners.

- **Connection mode**

  In the "Permanent" connection mode, there is a permanent connection to the communications partner.

- **Connection establishment**

  Specifies the communications partner that establishes the connection (always the CP).

- **Partner port**

  Port number of the communications partner

"Connection to redundant partner" (only with DNP3 / IEC)

- **Redundancy mode**

  Enable the option if the communications partner is a redundant master.

For information on the other parameters see above.

"Advanced settings"

- **Partner monitoring time (only with DNP3 / IEC)**

  If the CP does not receive a sign of life from the communications partner within the configured time, the CP interprets this as a fault/error on the partner. If you enter 0, the function is deactivated.

- **Report partner status (connection to partner)**

  If the function is enabled, the CP signals the status of the connection to the communications partner to the CPU.

  – Bit 0 of "PLC tag for partner status" (data type WORD) is set to 1 if the partner can be reached.

  – Bit 1 is set to 1 if all the paths to the remote partner are OK (useful with redundant paths).

  – Bits 2-3 indicate the status of the send buffer (frame memory).
  The following values are possible:

  - 0: Send buffer OK

  - 1: Send buffer threatening to overflow (more than 80 % full).

  - 3: Send buffer has overflowed (fill level 100 % reached).

  As soon as the fill level drops below 50%, bits 2 and 3 are reset to 0.

  Bits 4 to 15 of the PLC tags are not used and do not need to be evaluated in the program.

DNP3-specific settings

- **DNP3 level**

  DNP3 conformity level supported by the partner.

- **Event transmission mode**

  Mode with which the frames in the send buffer of the CP (events) are transferred:

  – Chronological transfer of individual frames

  or

  – Block-by-block transfer of the frames of a data point

4.5.5.2 Addressing of single and redundant communications partners

Addressing the telecontrol server

- **Addressing of a single telecontrol server**

  Configure the IP address of the telecontrol server or the DSL router when connecting via the Internet.

  When using a DynDNS service with the host name (FQDN) can be specified.

- **Addressing of the TCSB redundancy group by the stations using one IP address**

  In the LAN in the master station to which the TCSB server PCs and the DSL router (e.g. SCALANCE M) are connected, the Network Load Balancing (NLB) of the computer operating system will assign a common virtual IP address to the two server PCs.

  This IP address is configured depending on the network setup:

  – If a CP without a DSL router is connected, the virtual address assigned by the NLB must be configured in the CP as the IP address of the telecontrol server.

  – If a DSL router is used, only one IP address will be configured to address the redundant telecontrol server in the stations, the public address of the DSL router.

    Set the port forwarding (TCP) on the DSL router so that the public IP address (external network) is led to the virtual IP address of the TCSB server PCs (internal network). Only the public IP address is reachable from the Internet. The station does not therefore receive any information telling it which of the two computers of the redundancy group it is connected to.

Addressing redundant DNP3 or IEC masters

For each master specify the master station address and the IP address being used.

4.5.5.3 Partner for inter-station communication

Only when using the "TeleControl Basic" protocol

Inter-station communication

In this table, you specify the S7 stations and CPs with which the current station will use inter-station communication. Connections for inter-station communication run via the telecontrol server.

Partner

The partner number is assigned by the system. It is required during data point configuration to assign data points to their communications partners.

For inter-station communication, the partner is addressed with the parameters "Project", "Station" and "Slot".

Project

Here, enter the project number of the CP in the partner station. (Parameter group "Security > CP identification" on the partner)

Station

Here, enter the station number of the CP in the partner station. (Parameter group "Security > CP identification" on the partner)

Slot

Here, enter the slot number of the CP in the partner station via which the connection will be established.

Frame memory

When enabled, the frames are stored in the send buffer (frame memory) of the CP if the connection is disturbed. Note that the capacity of the frame memory is shared by all communications partners.

If the option is disabled, frames for events are stored in the image memory of the CP; in other words if there are problems on the connection older values are overwritten by new values.

Access ID

The access ID displayed here is formed from the hexadecimal values of project number, station number and slot. The parameter of the type DWORD is allocated as follows:

- Bits 0 - 7: Slot
- Bits 8 - 20: Station number
- Bits 21 - 31: Project number

4.5.6 Communication with the CPU

Communication with the CPU

Using the first three parameters you specify the CPU access by the CP in the CPU scan cycle. You will find the structure of the CPU scan cycle in the section Read cycle (Page 69).

The fourth parameter "Frame memory size" decides the size of the send buffer on the CP for frames of data points that are configured as an event.

- **Cycle pause time**

  Wait time between two scan cycles of the CPU memory area

- **Max. number of write jobs**

  Maximum number of write jobs to the CPU memory area within a CPU scan cycle

- **Max. number of read jobs**

  Maximum number of low-priority read jobs from the CPU memory area within a CPU scan cycle.

- **Frame memory size**

  Here, you set the size of the frame memory for events (send buffer).

  The size of the frame memory is divided equally among all configured communications partners. You will find the size of the frame memory in the section Configuration limits and performance data (Page 17).

  You will find details of how the send buffer works (storing and sending events) as well as the options for transferring data in the section Process image, types of transmission, event classes, triggers (Page 62).

Watchdog bit

- **CP monitoring**

  Via the watchdog bit the CPU can be informed of the status of the telecontrol communication of the CP.

CP time of day

- **CP time to CPU**

  Using this function, the CP can make its time of day available to the CPU.

  You will find details in the STEP 7 information system.

4.5.7 Data point configuration

4.5.7.1 Configuring the data points

Creating data points and messages

You configure the data points and messages in STEP 7 in the editor for the data point and message configuration. You can find this using the project tree:

Project > directory of the relevant station > Local modules > CP

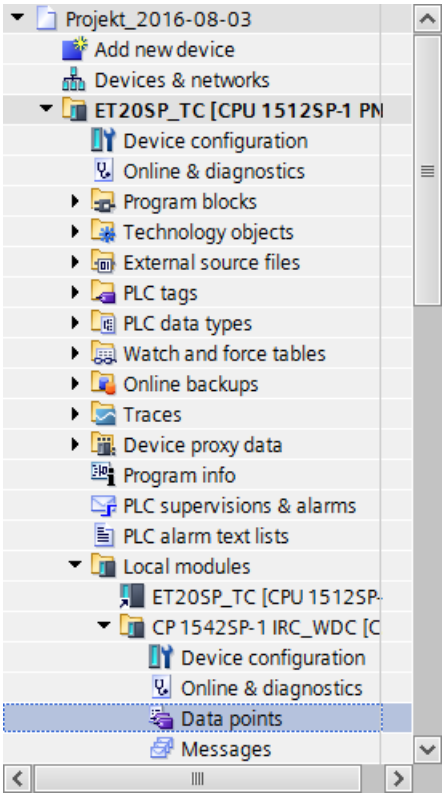


Figure 4-1 Open the data point and message editor

Open the data point and message editor by double-clicking on the entry "Data points" or "Messages".

Requirement for data points: PLC tags and/or data blocks (DBs)

PLC tags or DBs must first be created in the CPU program to allow configuration of the data points.

The PLC tags for data point configuration can be created in the standard tag table or in a user-defined tag table.

Remember the maximum possible number of PLC tags the can be used for data point configuration in the section Configuration limits and performance data (Page 17).

Access to the memory areas of the CPU

The values of the PLC tags or DBs referenced by the data points are read and transferred to the communications partner by the CP. Data received from the communications partner is written by the CP to the CPU via the PLC tags or DBs.

The address ranges, formats and S7 data types of the PLC tags that are compatible with the protocol-specific data point types of the CP can be found in the section Datapoint types (Page 58).

Properties of the data points

All PLC tags intended to be used for data point configuration must have the attribute "Visible in HMI".

Note

Length of the data point names

If you want to use the maximum number of configurable data points, assign data point names, CP names and station names that are as short as possible.

Character set for data point names

When you create a data point, a preset name "DataPoint_n" is adopted. In the data point table and in the "General" tab of the data point you can change the name of the data point.

When assigning names only ASCII characters from the band 0x20 ... 0x7e may be used with the exceptions listed below.

The following characters are forbidden since they do not adhere to the syntax rules of TCSB for OPC items:

Non-permitted characters: . ' [ ] / \ |
period, apostrophe, square brackets, slash, back slash, vertical line (pipe)

4.5.7.2 Datapoint types

Supported data point types of the CP 1542SP-1 IRC

During the configuration of the user data to be transferred by the CP 1542SP-1 IRC, each data point is assigned a protocol-specific data point type. The data point types along with the compatible S7 data types are listed below. They are grouped according to format (memory requirements).

TeleControl Basic: Data point types

Table 4- 1 Supported data point types and compatible S7 data types

Format (memory requirements)	Data point type	S7 data types	Address area
Bit	Digital input	Bool	I, Q, M, DB
	Digital output	Bool	Q, M, DB
	Command output	Bool	Q, M, DB
Byte	Digital input	Byte, USInt	I, Q, M, DB
	Digital output	Byte, USInt	Q, M, DB
Integer with sign (16 bits)	Analog input	Int	I, Q, M, DB
	Analog output	Int	Q, M, DB
Counter (16 bits)	Counter input	Word, UInt	I, Q, M, DB
Integer with sign (32 bits)	Analog input	DInt	Q, M, DB
	Analog output	DInt	Q, M, DB
Counter (32 bits)	Counter input	UDInt, DWord	I, Q, M, DB
Floating-point number with sign (32 bits)	Analog input	Real	Q, M, DB
	Analog output	Real	Q, M, DB
Floating-point number with sign (64 bits)	Analog input	LReal	Q, M, DB
	Analog output	LReal	Q, M, DB
Block of data (1 .. 64 bytes)	Data	ARRAY [1)]	DB
	Data	ARRAY [1)]	DB

[1)] For the possible formats of the ARRAY data type, refer to the following section.

Block of data (ARRAY)

With the ARRAY data type, contiguous memory areas up to a size of 64 bytes can be transferred. The following S7 data types are compatible components of ARRAY:

- Byte, USInt (total of up to 64 per data block)
- Int, UInt, Word (total of up to 32 per data block)
- DInt, UDInt, DWord (total of up to 16 per data block)

Time stamp in UTC format

Time stamps are transferred in UTC format (48 bits) and contain the time difference in milliseconds since 01.01.1970.

DNP3: Data point types

Table 4- 2 Supported data point types, DNP3 object groups, variants and compatible S7 data types

Format (memory requirements)	Data point type	DNP3 object group [variations]	Direction	S7 data types	Operand area
Bit	Binary Input	**1** [1, 2]	in	Bool	I, Q, M, DB
	Binary Input Event	**2** [1, 2]	in	Bool	I, Q, M, DB
	Binary Output [1]	**10** [2]	out		
	Binary Output Event [1]	**11** [1, 2]	out		
	Binary Command	**12** [1]	out	Bool	Q, M, DB
Integer (16 bits)	Counter Static	**20** [2]	in	UInt, Word	I, Q, M, DB
	Frozen Counter [2]	**21** [2, 6]	in		
	Counter Event	**22** [2, 6]	in	UInt, Word	I, Q, M, DB
	Frozen Counter Event [3]	**23** [2, 6]	in		
	Analog Input	**30** [2]	in	Int	I, Q, M, DB
	Analog Input Event	**32** [2]	in	Int	I, Q, M, DB
	Analog Output Status [4]	**40** [2]	out		
	Analog Output	**41** [2]	out	Int	Q, M, DB
	Analog Output Event [4]	**42** [2, 4]	out		
Integer (32 bits)	Counter Static	**20** [1]	in	UDInt, DWord	I, Q, M, DB
	Frozen Counter [2]	**21** [1, 5]	in		
	Counter Event	**22** [1, 5]	in	UDInt, DWord	I, Q, M, DB
	Frozen Counter Event [3]	**23** [1, 5]	in		
	Analog Input	**30** [1]	in	DInt	Q, M, DB
	Analog Input Event	**32** [1]	in	DInt	Q, M, DB
	Analog Output Status [4]	**40** [1, 3]	out		
	Analog Output	**41** [1]	out	DInt	Q, M, DB
	Analog Output Event [4]	**42** [1]	out		
Floating-point number (32 bits)	Analog Input	**30** [5]	in	Real	Q, M, DB
	Analog Input Event	**32** [5, 7]	in	Real	Q, M, DB
	Analog Output Status [4]	**40** [3]	out		
	Analog Output	**41** [3]	out	Real	Q, M, DB
	Analog Output Event [4]	**42** [5, 7]	out		
Floating-point number (64 bits)	Analog Input	**30** [6]	in	LReal	Q, M, DB
	Analog Input Event	**32** [6, 8]	in	LReal	Q, M, DB
	Analog Output	**41** [4]	out	LReal	Q, M, DB
	Analog Output Event [4]	**42** [6, 8]	out		
Block of data (1...64 bytes) [5]	Octet String / Octet String Output	**110** [-]	in, out	[5]	DB
	Octet String Event [5]	**111** [-]	in, out	[5]	DB

Format (memory requirements)	Data point type	DNP3 object group [variations]	Direction	S7 data types	Operand area

[1] This object group can be configured in the Data point editor of STEP 7 using the substitute object group 12.

[2] This object group can be configured in the Data point editor of STEP 7 using the substitute object group 20.

[3] This object group can be configured in the Data point editor of STEP 7 using the substitute object group 22.

[4] This object group can be configured in the Data point editor of STEP 7 using the substitute object group 41.

[5] With these data point types, contiguous memory areas up to a size of 64 bytes can be transferred. All S7 data types with a size between 1 and 64 bytes are compatible.

Explanation of the table footnotes [1], [2], [3], [4]: Configuring data points using substitute object groups

The initial data point types of the following object groups can be configured using the substitute object groups listed above:

- 10 [2]
- 11 [1, 2]
- 21 [1, 2, 5, 6]
- 23 [1, 2, 5, 6]
- 40 [1, 2, 3]
- 42 [1, 2, 4, 5, 6, 7, 8]

To configure the DNP3 CP, use the specified substitute object group.

Assign each data point on the master using the configurable data point index in STEP 7. The data point of the DNP3 CP is then assigned to the corresponding data point on the master.

Example of configuring the data point Binary Output (10 [2])
The data point is configured as follows:
On the DNP3 CP as Binary Command (12 [1])
On the master as Binary Output (10 [2])

With the data point types Binary Output Event (11) and Analog Output Event (42) you also need to enable mirroring back, refer to the next section.

Configuration of the mirroring back for output events (object groups 11 and 42)

You first create the data point types Binary Output Event (object group 11) and Analog Output Event (object group 42) as described above as data points of the object groups 12 or 41.

The local values of these two object groups can be monitored for change and the changes transferred to the master. Changing a local value can, for example, be caused by manual operator input on site.

To allow the value resulting from local events or interventions to be transferred to the master, the data point in question requires a channel for mirroring back. You configure this mirroring back function using the "Value monitoring" option in data point configuration, General tab.

Remember that to use the mirror back function, you need to interconnect the local values in the controller with the relevant PLC tag of the data point.

Time stamp of the DNP3 CP in UTC format

Time stamps are transferred in UTC format (48 bits) and contain milliseconds since 01.01.1970.

IEC: Data point types

Table 4- 3 Supported data point types, IEC types and compatible S7 data types

Format (memory requirements)	Data point type	IEC type	Direction	S7 data types	Operand area
Bit	Single point information	<1>	in	Bool	I, Q, M, DB
	Single point information with time tag [1]	<30>	in	Bool	I, Q, M, DB
	Single command	<45>	out	Bool	Q, M, DB
Byte	Step position information	<5>	in	Byte, USInt	I, Q, M, DB
	Step position information with time tag [1]	<32>	in	Byte, USInt	I, Q, M, DB
Integer (16 bits)	Measured value, normalized value	<9>	in	Int	I, Q, M, DB
	Measured value, normalized value with time tag [1]	<34>	in	Int	I, Q, M, DB
	Measured value, scaled value	<11>	in	Int	I, Q, M, DB
	Measured value, scaled value with time tag [1]	<35>	in	Int	I, Q, M, DB
	Set point command, normalised value	<48>	out	Int	Q, M, DB
	Set point command, scaled value	<49>	out	Int	Q, M, DB
Integer (32 bits)	Bitstring of 32 bits	<7>	in	UDInt, DWord	I, Q, M, DB
	Bitstring of 32 bits with time tag CP56Time2a [1]	<33>	in	UDInt, DWord	I, Q, M, DB
	Integrated totals	<15>	in	UDInt, DWord	I, Q, M, DB
	Integrated totals with time tag CP56Time2a [1]	<37>	in	UDInt, DWord	I, Q, M, DB
	Bitstring of 32 bits	<51>	out	UDInt, DWord	Q, M, DB
Floating-point number (32 bits)	Measured value, short floating point number	<13>	in	Real	Q, M, DB
	Measured value, short floating point number with time tag CP56Time2a [1]	<36>	in	Real	Q, M, DB
	Set point command, short floating point number	<50>	out	Real	Q, M, DB
Block of data (1...2 Bit) [2]	Double-point information	<3>	in	[2]	DB
	Double-point information with time tag CP56Time2a [1]	<31>	in	[2]	DB
	Double command	<46>	out	[2]	DB
	Regulating step command	<47>	out	[2]	DB

Format (memory requirements)	Data point type	IEC type	Direction	S7 data types	Operand area
Block of data (1...32 Bit) [3]	Bitstring of 32 bits [3]	<7>	in	[3]	DB
	Bitstring of 32 bits with time tag CP56Time2a [1] [3]	<33>	in	[3]	DB
	Bitstring of 32 bits [3]	<51>	out	[3]	DB

[1] For the format of the time stamp, see the following section.

[2] For these data point types, create a data block with an array of precisely 2 bool.

[3] With these data point types, contiguous memory areas up to a size of 32 bits can be transferred. Only the S7 Bool data type is compatible.

Time stamp with the IEC CP

IEC CP time stamps are transferred according to the IEC specification in the "CP56Time2a" format. Note that in the frames only the first 3 bytes for milliseconds and minutes are transferred.

4.5.7.3 Process image, types of transmission, event classes, triggers

Saving the data point values

The values of data points are stored in the image memory of the CP and transferred only when queried by the communications partner.

Events are also stored in the send buffer and can be transferred unsolicited.

Data points are configured as a static value or as an event using the "Type of transmission" parameter (see below):

- **Static value (no event)**

  Static values are entered in the image memory (process image of the CP).

  Static values correspond to the following classes:

  – DNP3: Class 0

  – IEC: Class 2

- **Event**

  The values of data points configured as an event are also entered in the image memory of the CP. The value of the event is sent unsolicited to the communications partner if this function is enabled by the master.

  The values of events are also entered in the send buffer of the CP.

  Events correspond to the following classes:

  – DNP3: Class 1 / 2 / 3

  – IEC: Class 1

The image memory, the process image of the CP

All the current values of the configured data points are stored in the image memory. New values of a data point overwrite the last stored value in the image memory.

The values are sent after being queried by the communications partner. Refer to "Transfer after call" in the section "Types of transmission".

The send buffer

The send buffer of the CP is the memory for the individual values of data points that are configured as an event. The maximum number is divided equally among all configured and enabled communications partners. You configure the size of the send buffer with the parameter "Frame memory size", see the section Communication with the CPU (Page 55).

If the connection to a communications partner is interrupted, the individual values of the events are retained in the buffer. When the connection returns, the buffered values are sent. The frame memory operates chronologically; in other words, the oldest frames are sent first (FIFO principle).

If a frame was transferred to the communications partner, the transferred value is deleted from the send buffer.

If frames cannot be transferred for a longer period of time and the send buffer is threatening to overflow, the response is as follows depending on the protocol being used:

- TeleControl Basic

  The forced image mode

  If the send buffer reaches a fill level of 80%, the CP changes to the forced image mode. New values from data points configured as an event are no longer added to the send buffer but rather they overwrite older existing values in the image memory.

  When the connection to the communications partner returns, the CP changes back to the send buffer mode if the fill level of the send buffer has fallen below 50%.

- DNP3 / IEC

  If a send buffer fill level of 100% is reached, the oldest values are overwritten.

  When using the DNP3 protocol, additional conditions for sending the events can be specified:

  – A maximum number of events in the send buffer, configurable for each event class.

  – A configurable maximum storage period for events in the send buffer.

Types of transmission

The following types of transmission are possible:

- **Transfer after call (class 0)**

  The current value of the data point is entered in the image memory of the CP. New values of a data point overwrite the last stored value in the image memory.

  After being called by the communications partner, the current value at the time is transferred.

- **Triggered (events)**

  The values of data points configured as an event are entered in the image memory and also in the send buffer of the CP.

  The values of events are saved in the following situations:

  – The configured trigger conditions are fulfilled (data point configuration > "Trigger" tab, see below)

  – The value of a status bit of the status of the identifiers of the data point changes see also the section Status IDs of the data points (Page 66).

Event classes with the "Triggered" type of transmission

Depending on the protocol used the following event classes are available:

- **TeleControl Basic**
  - **Every value triggered**

    Each value change is entered in the send buffer in chronological order.

  - **Current value triggered**

    Only the last, current value is entered in the send buffer. It overwrites the value stored there previously.

- **DNP3**

  The evaluation of the following classification must be handled by the master.

  - **Event class 1**

    Class according to DNP3 protocol: Class 1

    Each value change is entered in the send buffer in chronological order.

  - **Event class 2**

    Class according to DNP3 protocol: Class 2

    Each value change is entered in the send buffer in chronological order.

  - **Event class 3**

    Class according to DNP3 protocol: Class 3

    Only the current value at the time the trigger condition is met is entered in the send buffer and overwrites the last value stored there.

- **IEC**

  Both of the following event classes correspond to the user data class 1 of the IEC protocol

  – **Every value triggered**

    Each value change is entered in the send buffer in chronological order.

  – **Current value triggered**

    Only the current value at the time the trigger condition is met is entered in the send buffer and overwrites the last value stored there.

Trigger

Trigger types

Various trigger types are available for event-driven transfer:

- **Threshold value trigger**

  The value of the data point is transferred when this reaches a certain threshold. The threshold is calculated as the difference compared with the last stored value, refer to the section Threshold value trigger (Page 71).

- **Time trigger**

  The value of the data point is transferred at configurable intervals or at a specific time of day.

- **Event trigger**

  The value of the data point is transferred when a configurable trigger signal is fired. For the trigger signal, the edge change (0 → 1) of a trigger bit is evaluated that is set by the user program. When necessary, a separate trigger bit can be configured for each data point.

  Resetting the trigger tag in the bit memory area / DB:

  If the memory area of the trigger tag is in the bit memory or in a data block, the trigger tag is reset to zero when the data point value is transferred.

Transmission time of the frame

Whether the value of a data point is transferred to the communications partner immediately after the trigger or after a delay depends on the protocol used and the settings.

- **TeleControl Basic**

  You specify the time of transmission with the parameter "Transmission mode" in the "Trigger" tab of the data point:

– **Unsolicited**

The value is transferred immediately.

– **Conditional spontaneous**

The value is transferred only when one of the following conditions is fulfilled:

- The telecontrol server queries the station.
- The value of another event with the Transmission mode “Unsolicited" is transferred.
- The fill level of the transmission buffer has reached 80% of its maximum capacity.

- **DNP3 / IEC**

The spontaneous transmission in these protocols depends on whether spontaneous sending or asymmetric communication is possible in the network.

4.5.7.4 Status IDs of the data points

Status IDs of data points

The status IDs od the data points listed below are transferred for each data point in each frame. They differ slightly in the three protocol types.

For the meaning of the status bits, see below. The "Meaning" (2nd table row) relates to the "bit status" (3rd table row).

Generation of events if a data point status changes

With data points that were configured as an event, the change to the status bit of the status identifiers described below also leads to an event being generated.

Example: If the value of the status "RESTART" of a data point configured as an event changes form 1 (value not yet updated) to 0 (value updated) when the station starts up, this causes an event to be generated.

Status IDs - TeleControl Basic

The status bits are converted to the OPC quality code as follows by TCSB.

- Quality = BAD, If:

  NON_EXISTENT or OVER_RANGE = 1

- Quality = UNCERTAIN, If:

  RESTART or CARRY or SB = 1

- Quality = GOOD, If:

  Bits 1, 2, 3, 5 and 6 = 0

Table 4- 4 Bit assignment of status byte 0

Bit	7	6	5	4	3	2	1	0
Flag name	-	NON_ EXISTENT	SB	LOCAL_ FORCED	CARRY	OVER_ RANGE	RESTART	ONLINE
Meaning	-	Data point does not exist or S7 address unreachable	Substitute value	*(Bit is not set)*	Counted value overflow before reading the value	Limit value of the analog value preprocessing overshot / undershot	Value not yet updated after start	Value is valid, CPU in RUN
Bit status	*(always 0)*	1	1	*(irrelevant)*	1	1	1	1

Status IDs - TeleControl Basic

The status IDs can be evaluated by the master. They correspond to the following elements of the specification:

OBJECT FLAGS - DNP3 Specification, Volume 6, Data Object Library - Part 1

Table 4- 5 Bit assignment of the status byte

Bit	7	6	5	4	3	2	1	0
Flag name	-	-	-	LOCAL_ FORCED	DISCONTI NUITY	OVER_ RANGE	RESTART	ONLINE
Meaning	-	-	-	Local operator control	Counted value overflow before reading the value	Limit value of the analog value preprocessing overshot / undershot	Value not updated after start	Value is invalid
Bit status	*(always 0)*	*(always 0)*	*(always 0)*	1	1	1	1	1

Status IDs - IEC

The status IDs can be evaluated by the master. They correspond to the following elements of the specification:

Quality descriptor - IEC 60870 Part 5-101

Table 4- 6 Bit assignment of the status byte

Bit	7	6	5	4	3	2	1	0
Flag name	-	-	SB substituted	-	CY carry	OV overflow	NT not topical	IV invalid
Meaning	-	-	Substitute value	-	Counted value overflow before reading the value	Value range exceeded, analog value	Value not updated	Value is valid
Bit status	*(always 0)*	*(always 0)*	1	*(always 0)*	1	1	1	0

4.5.7.5 Rules for configuring the data point index:

Configuration of the data point index

Below you will find the configuration rules for the data point index depending on the protocol being used.

TeleControl Basic

Within a CP, the indexes of the data point classes must comply with the following rules:

- Input

  The index of a data point of the type input must be unique throughout all data point types (digital inputs, analog inputs etc.).

- Output
  - A data point of the type output can have the same index as a data point of the type input.
  - Several data points of the type output can have the same index.

Note

Data points for the inter-station communication with a CP in another S7 station

Note that for inter-station communication, the indexes of the two corresponding data points (data point pair) must be identical for the sending and receiving CP.

DNP3

On a CP, data point indexes must be unique within each of the following object groups:

- Binary Input / Binary Input Event
- Binary Output / Binary Command
- Counter / Counter Event
- Analog Input / Analog Input Event
- Analog Output
- Octet String / Octet String Event

Indexes of two data points in different object groups can be identical.

IEC

The data point indexes must be unique in a CP.

Data point indexes assigned twice are indicated as errors in the consistency check and prevent the project being saved.

4.5.7.6 Read cycle

Priority of the data points

The cyclic reading of the values of input data points from their assigned PLC tags on the CPU can be prioritized.

Less important input data points do not need to be read in every CPU scan cycle. Important input data points, on the other hand, can be prioritized for updating in every CPU scan cycle.

You can prioritize the data points in STEP 7 in the data point configuration in the "General" tab with the "Read cycle" parameter. There you will find the two following options for input data points:

- Fast cycle
- Normal cycle

The data points are read according to the method described below.

Structure of the CPU scan cycle

The cycle (including the pause) with which the CP scans the memory area of the CPU is made up of the following phases:

- **High-priority read jobs**

  The values of input data points with the scan priority "High-priority" are read in every scan cycle.

- **Low priority read jobs**

  Some of the values of input data points with the scan priority "Low-priority" are read in every scan cycle.

  The number of values read per cycle is specified for the CP in the "Communication with the CPU" parameter group with the "Max. number of read jobs" parameter. The values that exceed this value and can therefore not be read in one cycle are then read in the next or one of the following cycles.

- **Write jobs**

  In every cycle, the values of a certain number of unsolicited write jobs are written to the CPU. The number of values written per cycle is specified for the CP in the "Communication with the CPU" parameter group with the "Max. number of write jobs" parameter. The values whose number exceeds this value are then written in the next or one of the following cycles.

- **Cycle pause time**

  This is the waiting time between two scan cycles. It is used to reserve adequate time for other processes that access the CPU via the backplane bus of the station.

Duration of the CPU scan cycle

Since no fixed time can be configured for the cycle and since the individual phases cannot be assigned a fixed number of objects, the duration of the scan cycle is variable and can change dynamically.

4.5.7.7 "Trigger“ tab

Trigger

Data points are configured as a static value or as an event using the "Type of transmission" parameter:

Saving the value of a data point configured as an event

Saving the value of a data point configured as an event in the send buffer (message memory) can be triggered by various trigger types:

- **Threshold value trigger**

  The value of the data point is saved when this reaches a certain threshold. The threshold is calculated as the difference compared with the last stored value, refer to the section Threshold value trigger (Page 71).

- **Time trigger**

  The value of the data point is saved at configurable intervals or at a specific time of day.

- **Event trigger (Trigger tag)**

  The value of the data point is saved when a configurable trigger signal is fired. For the trigger signal, the edge change (0 → 1) of a trigger tag is evaluated that is set by the user program. When necessary, a separate trigger tag can be configured for each data point.

  Resetting the trigger tag in the bit memory area / DB:

  If the memory area of a trigger tag is in the bit memory or in a data block, the CP resets the trigger variable itself to 0 (zero) as soon as the value of the data point has been transferred. This can take up to 500 milliseconds.

Note

Fast setting of triggers

Triggers must not be set faster than a minimum interval of 500 milliseconds. This also applies to hardware triggers (input area).

Note

Hardware trigger

You need to reset hardware triggers via the user program

Transferring the value of a data point configured as an event

You specify whether the value of a data point is transferred to the communications partner immediately after the trigger fires or after a delay in the "Transmission mode" parameter.

Transmission mode

The transmission mode of a frame is set in the "Trigger" tab of the data point. With the option, you specify whether messages of events are sent immediately or following a delay:

- Immediate transfer - Spontaneous

  The value is transferred immediately.

- Buffered transfer - Conditionally spontaneous

  The value is transferred only when one of the following conditions is fulfilled:

  – The communications partner queries the station.

  – The value of another event with the transmission mode “Spontaneous" is transferred.

4.5.7.8 Threshold value trigger

Note

Threshold value trigger: Calculation only after "Analog value preprocessing"

Note that the analog value preprocessing is performed before the check for a configured threshold value and before calculating the threshold value.

This affects the value that is configured for the threshold value trigger.

Note

No Threshold value trigger if Mean value generation is configured

If mean value generation is configured, no threshold value trigger can be configured for the analog value event involved.

For the time sequence of the analog value preprocessing refer to the section Analog value preprocessing (Page 73).

Threshold value trigger

Function

If the process value deviates by the amount of the threshold value, the process value is saved.

Two methods are used to calculate the threshold value deviation:

- **Absolute method**

  With binary and counter values as well as with analog values with configured mean value generation, the absolute method is used to calculate the threshold value deviation.

- **Integrative method**

  With analog values without configured mean value generation, the integrating method is used to calculate the threshold value deviation.

  In the integration threshold value calculation, it is not the absolute value of the deviation of the process value from the last stored value that is evaluated but rather the integrated deviation.

Absolute method

For each binary value a check is made to determine whether the current (possibly smoothed) value is outside the threshold value band. The current threshold value band results from the last saved value and the amount of the configured threshold value:

- Upper limit of the threshold value band: Last saved value + threshold value
- Lower limit of the threshold value band: Last saved value - threshold value

As soon as the process value reaches the upper or lower limit of the threshold value band, the value is saved. The newly saved value serves as the basis for calculating the new threshold value band.

Integrative method

The integration threshold value calculation works with a cyclic comparison of the integrated current value with the last stored value. The calculation cycle in which the two values are compared is 500 milliseconds.
(Note: The calculation cycle must not be confused with the scan cycle of the CPU memory areas).

The deviations of the current process value are totaled in each calculation cycle. The trigger is set only when the totaled value reaches the configured value of the threshold value trigger and a new process value is entered in the send buffer.

The method is explained based on the following example in which a threshold value of 2.0 is configured.

Table 4- 7 Example of the integration calculation of a threshold value configured with 2.0

Time [s] (calculation cycle)	Process value stored in the send buffer	Current process value	Absolute deviation from the stored value	Integrated deviation
0	**20.0**	**20.0**	0	0
0.5		20.3	+0.3	0.3
1.0		19.8	-0.2	0.1
1.5		20.2	+0.2	0.3
2.0		20.5	+0.5	0.8
2.5		20.3	+0.3	1.1
3.0		20.4	+0.4	1.5
3.5	**20.5**	**20.5**	+0.5	**2.0**
4.0		20.4	-0.1	-0.1
4.5		20.1	-0.4	-0.5
5.0		19.9	-0.6	-1.1
5.5		20.1	-0.4	-1.5
6.0	**19.9**	**19.9**	-0.6	**-2.1**

With the changes in the process value shown in the example, the threshold value trigger configured with 2.0 fires twice:

- At the time 3.5 s: The value of the integrated deviation is at 2.0. The new process value stored in the send buffer is 20.5.
- At the time 6.0 s: The value of the integrated deviation is at 2.1. The new process value stored in the send buffer is 19.9.

In this example, if a deviation of the process value of approximately 0.5 should fire the trigger, then with the behavior of the process value shown here a threshold value of approximately 1.5 ... 2.5 would need to be configured.

4.5.7.9 Analog value preprocessing

CPs with data point configuration support analog value preprocessing. For analog value data points, some or all of the functions described below can be configured.

Requirements and restrictions

You will find the requirements for the configuration of the preprocessing options and restrictions in the section relating to the particular function.

Note

Restrictions due to configured triggers

The analog value preprocessing options "Fault suppression time", "Limit value calculation" and "smoothing" are not performed if no threshold value trigger is configured for the relevant data point.. In these cases, the read process value of the data point is entered in the image memory of the CP before the preprocessing cycle of the threshold value calculation (500 ms) elapses.

Sequence of the analog value preprocessing options

The values of analog inputs configured as an event are processed on the CPU according to the following scheme:

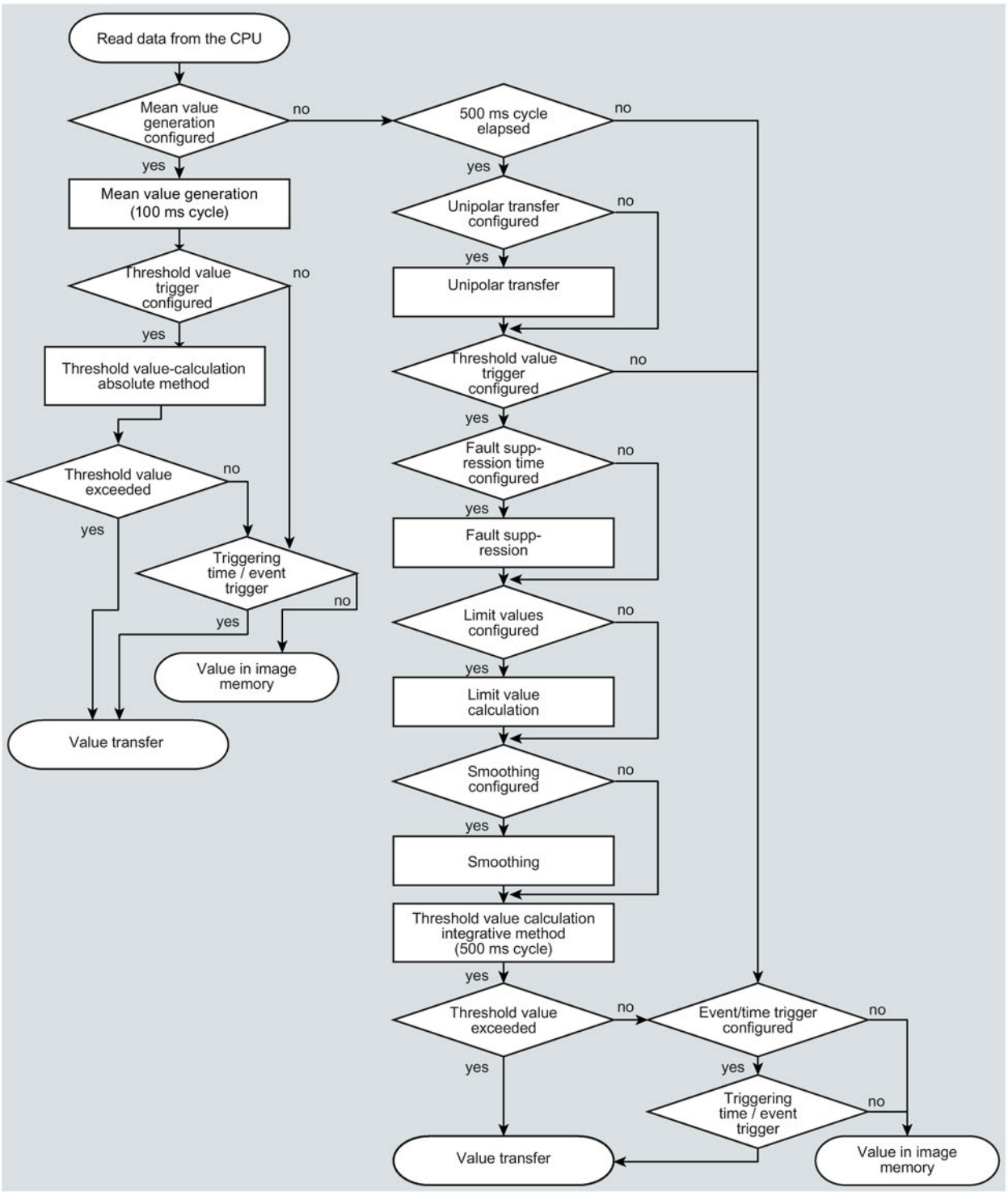


Figure 4-2 Sequence of the analog value preprocessing

The 500 millisecond cycle is started by the integrative threshold value calculation. In this cycle, the values are saved even when the following preprocessing options are enabled:

- Unipolar transfer
- Fault suppression time
- Limit value calculation
- Smoothing

Mean value generation

Note

Restricted preprocessing options if mean value generation is configured

If you configure mean value generation for an analog value event, the following preprocessing options are not available:

- Unipolar transfer
- Fault suppression time
- Smoothing

Function

With this parameter, acquired analog values are transferred as mean values.

If mean value generation is active, it makes sense to configure a time trigger..

The current values of an analog data point are read in a 100 millisecond cycle and totaled. The number of read values per time unit depends on the read cycle of the CPU and the CPU scan cycle of the CP.

The mean value is calculated from the accumulated values as soon as the transfer is triggered by a trigger. Following this, the accumulation starts again so that the next mean value can be calculated.

The mean value can also be calculated if the transmission of the analog value message is triggered by a request from the communications partner. The duration of the mean value calculation period is then the time from the last transmission (for example triggered by the trigger) to the time of the request. Once again, the accumulation restarts so that the next mean value can be calculated.

Input modules: Overflow range / underflow range

As soon as a value is acquired in the overflow or underflow range, mean value generation is stopped. The value 32767 / $7FFF_h$ or -32768 / 8000_h is saved as an invalid mean value for the current mean value calculation period and sent with the next message.

The calculation of a new mean value is then started. If the analog value remains in the overflow or underflow range, one of the two values named is again saved as an invalid mean value and sent when the next message is triggered.

Note

Fault suppression time > 0 configured

If you have configured an error suppression time and then enable mean value generation, the value of the error suppression time is grayed out but no longer used. If mean value generation is enabled, the error suppression time is set to 0 (zero) internally.

Unipolar transfer

Restrictions

Unipolar transfer cannot be configured at the same time as mean value generation. Enabling unipolar transfer has no effect when mean value generation is activated.

Function

With unipolar transfer, negative values are corrected to zero. This can be desirable if values from the underrange should not be transferred as real measured values.

Exception: With process data from input modules, the value -32768 / 8000_h for wire break of a live zero input is transferred.

With a software input, on the other hand, all values lower than zero are corrected to zero.

Fault suppression time

Requirements for the function

Configuration of the threshold trigger for this data point

Restrictions

The fault suppression time cannot be configured at the same time as mean value generation. A configured value has no effect when mean value generation is activated.

Function

A typical use case for this parameter is the suppression of peak current values when starting up powerful motors that would otherwise be signaled to the control center as a disruption.

The transmission of an analog value in the overflow ($7FFF_h$) or underflow range (8000_h) is suppressed for the specified time. The value $7FFF_H$ or 8000_H is only sent after the fault suppression time has elapsed, if it is still pending.

If the value returns to the measuring range before the fault suppression time elapses, the current value is transferred.

Input modules

The suppression is adjusted to analog values that are acquired directly by the S7 analog input modules as raw values. These modules return the specified values for the overflow or underflow range for all input ranges (also for live zero inputs).

An analog value in the overflow range (32767 / $7FFF_h$) or underflow range (-32768 / 8000_h) is not transferred for the duration of the fault suppression time. This also applies to live zero inputs. The value in the overflow/underflow range is only sent after the fault suppression time has elapsed, if it is still pending.

Recommendation for finished values that were preprocessed by the CPU:

If the CPU makes preprocessed finished values available in bit memory or in a data block, suppression is only possible or useful if these finished values also adopt the values listed above 32767 / $7FFF_h$ or -32768 / 8000_h in the overflow or underflow range. If this is not the case, the parameter should not be configured for preprocessed values.

For finished values preprocess in the CPU, the limits for the overflow and underflow can be freely assigned.

Smoothing factor

Requirements for the function

Configuration of the threshold trigger for this data point

Restrictions

The smoothing factor cannot be configured at the same time as mean value generation. A configured value has no effect when mean value generation is activated.

Function

Analog values that fluctuate quickly can be evened out using the smoothing function.

The smoothing factors are calculated according to the following formula as with S7 analog input modules.

$$y_n = \frac{x_n + (k-1)y_{n-1}}{k}$$

where
y_n = smoothed value in the current cycle
x_n = value acquired in the current cycle n
k = smoothing factor

The following values can be configured for the module as the smoothing factor.

- 1 = No smoothing
- 4 = Weak smoothing
- 32 = Medium smoothing
- 64 = Strong smoothing

Set limit value 'low' / Set limit value 'high'

Requirements for the function

- Configuration of the threshold trigger for this data point
- PLC tag in the bit memory operand area or data area

  The analog value data point must be linked to a PLC tag in the bit memory or data area (data block). For PLC tags of hardware modules (input operand area) limit value configuration is not possible.

The configuration of limit values is pointless for measured values that have already been preprocessed on the CPU.

Function

In these two input boxes, you can set a limit value in the direction of the start of the measuring range or in the direction of the end of the measuring range. You can also evaluate the limit values, for example as the start or end of the measuring range.

Status identifier "OVER_RANGE"

If a limit value is overshot or undershot, the status identifier "OVER_RANGE" of the data point is set. This status identifiers are described in the section Status IDs of the data points (Page 66).

The "OVER_RANGE" bit of the status identifier of the data point is set as follows when the relevant analog value is transferred:

- Limit value 'high':
  - If the limit value is exceeded: OVER_RANGE = 1
  - If the value falls below the limit value: OVER_RANGE = 0
- Limit value 'low':
  - If the value falls below the limit value : OVER_RANGE = 1
  - If the value then exceeds the limit value: OVER_RANGE = 0

Configuration of the limit value

The limit value is configured as a whole decimal number. The range of values is based on the range of values of the raw value of analog input modules.

Range	Raw value (16 bits) of the PLC tag		Module output [mA]			Measuring range [%]
	Decimal	Hexadecimal	0 .. 20 (unipolar)	-20 .. +20 (bipolar)	4 .. 20 (life zero)	
Overflow	32767	7FFF	> 23.515	> 23.515	> 22.810	> 117.593
Overrange	32511 ... 27649	7EFF ... 6C01	23.515 ... 20.001	23.515 ... 20.001	22.810 ... 20.001	117.593 ... 100.004
Nominal range (unipolar / life zero)	27648 ... 0	6C00 ... 0000	20 ... 0		20 ... 4	100 ... 0

Range	Raw value (16 bits) of the PLC tag		Module output [mA]			Measuring range [%]
	Decimal	Hexadecimal	0 .. 20 (unipolar)	-20 .. +20 (bipolar)	4 .. 20 (life zero)	
Nominal range (bipolar)	27648 ... 0 ... -27648	6C00 ... 0000 9400		20 ... 0 ... -20		100 ... 0 ... -100
Underrange (unipolar / life zero)	-1 ... -4864	FFFF ... ED00	-0.001 ... -3.518		3.999 ... 1.185	-0.004 ... -17.59
Underrange (bipolar)	-27649 ... -32512	93FF ... 8100		-20.001 ... -23.516		-100.004 ... -117.593
Undershoot / wire break	-32768	8000	< -3.518		< 1.185	< -17.593

Note

Evaluation of the value even when the option is disabled

If you enable one or both options and configure a value and then disable the option later, the grayed out value is nevertheless evaluated.

To disable the two options, delete the previously configured values limit values from the input boxes and then disable the relevant option.

Recommendation for quickly fluctuating analog values:

If the analog value fluctuates quickly, it may be useful to smooth the analog value first if limit values are configured.

4.5.8 Message configuration

Configuring e-mails

If important events occur, the CP can send e-mails to a communications partner.

You configure the e-mail in STEP 7 in the editor for the data point and message configuration. You can find this using the project tree:

Project > directory of the relevant station > Local modules > CP

For the view in STEP 7, refer to the section Configuring the data points (Page 56).

Requirements and necessary information

Remember the following requirements in the CP configuration for the transfer of e-mails:

- Enabling telecontrol communication ("Communication types") parameter group
- Configuring the "E-mail configuration" parameter group (see "Security" parameter group)

  To do this, you require the following information:

  – Access data of the SMTP server: Address, port number, user name, password

  – Email address of the recipient

Trigger: Triggering e-mail transfer

Using the "Trigger" parameter group in the message table, you configure which of the following events triggers the sending of the e-mail.

- CPU changes to STOP.
- CPU changes to RUN.
- The connection to the partner is interrupted.
- The connection to the partner is re-established.
- A trigger signal is fired.

  For the trigger signal to send the e-mail, the edge change (0 → 1) of a trigger bit is evaluated that is set by the user program. When necessary, a separate trigger bit can be configured for each e-mail.

  If the memory area of the trigger bit is in the bit memory or in a data block, the trigger bit is reset to zero when the e-mail is sent.

With the "TeleControl Basic" protocol, the following events can be configured as the trigger of an e-mail:

- Connection establishment to the partner has failed.
- A TeleService session has started.
- A TeleService session has ended.

Include value Transfer the value of a PLC tag with a message

If you enable the option "Include value" in the "Trigger" parameter group, the CP sends a value for the placeholder $$ from the memory area of the CPU in the message. To do this enter "$$" as a placeholder for the value to be sent in the message text.

Select a PLC tag whose value will be integrated in the message. The value is entered in the message text instead of the placeholder $$.

$$ can be a placeholder for data point types with a simple data type up to a size of 32 bits.

Enable identifier for processing status

If this option is enabled in STEP 7, a status is output on the CP that provides information about the processing status of the sent message. The status is written to a PLC tag of the type DWORD. Select this tag via the "PLC tag for processing status" box.

If there are problems delivering messages, you can determine the status for example via the Web server of the CPU by displaying the value of the PLC tag there.

For the significance of the individual statuses, refer to the section Processing status of the telecontrol e-mails (Page 102).

4.5.9 Security > CP identification

CP identification

Only valid when using the "TeleControl Basic" protocol.

- Project number

  The project number is the same for all telecontrol CPs in a STEP 7 project. TCSB evaluates project numbers from 1 ... 2000. If you change the project number, this parameter is changed for all CPs in the STEP 7 project.

- Station number

  For each station with a telecontrol CP, an individual station number is configured. TCSB evaluates station numbers from 1 ... 8000.

- Telecontrol password

  Password for the authentication of the CP on the telecontrol server. 8 ... 29 characters of the ASCII character set 0x20...0x7e. The password can be the same for all CPs of the STEP 7 project.

  The same password is configured in the "TCSB" application for this station.

4.5.10 Security > DNP3 security options

Authentication and key exchange with the DNP3 protocol

If the Security functions are enabled, the master and station (CP) authenticate themselves with a secret key, the pre-shared key.

With the help of the common pre-shared key, after the first connection establishment between master and DNP CP session keys are agreed that are then renewed cyclically. Renewal of the session keys is normally initiated by the master. The criteria for renewing the key are specified in the following parameters.

- Authentication requests before key exchange
- Key exchange interval

As soon as one of these conditions is met, the session key is renewed.

DNP3 security options

- **Enable DNP3 security options**

  Method with which the CP authenticates itself to the master.

  – Disabled

    Non-secure authentication. If this option is selected the CP logs on only using its station address.

  – Enabled

    Secure authentication. If this option is selected, the CP and master use the DNP3 Security mechanisms. The parameters are configured as follows.

- **IKE mode**

  Selection of the mode for key exchange (IKE)

  – The Main Mode is the default mode.

  – The Aggressive Mode is somewhat faster but transfers the identity unencrypted.

- **Security statistics**

  Specifies whether the statistics of security events are sent to the master. Security events are authentication requests to the CP. If the option is enabled, authentication requests with date, time and result are saved on the CP and sent to the master for further evaluation.

- **SHA-1 interlock**

  Setting to select whether the CP may use the secure hash algorithm SHA-1 if "SHA-256" was configured as the Secure hash algorithm and the master does not support SHA-256. Meaning of the options:

  – SHA-1 mode allowed

    The CP can use SHA-1 if the master does not support SHA-256.

  – SHA-1 mode not allowed

    The CP may not use SHA-1.

    Note: If the master does not support SHA-256, no connection will be established if this option is selected.

- **Secure hash algorithm**

  Selection of the Secure Hash Algorithm (SHA). Possible selections:

  – SHA-1

  – SHA-256

- **Key wrap algorithm**

  Selection of the Advanced Encryption Standard (AES). Possible selections:

  – AES-128

  – AES-256

- **Key length**

  Length of the pre-shared key in bytes

  The following lengths are used depending on the key wrap algorithm.

  – For AES-128: 16 bytes

  – For AES-256: 32 bytes

- Max. number of key exchange requests

  The function is disabled.

- **Authentication requests before key exchange**

  Maximum number of authentication requests of the CP with the master before the session key is renewed.

  If you enter 0 (zero), the function is deactivated and the session key is renewed only depending on the key exchange interval.

  Recommendation: Set the number for the CP twice as high as for the master.

- **Key exchange interval**

  Period after which the session key is exchanged again between the CP and the master.

  If you enter 0 (zero), the function is deactivated and the key will never be renewed.

  The interval must be matched up on both communications partners.

- **Authentication timeout**

  Maximum waiting (seconds) time for the response from the master to an authentication request of the CP.

  Exceeding the wait time is evaluated as an error by the CP. In this case, the CP generates a Security event and sends this to the master.

  Range of values: 1 ... 65535

- **Pre-shared key**

  The pre-shared key of the CP must be identical to the pre-shared key that the master uses.

  The key must have the key length configured above (2 characters per byte).

  The pre-shared key can be configured in two ways:

  – Manual configuration

    Enter the pre-shared key manually as a hexadecimal value.

  – Import as file

    Import the pre-shared key from the file system of the engineering station if the pre-shared key was generated by the master or another system.

4.5.11 Security > E-mail configuration

E-mail configuration

- **No configuration**

  As default, the sending of e-mails is disabled.

- **Activate SMTP**

  Enable this option if you want to use the sending of unencrypted e-mails via SMTP port 25.

- **Enable SSL/TLS**

  If your e-mail service provider only supports encrypted transfer, enable this option. Select the protocol via the port number:

  – Port no. 587

    When using STARTTLS the CP sends encrypted e-mails.

  – Port no. 465

    When using SSL/TLS (SMTPS) the CP sends encrypted e-mails.

  Ask your e.mail service provider which option is supported.

  If you want to use an Internet connection with an IPv6 infrastructure, note the information in the section IPv6 (Page 41).

4.6 Security configuration(CP 1543SP-1)

4.6.1 VPN

4.6.1.1 VPN (Virtual Private Network)

VPN tunnel

Virtual Private Network (VPN) is a technology for secure transportation of confidential data in public IP networks, for example the Internet. With VPN, a secure connection (tunnel) is set up and operated between two secure IT systems or networks via a non-secure network.

One of the main features of the VPN tunnel is that it forwards all frames even from protocols of higher layers (HTTP, FTP etc.).

The data traffic between two network components is transported practically unrestricted through another network. This allows entire networks to be connected together via a neighboring or intermediate network.

Properties

- VPN forms a logical subnet that is embedded in a neighboring (assigned) network. VPN uses the usual addressing mechanisms of the assigned network, however in terms of the data, it transports its own frames and therefore operates independent of the rest of this network.
- VPN allows communication of the VPN partners with the assigned network.
- VPN is based on tunnel technology and can be individually configured.
- Communication between the VPN partners is protected from eavesdropping or manipulation by using passwords, public keys or a digital certificate (authentication).

Areas of application

- Local area networks can be connected together securely via the Internet ("site-to-site" connection).
- Secure access to a company network ("end-to-site" connection)
- Secure access to a server ("end-to-end" connection)
- Communication between two servers without being accessible to third parties (end-to-end or host-to-host connection)
- Ensuring information security in networked automation systems
- Securing the computer systems including the associated data communication within an automation network or secure remote access via the Internet
- Secure remote access from a PC/programming device to automation devices or networks protected by security modules via public networks.

Cell protection concept

With Industrial Ethernet Security, individual devices or network segments of an Ethernet network can be protected:

- Access to individual devices and network segments protected by security modules is allowed.
- Secure connections via non-secure network structures becomes possible.

Due to the combination of different security measures such as firewall, NAT/NAPT routers and VPN via IPsec tunnels, security modules protect against the following:

- Data espionage
- Data manipulation
- Unwanted access

4.6.1.2 Creating a VPN tunnel for S7 communication between stations

Requirements

To allow a VPN tunnel to be created for S7 communication between two S7 stations or between an S7 station and an engineering station with a security CP (for example CP 1628), the following requirements must be met:

- The two stations have been configured.
- The CPs in both stations must support the security functions.
- The Ethernet interfaces of the two stations are located in the same subnet.

Note

Communication also possible via an IP router

Communication between the two stations is also possible via an IP router. To use this communications path, however, you need to make further settings.

Procedure

To create a VPN tunnel, you need to work through the following steps:

1. Creating a security user

   If the security user has already been created: Log on as a user.
2. Select the "Activate security features" check box
3. Creating the VPN group and assigning security modules
4. Configure the properties of the VPN group
5. Configure local VPN properties of the two CPs

You will find a detailed description of the individual steps in the following paragraphs of this section.

Creating a security user

To create a VPN tunnel, you require appropriate configuration rights. To activate the security functions, you need to create at least one security user.

1. In the local security settings of the CP, click the "User login" button.

   Result: A new window opens.
2. Enter the user name, password and confirmation of the password.
3. Click the "Logon" button.

   You have created a new security user. The security functions are now available to you.

With all further logons, log on as user.

Select the "Activate security features" check box

After logging on, you need to select the "Activate security features" check box in the configuration of both CPs.

You now have the security functions available for both CPs.

Creating the VPN group and assigning security modules

1. In the global security settings, select the entry "Firewall" > "VPN groups" > "Add new VPN group".
2. Double-click on the entry "Add new VPN group", to create a VPN group.

   Result: A new VPN group is displayed below the selected entry.
3. In the global security settings, double-click on the entry "VPN groups" > "Assign module to a VPN group".
4. Assign the security modules between which VPN tunnels will be established to the VPN group.

Note

Current date and current time on the CP for VPN connections

Normally, to establish a VPN connection and the associated recognition of the certificates to be exchanged, the current date and the current time are required on both stations.

Configure the properties of the VPN group

1. Double-click on the newly created VPN group.

   Result: The properties of the VPN group are displayed under "Authentication".
2. Enter a name for the VPN group. Configure the settings of the VPN group in the properties.

   These properties define the default settings of the VPN group that you can change at any time.

Note

Specifying the VPN properties of the CPs

You specify the VPN properties of the CPs in the "Security" > "Firewall" > "VPN" parameter group of the relevant module.

Result

You have created a VPN tunnel. The firewalls of the CPs are activated automatically: The "Activate firewall" check box is selected as default when you create a VPN group. You cannot deselect the check box.

Download the configuration to all modules that belong to the VPN group.

4.6.1.3 VPN communication with SOFTNET Security Client (engineering station)

VPN tunnel communication works only if the internal node is disabled

Under certain circumstances the establishment of VPN tunnel communication between SOFTNET Security ClientSOFTNET Security Client and the CP fails.

SOFTNET Security Client also attempts to establish VPN tunnel communication to a lower-level internal node. This communication establishment to a non-existing node prevents the required communication being established to the CP.

To establish successful VPN tunnel communication to the CP, you need to disable the internal node.

Use the procedure for disabling the node as explained below only if the described problem occurs.

Disable the node in the SOFTNET Security Client tunnel overview:

1. Remove the checkmark in the "Enable active learning" check box.

   The lower-level node initially disappears from the tunnel list.
2. In the tunnel list, select the required connection to the CP.
3. With the right mouse button, select "Enable all members" in the shortcut menu.

   The lower-level node appears again temporarily in the tunnel list.
4. Select the lower-level node in the tunnel list.
5. With the right mouse button, select "Delete entry" in the shortcut menu.

Result: The lower-level node is now fully disabled. VPN tunnel communication to the CP can be established.

4.6.1.4 Establishment of VPN tunnel communication between the CP and SCALANCE M

Create a VPN tunnel between the CP and a SCALANCE M router as described for the stations.

VPN tunnel communication will only be established if you have selected the check box "Perfect Forward Secrecy" in the global security settings of the created VPN group ("VPN groups > Authentication").

If the check box is not selected, the CP rejects establishment of the tunnel.

4.6.1.5 CP as passive subscriber of VPN connections

Setting permission for VPN connection establishment with passive subscribers

If the CP is connected to another VPN subscriber via a gateway, you need to set the permission for VPN connection establishment to "Responder".

This is the case in the following typical configuration:

VPN subscriber (active) ⇔ gateway (dyn. IP address) ⇔ Internet ⇔ gateway (fixed IP address) ⇔ CP (passive)

Configure the permission for VPN connection establishment for the CP as a passive subscriber as follows:

1. In STEP 7, go to the devices and network view.
2. Select the CP.
3. Open the parameter group "VPN“ in the local security settings.
4. For each VPN connection with the CP as a passive VPN subscriber, change the default setting "Initiator/Responder" to the setting "Responder".

4.6.2 Firewall

4.6.2.1 Pre-check of messages by the MAC firewall.

Each incoming or outgoing frame initially runs through the MAC firewall (layer 2). If the frame is discarded at this level, it will not be checked by the IP firewall (layer 3). This means that with suitable MAC firewall rules, IP communication can be restricted or blocked.

4.6.2.2 Online diagnostics and downloading to station with the firewall activated

Setting the firewall - steps involved

With the security function enabled, follow the steps outlined below:

1. In the global security settings (see project tree), select the entry "Firewall > Services > Define services for IP rules".
2. Select the "ICMP" tab.
3. Insert a new entry of the type "Echo Reply" and another of the type "Echo Request".
4. Now select the CP in the ET 200SP station.
5. Enable the advanced firewall mode in the local security settings of the CP in the "Security > Firewall" parameter group.
6. Open the "IP rules" parameter group.
7. In the table, insert a new IP rule for the previously created global services as follows:
   - Action: Allow; "From external -> To station " with the globally created "Echo request" service
   - Action: Allow; "From station -> to external" with the globally created "Echo reply" service
8. For the IP rule for the Echo Request, enter the IP address of the PG/PC in "Source IP address". This ensures that only PING packets from your PG/PC can pass through the firewall.

4.6.2.3 Notation for the source IP address (advanced firewall mode)

If you specify an address range for the source IP address in the advanced firewall settings of the CP, make sure that the notation is correct:

- Separate the two IP addresses only using a hyphen.

  Correct: 192.168.10.0-192.168.10.255

- Do not enter any other characters between the two IP addresses.

  Incorrect: 192.168.10.0 - 192.168.10.255

If you enter the range incorrectly, the firewall rule will not be used.

4.6.2.4 Firewall settings for S7 connections via a VPN tunnel

IP rules in advanced firewall mode

If you set up configured connections (S7, OUC) with a VPN tunnel between the CP and a communications partner, you will need to adapt the local firewall settings of the CP:

In advanced firewall mode ("Security > Firewall > IP rules") select the action "Allow*" for both communications directions of the VPN tunnel.

4.6.3 Filtering of the system events

Communications problems if the value for system events is set too high

If the value for filtering the system events is set too high, you may not be able to achieve the maximum performance for the communication. The high number of output error messages can delay or prevent the processing of the communications connections.

In "Security > Log settings > Configure system events", set the "Level:" parameter to the value "3 (Error)" to ensure the reliable establishment of the communications connections.

4.7 Table "Certificate manager" (CP 1542SP-1 IRC, CP 1543SP-1)

If the Security functions are enabled, in the STEP 7 project the certificates for all Security modules involved are generated for example to allow communication via VPN connections.

Certificates generated by STEP 7 such as SSL certificates or VPN group certificates are automatically assigned to the corresponding modules and do not need to be assigned using the local security settings.

The local certificate manager

Certificates that were imported via the certificate manager in the global security settings are not automatically assigned to the corresponding modules. Imported certificates must be included in the list of trustworthy partner certificates manually via the entry "Certificate manager" in the local Security settings. When assigning a CA certificate the module is also assigned the certificates derived from it.

Parameter group "Security" > table "Certificate manager"

Via the local certificate manager assign certificates to the CP for certain services (e.g. secure sending of e-mails).

1. To do this, click the table cell "Add new".
2. Click on the button on a white background "...".
3. In the certificate list that opens, you can either add a new certificate using the "Add" button or select an existing certificate of the project using the check mark symbol.

   You can recognize the properties of the displayed certificates in the global certificate manager.

Certificates for the CP 1542SP-1 IRC

Requirement in the global security settings

For the secure sending of e-mails, import the certificate of the e-mail service provider into the certificate manager.

Assign the certificate in the CP configuration

Select the following certificate in the CP configuration:

- Table "Trustworthy client certificates":

  The certificate of the e-mail service provider

Certificates for the CP 1543SP-1

Before certificates can be referenced in the program blocks for Secure Communication, these certificates must be assigned to the Security module as device certificates via the local certificate manager.

Requirement in the global security settings

To be able to assign the CP certificate of a communications partner, you need to first import the certificates of the partner in the global certificate manager (Global security settings).

To make the assigned certificate known to the partner module, this certificate must be entered in the list of trustworthy partner certificates after import.

Assign the certificates in the CP configuration

Select the following certificates in the CP configuration:

- Table "Device certificates":

  The device certificate of the CP generated by STEP 7
- Table "Certificates of the partner devices":

  The imported certificate of the partner

Programming (OUC)

5

5.1 Program blocks for OUC

Using the program blocks for Open User Communication (OUC)

Connections of Open User Communication are not configured.

For TCP / UDP / ISO-on-TCP communication via Ethernet, the blocks of Open User Communication (OUC) listed below are used. For this, create a suitable program blocks. You will find details on the program blocks in the information system of STEP 7.

Note

Different program block versions

Note that in STEP 7 you cannot use different versions of a program block in a station.

Supported program blocks for OUC

Program blocks for all three CP types

The following instructions in the specified minimum version are available for programming Open User Communication for all three CP types:

- **TSEND_C V3.0 / TRCV_C V3.1**

  Compact blocks for connection establishment/termination and for sending and receiving data

  or

- **TCON V4.0 / TDISCON V2.1**

  Connection establishment / connection termination

- **TUSEND V4.0 / TURCV V4.0**

  Sending and receiving data via UDP

- **TSEND V4.0 / TRCV V4.0**

  Sending and receiving data via TCP or ISOonTCP

- **TMAIL_C V4.0**

  Sending e-mails

The program block can be found in STEP 7 in the "Instructions > Communication > Open User Communication" window.

Connection descriptions in system data types (SDTs)

For the connection description, the blocks listed above use the parameter CONNECT (or MAIL_ADDR_PARAM with TMAIL_C). The connection description is stored in a data block whose structure is specified by the system data type (SDT).

Creating an SDT for the data blocks

You create the SDT required for every connection description as a data block. You generate the SDT type in STEP 7 by entering the name (e.g. "TCON_Param") in the "Data type" box manually in the declaration table of block instead of selecting an entry from the "Data type" drop-down list. The corresponding SDT is then created with its parameters.

Depending on the security functions supported, the three CP types support the following SDTs:

SDTs for all three CP types

The following SDTs can be used by all three CP types:

- **TCON_Param**

  For transferring frames via TCP

- **TADDR_Param**

  For transferring frames via UDP

- **TCON_IP_RFC**

  For transferring frames via ISO-on-TCP

- **TMail_V4**

  For transferring e-mails addressing the e-mail server using an IPv4 address

- **TMail_V6**

  For transferring e-mails addressing the e-mail server using an IPv6 address

- **TMail_FQDN**

  For transferring e-mails addressing the e-mail server using the host name

You will find the description of the SDTs with their parameters in the STEP 7 information system under the relevant name of the SDT.

SDT for CP 1542SP-1 IRC and CP 1543SP-1

These two CP types can use the following SDT for e-mail connections with Security function:

- **TMail_V4_SEC**

  For secure transfer of e-mails addressing the e-mail server using an IPv4 address

- **TMail_QDN_SEC**

  For secure transfer of e-mails addressing the e-mail server using the host name

SDT only for CP 1543SP-1

The CP 1543SP-1 can use the following SDT for data transfer with Security function:

- **TCON_IP_V4_SEC**

  For the secure transfer of data via TCP

Connection establishment and termination

Connections are established using the program block TCON. Note that a separate program block TCON must be called for each connection.

A separate connection must be established for each communications partner even if identical blocks of data are being sent.

After a successful transfer of the data, a connection can be terminated. A connection is also terminated by calling "TDISCON".

Note

Connection abort

If an existing connection is aborted by the communications partner or due to disturbances on the network, the connection must also be terminated by calling TDISCON. Make sure that you take this into account in your programming.

Diagnostics and maintenance 6

6.1 Diagnostics options

The following diagnostics options are available.

LEDs of the module

For information on the LED displays, refer to the section LEDs (Page 25).

STEP 7: The "Diagnostics" tab in the Inspector window

Here, you can obtain the following information on the selected module:

- Entries in the diagnostics buffer of the CPU
- Information on the online status of the module

STEP 7: Diagnostics functions in the "Online > Online and diagnostics" menu

Using the online functions, you can read diagnostics information from the CP from an engineering station on which the project with the CP is stored. You obtain the following static information on the selected module:

- General information on the module
- Diagnostics status
- Information on the interfaces of the module

  Information on other functions of the module

If you want to operate online diagnostics with the station via the CP, you need to activate the online functions in the parameter group "Communication types" see the section Communication types (Page 44).

You will find further information on the diagnostics functions of STEP 7 in the STEP 7 information system.

Web server of the CPU

Via the CP you can access the Web server of the CPU and the information available there. For access, refer to the section Web server of the CPU (Page 100).

SNMP

For information on the functions, refer to the section Diagnostics with SNMP (Page 98).

6.2 Diagnostics with SNMP

Requirement

The requirement for using SNMP is the enabling of the function in the configuration, see section SNMP (Page 43).

SNMP (Simple Network Management Protocol)

SNMP is a protocol for diagnostics and managing networks and nodes in the network. To transmit data, SNMP uses the connectionless UDP protocol.

The information on the properties of SNMP-compliant devices is entered in MIB files (MIB = Management Information Base).

You will find detailed information on SNMP and the Siemens Automation MIB in the manual /6/ (Page 118).

Scope of performance of the CPs

The CPs support the following SNMP version:

- **CP 1542SP-1, CP 1542SP-1 IRC**
  - SNMPv1
- **CP 1543SP-1**
  - SNMPv1
  - SNMPv3 (with activated Security functions)

Traps are not supported by the CP.

Supported MIBs in SNMPv1

The CPs support the following MIBs:

- **MIB II (acc. to RFC1213)**

  The CP supports the following groups of MIB objects:
  - System
  - Interfaces
  - IP
  - ICMP
  - TCP
  - UDP
  - SNMP
- **LLDP MIB**
- **Siemens Automation MIB**

  Note the rights for writing to the MIB objects, see the next section (SNMPv3).

Supported MIB objects in SNMPv3

If SNMPv3 is enabled, the CP returns the contents of the following MIB objects:

- **MIB II (acc. to RFC1213)**

  The CP supports the following groups of MIB objects:

  – System

  – Interfaces

    The "Interfaces" MIB object provides status information about the CP interfaces.

  – IP (IPv4/IPv6)

  – ICMP

  – TCP

  – UDP

  – SNMP

  The following groups of the standard MIB II are not supported:

  – Adress Translation (AT)

  – EGP

  – Transmission

- **LLDP MIB**
- **Siemens Automation MIB**

  Note that write access is permitted only for the following MIB objects of the "System" group:

  – sysContact

  – sysLocation

  – sysName

    A set sysName is sent as the host name using DHCP option 12 to the DHCP server to register with a DNS server.

  For all other MIB objects and groups, only read access is possible for security reasons.

Access rights using community names (SNMPv1)

TCP uses the following community strings to control the permissions for access to the SNMP agent:

Table 6- 1 Access rights in the SNMP agent

Type of access	Community string *)
Read access	public
Read and write access	private

*) Note the use of lowercase letters!

6.3 Web server of the CPU

The Web server of the CPU

The CPU has a Web server which you can access from an engineering station using HTTP/HTTPS via the CP.

The Web server of the CPU provides a wide variety of functions for diagnostics and service purposes for example loading firmware files. You will find detailed information in the system manual /2/ (Page 117)and in the information system of STEP 7 in the topic and under the heading "Web server".

Requirements for access to the Web server

Permitted web browsers

You will find the Web browsers supported on the engineering station for access to the Web server of the CPU in the STEP 7 information system under the heading "Web server".

Requirements in the CPU configuration

1. Open the corresponding project on the engineering station.
2. Select the CPU of the station involved in STEP 7.
3. Select the "Web server" entry.
4. In the parameter group "General", select the "Enable Web server for this interface" option.
5. In the user management create a user with suitable rights on the CPU.

   To load firmware you need to assign this user the right to perform firmware updates in the access level.

   The user name and password are required later for access.
6. Configuration of the option "Allow access only using HTTPS" in the parameter group "General"

   Depending on whether you want to access the Web server using HTTP or HTTPS, the configuration of the parameter differs:

   – "Allow access only using HTTPS" enabled

     Connection establishment is possible only using HTTPS.

   – "Allow access only using HTTPS" disabled

     Connection establishment is possible using HTTP and HTTPS.

Additional requirements in the configuration of the CP 1543SP-1

Activate the firewall in the "Security" parameter group.

Depending on the protocol used you need to make the following further settings in the parameter group of the firewall "From external to station".

- With connection establishment using HTTP
  - Enable the "Allow HTTP" option.
  - Enable the "Allow HTTPS" option
    Reason: There is a switch to HTTPs after authentication on the Web server.
- With connection establishment using HTTPS
  - Disable the "Allow HTTP" option
  - Enable the "Allow HTTPS" option.

Establishing a connection to the Web server

Follow the steps below to connect to the Web server of the CPU from the engineering station.

These two variants are described in the following sections.

Connection establishment with HTTP

1. Connect the PC on which the new firmware file is located to the CP via the Ethernet interface.
2. Enter the address of the CP in the address box of your web browser:
   http://<IP address>
3. Press the Enter key.

   The start page of the Web server opens.
4. Click on the "Download certificate" entry at the top right of the window.

   The "Certificate" dialog opens.
5. Download the certificate to your PC by clicking the "Install certificate ..." button.

   The certificate is loaded on your PC.

   You will find information on downloading a certificate in the help of your Web browser and in the STEP 7 information system under the keyword "Certificates for Web server".

When the connection has changed to the secure mode HTTPS (https://<IP address>/..." in the address box of the Web server), you can work with the Web server for example download a firmware file (see the following section).

If you terminate the connection to the Web server, the next time you can log in with the Web server without downloading the certificate using HTTP.

Connection establishment with HTTPS

1. Connect the PC on which the new firmware is located to the CP or CPU via the Ethernet interface.
2. Enter the address of the CP in the address box of your web browser:
   https://<IP address>
3. Press the Enter key.

   The start page of the Web server opens.

You can work with the Web server.

Downloading firmware files via the Web server of the CPU

Requirement: The new firmware file is stored on your engineering station.

1. Log in on the start page of the Web server.
2. After logging in, select the entry "Module status" in the navigation panel of the Web server.
3. Select the CP in the module list.
4. Select the "Firmware" tab lower down in the window.
5. Browse for the firmware file on your PC using the "Browse..." button and download the file to the station using the "Run update" button.

Refer to the information on the duration of the firmware update in the section Downloading firmware (Page 104).

6.4 Processing status of the telecontrol e-mails

Configuration of the processing status of telecontrol e-mails (CP 1542SP-1 IRC)

The following status identifiers apply to e-mails configured with the message editor of the CP 1542SP-1 IRC, see also section Message configuration (Page 79).

E-mails sent via program blocks of Open User Communication return a different status via the block (see block help).

Processing status of the telecontrol e-mails

The meaning of the status of the "PLC tag for processing status" is as follows:

Table 6- 2 Meaning of the status ID output in hexadecimal format

Status	Meaning
0000	Transfer completed free of errors
82xx	Other error message from the e-mail server Apart from the leading "8", the message corresponds to the three-digit error number of the SMTP protocol.
8401	No channel available. Possible cause: There is already an e-mail connection via the CP. A second connection cannot be set up at the same time.
8403	No TCP/IP connection could be established to the SMTP server.
8405	The SMTP server has denied the login request.
8406	An internal SSL error or a problem with the structure of the certificate was detected by the SMTP client.
8407	Request to use SSL was denied.
8408	The client could not obtain a socket for creating a TCP/IP connection to the mail server.
8409	It is not possible to write via the connection. Possible cause: The communications partner reset the connection or the connection aborted.
8410	It is not possible to read via the connection. Possible cause: The communications partner terminated the connection or the connection was aborted.
8411	Sending the e-mail failed. Cause: There was not enough memory space for sending.
8412	The configured DNS server could not resolve specified domain name.
8413	Due to an internal error in the DNS subsystem, the domain name could not be resolved.
8414	An empty character string was specified as the domain name.
8415	An internal error occurred in the cURL module. Execution was aborted.
8416	An internal error occurred in the SMTP module. Execution was aborted.
8417	Requests to SMTP on a channel already being used or invalid channel ID. Execution was aborted.
8418	Sending the e-mail was aborted. Possible cause: Execution time exceeded.
8419	The channel was interrupted and cannot be used before the connection is terminated.
8420	Certificate chain from the server could not be verified with the root certificate of the CP.
8421	Internal error occurred. Execution was stopped.
8450	Action not executed: Mailbox not available / unreachable. Try again later.
84xx	Other error message from the e-mail server Apart from the leading "8", the message corresponds to the three-digit error number of the SMTP protocol.
8500	Syntax error: Command unknown. This also includes the error of having a command chain that is too long. The cause may be that the e-mail server does not support the LOGIN authentication method. Try sending e-mails without authentication (no user name).
8501	Syntax error. Check the following configuration data: Alarm configuration > E-mail data (Content): • Recipient address ("To" or "Cc").

Status	Meaning
8502	Syntax error. Check the following configuration data: Alarm configuration > E-mail data (Content): • Email address (sender)
8535	SMTP authentication incomplete. Check the "User name" and "Password" parameters in the CP configuration.
8550	SMTP server cannot be reached. You have no access rights. Check the following configuration data: • CP configuration > E-mail configuration: – User name – Password – Email address (sender) • Alarm configuration > E-mail data (Content): – Recipient address ("To" or "Cc").
8554	Transfer failed
85xx	Other error message from the e-mail server Apart from the leading "8", the message corresponds to the three-digit error number of the SMTP protocol.

6.5 Downloading firmware

New firmware versions of the CP

If a new firmware version is available for the CP, you will find this on the Internet pages of Siemens Industry Online Support:

Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/dl)

Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/dl)

There are three different ways of loading a new firmware file on the CP:

- Saving the firmware file on the memory card of the CPU

  You will find a description of the procedure for loading on the memory card of the CPU on the Internet page of Industry Online Support shown above.

- Loading the firmware with the online functions of STEP 7 via Ethernet / Internet

  The description of these methods follows.

- Downloading the firmware via the Web server of the CPU

  You will find the description of these methods in the section Web server of the CPU (Page 100).

Note

Duration of the firmware update

Downloading a new firmware file can take several minutes.

Note that the procedure takes longer the larger the station due to I/O modules.

Always wait until the completion of the firmware update can be recognized from the LEDs (LED pattern "Maintenance demanded" - End of the firmware update).

Loading the firmware with the online functions of STEP 7 via Ethernet / Internet

Requirements:

- The CP or the CPU can be reached via the IP address.
- The engineering station and the CP are located in the same subnet.
- The new firmware file is stored on your engineering station.
- The engineering station is connected to the network.
- The relevant STEP 7 project is open on the engineering station.

Procedure:

1. Select the CP or the CPU of the station whose CP you want to update with new firmware.
2. Enable the online functions using the "Connect online" icon.
3. In the "Connect online" dialog, select the Ethernet interface in the "Type of PG/PC interface" list box.
4. Select the slot of the CP or the CPU.

   Both methods are possible.
5. Click on "Start search" to search for the module in the network and to specify the connection path.

   When the module is found it is displayed in the table.
6. Connect using the "Connect" button.

   The "Connect online" wizard guides you through the remaining steps in installation.
7. In the network view, select the CP and select the "Online & Diagnostics" shortcut menu (right mouse button).
8. In the navigation panel of the Online & Diagnostics view select the entry "Functions > Firmware update".
9. Using the "Browse" button (parameter group "Firmware loader") search for the new firmware file in the file system of the engineering station.
10. Start to download the firmware with the "Start update" button when the correct version of the signed firmware is displayed in the "Status" output box.

You will find further information on the online functions in the STEP 7 information system.

6.6 Module replacement

CAUTION

Read the system manual "SIMATIC ET 200SP Distributed I/O System"

Prior to installation, connecting up and commissioning, read the relevant sections in the system manual "SIMATIC ET 200SP Distributed I/O System" refer to the documentation in the Appendix.

When installing and connecting up, keep to the procedures described in the system manual "SIMATIC ET 200SP Distributed I/O System".

Make sure that the power supply is turned off when installing/uninstalling the devices.

Module replacement

The STEP -7 project data of the CP is stored on the local CPU. If there is a fault on the device, this allows simple replacement of the CP without needing to download the project data to the station again.

When the station starts up again, the new CP reads the project data from the CPU.

Technical specifications

7

Technical specifications		
Article numbers	CP 1542SP-1	6GK7542-6UX00-0XE0
	CP 1542SP-1 IRC	6GK7542-6VX00-0XE0
	CP 1543SP-1	6GK7543-6WX00-0XE0
Attachment to Industrial Ethernet		
Quantity	1	
Design	Slot for bus adapter	
Properties	100BASE-TX, IEEE 802.3-2005, half duplex/full duplex, autocrossover, autonegotiation, galvanically isolated	
Transmission speed	10/100 Mbps	
Permitted cable lengths Ethernet, copper, at 100 Mbps *		
Cable type - Copper	Max. lengths	
TP Torsion Cable	• Max. 55 m TP Torsion Cable with IE FC RJ45 Plug 180 • Max. 45 m TP Torsion Cable with IE FC RJ45 + 10 m TP Cord via IE FC RJ45 Outlet	
TP FC Marine Cable, TP FC Trailing Cable, TP FC Flexible Cable, TP FC FRNC Cable, TP FC Festoon Cable, TP FC Food Cable	• Max. 55 m TP Torsion Cable with IE FC RJ45 Plug 180 • Max. 75 m TP Torsion Cable + 10 m TP Cord via IE FC RJ45 Outlet	
TP FC Standard Cable	• Max. 100 m TP FC Standard Cable with IE FC RJ45 Plug 180 • Max. 90 m TP FC Standard Cable + 10 m TP Cord via IE FC RJ45 Outlet	
Permitted cable lengths Ethernet, fiber-optic cable (FO cable), at 100 Mbps *		
Cable type - Glass FO (multiode).	Max. lengths	
• FO FRNC Cable GP, FO Standard Cable GP, FO Ground Cable, FO Trailing Cable, FO Trailing Cable GP, FO Robust Cable GP	• Max. 2000 m	
• INDOOR FO cable, FO standard cable, flexible FO, trailing cable	• Max. 750 m	
• FO Robust Cable GP	• Max. 2000 m	
Cable type - PCF and plastic FO cable	Max. lengths	

Technical specifications		
• POF Standard Cable GP 980/1000, POF Trailing Cable 980/1000	• Max. 50 m	
• PCF Standard Cable GP, PCF Trailing Cable, PCF Trailing Cable GP	• Max. 100 m	
Electrical data		
External power supply (X80), design	Socket Terminal block for socket	Two terminals with reverse polarity protection 2 x two terminal for single or redundant power supply
Power supply (external)	• Type of voltage • Permitted low limit • Permitted high limit	• 24 VDC • 19.2 V • 28.8 V
Current consumption	• From 24 VDC (external) • From backplane bus (3.3 V)	• 250 mA (typ.) • 4 mA (typ.)
Maximum Inrush current	(Rated value)	12 A
Effective power loss	(typical)	6 W
Permitted ambient conditions		
Ambient temperature	During operation with the rack installed horizontally	0 .. + 60 °C
	During operation with the rack installed vertically	0 .. + 50 °C
	During storage	-40 .. +70 °C
	During transportation	-40 .. +70 °C
Relative humidity	During operation	≤ 95 % at 25 °C, no condensation
Design, dimensions and weight		
Module format	Compact module ET 200SP	
Degree of protection	IP20	
Weight		
• Without bus adapter	• 180 g	
• With bus adapter 2xRJ45	• 230 g	
Dimensions (W x H x D)	60 x 117 x 74 mm	
Installation options	DIN rail (35 mm)	
Mean Time Between Failures (MTBF)		
• At + 40 °C	• 56.87 years	
• At + 60 °C	• 24.78 years	
Product functions **		

***** For details of the cable lengths see ET 200SP system manual, /2/ (Page 117).

****** You will find additional properties and performance data in the section Application and functions (Page 11).

Approvals

A

Approvals issued

Note

Issued approvals on the type plate of the device

The specified approvals apply only when the corresponding mark is printed on the product. You can check which of the following approvals have been granted for your product by the markings on the type plate.

Scope of validity of the approvals

The approvals listed below are valid for the CP.

The tests required for the approvals were performed with a plugged-in bus adapter.

The bus adapters have their own approvals, that are not listed here.

EC declaration of conformity

CE

The CP meets the requirements and safety objectives of the following EU directives and it complies with the harmonized European standards (EN) for programmable logic controllers which are published in the official documentation of the European Union.

- **2014/34/EU (ATEX explosion protection directive)**

  Directive of the European Parliament and the Council of 26 Febrary 2014 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres, official journal of the EU L96, 29/03/2014, pages. 309-356

- **2014/30/EU (EMC)**

  EMC directive of the European Parliament and of the Council of February 26, 2014 on the approximation of the laws of the member states relating to electromagnetic compatibility.; official journal of the EU L96, 29/03/2014, pages. 79-106

- **2011/65/EU (RoHS)**

  Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, official journal of the EC L174, 01/07/2011, page 88-110

The EC Declaration of Conformity is available for all responsible authorities at:

Siemens Aktiengesellschaft
Division Process Industries and Drives
Process Automation
DE-76181 Karlsruhe
Germany

You will find the EC Declaration of Conformity on the Internet at the following address:

Link: (https://support.industry.siemens.com/cs/ww/en/ps/)

> Entry type: "Certificates", certificate type: "EC declaration of conformity"

IECEx

The CP meet the requirements of explosion protection according to IECEx.

IECEx certificate: IECEx DEK 14.0089X

The CP meets the requirements of the following standards:

- IEC 60079-0

  Hazardous areas - Part 0: Equipment - General requirements

- EN 60079-15

  Explosive atmospheres - Part 15: Equipment protection by type of protection 'n'

You can see the current versions of the standards in the IECEx certificate that you will find on the Internet at the following address:

Link: (https://support.industry.siemens.com/cs/ww/en/ps/)

The conditions must be met for the safe deployment of the CP according to the section Notes on use in hazardous areas according to ATEX / IECEx (Page 31).

You should also note the information in the document "Use of subassemblies/modules in a Zone 2 Hazardous Area" that you will find on the Internet at the following address:

Link: (https://support.industry.siemens.com/cs/ww/en/view/78381013)

ATEX

The CP meets the requirements of the EC directive 2014/34/EU "Equipment and Protective Devices for Use in Potentially Explosive Atmospheres".

Applied standards:

- EN 60079-0

  Hazardous areas - Part 0: Equipment - General requirements

- EN 60079-15

  Explosive atmospheres - Part 15: Equipment protection by type of protection 'n'

The current versions of the standards can be seen in the EC Declaration of Conformity, see above.

ATEX approval: II 3 G Ex nA IIC T4 Gc

Test number: DEKRA 12 ATEX0240 X

The conditions must be met for the safe deployment of the CP according to the section Notes on use in hazardous areas according to ATEX / IECEx (Page 31).

You should also note the information in the document "Use of subassemblies/modules in a Zone 2 Hazardous Area" that you will find on the Internet at the following address:

Link: (https://support.industry.siemens.com/cs/ww/en/view/78381013)

EMC

The CP meets the requirements of the EC Directive 2014/30/EU "Electromagnetic Compatibility" (EMC directive).

Applied standards:

- EN 61000-6-4

  Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

- EN 61000-6-2

  Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments

RoHS

The CP meets the requirements of the EC directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Applied standard:

- EN 50581:2012

c(UL)us

Applied standards:

- Underwriters Laboratories, Inc.: UL 61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements)
- IEC/UL 61010-2-201 (Safety requirements for electrical equipment for measurement, control and laboratory use. Particular requirements for control equipment)
- Canadian Standards Association: CSA C22.2 No. 142 (Process Control Equipment)

Report / UL file: E85972 (NRAG, NRAG7)

cULus Hazardous (Classified) Locations

Underwriters Laboratories, Inc.: CULUS Listed E223122 IND. CONT. EQ. FOR HAZ. LOC.

Applied standards:

- ANSI ISA 12.12.01
- CSA C22.2 No. 213-M1987

APPROVED for Use in:

- Cl. 1, Div. 2, GP. A, B, C, D T4
- Cl. 1, Zone 2, GP. IIC T4

Ta: Refer to the temperature class on the type plate of the CP

Report / UL file: E223122 (NRAG, NRAG7)

Note the conditions for the safe deployment of the CP according to the section Notes on use in hazardous areas according to UL HazLoc (Page 31).

FM

Factory Mutual Approval Standard Class Number 3600, 3611, 3810

Class I, Division 2, Group A, B, C, D, T4 or Class I, Zone 2, Group IIC, T4

Ta: Refer to the temperature class on the type plate of the CP

Australia - RCM

The CP meets the requirements of the AS/NZS 2064 standards (Class A).

Marking for the customs union

EAC (Eurasian Conformity)

Customs union of Russia, Belarus and Kazakhstan

Declaration of the conformity according to the technical regulations of the customs union (TR CU)

MSIP 요구사항 - For Korea only

Certification Number: MSIP-REM-S49-ET200SP

A급 기기(업무용 방송통신기자재)

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며, 가정 외의 지역에서 사용하는것을 목적으로 합니다.

Current approvals

SIMATIC NET products are regularly submitted to the relevant authorities and approval centers for approvals relating to specific markets and applications.

If you require a list of the current approvals for individual devices, consult your Siemens contact or check the Internet pages of Siemens Industry Online Support:

Link: (http://support.automation.siemens.com/WW/view/en/45605894)

Dimension drawings

B

All dimensions in the dimension drawings are in millimeters.

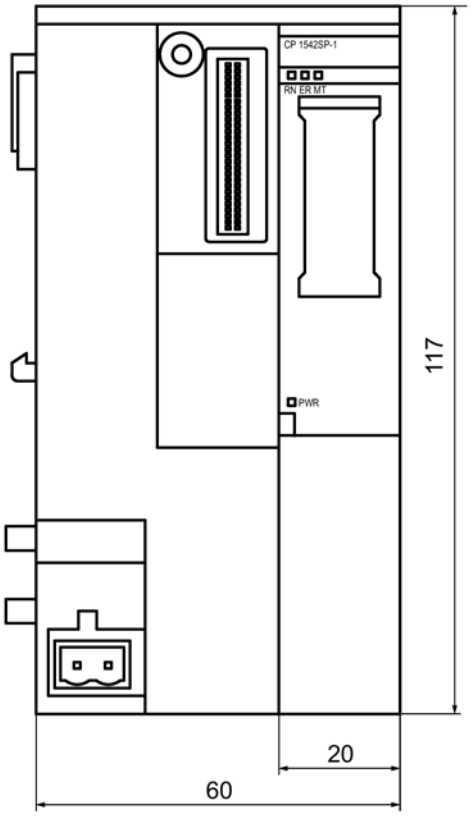


Figure B-1 Front view of the CP

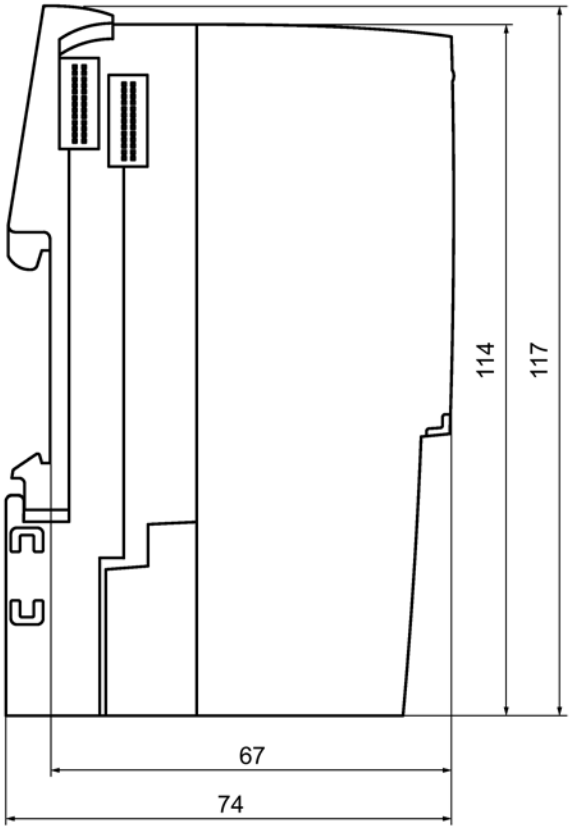


Figure B-2 Side view (left) of the CP

Accessories

C

C.1 BusAdapter

BusAdapter

To connect to the Ethernet network, the CP requires a BusAdapter. A BusAdapter does not ship with the CP.

Figure C-1 Example of a bus adapter, here BA SCRJ/RJ45

The CP supports the following bus adapters:

- BA 2×RJ45

  PROFINET bus adapter with the following connectors:

  – 2 x Ethernet jack RJ-45

  Article number: 6ES7193-6AR00-0AA0

- BA 2xFC

  PROFINET bus adapter with the following connectors:

  – 2 x direct connection of the bus cable (FastConnect)

  Article number: 6ES7193-6AF00-0AA0

- BA 2xSCRJ

  PROFINET bus adapter with the following connectors:

  – 2 x fiber-optic cable POF/PCF

  Article number: 6ES7193-6AP00-0AA0

- BA SCRJ/RJ45

  PROFINET bus adapter, media converter FO - copper with the following connectors:

  – 1 x fiber-optic cable POF/PCF

  – 1 x Ethernet jack RJ-45

  Article number: 6ES7193-6AP20-0AA0

- BA SCRJ/FC

  PROFINET bus adapter, media converter FO - copper with the following connectors:

  – 1 x fiber-optic cable POF/PCF

  – 1 x direct connection of the bus cable (FastConnect)

  Article number: 6ES7193-6AP40-0AA0

- BA 2xLC

  PROFINET bus adapter, media converter FO - copper with the following connectors:

  – 2 x fiber-optic cable glass fiber

  Article number: 6ES7193-6AG00-0AA0

- BA LC/RJ45

  PROFINET bus adapter, media converter FO - copper with the following connectors:

  – 1 x fiber-optic cable glass fiber

  – 1 x Ethernet jack RJ-45

  Article number: 6ES7193-6AG20-0AA0

- BA LC/FC

  PROFINET bus adapter, media converter FO - copper with the following connectors:

  – 1 x fiber-optic cable glass fiber

  – 1 x direct connection of the bus cable (FastConnect)

  Article number: 6ES7193-6AG40-0AA0

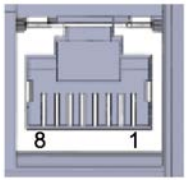
You will find further details in the manual /2/ (Page 117) and in the Siemens Industry Mall in Link: (https://mall.industry.siemens.com).

C.2 Assignment of the Ethernet interface of the bus adapter

Pinout of the Ethernet interface

The table below shows the pin assignment of the Ethernet interface. The pin assignment corresponds to the Ethernet standard 802.3-2005, 100BASE-TX version.

Table C- 1 Pin assignment of the Ethernet interface

View of the RJ-45 jack	Pin	Signal name	Assignment
	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

Documentation references

D

Where to find Siemens documentation

- Article numbers

  You will find the article numbers for the Siemens products of relevance here in the following catalogs:

  – SIMATIC NET - Industrial Communication / Industrial Identification, catalog IK PI

  – SIMATIC - Products for Totally Integrated Automation and Micro Automation, catalog ST 70

  You can request the catalogs and additional information from your Siemens representative. You will also find the product information in the Siemens Industry Mall at the following address:

  Link: (https://mall.industry.siemens.com)

- Manuals on the Internet

  You will find SIMATIC NET manuals on the Internet pages of Siemens Industry Online Support:

  Link: (https://support.industry.siemens.com/cs/ww/en/ps/15247/man)

  Go to the required product in the product tree and make the following settings:

  Entry type “Manuals”

- Manuals on the data medium

  You will find manuals of SIMATIC NET products on the data medium that ships with many of the SIMATIC NET products.

/1/

SIMATIC
CP 1542SP-1, CP 1542SP-1 IRC, CP 1543SP-1
Operating instructions
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/man)
Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man)

/2/

SIMATIC
ET 200SP - Distributed I/O System
system manual
Siemens AG
Link: (http://support.automation.siemens.com/WW/view/en/58649293)

/3/

SIMATIC NET
TeleControl Server Basic (Version V3)
Operating Instructions
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/6/

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Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/15392/man)

/7/

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Industrial Ethernet / PROFINET
System manual
Siemens AG

- Industrial Ethernet
  Link: (https://support.industry.siemens.com/cs/ww/de/view/27069465)
- Passive network components
  Link: (https://support.industry.siemens.com/cs/ww/en/view/84922825)

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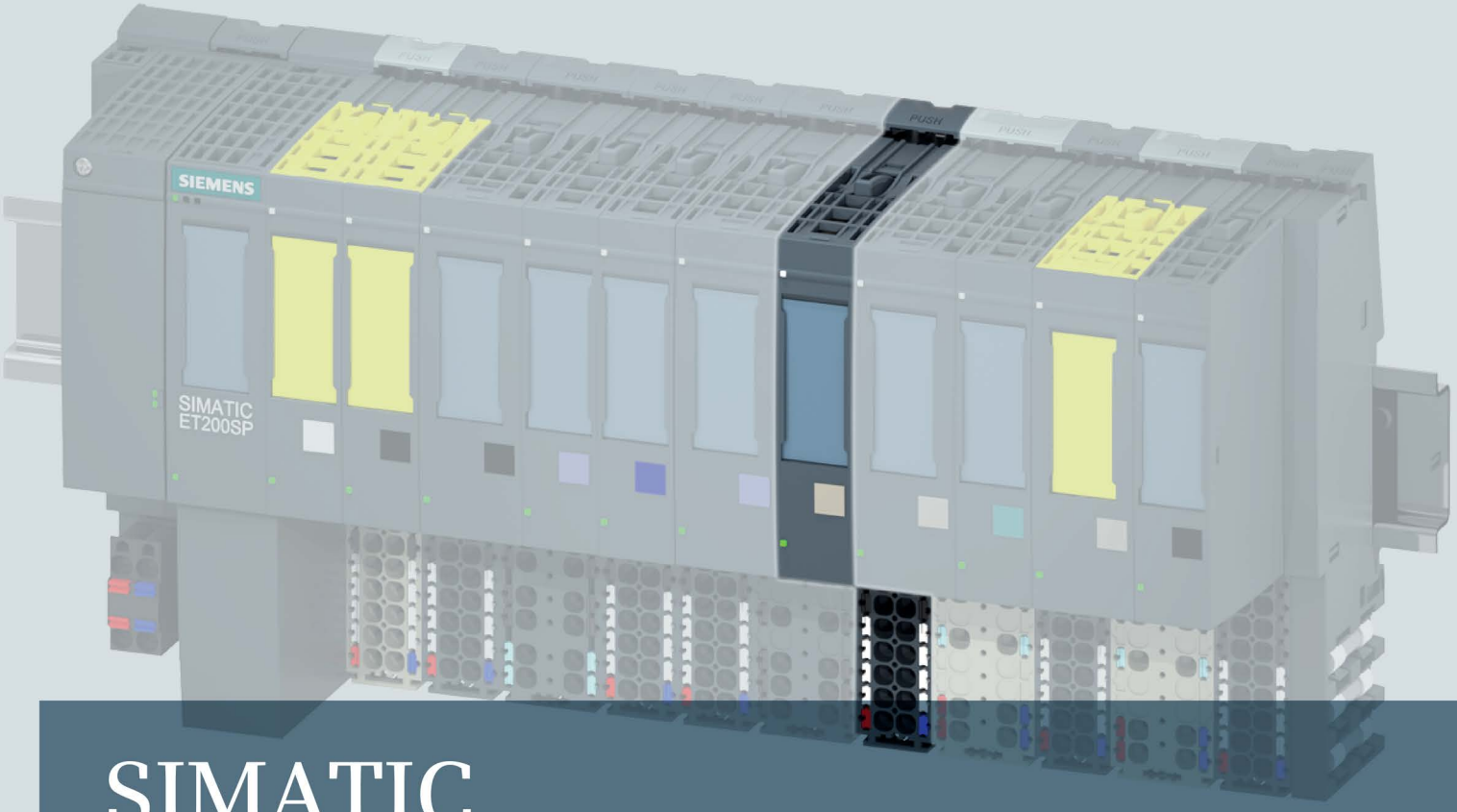

SIMATIC

ET 200SP

Communication module IO-Link Master CM 4xIO-Link (6ES7137-6BD00-0BA0)

Manual

Edition 02/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
Communication module
IO-Link Master CM 4xIO-Link
(6ES7137-6BD00-0BA0)

Manual

Preface

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Product overview 2

Connecting 3

Parameters/address space 4

Diagnostic alarms 5

Technical specifications 6

Appendix A

02/2015

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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A5E03856846-AC
℗ 02/2015 Subject to change

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual. It describes functions that generally affect the ET 200SP distributed I/O system.

The information provided in this manual and in the system manual and function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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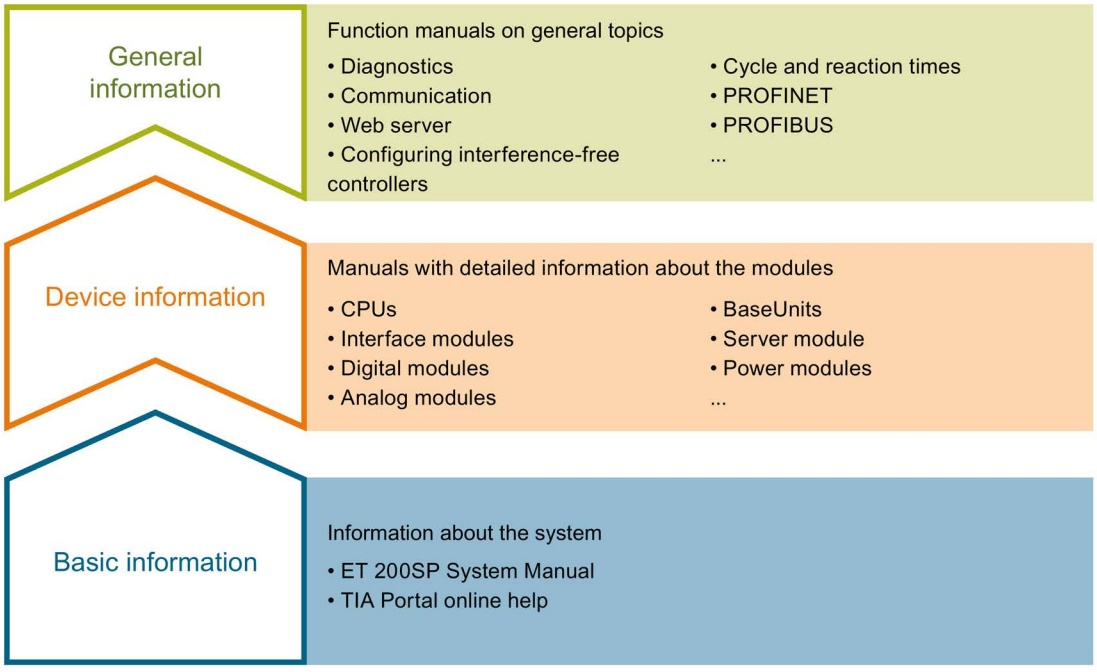
Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

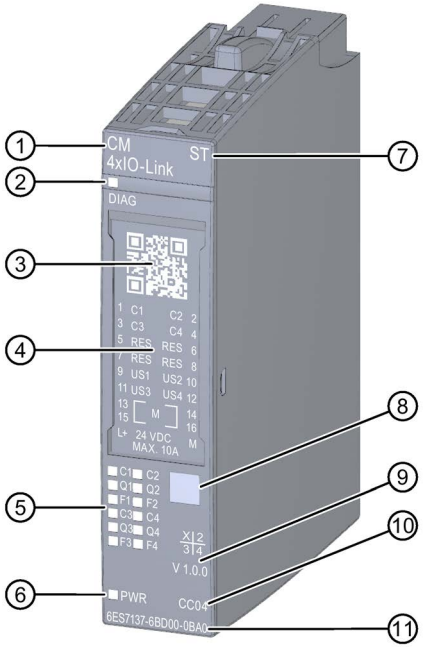
2

2.1 Properties

Article number

6ES7137-6BD00-0BA0

View of the module



① Module type and name
② LED for diagnostics
③ QR code
④ Connection diagram
⑤ LEDs for status and error displays
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-1 View of the IO-Link Master CM 4xIO-Link communication module

Properties

The module has the following technical properties:

- IO-Link master according to IO-Link specification V1.1
- Serial communication module with 4 ports (channels)
- Data transmission rate COM1 (4.8 kbaud), COM2 (38.4 kbaud), COM3 (230.4 kbaud)
- SIO mode (standard IO mode)
- Suitable for connecting up to 4 IO-Link devices (3-wire connection) or 4 standard actuators or encoders
- Programmable diagnostics function by port

The module supports the following functions:

Table 2- 1 Version dependencies of the module functions

Function	Firmware version of the module
Firmware update	V1.0 or higher
Identification and maintenance data (I&M)	V1.0 or higher
PROFIenergy	V1.0 or higher
Parameter assignment of the IO-Link parameters by means of S7-PCT	V1.0 or higher
Module replacement with automatic data recovery without engineering for IO-Link master and IO-Link device	V1.0 or higher
Time-based IO (time stamping)	V2.0 or higher
Variable address area of I/O data with up to 32 bytes inputs and 32 bytes outputs	V2.0 or higher
Variable address area of I/O data with up to 144 bytes inputs and 128 bytes outputs	V2.1 or higher

The module can be used with the following engineering tools:

Table 2- 2 Engineering tools depending on the firmware version of the module

Firmware version of the module	S7-PCT	STEP 7 (TIA Portal)	STEP 7 V5.5	GSD file
V1.0 (in PROFINET station)	V3.0 or higher	V12 SP1 or higher	As of V5.5 SP3 with HSP0231 as of V1.0	X
V1.0.3 (in PROFIBUS station)	V3.1 or higher	V13 or higher	As of V5.5 SP3 with HSP0231 as of V1.0	X
V2.0	V3.2 or higher	As of V13 (Time-based IO only with CPU S7-1500)	As of V5.5 SP3 with HSP0231 as of V1.0 (without Time-based IO)	X (without Time-based IO)
V2.1	As of V3.3 and SupportedModules.xml V1.2	As of V13 SP1 with HSP0136 as of V1.0 (Time-based IO only with CPU S7-1500)	As of V5.5 SP4 with HSP0231 as of V4.0 (without Time-based IO)	X (without Time-based IO)

Accessories

The following accessories can be used with the module and are not included in the scope of delivery:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual in the Accessories/Spare parts section.

2.2 Functions

IO-Link is a point-to-point connection between a master and a device. Both conventional and intelligent sensors/actuators can be used as devices at the IO-Link via unshielded standard cables using proven 3-wire technology. IO-Link is backward compatible with conventional digital sensors and actuators. The circuit state and data channel are designed in proven 24 V DC technology.

Reference

Additional information can be found in the IO-Link System (http://support.automation.siemens.com/WW/view/en/65949252) function manual.

2.3 Replacement of the IO-Link Master CM 4xIO-Link communication module with an electronic coding element

If you remove the communication module from the BaseUnit, part of the electronic coding element remains in the BaseUnit. The parameters of the IO-Link Master CM 4xIO-Link and of the IO-Link devices are stored in this part. A newly inserted (but not yet configured) IO-Link master takes over the parameters from the electronic coding element.

⚠ CAUTION

Removal and insertion

Plugging in the IO-Link Master CM 4xIO-Link communication module when the load is switched on can result in dangerous conditions in your plant.

The ET 200SP distributed I/O system may be damaged as a result.

The IO-Link Master CM 4xIO-Link communication module should only be plugged in or pulled out when the load is switched off.

Reference

For more information on the topic of "Coding element", refer to the Changing the type of an I/O module chapter of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.4 Time-based IO

Time-based IO ensures that signals are output with a precisely defined response time. A combination of inputs and outputs allows, for example, passing products to be measured precisely or liquids to be dosed optimally.

As of firmware version V2.0.0, the IO-Link master supports the Time-based IO function. You configure the connected IO-Link devices with time stamp functionality as normal with the SIMATIC S7 Port Configuration Tool (S7-PCT). In the "Ports" tab in S7-PCT, set the necessary parameters in the "Operating mode" section:

- IO-Link_Time_based_IO_IN
- IO-Link_Time_based_IO_OUT
- IO-Link_Time_based_IO_INOUT

The Time-based IO function can be used for IO-Link master with 32 bytes I/O data. Larger I/O data ranges are not supported by Time-based IO.

Note

Time stamp function

The time stamp function requires defined address assignment (mapping).

If the address area you require is already occupied, you must modify the user data arrangement of the IO-Link devices in the address space of the IO-Link master.

The "High-precision input/output with Time-based IO" function manual describes how to move user data in the address space.

Reference

You can find more information about Time-based IO in the High-precision input/output with Time-based IO (http://support.automation.siemens.com/WW/view/en/82527590) function manual.

2.5 Reset communication module to factory settings

Effects of resetting to the factory settings

Use the "Reset to factory settings" function to restore the parameter assignments of your IO-Link Master CM 4xIO-Link communication module made with S7-PCT to the factory state.

After a "Reset to factory settings", the parameters of the IO-Link Master CM 4xIO-Link communication module are assigned as follows:

- The ports are in DI mode
- The ports are mapped to the relative addresses 0.0 ... 0.3
- The PortQualifier is disabled
- I&M data 1 to 3 is deleted
- The electronic coding element (if it exists) is deleted

Note

The device parameters are deleted and the factory state is restored.

You should reset a removed IO-Link Master CM 4xIO-Link communication module to the factory settings before you place it in storage.

Procedure

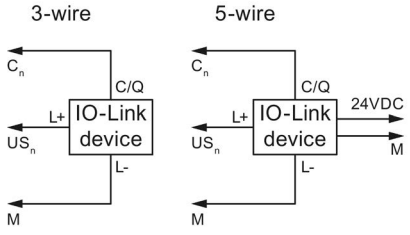
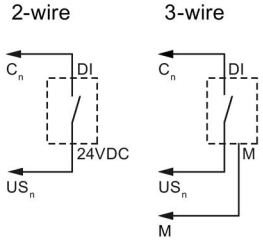
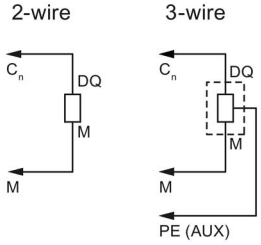
To perform a "Reset to factory settings", proceed as described in the S7-PCT online help.

Connecting

3

3.1 Pin assignment

Terminal assignment for the IO-Link Master CM 4xIO-Link communication module (6ES7137-6BD00-0BA0)						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Notes**	**BaseUnits**[1]	**Color coding label**
1	C1	**2**	C2	• C_n: Communication signal, DI, DQ • RES: reserved, may not be assigned • US_n: Supply voltage (positive) • M: Ground	A0	 CC04 6ES7193-6CP04-2MA0
3	C3	**4**	C4			
5	RES	**6**	RES			
7	RES	**8**	RES			
9	US1	**10**	US2			
11	US3	**12**	US4			
13	M	**14**	M			
15	M	**16**	M			
L+	24VDC	**M**	Ground			

Connection examples		
IO-Link operating mode	**Operating mode DI**	**Operating mode DQ**
		

[1] see also system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)

NOTICE

Internal encoder supply

Use only the supply voltage (US_n/M) made available by the IO-Link Master CM 4xIO-Link communication module to supply the IO-Link device (L+/L-).

3.2 Block diagram

The following figure shows the block diagram of the IO-Link Master CM 4xIO-Link communication module.

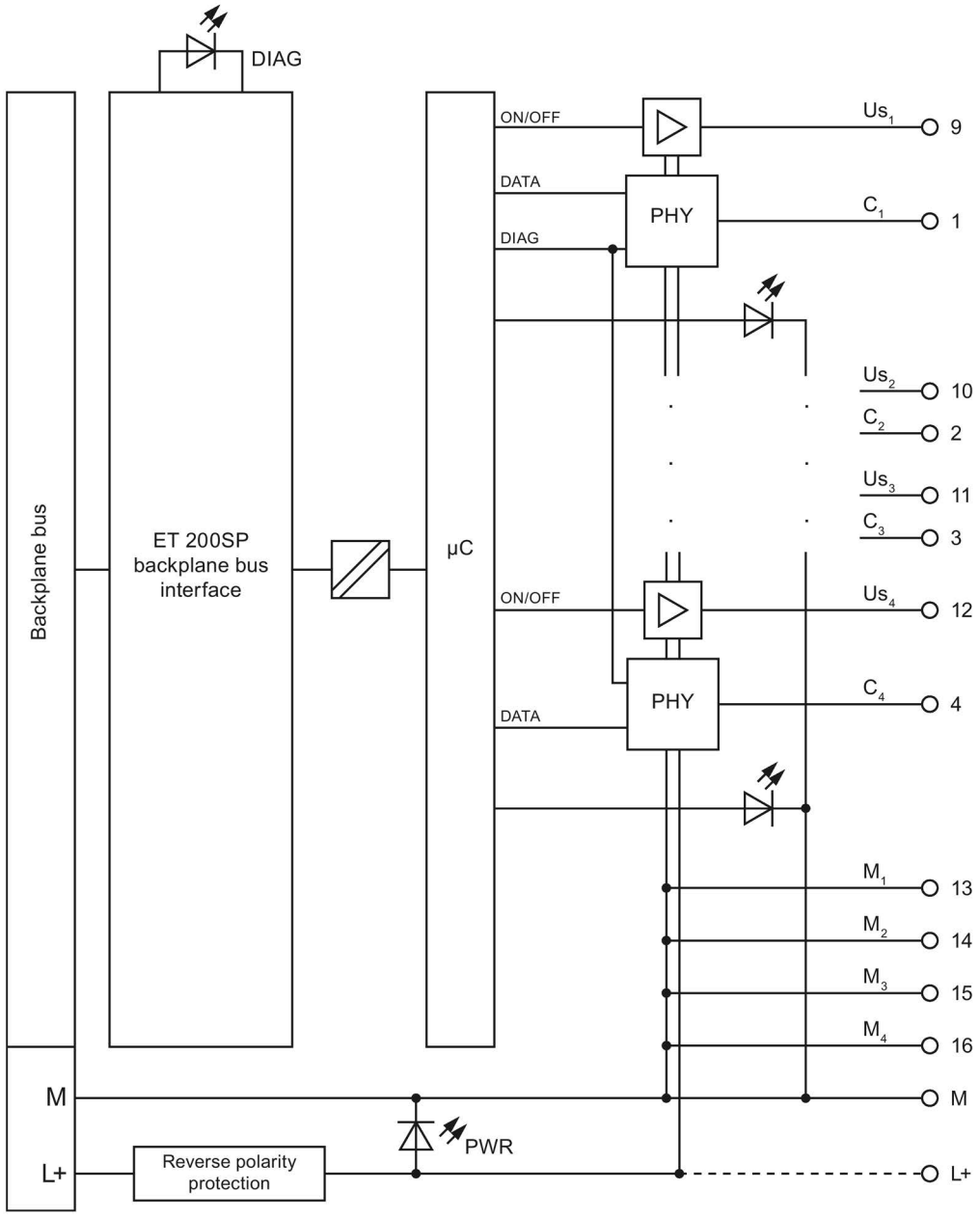


Figure 3-1 Block diagram

Parameters/address space

4

4.1 Parameters

GSD file parameters

The following table shows the parameters for the IO-Link Master CM 4xIO-Link communication module.

Table 4- 1 Parameters (GSD file)

Parameters	Value range	Default	Configuration in RUN	Efficiency range
Diagnostics missing supply voltage L+	• disable • enable	disable	Yes	Module
Diagnostics port 1	• disable • enable	disable	Yes	Port (channel)
Diagnostics port 2	• disable • enable	disable	Yes	Port (channel)
Diagnostics port 3	• disable • enable	disable	Yes	Port (channel)
Diagnostics port 4	• disable • enable	disable	Yes	Port (channel)
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module

4.2 Declaration of parameters

Diagnostics Supply voltage L+ missing

Enabling the diagnostic alarm for missing or insufficient supply voltage L+.

Diagnostics port 1 to port 4

This parameter allows diagnostics to be individually enabled for the four IO-Link ports.

The following assignment applies here:

- Port 1 → Channel 1
- Port 2 → Channel 2
- Port 3 → Channel 3
- Port 4 → Channel 4

Potential group

With the "Potential group" parameter, you specify whether the module is inserted on a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the black BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Address space of the IO-Link Master CM 4xIO-Link communication module

The size of the input and output addresses of the IO-Link Master CM 4xIO-Link communication module with firmware version V1.0 is 32 bytes in each case. As of firmware version V2.0, the modules support a variable address space for I/O data. You specify the assignment of the IO-Link devices in S7-PCT.

The following table lists the possible settings of the supported address spaces for I/O data:

Supported address space for I/O data	IO-Link master with firmware V1.0	IO-Link master with firmware V2.0	IO-Link master with firmware V2.1
1 byte input/1 byte output		X	X
2 bytes inputs/2 bytes outputs		X	X
8 bytes inputs/8 bytes outputs		X	X
16 bytes inputs/16 bytes outputs		X	X
32 bytes inputs/32 bytes outputs	X	X	X
64 bytes inputs/64 bytes outputs			X
144 bytes inputs[1]/128 bytes outputs			X

[1] The address area 144 bytes inputs comprises additional quality information (port qualifier) as well as the 128 bytes process data.

Note

Use of the IO-Link Master CM 4xIO-Link with I/O data > 32 bytes

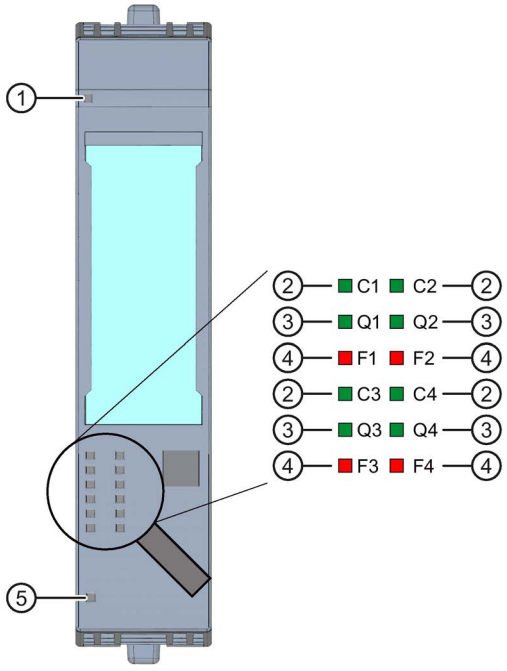
IM 155-6 PN HF/ST interface modules with firmware versions up to V3.0 only support I/O data up to 32 bytes. If you are using IO-Link Master CM 4xIO-Link with I/O data > 32 bytes, you need the IM 155-6 PN HF/ST interface module with firmware version as of V3.1.

Diagnostic alarms

5

5.1 Status and error displays

LED display



①	Diagnostics (DIAG)	(green/red)
②	Port status (Cn)	(green)
③	Channel status (Qn)	(green)
④	Port error (Fn)	(red)
⑤	Supply voltage L+ (PWR)	(green)

n - Channel number

Figure 5-1 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the Diagnostic alarms (Page 22) chapter.

LED DIAG

Table 5- 1 DIAG LED fault display

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module is not configured
On	Module parameterized and no module diagnostics
Flashes	Module parameterized and module diagnostics

Cn LEDs

Table 5- 2 Status displays of C1, C2, C3 and C4 LEDs

C1, C2, C3 or C4	Meaning
Off	Port disabled or in SIO mode
Flashes	Port in IO-Link mode, device not connected or port not connected with the configured device
On	Port in IO-Link mode, device not connected

Qn LEDs

Table 5- 3 Status displays of Q1, Q2, Q3 and Q4 LEDs

Q1, Q2, Q3 or Q4	Meaning
Off	Process signal = 0 in SIO mode, deactivated or in IO-Link mode
On	Process signal = 1 in SIO mode

Fn LEDs

Table 5- 4 F1, F2, F3 and F4 LED error displays

F1, F2, F3 or F4	Meaning
☐ Off	No error
■ On	Error

LED PWR

Table 5- 5 Status display of the PWR LED

PWR	Meaning
☐ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

5.2 Diagnostic alarms

Module errors are indicated as diagnostics (module status) only in IO-Link mode.

Table 5- 6 Error types

Diagnostic alarm	Error code	Meaning (IO-Link error code)	IO-Link master	IO-Link device
Short-circuit	1_H	• Short-circuit in the process cables on the IO-Link device (1804_H)	X	
		• Short-circuit on IO device (7710_H)		X
Undervoltage	2_H	• Supply voltage too low (5111_H, 5112_H)		X
Overvoltage	3_H	• Supply voltage too high (5110_H)		X
Overheating	5_H	• Temperature exceeded on master (1805_H)	X	
		• Temperature exceeded on device (4000_H, 4210_H)		X
Wire break	6_H	• No IO-Link device connected • There is a break in the signal line to the IO-Link device • IO-Link device cannot communicate due to another error (1800_H)	X	
Overflow	7_H	• Process tag range exceeded ($8C10_H$) • Measuring range exceeded ($8C20_H$)		X
Underflow	8_H	• Process tag range too low ($8C30_H$)		X
Error	9_H	• All IO-Link error codes which are not listed here are mapped to this PROFIBUS DP error		X
Configuration error	10_H	• Cannot configure IO-Link master (1882_H, 1883_H) • Incorrect device (1802_H) • Storage error (1886_H)	X	
		• Device was not configured correctly (6320_H, 6321_H, 6350_H)		X
Supply voltage missing	11_H	• L+ supply voltage for device missing (1806_H) • L+ supply voltage for device too low (<20 V) (1807_H)	X	
Defective fuse	12_H	• Fuse on device is defective (5101_H)		X
Safety shutdown	19_H	• Serious error (master has to be replaced) (1880_H)	X	
External fault	$1A_H$	• Error in data storage (1809_H, $180A_H$, $180B_H$, $180C_H$, $180D_H$) • Consistency error in electronic coding element (1885_H) • More than 6 errors are pending simultaneously on the IO-Link device (1808_H)	X	

Technical specifications

6

Technical specifications of the IO-Link Master CM 4xIO-Link communication module

	6ES7137-6BD00-0BA0
Product type designation	ET 200SP, CM 4xIO-Link
General information	
Firmware version	V2.1
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 / -
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4 (in compatibility mode Firmware V1.0)
PROFIBUS as of GSD version/GSD revision	- / GSD as of revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
Supply voltage	
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V; 20.5 V if IO-Link is used, because the supply voltage for IO-Link devices on the master must be at least 20 V.
Valid range high limit (DC)	28.8 V
Polarity reversal protection	Yes
Input current	
Current consumption, max.	45 mA; without load
Encoder supply	
Number of outputs	4
Output current, rated value	200 mA
Power loss	
Power loss, typ.	1 W
Digital outputs	
Cable length	
Cable length unshielded, max.	20 m; also applies to shielded cables

	6ES7137-6BD00-0BA0
IO-Link	
Number of ports	4
Number of ports	
• of which can be controlled at the same time	4
IO-Link protocol 1.0	Yes
IO-Link protocol 1.1	Yes
Transmission rate	4.8 kBd (COM1); 38.4 kBd (COM2), 230.4 kBd (COM3)
Cycle time, min.	2 ms; dynamic, dependent on the user data length
Size of process data, input per port	32 byte; max.
Size of process data, input per module	144 byte; max.
Size of process data, output per port	32 byte; max.
Size of process data, output per module	128 byte; max.
Memory size for device parameters	2 Kbyte; for each port
Cable length unshielded, max.	20 m; max.
Operating modes	
IO-Link	Yes
DI	Yes
DO	Yes; max. 100 mA
Connection of IO-Link devices	
Port type A	Yes
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes; only for PROFINET
Constant bus cycle time	Yes
Bus cycle time (TDP), min.	250 µs
Jitter, max.	36 µs; typical +/-
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	
Diagnostic interrupt	Yes; the port diagnostics is only available in IO-Link mode.
Diagnostic alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Diagnostic indicator LED	
Monitoring of supply voltage	Yes, green PWR LED
Channel status display	Yes; per channel one green LED for channel status Qn (SIO mode) and PORT status Cn (IO-Link mode)
For channel diagnostics	Yes; red Fn LED
For module diagnostics	Yes; green / red DIAG LED

	6ES7137-6BD00-0BA0
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between the different circuits	75 V DC / 60 VAC (basic insulation)
Insulation	
Insulation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	30 g

Overview of the response time

The following figure shows the response time for IO-Link without Time-based IO.

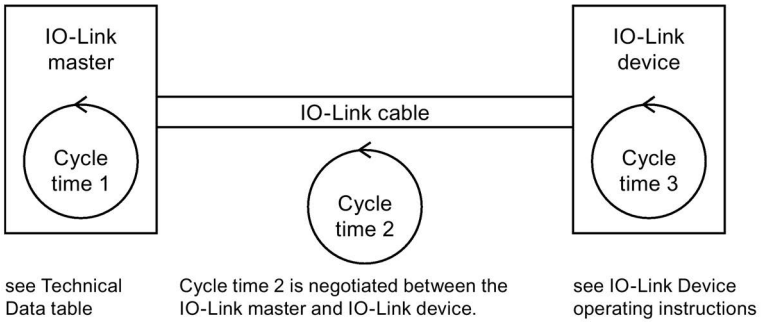


Figure 6-1 Cycle time for IO-Link without Time-based IO

Dimensional drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Appendix A

A.1 Parameter data record

Configuration in the user program

You can configure the modules in runtime.

Changing parameters in runtime

The module parameters are included in data record 128. You can transmit the modifiable parameters to the module with the WRREC instruction. The parameters set with STEP 7 are not changed in the CPU by this action.

Instruction for configuration

The following instruction is provided for configuring the IO-Link Master CM 4xIO-Link communication module in the user program:

Table A- 1 Instruction for configuration

Instruction	Application
SFB 53 "WRREC"	Transfer of the alterable parameters to the selected module of the ET 200SP.

Note

If you transfer invalid parameters to the module with the SFB 53 "WRREC" instruction, the module discards the transferred parameters and works with the last valid parameter assignment.

Error message

In the event of an error the following return value is reported:

Table A- 2 Error message

Error code	Meaning
$80B1_H$	Error in data length
$80E0_H$	Error in header information
$80E1_H$	Parameter error

Structure of data record 128

Table A- 3 IO-Link parameters

Offset	Description	Type	Default	Description
0	Version	1 byte	0x02	Shows the structure of the record 0x02 for the IO-Link master in accordance with IO-Link V1.1
1	Parameter length	1 byte	0x02	Parameter length (2 bits + 2 headers)
IO-Link start parameters				
2	Port diagnostics (Port1 1 to n)	1 byte	0x00	Activating the diagnostics for port 1 to n
3	Module properties	1 byte	0x00	Load voltage diagnostics

Table A- 4 Data record: Version

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved		Major version (00)		Minor version (0010)			

Table A- 5 Data record: Port diagnostics

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved				EN_Port4	EN_Port3	EN_Port2	EN_Port1

EN_Portx:

0 = Diagnostics deactivated

1 = Diagnostics activated

Table A- 6 Data record: Module properties

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved						EN_L+	Reserved

EN_L+:

0 = No diagnostics, if no voltage is applied

1 = Diagnostics, if L+ connected

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SIMATIC

ET 200SP

AS-Interface Master CM AS-i Master ST (3RK7137-6SA00-0BC1)

Manual

Edition 05/2015

Answers for industry.

SIEMENS

SIMATIC

ET 200SP
AS-Interface master
CM AS-i Master ST
(3RK7137-6SA00-0BC1)

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 05/2015 Subject to change

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Foreword

Purpose of the documentation

This device manual supplements the "ET 200SP Distributed I/O System" System Manual. Functions that pertain generally to the ET 200SP can be found in the "ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)" System Manual.

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

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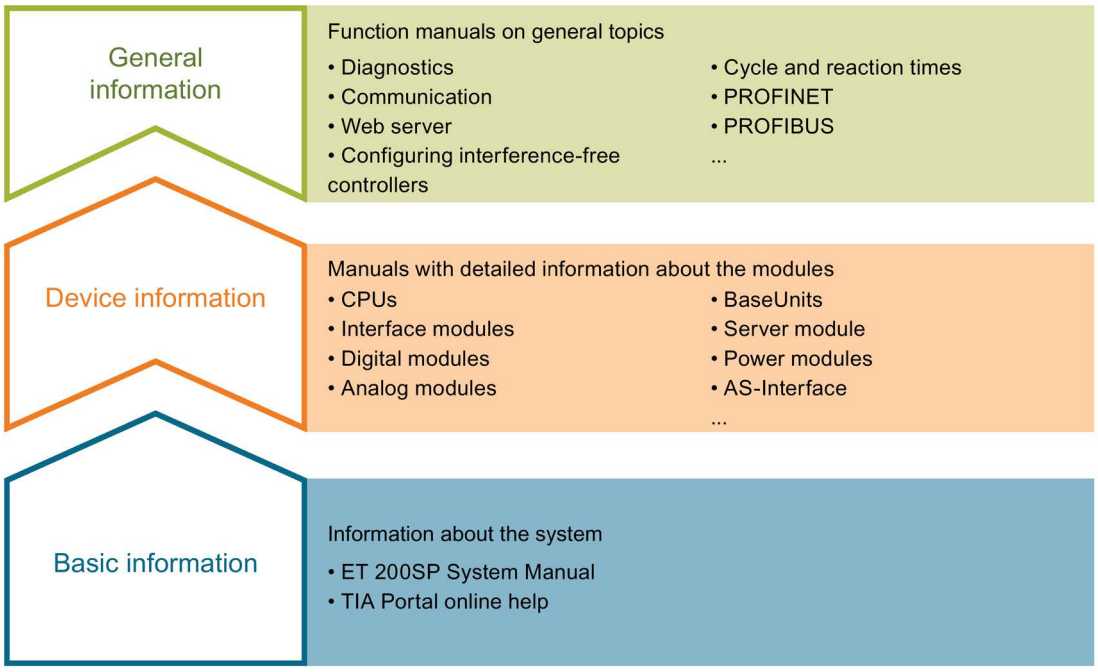
Documentation guide

1

The following paragraph gives you an overview of the additional documentation you need to use the CM AS-i Master ST.

The documentation for the SIMATIC ET200 SP distributed I/O system is subdivided into three areas.

This enables you to access the required content quickly.



Basic information

The System Manual describes configuration, assembly, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The *STEP 7* online help supports you with configuration and programming.

Device information

Manuals contain a compact description of the module-specific information, such as properties, connection diagrams, characteristics and technical specifications.

General information

The Function Manuals contain detailed descriptions on topics relating to the SIMATIC ET 200SP environment, such as configuring diagnostics, communications, web servers and controllers for problem-free operation.

The following paragraph gives you an overview of the additional documentation you need to use the CM AS-i Master ST.

Documentation for the ET 200SP distributed I/O system with the CM AS-i master ST

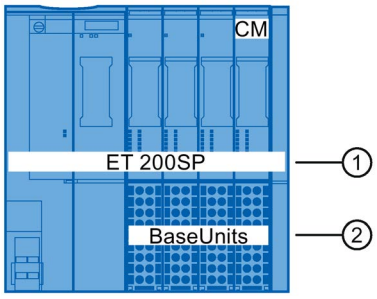


Figure 1-1 Example of a system structure

Table 1- 1 Documentation for the ET 200SP distributed I/O system with the CM AS-i master ST

No.	Component	Documentation	Most important contents
①	System	SIMATIC ET 200SP ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en) SIMATIC distributed I/O (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx)	• Application planning • Installation • Connecting • Commissioning • Technical specifications
②	BaseUnits	SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521)	• Connecting • Technical specifications

Changes and additions to the manuals are documented in the Product Information.

Safety instructions

2

Important safety instructions

⚠ WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

For use in Pollution Degree 2 Environment.

⚠ WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

When used in hazardous hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or a suitable enclosure. To comply with EU Directive 94/9 (ATEX 95), this enclosure must meet the requirements of at least IP54 in compliance with EN 60529.

⚠ WARNING

Explosion Hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not disconnect equipment when a flammable or combustible atmosphere is present.

⚠ WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not disconnect while circuit is live unless area is known to be non-hazardous.

⚠ WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Substitution of components may impair suitability for class I, division 2 or zone 2.

⚠ WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not open when energized.

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

The equipment is designed for operation with Safety Extra-Low Voltage (SELV) by a Limited Power Source (LPS).

This means that only SELV / LPS complying with IEC 60950-1, EN 60950-1, VDE 0805-1 must be connected to the power supply terminals.

The power supply unit for the equipment power supply must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 40 %. This criteria is fulfilled if supples are derived from SELV (Safety Extra-Low Voltage) only.

CAUTION

Failure to observe this information may result in property damage and bodily injury

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D or non-hazardous locations only.

CAUTION

Failure to observe this information may result in property damage and bodily injury

This equipment is suitable for use in Class I, Zone 2, Group IIC or non-hazardous locations only.

Product overview

3

3.1 Characteristics of the CM AS-i Master ST

Article number

3RK7137-6SA00-0BC1

Brief introduction to AS-Interface

AS-Interface or Actuator-Sensor-Interface (AS-i for short) is a fieldbus system for industrial use that is used to transmit digital and analog signals between a controller and machine or process in real-time. The system can be used for standard signals as well as for safety-related signals.

AS-Interface is designed to connect actuators and sensors to the controller as easily, flexibly and efficiently as possible.

The system consists of an AS-i master and up to 62 AS-i slaves that are simply plugged onto the yellow AS-i flat ribbon cable at any point or connected via terminals. The AS-i cable can be up to 100 m long with free choice of topology. A length of up to 200 m is possible with an additional extension plug. The system can be extended beyond that through the use of repeaters.

In addition, an AS-i power supply unit is connected to the cable such that the slaves and their connected sensors are supplied with operating voltage without additional cabling. Actuators are usually supplied with voltage by means of a 24 V cable, because they generally need more power than sensors.

A typical digital AS-i slave has up to 4 inputs and 4 outputs. The slaves are installed directly in the plant as close as possible to the sensors or actuators so that the connecting cables can be kept very short. The insulation displacement method is the preferred method for connection to the AS-i flat ribbon cable so that assembly can be completed without errors in the least amount of time. For safety-related signals, safety slaves and modules are available for safety-related processing of signals. In addition, analog slaves and complete switchgear with integrated AS-i slave are offered.

The default voltage fed in from the AS-i power supply unit is 30 V DC. As a result, sensors with a rated voltage of 24 V can be used without any problems despite the voltage drop on a longer AS-i cable. Because the AS-i cable transmits both operating DC voltage and modulated communication signals, the AS-i power supply unit contains a data decoupling unit for separating the two voltage waveforms.

A standard power supply can be used in place of the easy-to-use AS-i power supply if the AS-i cable is connected via a separate data decoupling module. When a standard power supply with 24 V DC is used, it must be ensured that the connected AS-i components and sensors are designed for operation with the corresponding lower voltage.

You will find further information on the Internet at: AS-Interface (http://www.siemens.com/as-interface).

Use of the module

The CM AS-i Master ST module is a communication module for use in the SIMATIC ET 200SP Distributed I/O System.

The CM AS-i Master ST features a 20 mm wide ET 200SP module housing. A BaseUnit (BU) is required for use in the ET 200SP. The CM AS-i Master ST can be plugged into C0-type BaseUnits (BU).

You can plug several CM AS-i Master ST modules into one SIMATIC ET 200SP station. Each CM AS-i Master with firmware version V1.0 occupies 32 bytes of I/O address space. From firmware version V1.1 onwards, the CM AS-i Master ST supports up to 288 bytes of I/O address space. The number of possible AS-i master modules depends on the maximum address space of the utilized Interface Module (IM) of the ET 200SP or the utilized ET 200SP CPU.

In a SIMATIC ET 200SP station with an IM 155-6 PN ST standard interface module and a maximum address space of 256 bytes, up to eight CM AS-i Master ST modules can be plugged in (when the I/O address space is configured as 32 bytes).

Significantly more modules can be plugged into a SIMATIC ET 200SP station with High Feature Interface Module IM 156-6 PN HF and a maximum address space of 1440 bytes.

If the ET 200SP contains other modules, the available address space is reduced and the maximum number of AS-i master modules is reduced accordingly. The maximum number of modules can be increased by shortening the I/O address space of the CM AS-i Master ST module.

For further information, see the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/84133942).

The CM AS-i Master ST module can generally be combined with all ET 200SP interface modules. Any exceptions to this are documented in the delivery release product announcement(s) of the interface module.

The CM AS-i Master ST module (Firmware V1.1 and higher) can generally be combined with all ET 200SP CPU modules (Firmware V1.8 and higher). Any exceptions to this are documented in the delivery release product announcement(s) for a CPU module.

The interface modules und CPU modules differ, among other things, in terms of the maximum number of I/O modules, the length of the I/O process image in the station and the length of the I/O process image for each I/O module. The technical specifications of the interface modules and CPU modules can limit the selection of possible parameters of the CM AS-i Master ST module. Note, in particular, that the length of the I/O process image of the CM AS-i Master ST module must be selected in such a way that the maximum length of the I/O process image of the interface module or CPU module is not exceeded.

View of the module

Figure 3-1 View of the CM AS-i Master ST

Properties

- Technical properties
  - AS-i master acc. to AS-Interface Specification 3.0
  - Transmission of digital I/O values to cyclic process image
  - Transmission of analog I/O values in the cyclic process image (Firmware V1.1 and higher) or via acyclic data record communication.
  - Configuration button can be connected to terminals
- Supported functions
  - I&M identification data
  - Firmware update
  - Configuration of the AS-i master and AS-i slaves via data records (Read / Write or command interface)

The module can be used with the following engineering versions:

Table 3- 1 Version dependence of the CM AS-i Master ST engineering versions

Firmware version of the module	*STEP 7* (TIA portal)	*STEP 7* V5.5	GSD file
V1.0	V12 and higher	V5.5 SP3 HF5 and higher	X
V1.1	V13 SP1 and higher	V5.5 SP3 HF5 and higher	X

For additional information, see product announcement for: CM AS-i Master ST (https://support.industry.siemens.com/cs/ww/en/view/72865595)

Table 3- 2 Version dependence of the CM AS-i Master ST functions

Function	Firmware version of the module
Configuring in *STEP 7* (TIA Portal) V12 and higher	V1.0 and higher
GSD file (PROFIBUS)	V1.0 and higher
GSD file (PROFINET)	V1.0 and higher
Access via command data records	V1.0 and higher
Structure of the process image: 32 bytes	V1.0 and higher
Transmission of digital I/O values in the cyclic process image	V1.0 and higher
Transmission of analog I/O values via data record transfer	V1.0 and higher
Firmware update	V1.0 and higher
Duplicate address detection	V1.0 and higher
Automatic address programming with manual writing of the ID1 code	V1.0 and higher
Write ID1 code to AS-i address "0"	V1.0 and higher
Configuring in *STEP 7* (TIA Portal) V13 SP1 and higher	V1.1 and higher
Status information for all slaves of the AS-i master system (TIA Portal)	V1.1 and higher
Detailed, device-specific diagnostics (TIA Portal)	V1.1 and higher
Configuring in *STEP 7* V5.5 and higher	V1.1 and higher
Option handling	V1.1 and higher
Proxy slave	V1.1 and higher
Structure of the process image: Up to 288 bytes, adjustable length	V1.1 and higher
Transmission of analog I/O values via process data	V1.1 and higher
Variable address area for I/O data	V1.1 and higher
Automatic address programming with automatic writing of the ID1 code	V1.1 and higher
AS-i slave_ID1_write_with_target_address	V1.1 and higher
Automatic duplicate address detection for AS-i voltage of either 24 V or 30 V	V1.1 and higher

Accessories

The following components can be used with the module:

- Labeling strips
- Reference identification label

3.2 Operating modes of the CM AS-i Master ST

The AS-i master has two operating modes:

- "Configuration mode"
- "Protected operation"

"Configuration mode"

"Configuration mode" can be used for commissioning an AS-i installation. You can also use "configuration mode" for productive operation. The AS-i bus configuration is not defined in this case. This means that error messages for a change of bus configuration are not possible.

You switch the AS-i master from "protected operation" to "configuration mode" in *STEP 7*. The "CM" LED (Configuration Mode) then lights up green.

In "configuration mode", the AS-i master can exchange data with every AS-i slave that is connected to the AS-i cable. This does not apply to AS-i slaves with the address "0". The AS-i master immediately detects and activates newly added AS-i slaves and includes them in cyclic data exchange. The digital process data of the connected AS-i slaves are stored according to a fixed scheme in the process image starting from a configurable start address. See "Transmitting AS-i digital values (Page 50)". The digital process image for the inputs of non-existent slaves is filled with the substitute value "0". Analog process data can only be accessed by means of data record communication.

In "configuration mode", configuration errors of AS-i slaves are not signaled to the higher-level station via an alarm and are not indicated by the "DIAG" LED.

"Protected operation"

In "protected operation", the AS-i master only exchanges data with the configured AS-i slaves. In case of changes to the bus configuration, error messages are automatically generated if diagnostics is enabled. See "Parameter assignment/addressing (Page 47)".

Configuration can be performed:

- By configuring the AS-i slaves in the *STEP 7* project (Configuration of the AS-i slaves in STEP 7 (Page 32))
- By transferring the slave configuration with the online "ACTUAL → CONF" function in *STEP 7* (Applying the slave configuration (Page 39))
- By calling the command interface in the SIMATIC user program with the following commands:
  - Store_Actual_Configuration (Page 113)
  - Write_overall_configuration (Page 130)
- Using the connected "SET" button (Configuration of the AS-i slaves using the "SET" button (Page 35))

If you have configured the AS-i slave in the *STEP 7* project, the changeover to "protected operation" occurs automatically.

Changeover between "configuration mode" and "protected operation"

- By switching the operating mode using the "Online functions in the TIA Portal (Page 38)".
- By calling the command interface in the user program of SIMATIC with command "Set_Operation_Mode (Page 118)".
- Using the connected "SET" button (Configuration of the AS-i slaves using the "SET" button (Page 35)).

Changeover is not possible if the AS-i slaves have been configured in the *STEP 7* project and the CPU is in RUN operating mode.

3.3 Firmware update

Performing a firmware update

Information about updating the firmware can be found in the ET 200SP System Manual.

Note

Following a firmware update, mark the current firmware version on the housing of the CM AS-i Master ST.

Current firmware updates are available on the Internet for download (https://support.industry.siemens.com/cs/ww/en/view/108742051).

Pay careful attention to the information on performing the firmware update contained in the download entry.

LED behavior during a firmware update

During a firmware update, the LEDs exhibit the following behavior:

- DIAG flashes red
- PWR is lit green
- Remaining AS-i LEDs are off

Note

Supply voltage during a firmware update

The AS-i voltage and the supply voltage of the ET 200SP station must not be switched off during a firmware update.

LED behavior after a successfully completed firmware update

When the TIA Portal is used, an error-free firmware update is indicated by the message that the firmware was successfully transferred. You must confirm the message using the button before you continue. Without confirmation, the LED status remains unchanged so that the firmware update is incomplete and must be repeated.

When *STEP 7* V5.5 (classic) is used, there is no concluding message and the LED status changes autonomously.

If the firmware is updated without errors, the LED status is updated:

- DIAG flashes red until the AS-i voltage is switched off and back on again
- PWR is lit green
- Remaining AS-i LEDs are lit

⚠ WARNING

Required intermediate step for firmware update of a CM AS-i Master ST with FW V1.0 using an ET 200SP CPU.

Failure to perform this step causes the CM AS-i Master ST to become permanently inoperable.

If you want to perform an update to a higher firmware version for a CM AS-i Master ST module with FW V1.0 and are using an ET 200SP configuration with an ET 200SP CPU in place of an interface module (IM), you must always perform the following intermediate step:

After the update of the LED status, the CM AS-i Master ST module must be removed from the ET 200SP BaseUnit. Instead of removing the module, it is also sufficient to switch off the AS-i voltage and the 24 V voltage of the ET 200SP. A TIA Portal error message appears approximately one minute after the module has been removed indicating that online access to the module is no longer possible. Confirm the error message. Then plug the module onto the BaseUnit again or switch the voltages back on.

Now repeat the firmware update. In this case, the intermediate step described here can be skipped.

The intermediate step is not required for:

- Firmware update of a CM AS-i Master ST module with active FW V1.1 or higher
- Use of an ET 200SP configuration with a PROFINET interface module (IM) and PROFINET connection to a released SIMATIC CPU
- Use of an ET 200SP configuration with a PROFIBUS interface module (IM) and PROFIBUS connection to a released SIMATIC CPU.

Note

For operation of the CM AS-i Master ST module in an ET 200SP configuration with an ET 200SP CPU in place of an interface module (IM), the following minimum requirements of the firmware and software versions apply:

- CM AS-i Master ST with FW V1.1 or higher, and
- ET 200SP CPU with FW V1.8 or higher (CPU 1510SP-1 PN, CPU 1510SP F-1 PN, CPU 1512SP-1 PN, CPU 1512SP F-1 PN, Open Controller CPU 1515SP PC)
- Configuration with *STEP 7* V13 SP 1 Update 4 or higher

Note

Restart after a firmware update

Following a firmware update, the AS-i voltage must be switched off and back on again in order for the new firmware to be activated.

Wait for the LED status to update before performing the restart. Otherwise the firmware update is not complete and must be repeated.

LED behavior in the event of an error during a firmware update

If an error occurs during the firmware update, the LEDs assume the following status:

- DIAG flashes red
- PWR is lit green
- Remaining AS-i LEDs indicate the status of the AS-i and are not relevant here.

In this case, switch the AS-i voltage off and back on again and repeat the firmware update.

Connection

4

4.1 Terminal assignment

Requirements

For connecting, you require a BaseUnit:

- Type C0 (light BaseUnit, e.g., item number 6ES7193-6BP20-0DC0)

Note that, within a BaseUnit group for AS-i consisting of light and dark BaseUnits, only the AS-i modules CM AS-i Master ST and F-CM AS-i Safety ST may be combined. Other I/O module types of the ET 200SP must always be separated from the BaseUnit group for AS-i using light BaseUnits.

Exception:

BaseUnits with power busbars without connection to the terminals of the plug-in I/O module can be used within a BaseUnit group for AS-i. These BaseUnits include the following dark BaseUnits with 20 mm width:

- BU20-P12+A0+4B (BU type B1)
- BU20-P12+A0+0B (BU type D0)
- BU20-P8+A4+0B (BU type F0)

Make sure that external voltage from adjacent BaseUnits cannot under any circumstances be connected to the AS-i modules.

⚠ WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to an AS-i power supply unit that meets the conditions indicated in Section "Schematic circuit diagram (Page 27)", "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

General terminal assignment

Table 4- 1 Terminal assignment of the CM AS-i Master ST

Terminal	Assignment	Description
1	SET1	Connection of the "SET" button (optional),
2	SET2	see "Configuration of the AS-i slaves using the "SET" button (Page 35)"
3	RES	Reserved
4	RES	Reserved
5	RES	Reserved
6	RES	Reserved
1L, 2L [1)]	ASI+	Connection of the AS-i cable, positive polarity
1N, 2N [1)]	ASI-	Connection of the AS-i cable, negative polarity

1) The terminals are connected through in the BaseUnit.

Connecting an external "SET" button

You can connect a "SET" button to terminals "SET1" and "SET2" of the AS-i master. This enables you to apply the ACTUAL configuration of the connected AS-i slaves as the CONFIGURED configuration. This function is activated by closing the button contact on the SET1 and SET2 terminals.

The maximum cable length between the terminal and "SET" button is 0.5 m.

Use two wires routed in parallel for connecting the button (not included in the scope of delivery).

See also

"ET 200SP Distributed I/O System" System Manual
(http://support.automation.siemens.com/WW/view/en/58649293/0/en)

"ET 200SP BaseUnits" Manual
(http://support.automation.siemens.com/WW/view/en/59753521/0/en)

4.2 Schematic circuit diagram

Schematic circuit diagram

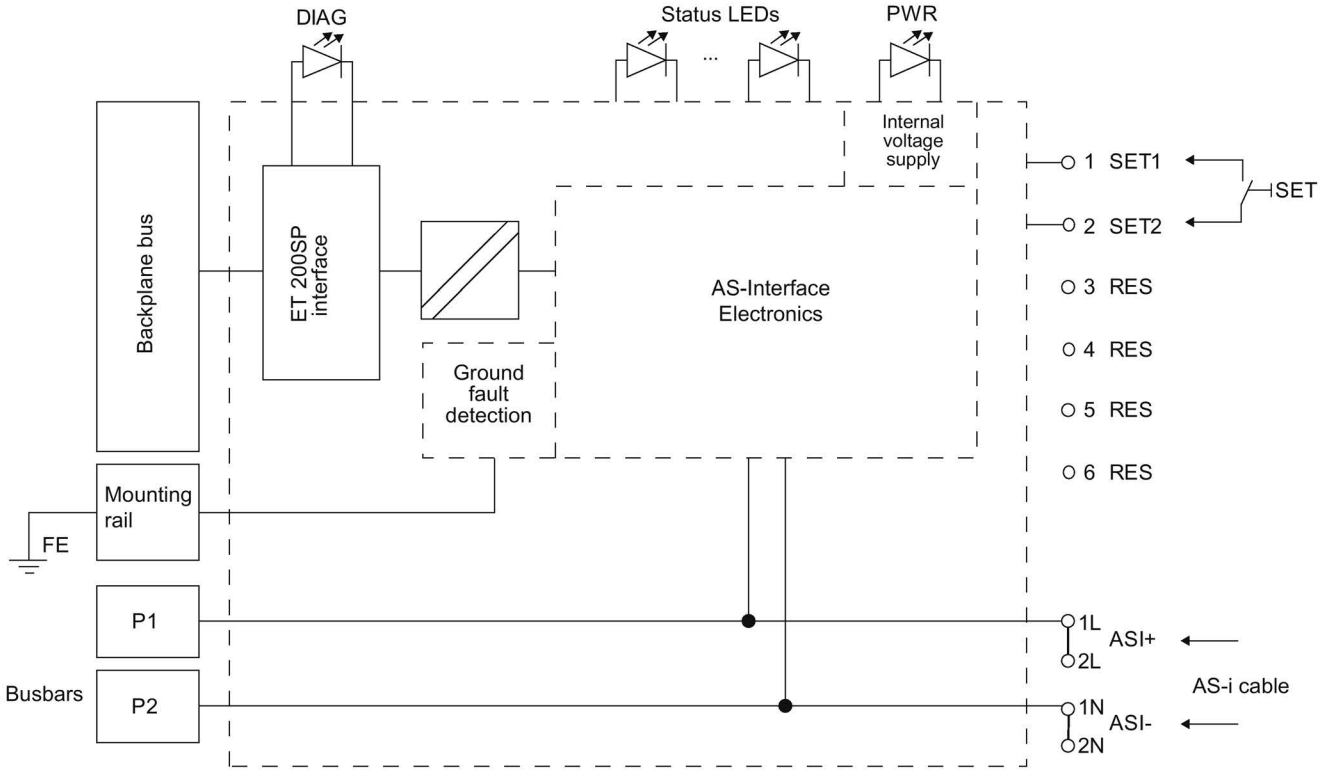


Figure 4-1 Circuit diagram of the CM AS-i Master ST

1L, 2L are connected through in the BaseUnit.

1N, 2N are connected through in the BaseUnit.

Connection to power busbars

The following are connected via the CM AS-i Master ST:

- 1L and power busbar P1
- 1N and power busbar P2

The maximum permitted current here is 4 A. For a conducted current of 4 A, the reduced ambient temperature range applies:

- Max. 55 °C for a horizontally mounted rail
- Max. 50 °C for a vertically mounted rail

If safety-related signals are to be processed on the AS-i cable, you can arrange a dark BaseUnit type C1 to the right of the light BaseUnit type C0 with the CM AS-i Master ST module and plug a safety-related F-CM AS-i Safety ST module onto this dark BaseUnit. The AS-i cable is continued from the light BaseUnit to the dark BaseUnit via the power busbars so that the F-CM AS-i Safety ST module is connected to the AS-i network of the master without additional wiring.

It is not permitted to transmit the AS-i voltage from the connecting terminals on the front of the dark BaseUnit because a current draw of this type may cause an overload in the modules.

Connect the AS-i cable with AS-i power supply unit and AS-i slaves only to terminals 1L, 2L (ASI+) and 1N, 2N (ASI-) of the light BaseUnit.

You can find additional information on safety-related processing in the "Fail-safe module F-CM AS-i Safety ST (https://support.industry.siemens.com/cs/ww/en/view/90265988)" manual.

Power supply units supported for AS-Interface

A connected power supply unit must have the following properties:

- Rated output voltage 30 V DC (AS-Interface Standard) or 24 V DC (AS-i Power24V)
- PELV/SELV (Protective/Safety Extra-Low Voltage) standard
- Residual ripple < 250 mVpp
- Limiting of output voltage to max. 40 V in the event of a fault

The Siemens power supply units for AS-Interface meet these requirements (see operating instructions of the power supply unit).

Use an AS-Interface power supply unit (with integrated data decoupling) or a combination of a standard power supply unit and a data decoupling module.

When AS-i Power24V is used, there are limitations on the cable length (max. 50 m AS-i cable) and usability of AS-i components and connected sensors/actuators due to the reduced voltage.

Additional notes:

- AS-Interface System Manual (http://support.automation.siemens.com/WW/view/en/26250840/0/en)
- FAQ "Compatibility for AS-i Power24V" (http://support.automation.siemens.com/WW/view/en/42806066)

Power supply

The CM AS-i Master ST is fully powered from the AS-i voltage. Only the internal backplane bus interface for the ET 200SP station (including the DIAG LED) is powered from the operating voltage of the ET 200SP station.

If the operating voltage of the ET 200SP station fails, the communication between the AS-i master and AS-i slaves continues without interruption, in which case the outputs of the AS-i slave are reset to zero.

Configuring

5

5.1 Requirements

Introduction

You configure the ET 200SP station and its CM AS-i Master ST and assign their parameters using *STEP 7* or the configuration software of another manufacturer.

Configuring the CM AS-i Master ST

Configuring in *STEP 7* or another configuration software is required in order to use the CM AS-i Master ST in an ET 200SP. A distinction is made here between the necessary basic configuration of the AS-i master and the optional configuration of the AS-i slaves.

You can configure the module using *STEP 7* or with a GSD file. Version dependencies:

Table 3-1 Version dependence of the CM AS-i Master ST engineering versions (Page 17)

Note

CM AS-i Master ST in the hardware catalog of *STEP 7*

If the CM AS-i Master ST module in the applicable firmware version is not listed in the hardware catalog of *STEP 7* , you will need a "Hardware Support Package". You can install this HSP from the Internet using the corresponding function in *STEP 7*.

Further information can be found in the documentation and in the online help for *STEP 7*.

Installing the HSP in *STEP 7* V5.5 (classic)	"HW Config" > "Options" menu > "Install HW Updates"
Installing the HSP in *STEP 7* V13 (TIA Portal):	"Options" menu > "Support packages"

You can find additional information on the HSP and download it in Internet (https://support.industry.siemens.com/cs/ww/en/view/108742051).

Download the GSD file from the internet:

PROFINET GSD file (https://support.industry.siemens.com/cs/ww/en/view/57138621)

PROFIBUS GSD file (https://support.industry.siemens.com/cs/ww/en/view/73016883)

Observe the *STEP 7* online help or the documentation of the configuration software manufacturer.

Configuring the AS-i system requires two steps:

1. Basic configuration of the AS-i master (Basic configuration of the CM AS-i Master ST (Page 31))
2. Configuration of the AS-i slaves

Configuring the AS-i slaves includes defining the slave modules and, if necessary, assigning the slave operating parameters.

See also

Configuration of the AS-i slaves in STEP 7 (Page 32)

Configuration of the AS-i slaves using the "SET" button (Page 35)

Configuration of the AS-i slaves via the control panel in the TIA Portal (Page 37)

Configuration of the AS-i slaves using the PLC program (Page 37)

Characteristics of the CM AS-i Master ST (Page 15)

5.2 Basic configuration of the CM AS-i Master ST

The following is carried out as a result of the basic configuration:

- The AS-i master is made known with the system.
- The length of the cyclic process image is made known (length can be set in FW V1.1 and higher).
- The operating parameters of the AS-i master are assigned.

Procedure

The basic configuration is performed by inserting the AS-i master module into the project of the configuration software.

Change the operating parameters according to their use. You will find information on operating parameters in the Sections:

- Parameters (Page 47)
- Explanation of the parameters (Page 47)

Should the need arise, you can change the size of the process image to be transferred as follows:

- In *STEP 7* in the "Properties" dialog of the AS-i master
- When the GSD file is used, by selecting the respective module variant from the GSD selection list

Further information on the process image:

- Address space (Page 48)

See also

Configuration of the AS-i slaves in STEP 7 (Page 32)

5.3 Configuration of the AS-i slaves

5.3.1 Configuration of the AS-i slaves in STEP 7

During configuration of the AS-i slaves, you specify the stations that the AS-i master is to communicate with in *STEP 7*.

Configuration in *STEP 7* provides the following advantages:

- AS-i slaves are displayed graphically in the network view along with their AS-i addresses (*STEP 7* (TIA Portal)) or displayed as a list (*STEP 7* V5.5 and higher).
- The assigned I/O addresses of an AS-i slave are displayed in the Properties window of the AS-i slave.
- The slave parameters can be configured in the *STEP 7* user interface.
- The configuration of the slaves is stored in the *STEP 7* project, which makes documentation easier.
- The configuration data is stored in the PLC and transferred automatically when the AS-i master is replaced.
- During power-up, the AS-i master switches automatically to "protected operation".
- The diagnostic status of the slave is displayed in *STEP 7* (TIA portal) in the network view as a symbol (currently only in combination with S7-300 / S7-400 CPU).

Note

If you do not configure any AS-i slaves in *STEP 7* or if you configure using a GSD file, AS-Interface uses the CONFIGURED configuration saved in the AS-i master. The following sections describe how you can create the CONFIGURED configuration:

- Configuration of the AS-i slaves using the "SET" button (Page 35)
- Configuration of the AS-i slaves via the control panel in the TIA Portal (Page 37)
  This does not apply when configuring with a GSD file.
- Configuration of the AS-i slaves using the PLC program (Page 37)

Procedure

You activate configuration of the AS-i slaves in *STEP 7*:

- In *STEP 7* (TIA Portal) by connecting at least one AS-i slave to the AS-i master over an AS-i network in the network view.
- In *STEP 7* V5.5, by inserting at least one AS-i slave in the configuration table of the AS-i master (FW V1.1 and higher).

When the AS-i slaves are configured in *STEP 7*, configuration is not possible using the "SET" button, via the online function or the PLC program.

This configuration switches the AS-i master automatically to "protected operation".

Option 1: Selection from the hardware catalog

To configure the AS-i slaves, open the hardware catalog in *STEP 7*.

STEP 7 (TIA Portal).

In *STEP 7* (TIA Portal), you will find the AS-i slaves under "Field devices".

1. Select a module from the hardware catalog.
2. Drag the module to the network view.
3. Connect the AS-i interface of the module (yellow square in the slave symbol) to the AS-i interface of the AS-i master (yellow square in the master) or directly to the yellow line of the AS-i subnet. When a connection is made to the AS-i subnet, a free AS-i address is automatically assigned in the configuration.

   You can change this AS-i address in the properties dialog of the AS-i slave in the "AS-Interface" area.

STEP 7 V5.5:

1. Open the "Object properties" dialog of the CM AS-i Master ST in the ET 200SP. To do so, select "Object properties" in the shortcut menu.
2. Click the "Slave configuration" tab (FW V1.1 and higher) in the "Properties..." dialog of the CM AS-i Master ST (FW V1.1 and higher) to open it.
3. Double-click the desired AS-i address (1A, B, 2A, B, etc.) to open the "Configuration" of the AS-i slave.
4. Click the "Select" button to open the "Slave selection dialog".
5. Select a slave in this dialog.

   Alternatively: Select a slave from the "Module" list box.

Option 2: Reading out an existing AS-i configuration

If an AS-i cable with AS-i slaves is connected to the AS-i master, you can transfer the connected slaves to the configuration of *STEP 7*. The connected AS-i slaves must have addresses other than "0".

Procedure:

1. Switch on the AS-i voltage.
2. Compile the project and download it to the station.
3. *STEP 7* (TIA Portal):
   - Right click the AS-i master.
   - Select "Hardware detection" in the shortcut menu.

   STEP 7 V5.5:
   - Select the ET 200SP.
   - Open the "Properties" dialog of the CM AS-i Master ST by double-clicking the slot of the CM AS-i Master ST, for example.
   - Change to the "Options AS-i slaves" tab.
   - Click the "Upload to PG" button.

4. The detected slaves are applied as universal slaves in the project.

   Note

   Automatic reading out of article numbers is not possible.

   Slave addresses already present in the project are not overwritten. If you want to transfer a slave address that is already present, you must delete the existing slave in the hardware detection before the readout.

5. You can now edit the slaves applied to the project as if you had taken them directly from the hardware catalog.

The following basic types are available:

- Siemens AS-i slave
- Universal slave with the following forms:
  - AS-i F Slave Universal for safety-related applications
  - AS-i Standard Slave Universal, for configuring with standard address or extended address (A/B slaves)
  - Universal AS-i Proxy Slave

The article numbers for the slaves are only saved in the offline project. Comparison of the article numbers in the offline project with those of the slaves on the AS-i cable is not performed. The AS-i master uses the configuration data of the slave profile (IO.ID.ID2) and ID1 code of the AS-i slave for comparison of the actual status with the configured status.

Configuring the properties of Siemens AS-i slaves

When you use an AS-i slave from Siemens, you select the slave directly from the hardware catalog.

This selection offers the following properties:

- The device type is represented in *STEP 7* (TIA Portal) using an image.
- The meaning of the slave parameters is displayed as text.
- The underlying slave profile is already set. The IO, ID and ID2 identifiers do not need to be entered.

Parameter bits that are irrelevant for the Siemens slave are set to the default value "1". They cannot be changed.

The ID1 code is preassigned according to the factory setting of the Siemens slave. If you change the ID1 code of the slave, you must also change the setting in the slave configuration.

See also the command "AS-i-Slave_ID1_schreiben_mit_Zieladresse (Write ID1 code with destination address) (Page 159)".

Configuring the properties of universal AS-i slaves

When configuring with the universal AS-i slave or universal AS-i F slave, you must make the following settings:

- Profile identification of the AS-i slave (IO, ID, ID2)
- Parameters of the AS-i slave

You will find the profile identification, the ID1 code, and the meaning of the AS-i slave parameters in the documentation for the AS-i slave.

The I/O assignment of the slave is shown, depending on the specified profile identification, in the "Configuration" section.

See also

Applying the slave configuration (Page 39)

Store_Actual_Configuration (Page 113)

5.3.2 Configuration of the AS-i slaves using the "SET" button

Functional principle

You can connect a "SET" button to terminals "SET1" and "SET2" of the AS-i master. This supports the teaching procedure for the connected AS-i slaves. This function is activated by closing the button contact on the SET1 and SET2 terminals.

Behavior in "configuration mode" and in "protected operation"

Table 5- 1 "Configuration mode"/"Protected operation"

Mode of the CM AS-i Master ST	Behavior of the "CM" LED
"Configuration mode"	The "CM" LED lights up.
"Protected operation"	The "CM" LED does not light up.

When the AS-i master is in "configuration mode", the AS-i master is configured automatically when the "SET" button is pressed. Configuration is carried out as follows:

1. The CM AS-i Master ST saves the AS-i slave configuration present on the AS-i cable as the CONF configuration in non-volatile memory.
2. The AS-i master then switches over to "protected operation".

If the AS-i master is in "protected operation", it will switch to "configuration mode" when the "SET" button is pressed.

The "SET" button is only activated when the CPU is in "STOP" state or after disconnecting the bus from the IM module of the ET 200SP.

Requirements

Ensure the following states exist:

1. The CPU is in "STOP" state or the bus is disconnected from the IM module of the ET 200SP.
2. The AS-i master and all AS-i slaves are connected to the AS-Interface and supplied with voltage.
3. No AS-i slave with address 0 is connected to AS-Interface. The AS-i slaves have unique addresses that differ from one another.

Procedure

1. Check whether the AS-i master is in "configuration mode". (The "CM" LED lights up.)

   If the "CM" LED does not light up, switch the AS-i master to "configuration mode" by pressing the "SET" button once.
2. Press the "SET" button. This configures the AS-i master. In so doing, the ACTUAL configuration detected is saved as the CONF configuration in non-volatile memory in the CM AS-i Master ST. At the same time, the AS-i master switches over to "protected operation". The "CM" LED goes out.

Note

Parameter setting when configuring with the "SET" button

If no AS-i slaves are connected, all internal lists are set to default values. In particular, the following are set: all AS-i parameters = F_{Hex} and bit "AutoAdress_Enable = 1".

When configuring is performed using the "SET" button, the parameter value in the volatile memory of the AS-i master for each slave applied to the CONF configuration is saved as a non-volatile parameter. For slaves that are not present, the default value F_H is applied to the non-volatile memory. This corresponds to the function of the Set_Permanent_Parameter (Page 107) command.

Note

The existing configuration can be overwritten using the "SET" button

Note regarding the CM AS-i Master ST:

A configuration of AS-i slaves specified using *STEP 7* and downloaded to the S7 station is transferred to the AS-i master again during S7 station start-up or after station recovery of the head module. Any configuration implemented using the "SET" button will be overwritten.

When configuring with the "SET" button, if no slaves are connected to AS-Interface, the CONFIGURED configuration in the master is deleted along with the profile definition for proxy slaves (see Section "AS-i proxy slave (Page 45)"). The AS-i voltage must be present.

See also

Terminal assignment (Page 25)

5.3.3 Configuration of the AS-i slaves via the control panel in the TIA Portal

You can also execute the functionality of the "SET" button described in Section "Configuration of the AS-i slaves using the "SET" button (Page 35)" via the control panel in *STEP 7*.

When configuring the AS-i slaves over the control panel in TIA Portal, if no slaves are connected to AS-Interface, the CONFIGURED configuration in the master is deleted along with the profile definition for proxy slaves (see Section "AS-i proxy slave (Page 45)"). The AS-i voltage must be present.

5.3.4 Configuration of the AS-i slaves using the PLC program

You can use the PLC program to completely define the configuration of the AS-i slaves.

The command interface of the AS-i master is available for this. You use the Write_overall_configuration (Page 130) command to specify the CONF configuration of the AS-i slaves in the AS-i master, similarly as when configuring the slave in the TIA Portal.

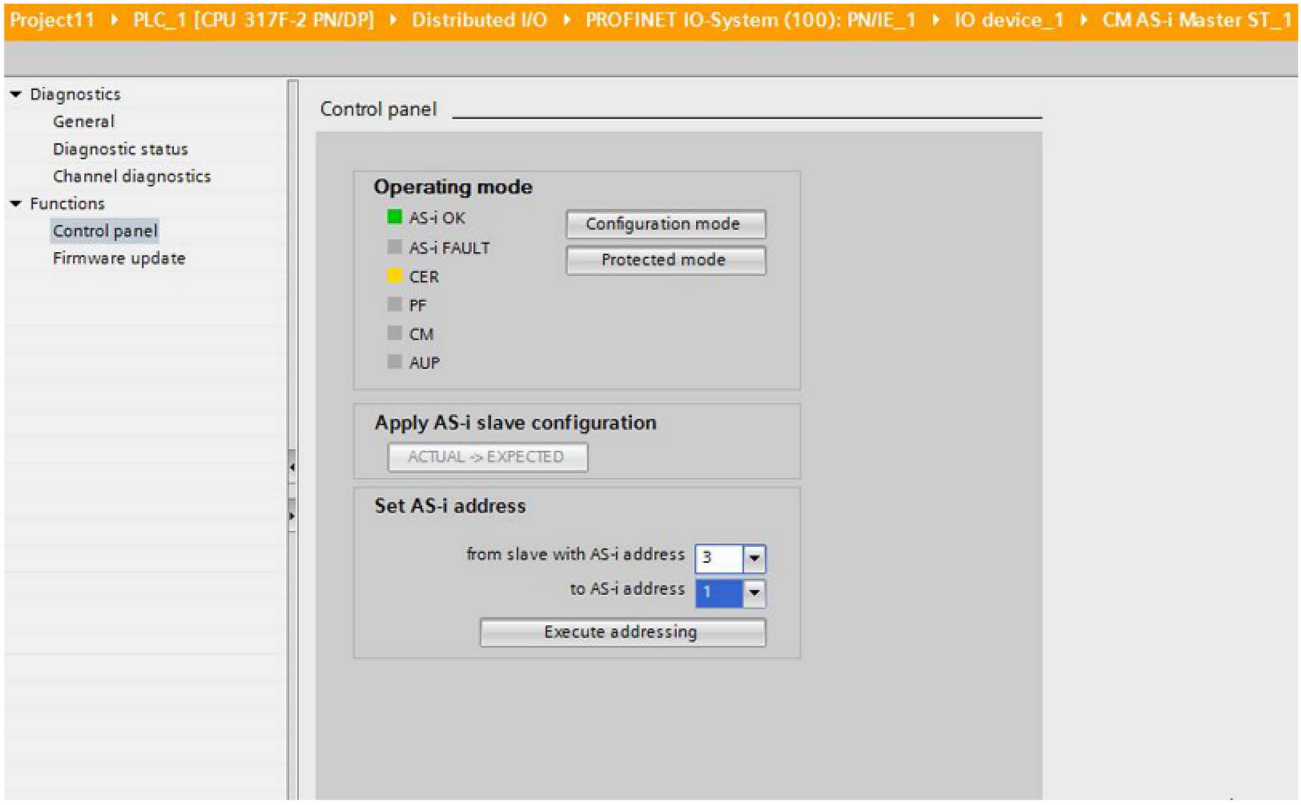
The Store_Actual_Configuration (Page 113) command allows you to save the ACTUAL configuration as the CONF configuration in the AS-i master, similarly as when using the "SET" button for this.

5.4 Online functions in the TIA Portal

5.4.1 Switching from one operating mode to another

In *STEP 7* "Online" > "Diagnostics", you can switch between "protected operation" and "configuration mode" under "Functions". There are two buttons:

- "Configuration mode"
- "Protected operation"



The LEDs on the AS-i master and in *STEP 7* indicate the current operating mode of the AS-i master. You will find additional information in Section "Meaning of the LEDs (Page 64)".

The operating mode can only be switched when the CPU is in "STOP" state.

Note

Online functions

The online functions can only be performed when at least the basic configuration has been completed and the configuration has been loaded into the ET 200SP station.

5.4.2 Applying the slave configuration

Application

This step is only necessary if AS-i slaves have not been configured in *STEP 7* and the configuration of the AS-i slaves is not performed using the "SET" button.

If AS-i slaves have already been configured in *STEP 7* and the slave configuration has been downloaded to the AS-i master, the system deactivates the function for applying the slave configuration. It is then no longer possible for this function to be called.

Requirements

The following requirements must be satisfied to do this:

- The CPU is in "STOP" state.
- The AS-i master and all AS-i slaves are connected to the AS-Interface and supplied with voltage.
- No AS-i slave with addess 0 is connected to the AS-Interface. The AS-i slaves have unique addresses that differ from one another.
- The AS-i master is in "configuration mode".

Applying the slave configuration

The "ACTUAL → CONF" button in the "Online" > "Diagnostics" window can be used to apply the configuration of slaves connected to the master.

The following data of the AS-i slaves is saved in non-volatile memory in the AS-i master:

- AS-i addresses
- The slave profile for each AS-i slave: IO code, ID code, ID2 code
- ID1 code for each AS-i slave

It is not possible to apply the slave configuration via the "ACTUAL -> CONF" button if AS-i slaves have already been configured in *STEP 7* and downloaded to the AS-i master or if the CPU is in "RUN" state. You reactivate the "ACTUAL -> CONF" function by downloading only the basic configuration – that is, the configuration without configured AS-i slaves – in *STEP 7* again.

Note

Parameter setting when applying the slave configuration

When configuring is performed using the "ACTUAL→CONF" button, the parameter value in the volatile memory of the AS-i master for each slave applied to the CONF configuration is saved as a non-volatile parameter. For slaves that are not present, the default value F_H is applied to the non-volatile memory. This corresponds to the function of the Set_Permanent_Parameter (Page 107) command.

5.4.3 Setting the address of an AS-i slave

In the "Online" > "Diagnostics" window, you can assign a new address to an AS-i slave using a selection menu and the "Execute addressing" button. Only free AS-i addresses are available here.

5.5 Variable configuration

Option handling and proxy slaves can be combined.

5.5.1 Option handling

A machine consists of a basic configuration and several expansion stages. The overall configuration is configured in the *STEP 7* project. The slaves that belong to an expansion stage are configured as optional slaves. When the system is commissioned, the user program (PLC) defines which expansion stages are installed. The configuration in *STEP 7* remains unchanged.

You can use option handling to activate and deactivate AS-i slaves that you have defined in HW Config in the user program during operation.

You configure the AS-i slaves in the AS-i master as described in Section "Configuration of the AS-i slaves in STEP 7 (Page 32)":

1. Activate option handling.

   STEP 7 (TIA Portal):

   – Select "Options > Option handling" in the slave properties dialog.

   – Select the "Option handling" check box.

   STEP 7 V5.5:

   – Select the "Slave configuration" tab in the "Properties..." dialog of the CM AS-i Master ST.

   – Double-click the desired AS-i address (1A, B, 2A, B, etc.) to open the "Configuration" of the AS-i slave.

   – Select the "Option handling" check box.

   This activates the option handling for this slave.

2. Activate the slave using the user program (PLC).

   You can also deactivate the slave in the user program.

The AS-i master treats an optional slave that is not activated like a slave that is not configured. The AS-i master treats an activated optional slave like a slave that is configured without option handling.

Procedure

1. Define the AS-i slaves in *STEP 7* (TIA Portal) > Network view or in *STEP 7* V5.5 > "HW Config".
2. Specify whether option handling is enabled for each AS-i slave.
3. In the user program, you can activate or deactivate AS-i slaves for which option handling is activated during runtime. To do this, a combination of 2 bits must be set or reset in data record DS 131.

Note

Option handling and safe AS-i slaves

When data record DS 131 is written to the CM AS-i Master ST module, the signals of the safety-related slaves on the same bus are reset. Before transferring the option data record DS 131, ensure that the system is in an operating state in which a safety signal reset will not adversely affect the course of operation. Before restarting, error acknowledgement or reintegration must be performed for the safe AS-i inputs and, where applicable, the safe AS-i outputs. The correct procedure for the fail-safe evaluation system used must be observed.

See also

DS 131 Activate/deactivate optional slaves (Page 43)

DS 131 Read status of option handling (Page 44)

Set_Configuration_Online (Page 158)

5.5.1.1 DS 131 Activate/deactivate optional slaves

Description

By writing this data record, you activate or deactivate slaves configured as optional on the AS-i bus.

Table 5- 2 Structure of DS 131 write

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 1	Reserved							
2 … 9	List of slaves to be activated							
	Bit = 0	No action						
	Bit = 1	The slave will be activated.						
10 ... 17	List of slaves to be deactivated							
	Bit = 0	The slave will not be deactivated.						
	Bit = 1	The slave will be deactivated.						

Note

Identical entries in each list

If a "1" is entered for an AS-i slave in both lists, the slave will be deactivated.

Note

Activated/deactivated status of the optional slaves

The activated/deactivated status of the optional slaves is stored in non-volatile memory of the master and is retained even if a new configuration is downloaded to the master. The status of an optional slave is set to deactivated if the slave is not set as optional in a configuration.

If a configuration contains slaves without option handling, the status stored internally in the master for these slaves is reset (bit = 0).

See also

Address space (Page 48)

Option handling (Page 41)

5.5.1.2 DS 131 Read status of option handling

Description

The current status of the slaves configured as optional is returned by reading this data record.

Table 5- 3 Structure of DS 131 read

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 1	Reserved							
2 … 9	List of activated, optional slaves							
	Bit = 0	The optional slave is deactivated or the optional slave is not an optional slave.						
	Bit = 1	The optional slave is activated.						
10 ... 17	List of configured, optional slaves							
	Bit = 0	The slave is not configured as an optional slave or it is not contained in the configuration.						
	Bit = 1	The slave is configured as an optional slave.						

If a slave is configured as not optional, then the associated bit in the list of activated optional slaves in the non-volatile memory of the master is reset to the value 0.

See also

Option handling (Page 41)

5.5.2 AS-i proxy slave

Description

A proxy slave is used to represent any given slave. This means you define the I/O addresses in the PLC program in advance. You define the slave itself at runtime.

Procedure

- Configure a proxy slave in "*STEP 7* > HW Config" with the associated digital and / or analog I/O addresses. You can then use these I/O addresses in the user program to access the data of the proxy slave once you have defined the slave profile at runtime.

  To do this, select the proxy slave from the universal AS-i slaves in the hardware catalog.
- At runtime, specify in the PLC program which slave type should be operated under this address.
- You define the slave profile of the proxy slave by changing the overall configuration ("Set_Configuration_Online (Page 158)" command). In this case, the AS-i branch is not reset.
- The slave type defined in the user program is retained in the CM AS-i Master ST module, even after the power supply has been switched off.
- The slave type of a proxy slave defined in the user program is retained in the CM AS-i Master ST module, even after the hardware configuration has been reloaded into the station.

Applications

- Variable machine configurations that can be changed at runtime.
- Flexible expansion of the system in the future, without the need to specify the actual type of slave beforehand.

Parameter assignment/addressing

6

6.1 Parameters

Parameters of the AS-i master

Table 6- 1 Assignable parameters and their default setting (GSD file)

Parameters	Value range	Default
Diagnostic interrupt in case of errors in AS-i configuration	• Enable • Disable	Enable
Diagnostic interrupt in case of AS-i cable fault	• Enable • Disable	Enable
Automatic address programming	• Enable • Disable	Enable
Ground-fault monitoring activated	• Enable • Disable	Enable
Automatic ID1 code assignment (Firmware V1.1 and higher)	• Enable • Disable	Disable
Duplicate address detection[1)]	• Enable for AS-i voltage 24 V • Enable for AS-i voltage 30 V • Disable	Disable

1) This parameter is divided into "Deactivate duplicate address detection" and "Duplicate address detection for 24 V" depending on the GSD variant.

6.2 Explanation of the parameters

Diagnostic interrupt if AS-i configuration error:

With this parameter, you specify whether AS-i configuration errors will be signaled to the higher-level system. The following are signaled as a configuration error:

- A surplus slave
- A missing slave
- A slave of the wrong type

Diagnostic interrupt if AS-i cable fault:

This parameter is used to specify whether faults concerning the AS-i cable should be reported to the higher-level system. Possible AS-i cable faults are:

- Ground fault
- Insufficient AS-i voltage
- Peripheral fault of an AS-i slave

Automatic address programming:

When a defective AS-i slave is being replaced, you use this parameter to specify whether the configured AS-i address will be automatically assigned to the new device.

For details on this functionality, see Section "Replacing a defective AS-i slave / automatic address programming (Page 74)"

Ground-fault monitoring activated:

This parameter is used to specify whether ground faults on the AS-i cable should be detected by the AS-i master. Deactivate this setting if you are using an external unit for ground fault detection.

Automatic ID1 code assignment:

When you activate this parameter, in the case of automatic address programming the ID1 code of a slave is written to the value specified during configuring.

Duplicate address detection:

The duplicate address detection function can identify inadvertent duplicate addressing. When you activate it, you must select the AS-i line voltage in use.

This parameter is divided into "Deactivate duplicate address detection" and "Duplicate address detection for 24 V" depending on the GSD variant.

6.3 Address space

The assignment of the address space is described in the following Section:

Data exchange between the user program and AS-i slaves (Page 49)

Data exchange between the user program and AS-i slaves

7

7.1 Access to AS-Interface

The distributed I/O system communicates with the AS-i slaves via the CM AS-i Master ST. The AS-i communication objects are mapped onto a continuous data area for input and output data.

Firmware V1.1 and higher

From Firmware V1.1 and higher, you can flexibly arrange the process image:

- Shortening the process image for a process image with maximum length of 288 bytes.
- Map analog values and digital values in one process image
- Variable division of the process image:
  - The slave address is not bound to a specific position in the process image.
  - The number of bits per slave can vary.

    For example, the digital input data of the slave at address 1 can be one bit long and the analog data of the slave at address 5 can be two bytes long.

If your configuration contains fewer AS-i slaves, you may reduce the length of the reserved I/O area (depending on the configuration software version).

This reduces the volume of data to be transmitted on PROFIBUS or PROFINET. You set the length of the I/O area in *STEP 7* (TIA Portal) in the properties of the AS-i master. This does not change the assignment of the slave address to the offset. This means:

When the length is reduced, the higher AS-i bus addresses can no longer be addressed.

7.2 Transmitting AS-i digital values

If there are no slaves, the input data is filled with 0 values. In the output direction, the non-assigned values have no effect.

Special characteristics of AS-i Safety slaves

The AS-i master performs a non-safe evaluation for the data of safe input slaves. The evaluation is represented in the process image of a Safety input slave as follows:

Table 7- 1 Process image of a Safety input slave

Bit 3	Bit 2	Bit 1	Bit 0	Meaning
0	0	0	0	All contacts are open.
0	0	0	1	F-IN1 is closed.
0	1	0	0	F-IN2 is closed.
0	1	0	1	F-IN1 and F-IN2 are closed.

Likewise, the AS-i master evaluates in a non-safe manner to determine whether a safe AS-i output is to be addressed. The information is in the input process image of the PLC:

Table 7- 2 Process image of the "safety module"

Bit 3	Bit 2	Bit 1	Bit 0	Meaning
0	0	0	0	The safe AS-i output is deactivated.
1	1	1	1	The safe AS-i output is switched on.

Note

This involves a non-safe evaluation of the safe signals.

Addressing of slaves by the controller

Input data and output data of the AS-i slaves are exchanged with the controller via an I/O area of 32 bytes. As a result, the digital values of up to 62 AS-i slaves are transmitted.

In doing so, 4 bits are assigned to each digital slave. The offset for accessing this data depends on the AS-i address of the AS-i slave.

Configuration example

The following graphic shows an example of addressing 4 digital slaves. In the example, you configure the start addresses n = 40 for the I/O data in *STEP 7* .

The bits with a gray background are relevant for the user program. The bits with a white background are not relevant for the user program, because AS-i slave bits are not assigned here.

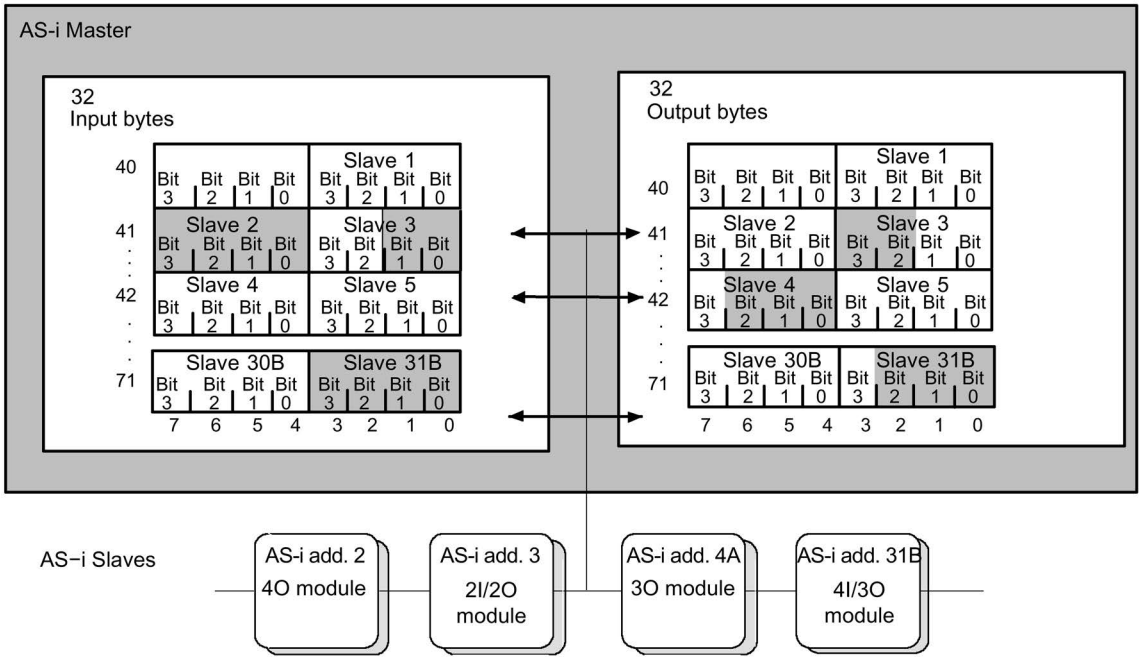


Figure 7-1 Example of addressing 4 digital slaves

The AS-i slave with address 3 and with two inputs and two outputs, referred to as a 2I/2O module, occupies bits 0 and 1 in input byte 41 and bits 2 and 3 in output byte 41 in the graphic, for example.

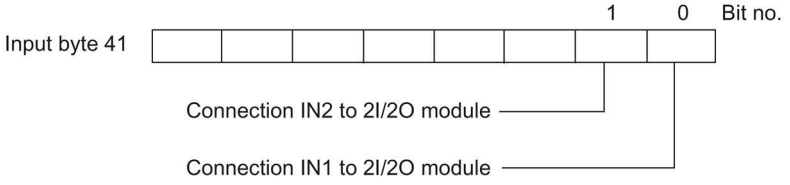


Figure 7-2 Example to show assignment of the AS-i connections of the 2I/2O modules to the data bits of the input bytes for slave with address 3

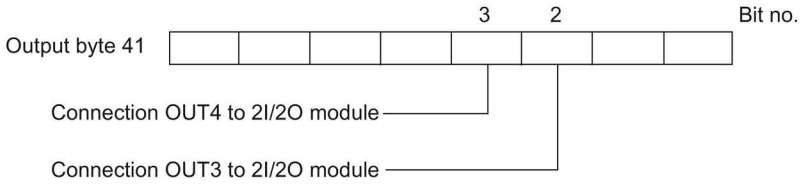


Figure 7-3 Example to show assignment of the AS-i connections of the 2I/2O modules to the data bits of the output bytes for slave with address 3

See also

List of abbreviations (Page 175)

7.2.1 CM AS-i Master ST with configured AS-i slaves

Boundary conditions:

- The larger the process image, the longer it takes to transmit it.

CM AS-i Master ST with configured AS-i slaves

If you configure the AS-i slaves according to Section "Configuration of the AS-i slaves in STEP 7 (Page 32)", you set the I/O addresses of the slaves using the properties dialog of the AS-i slave. The I/O address can be set individually in the area of the defined process image of the AS-i master. The input bits x.4 to x.7 in the first byte of the process image of the AS-i master cannot be used for AS-i slaves. The process image can contain input/output data of digital and analog slaves.

The bit length of a slave depends on the configured profile. It is defined in the AS-i specification and cannot be changed.

7.2.2 CM AS-i Master ST without configured AS-i slaves

Addressing of slaves by the controller

If you configure according to Sections "Configuration of the AS-i slaves using the "SET" button (Page 35)" to "Configuration of the AS-i slaves using the PLC program (Page 37)", the I/O addresses of digital slaves in the process image of the AS-i master are located at a fixed position according to the following table. The I/O data of digital slaves can be accessed via a data record.

Input data and output data of the AS-i slaves are exchanged with the controller via an I/O area with a size of 32 bytes. As a result, the digital values of up to 62 AS-i slaves are transmitted. In doing so, 4 bits are assigned to each digital slave. The offset for accessing this data depends on the AS-i address of the AS-i slave.

If you configure a project without AS-i slaves, you can specify a digital address area that is 32 or 16 bytes long.

Default setting: 32 bytes long

In an I/O address area of 16 bytes, you can only assign standard addresses or A addresses for slaves. In an I/O address area of 32 bytes, you can also assign B addresses for slaves.

Table 7- 3 Bit assignment per digital slave

Byte number [1]		**Bit 7 … 4**				**Bit 3 … 0**			
n+0		Reserved				Slave 1 or 1A			
						Bit 3	Bit 2	Bit 1	Bit 0
n+1		Slave 2 or 2A				Slave 3 or 3A			
n+2		Slave 4 or 4A				Slave 5 or 5A			
n+3		Slave 6 or 6A				Slave 7 or 7A			
n+4		Slave 8 or 8A				Slave 9 or 9A			
n+5		Slave 10 or 10A				Slave 11 or 11A			
n+6		Slave 12 or 12A				Slave 13 or 13A			
n+7		Slave 14 or 14A				Slave 15 or 15A			
n+8		Slave 16 or 16A				Slave 17 or 17A			
n+9		Slave 18 or 18A				Slave 19 or 19A			
n+10		Slave 20 or 20A				Slave 21 or 21A			
n+11		Slave 22 or 22A				Slave 23 or 23A			
n+12		Slave 24 or 24A				Slave 25 or 25A			
n+13		Slave 26 or 26A				Slave 27 or 27A			
n+14		Slave 28 or 28A				Slave 29 or 29A			
n+15		Slave 30 or 30A				Slave 31 or 31A			
n+16	V1.0	Reserved				Slave 1B			
	V1.1.0 and higher	EFD[2]	CM[2]	CFGOK[2]	DIAG[2]				
n+17		Slave 2B				Slave 3B			
n+18		Slave 4B				Slave 5B			
n+19		Slave 6B				Slave 7B			
n+20		Slave 8B				Slave 9B			
n+21		Slave 10B				Slave 11B			
n+22		Slave 12B				Slave 13B			
n+23		Slave 14B				Slave 15B			
n+24		Slave 16B				Slave 17B			
n+25		Slave 18B				Slave 19B			
n+26		Slave 20B				Slave 21B			
n+27		Slave 22B				Slave 23B			
n+28		Slave 24B				Slave 25B			
n+29		Slave 26B				Slave 27B			
n+30		Slave 28B				Slave 29B			
n+31		Slave 30B				Slave 31B			
		Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0

1) n = Start address

2) You can activate and deactivate these status bits in *STEP 7* (TIA Portal).

List of abbreviations (Page 175)

7.3 Transferring AS-i analog values

The following information only applies to AS-i slaves whose data is stored in the analog area.

Note

The CM AS-i Master ST does not support the transmission of analog values in accordance with AS-i Slave Profile 7.1 / 7.2. Transmission of analog values must be implemented in the software for these slaves.

Analog interface between the CPU and the CM AS-i Master ST

In the user program, you use the process image (Firmware V1.1 and higher) or data records to access I/O data of analog slaves.

For more detailed information, refer to Section "Accessing AS-i analog data via the process image (Page 57)".

Representation of the analog values or the transparent values

The analog values are to be interpreted as 16-bit values in two's complement.

The transparent/digital values must be interpreted as two independent bytes.

In the case of AS-i slave profiles for transparent/digital data, the AS-i master passes through the data of the AS-i slave to the controller without interpreting the content.

For universal AS-i slaves, the following is displayed in the "Configuration" field in *STEP 7*:

- Information about the number of channels
- Information about the resolution
- Information about the data frame of transparent I/O data

In the documentation for the respective AS-i slave, you will find further information about:

- Value range
- Measuring range
- Accuracy of analog slaves
- Meaning of transparent data

Special cases in analog value transfer

- In the input direction, the AS-i master sends a substitute value in the event of a slave failure or AS-i communication error:
  - For slaves with analog transmission, the AS-i master always supplies the substitute value $7FFF_H$, if the slave fails after power-up of the master.

    "Transparent" mode exception:

    For slaves according to the following profiles, the AS-i master supplies the substitute value 0000_H:

    7.3.0 to 7.3.3 (Type CTT1, output slave 16 DO in "Transparent" mode)

    7.3.8 to 7.3.A (Type CTT1, input slave 16 DI in "Transparent" mode)

    7.A.A (CTT3, 8 DI / 8 DO slave with A/B address)

    7.A.8 (ID1 = 3, 4, 5) (Type CTT4, max. 16 DI slave with A/B address)

    7.A.5, 7.5.5 and B.A.5, if you have transparent input (Type CTT2)

    6.0.x where x = 2 … 7 (Type CTT5, in "Transparent" mode)
- In the output direction, the AS-i master sends logic "0" to all slaves in the event of a failure or in "STOP" state.
- If the AS-i master or the communication between the AS-i master and PLC fails, data record access to the analog values or transparent/digital input values is not possible. Note that the analog input values and transparent/digital input values are not updated in your user program in this case, and ensure a substitute value processing via the program.

NOTICE
Behavior in the event of a slave failure If the slave fails prior to or during the power-up of the AS-i master, the substitute value $7FFF_H$ may also be supplied. That is, the input bits of these transparent or digital slaves have the substitute value 1. For this reason, check whether the diagnostic data of these slaves indicate a slave failure and, if required, ensure an appropriate substitute value processing via the program.

Special characteristics of combined transaction type slaves

When using slaves in accordance with CTT 1 to 5, all or some I/O bits are used for special transfer functions in the process image for AS-i digital values. For further details, please refer to the documentation of the respective AS-i slave.

The following applies to these protocol bits:

- In the input direction, the AS-i master sets the value "0".
- In the output direction, the AS-i master ignores the bits.

7.3.1 Accessing AS-i analog data via the process image

If you assigned I/O addresses to the analog slaves when configuring, you can access the AS-i analog values with word commands (Firmware V1.1 and higher).

Analog and transparent I/O addresses for configured AS-i slaves

The analog and transparent I/O addresses of an AS-i slave can be freely assigned within the overall process image of the CM AS-i Master ST. This is regardless of the size of the process image. If you only require a few analog inputs and outputs in the process image and want to save space, you can change the length of the I/O data of an AS-i slave. If the set length is less than the actual length of the I/O data of the AS-i slaves, you cannot access the data at addresses greater than the set length via the process image. You can also deactivate the process image for analog inputs/outputs.

Access to analog I/O data is also possible via data records independent of the process image. You can find more detailed information on this in Section "Accessing AS-i analog data via acyclic services (Page 57)".

7.3.2 Accessing AS-i analog data via acyclic services

Representation of the analog values in the data records

Analog values are transferred in the data records numbered from 140 to 147.

- You access the analog input values using system functions for reading data records.
- You output analog values using system functions for writing data records.

In combination with SIMATIC S7, system function blocks SFB 52 "RDREC" and SFB 53 "WRREC" enable this.

Access to analog data via acyclic services can also be selected, for example, if there is a need to save I/O address space in SIMATIC S7.

NOTICE
Simultaneous write access via cyclic and acyclic services not possible Simultaneous write access to analog data of a slave is not permissible with different process values either via cyclic or acyclic services. If both services are used the analog output values that are output via cyclic and acyclic services to the same slave address must be synchronized with each other via the user program.

You can use data record lengths ranging from 2 bytes to 240 bytes for each data record number. For each slave address, an area of 8 bytes is available to address 4 analog channels.

The table below shows which data record is used by each AS-i slave to transfer the analog values. The subsequent table shows the assignment of analog values to the respective analog slaves.

The tables are applicable to analog inputs and analog outputs.

Table 7- 4 Access to analog values via data records

AS-i address of the slave	Start addresses for analog values in the data record							
	DS 140	DS 141	DS 142	DS 143	DS 144	DS 145	DS 146	DS 147
1	0	—	—	—	—	—	—	—
2	8	—	—	—	—	—	—	—
3	16	—	—	—	—	—	—	—
4	24	—	—	—	—	—	—	—
5	32	0	—	—	—	—	—	—
6	40	8	—	—	—	—	—	—
7	48	16	—	—	—	—	—	—
8	56	24	—	—	—	—	—	—
9	64	32	0	—	—	—	—	—
10	72	40	8	—	—	—	—	—
11	80	48	16	—	—	—	—	—
12	88	56	24	—	—	—	—	—
13	96	64	32	0	—	—	—	—
14	104	72	40	8	—	—	—	—
15	112	80	48	16	—	—	—	—
16	120	88	56	24	—	—	—	—
17	128	96	64	32	0	—	—	—
18	136	104	72	40	8	—	—	—
19	144	112	80	48	16	—	—	—
20	152	120	88	56	24	—	—	—
21	160	128	96	64	32	0	—	—
22	168	136	104	72	40	8	—	—
23	176	144	112	80	48	16	—	—
24	184	152	120	88	56	24	—	—
25	192	160	128	96	64	32	0	—
26	200	168	136	104	72	40	8	—
27	208	176	144	112	80	48	16	—
28	216	184	152	120	88	56	24	—
29	224	192	160	128	96	64	32	0
30	232	200	168	136	104	72	40	8
31	—	208	176	144	112	80	48	16

Examples / notes on reading this table:

The subsequent table shows the assignment of analog values to the respective analog slaves.

For additional information, refer to the operating instructions of the slaves.

Table 7- 5 Address range for the analog values of an AS-i slave

Byte no. (start address + offset)	Analog value channel
Start address + 0	Channel 1 / high byte
Start address + 1	Channel 1 / low byte
Start address + 2	Channel 2 / high byte
Start address + 3	Channel 2 / low byte
Start address + 4	Channel 3 / high byte
Start address + 5	Channel 3 / low byte
Start address + 6	Channel 4 / high byte
Start address + 7	Channel 4 / low byte

Analog A/B slaves with 2 channels only reserve half the address range. A slaves occupy bytes 0 to 3 and B slaves bytes 4 to 7.

Examples of the configuration:

1. Configuration:

   Analog slaves have the AS-i addresses 1 to 6.

   You use data record 140 and enter 48 as data record length.

2. Configuration:

   1 analog slave with AS-i address 7 is used.

   You use data record 141 and enter 24 as data record length. Only bytes 16 to 23 are relevant.

3. Configuration:

   The full address range for 31 analog slaves is used.

   You use data record 140 and enter 224 as data record length. You can then address analog slaves 1 to 28.

   For the remaining analog slaves 29 to 31, you use data record 147 in a second job and enter 24 as data record length.

4. Configuration:

   Analog slaves have the addresses 29 to 31.

   You use data record 147 and enter 24 as data record length.

Mixed access:

- Configuration:

  You want to access slaves 1 to 12 using I/O commands and slaves 13 to 31 using data records.

  You use data record 143 for slaves 13 to 31.

Alarms, faults and system events

8

8.1 Overview

Diagnostics options

The following diagnostics options are available for the AS-i master:

- LEDs on the module
- Diagnostics in *STEP 7*:
  - Online presentation of the network and device view
  - Diagnostic buffer
- Alarm messages in user program
- Creation of user-specific web pages via the web server of a connected SIMATIC controller

You will find information on the LEDs in Section "Meaning of the LEDs (Page 64)".

The diagnostic possibilities in *STEP 7* and in the user program are described in the following sections.

8.2 Diagnostics in STEP 7

Diagnostics in STEP 7

For diagnostics of the AS-i master and the AS-i slave, use the "Go online" function to switch *STEP 7* to "Online" status.

If you have configured AS-i slaves in *STEP 7*, the diagnostic information about slaves can be displayed in *STEP 7*.

The diagnostics of the AS-i slaves in STEP 7 V13 SP1 (TIA Portal) are not displayed via the online network view function. The information of the AS-i master is displayed symbolically in the device view. The status of these devices will also be displayed to the right of the device in the project navigation by means of a symbol. For an explanation of the different status symbols, please refer to the relevant tool tip.

STEP 7 offers several possibilities for requesting the diagnostic information of the AS-i master:

- Special diagnostic symbols indicate the status of the AS-i master in the network view of the device configuration. Red symbols signal an error, and green symbols indicate that the devices are OK.
- In *STEP 7* V13 SP1 (TIA Portal), you can call up information about the status of the AS-i master and AS-i slaves. To do so, open the diagnostics as follows:
  - Select the AS-i master.
  - Select "Online & diagnostics" in the shortcut menu.
  - In the "Online & diagnostics" view, select "Detailed diagnostics > Error overview".

    Here you see the current status of every AS-i slave address.

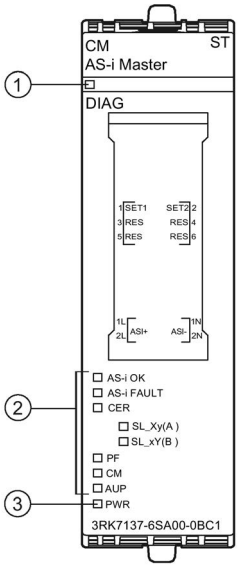
  To analyze sporadic errors, you can read out the error counter for the AS-i network.

  Diagnostics are also available in *STEP 7* V5.5 HSP 2092 V3.0 and higher.
- The control panel of the AS-i master can also be called up in this display. This shows the status of the LEDs.
- All the relevant events are stored in the diagnostic buffer of the CPU. You can display the diagnostic buffer in the "Online & Diagnostics" window for a selected CPU.

8.3 LED statuses

8.3.1 Arrangement of the LEDs on the CM AS-i Master ST

Introduction



① DIAG (green/red)
② Status LEDs (AS-Interface)
③ PWR (green)

Figure 8-1 Arrangement of the LEDs on the CM AS-i Master ST

8.3.2 Meaning of the LEDs

Meaning of the LEDs

The tables below explain the status and fault indications. Remedies for the diagnostic messages are in Section "Diagnostic messages (Page 69)".

"PWR" LED

Table 8- 1 Meaning of the "PWR" LED

PWR	Meaning
☐ OFF	The AS-i voltage is not provided (terminals L+, M).
■ Green ON	The AS-i voltage is provided (terminals L+, M).

"DIAG" LED

Table 8- 2 Meaning of the DIAG LED

DIAG	Meaning
☐ OFF	The supply voltage for the interface module of the ET 200SP is not provided.
✳ Green flashes	The AS-i master parameters have not been assigned.
■ Green ON	The AS-i master parameters have been assigned and are error-free. No diagnostic message of the AS-i master is pending.
✳ Red flashes	The AS-i master parameters have been assigned and the AS-i master signals diagnostic errors for the AS-i master or an AS-i slave or an active firmware update.

"AS-i OK" LED

Table 8- 3 Meaning of the AS-i OK LED

AS-i OK	Meaning
☐ OFF	An error has occurred (see AS-i FAULT LED) or the AS-i master is offline. This means: No I/O data exchange is taking place, e.g., during power-up.
■ Green ON	The AS-i bus is fault-free. I/O data exchange takes place.

"AS-i FAULT" LED

Table 8- 4 Meaning of the AS-i FAULT LED

AS-i FAULT	Meaning
☐ Red OFF	No AS-i cable faults have occurred. The AS-i master is in "Offline" mode.
■ Red ON	The AS-i bus has failed, e.g. the supply voltage for AS-Interface is too low, ground fault.
✻ Red "flashes"	A fault has occurred, e.g. a duplicate address or parameterization error has been detected.

"PF" LED

This LED indicates peripheral faults.

Table 8- 5 Meaning of the "PF" LED

PF	Meaning
Red OFF	No peripheral fault is being signaled.
Red ON	At least one AS-i slave is signaling a peripheral fault. Refer to the operating instructions for the respective slave for the meaning of the peripheral fault, e.g., overload at the standard outputs and/or overload of the sensor power supply of the standard inputs.

Firmware update (Page 21)

"CER" LED

This LED indicates configuration errors. It lights when the slave configuration detected on the AS-i cable does not match the CONFIGURED configuration in the AS-i master.

Table 8- 6 Meaning of the "CER" LED

CER	Meaning
Yellow OFF	No AS-i configuration error.
Yellow ON	Failure of an AS-i slave: • A configured AS-i slave is not present on the AS-i cable. • An excess slave not configured beforehand is present on the AS-i cable. • A connected slave has different configuration data (IO, ID, ID1, ID2) than the slave configured in the AS-i master. • A slave with address "0" is in "Configuration mode" on the AS-i bus.

"CM" LED

This LED indicates the operating status (Configuration Mode).

Table 8- 7 Meaning of the "CM" LED

CM	Meaning
☐ Green OFF	The AS-i master is in "protected operation".
■ Green ON	The AS-i master is in "configuration mode".
✻ Green flashes	During a firmware update: Errors have occurred during the firmware update.

"AUP" LED

This LED indicates whether automatic address programming is possible or not.

Table 8- 8 Meaning of the "AUP" LED

AUP	Meaning
☐ Green OFF	Automatic address programming is not possible. This LED is always off in configuration mode.
■ Green ON	When the AS-i master is in "protected operation", this LED indicates that automatic address programming of an AS-i slave is possible. Automatic address programming makes it easier to replace a defective AS-i slave on the AS-i cable. For more detailed information, refer to Section "Replacing a defective AS-i slave / automatic address programming (Page 74)".

"SL_Xy(A)" and "SL_xY(B)" LEDs

These LEDs indicate the slave addresses to which an error is signaled. The following states are taken into account:

- The slave has failed.
- The slave is an excess slave.
- The slave type is incorrect.
- Double addressing detected.

The following diagram shows the indication sequence:

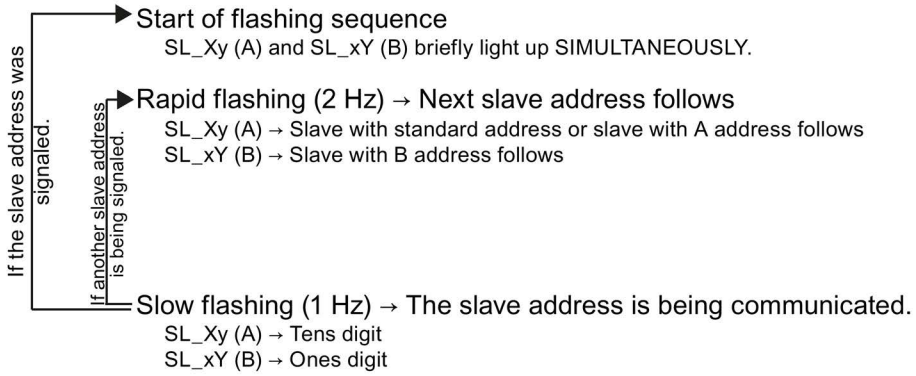


Figure 8-2 Indication sequence

Example: Slave 15 and 21B have failed

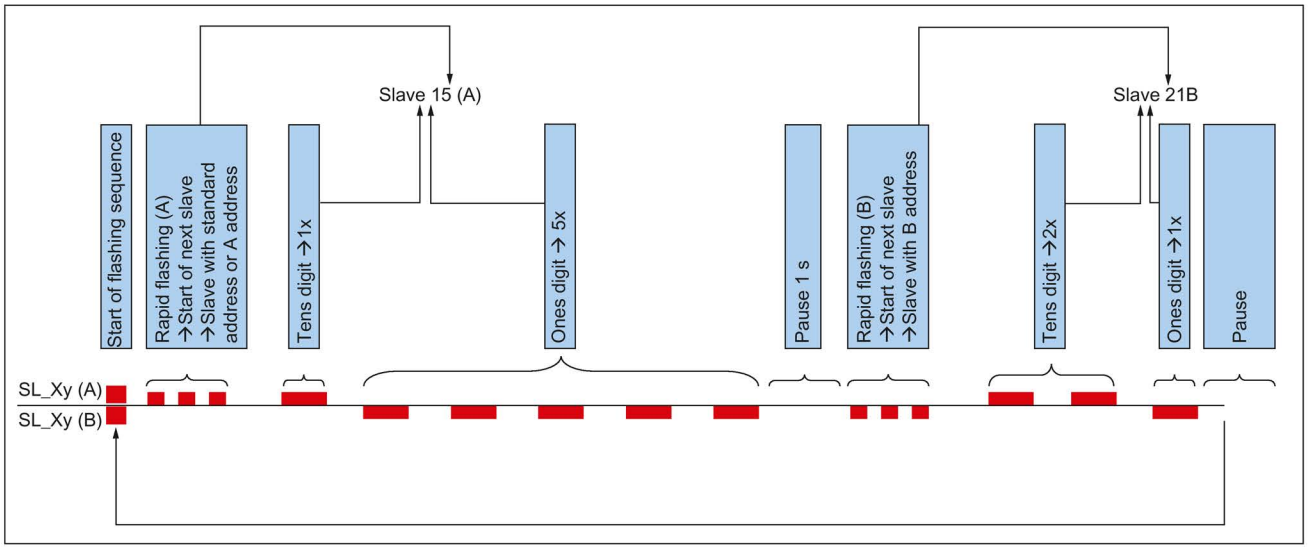


Figure 8-3 Example: Slave 15 and 21B have failed

8.4 Diagnostic messages

8.4.1 Alarms

The AS-i master sends a diagnostic interrupt request to the CPU in the following situations:

- The AS-i master has detected a problem, e.g. failure of a slave (incoming event).
- The problem was rectified or no longer exists (outgoing event).

If there is no OB 82 in the user program, a CPU of the S7-300 / S7-400 product range will switch to "STOP".

If an OB 82 exists, the operating system responds to an incoming event by calling the OB 82. The S7 CPU then interrupts the cyclic user program and enters the event in the system diagnostic buffer as a "Module fault" message.

Some diagnostic information is made available to the user in the local data of the OB 82, e.g.: Which module triggered the interrupt? What type of error has occurred?

Following execution of the OB 82, the S7 CPU continues the cyclic program from the point of interruption.

When parameterizing the CM AS-i Master ST, you can specify whether and in what cases a diagnostics interrupt should be triggered.

See Section "Parameter assignment/addressing (Page 47)"

See Section "Fault indications/fault remedies (Page 80)" for a list of possible error cases.

8.4.2 Possible response to the diagnostic interrupt

Diagnostic events of the AS-i master and all AS-i slaves are signaled by means of OB82, e.g. No voltage on AS-Interface, peripheral fault

Note

Diagnostic buffer

Please note that OB 82 is only called for the first error event. If an error caused by an AS-i slave is already active, subsequent AS-i slave errors will only be noted in the diagnostic buffer of the CPU.

The cause of the interrupt can be determined by reading out data records with diagnostic data during execution of the OB 82 block or during cyclic program execution. See Section "Data records for diagnostics (Page 82)".

8.4.3 Error messages

AS-i-specific faults

The following AS-i-specific faults are possible:

Channel / Fault type	Fault		Cause	Remedial measures
	No.	Message		
0400_H	1024	AS-i slave failed	An AS-i slave on an A address or a slave with standard address has failed. The channel number of the message shows the address of the affected AS-i slave. Possible causes: • The slave is defective. • There is a break in the cable • An overload of the sensor supply at the input slave or an overload of the actuator supply • Overload at the output for some slaves	Check: • AS-i slave • Connecting cables • Overload • EMC environment • Connected sensors and actuators
0401_H	1025	AS-i slave on B address failed	An AS-i slave on a B address has failed. The channel number of the message shows the address of the affected AS-i slave. Possible causes: • The slave is defective. • The cable is interrupted. • An overload of the sensor supply at the input slave or an overload of the actuator supply • Overload at the output for some slaves	Check: • AS-i slave • Connecting cables • Overload • EMC environment • Connected sensors and actuators

Channel / Fault type	Fault		Cause	Remedial measures
	No.	Message		
0402_H	1026	Peripheral fault in AS-i slave	An AS-i slave on an A address or a slave with a standard address signals a peripheral fault. The channel number of the message shows the address of the affected AS-i slave. Possible cause: • An overload at the output of a digital slave or an overload at the actuator • Measuring range exceeded for analog input slaves • Overload of the sensor supply at the input slave (only for some slave types) • Group fault message for M200D motor starters	Note the information in the manual for the AS-i slave. Check: • Slave • Overload • Connected sensors and actuators
0403_H	1027	Peripheral fault in AS-i slave on B address	An AS-i slave on a "B" address signals a peripheral fault. The channel number of the message shows the address of the affected AS-i slave. Possible cause: • An overload at the output of a digital slave or an overload at the actuator • Measuring range exceeded for analog input slaves • Overload of the sensor supply at the input slave (only for some slave types) • Group fault message for M200D motor starters	Note the information in the manual for the AS-i slave. Check: • Slave • Overload • Connected sensors and actuators
0404_H	1028	AS-i address used multiple times	Multiple AS-i slaves with the same profile and address are located on the AS-i bus. The affected slaves have a standard address or A address. The channel number of the message shows the address of the affected AS-i slave.	Change the addresses of the AS-i slaves to addresses that are unique in the network.
0405_H	1029	AS-i B address used multiple times	Multiple AS-i slaves with the same profile and address are located on the AS-i bus. The affected slaves have a B address. The channel number of the message shows the address of the affected AS-i slave.	Change the addresses of the AS-i slaves to addresses that are unique in the network.

Channel / Fault type	Fault		Cause	Remedial measures
	No.	Message		
0406_H	1030	No or erroneous voltage on the AS-i cable	The AS-i master has detected insufficient voltage on the AS-i cable. Data exchange on the AS-Interface has been stopped.	Check: • Voltage • Polarity on AS-i cable • Power supply
0407_H	1031	AS-i configuration error (CER)	The ACTUAL configuration of the AS-i slaves on the AS-i cable differs from the CONFIGURED configuration saved in the AS-i master. Possible causes of short-term failures: • High levels of electromagnetic interference are affecting the AS-i installation. Other possible causes: • The functional ground connection to the AS-i power supply unit or AS-i data decoupling module is not connected to ground potential. • Protected operation: A configured slave has failed or there is an excess slave on the bus. • Configuration mode: A slave with address "0" has been detected on the bus.	Check: • AS-i slave failure • Overload • Excess slave • Incorrect address • Incorrect slave type • EMC environment Remove the electromagnetic interference.
0408_H	1032	Ground fault on AS-i cable	A ground fault is present between AS-i+ and ground or between AS-i- and ground. Possible consequences: • Disruption of communication • Slave failure • Configuration error • Hazard as a result of secondary faults	Check: • Insulation fault on AS-i cable • Sensor/actuator cable Ensure that the ground fault is rectified.
$040A_H$	1034	Excess AS-i slave	There is an unconfigured AS-i slave with a default address or an A address on the AS-i bus. The channel number of the message shows the address of the affected AS-i slave.	Change the CONFIGURED configuration in the AS-i master or remove the AS-i slave.
$040B_H$	1035	Excess AS-i slave at B address	On the AS-i bus there is an unconfigured AS-i slave with a B address. The channel number of the message indicates the B address of the affected AS-i slave	Change the CONFIGURED configuration in the AS-i master or remove the AS-i slave.

Channel / Fault type	Fault		Cause	Remedial measures
	No.	Message		
$040C_H$	1036	Incorrect AS-i slave	On the AS-i bus there is an incorrect AS-i slave with a default address or an A address. The channel number of the message shows the address of the AS-i slave involved.	• Use the correct slave type. • Set the ID1 code on the slave in accordance with the CONFIGURED configuration.
$040D_H$	1037	Incorrect AS-i slave at B address	There is an incorrect AS-i slave with a B address on the AS-i bus. The channel number indicates the B address of the affected slave.	• Use the correct slave type. • Set the ID1 code on the slave in accordance with the CONFIGURED configuration.

8.5 Replacing a defective AS-i slave / automatic address programming

Automatic address programming after failure of one or more AS-i slaves - replacement of AS-i slave

The "Automatic address programming" function allows you to easily replace defective AS-i slaves.

Note

Automatic address programming

Automatic address programming is only possible if the AS-i master is operating in "protected operation" and **one or more** AS-i slaves have failed.

If several AS-i slaves have failed, you must uniquely identify the failed slaves in the configuration using the slave profile:

- IO code
- ID code
- ID2 code
- ID1 code

The automatic address programming function also supports slaves with the "CTT5" profile (multi-address slaves) and AS-i devices that contain multiple internal slave addresses. This requires each internal slave to have different identifications (IO code, ID code, ID2 code, and ID1 code).

Note

The automatic address programming function does not work if two identical slaves have failed.

Examples of devices with multiple internal slave addresses which support automatic address programming:

- Module K60 with 8DI/2DO (3RK2400-1HQ00-0AA3)
- Motor Starter M200D AS-i Standard (3RK1325-...).

If no address has yet been assigned to these devices (delivery state), only **one** address "0" is visible on the bus. The device automatically suppresses the other internal "0" addresses.

Note

Exceptions

The automatic address programming function is not available for the following devices, because the identifications of each internal slave are identical (IO code, ID code, ID2 code, and ID1 code).

- Module K60 with 8 DI (3RK1200-0DQ00-0AA3, 3RK2200-0DQ00-0AA3, 3RK2200-1DQ00-1AA3)
- Safety-related module K45 with 4 F-DI (3RK1205-0CQ00-0AA3).

Detection of a defective AS-i slave

An illuminated "AUP" LED signals the following in "protected operation":

- Slave failure was detected:
  - Exactly **one** slave has failed, or
  - A device containing multiple different slaves has failed, **or**
  - Multiple slaves or devices have failed, each of the failed slaves having a different configuration
- Automatic address programming by the AS-i master is possible.

If an AS-i slave fails, the AS-i master indicates the address of the failed slave via the "SL_Xy (A)" and "SL_xY (B)" LEDs.

If a device with multiple internal slave addresses fails, the AS-i master indicates the failure of multiple slaves.

Replacement of a defective AS-i slave

- Replace the defective AS-i slave with an **identical** AS-i slave with address "0" (setting in delivery state).
- Replace the defective AS-I device containing multiple internal slave addresses with an identical AS-i device with address "0" on all internal slaves (setting in delivery state).

> **Note**
>
> **Replacement of a defective AS-i slave**
>
> Only one address "0" may be configured on the bus at any one time. If you want to replace several slaves or devices, you must replace them one after the other with the AS-i master switched on.

For the new slave or device, the AS-i master programs the address or addresses of the original failed device.

The LEDs "AUP" and "CER" go out once all slaves have been correctly replaced.

8.6 Duplicate address detection

To ensure that the AS-Interface system functions correctly, all the AS-i slaves must have a unique AS-i address on the bus.

If the same AS-i address is assigned to one or more slaves, this incorrect assignment is referred to herein as a duplicate address.

As part of standard operation, the AS-i master monitors the data exchange for errors and thus often excludes slaves with a duplicate address automatically from the cyclic data exchange. This is the case for duplicate addresses in which the slave types are different (profile identification IO code, ID code, ID2 code, and ID1 code) and duplicate addresses for slaves having a different status at their inputs.

In "protected operation", this fault condition is displayed on the AS-i master as a configuration error with the relevant AS-i address and the affected slaves detect a communication error.

The duplicate address detection function of the CM AS-i Master ST also detects cases of slaves with duplicate address in which the cyclic data exchange is not excluded by standard mechanisms. Such cases include duplicate addresses in which the slave types are identical (profile identification, IO code, ID code, ID2 code, and ID1 code) and in which the slaves either have the same status at their inputs or have no inputs (output slaves).

When a duplicate address is detected, the AS-i master signals a duplicate address error and automatically resets the output data of the address concerned to "0" so that the outputs of the affected slaves are switched off. Communication with the affected slaves is not interrupted, i.e. the slaves do not signal a communication error.

For slaves without cyclic data communication, the duplicate address detection function of the CM AS-i Master ST cannot be executed.

Note

System behavior according to AS-i specification

If you connect a slave with duplicate address to the AS-i cable while the bus is operating, the added slave is initially excluded from cyclic data communication and its LEDs indicate a communication error. According to the specification, the AS-i master does not activate an AS-i slave until its address is recognized as a new address on the bus, e.g., when a power-up of the bus takes place. If the bus contains an active slave, no further automatic slave activation occurs on the same address during operation, even if an additional slave with the same address (duplicate address) is added.

However, manual activation of the the slave can be initiated via the command interface by writing parameters to the slave address.

For physical reasons, the duplicate address detection function of the CM AS-i Master ST cannot detect a duplicate address during cyclic data exchange in every configuration. Therefore, like for any AS-i system, it is essential to ensure when assigning AS-i addresses that each AS-i slave contains a unique AS-i address on the bus, e.g., by using addressing device 3RK1904-32AB02.

The duplicate address detection function can assist in identifying inadvertent duplicate addressing.

The duplicate address detection of the CM AS-i Master ST from firmware V1.1 and higher has been optimized for an AS-i cable length up to 100 m without branches.

The duplicate address detection function of firmware V1.0 is designed for shorter cable lengths.

The duplicate address detection function can be used in the specified and additional configurations, but it cannot be guaranteed that duplicate addresses will be uniquely detected in every case.

For configurations with an AS-i repeater, the duplicate address detection function does not work due to the separation of the cable into multiple segments.

Enabling the duplicate address detection function

For the CM AS-i Master ST with firmware V1.1 and higher, the duplicate address detection function is activated in the configuration via HW Config or the GSD setting. After a start or restart of the CM AS-i Master ST V1.1 and higher, the setting is accepted from HW Config or the GSD setting.

For the CM AS-i Master ST with firmware V1.0 and higher, the duplicate address detection function is deactivated when the AS-i Master is switched on and can be set by writing data record DS 100, see Chapter "DS 100 Switch duplicate address detection on/off (Page 173)". The activation status is saved in volatile memory of the AS-i master. After a startup or restart of the CM AS-i Master ST V1.0, the duplicate address detection function must be activated via the user program, if required.

Function description

The duplicate address detection function assists you in identifying inadvertent duplicate addressing.

When commissioning the AS-i system, check that duplicate address detection can be used for the AS-i configuration used.

- Install the complete AS-i system and ensure that the specified addresses of the slaves are correct and unique.
- Enable the duplicate address detection function. In firmware V1.1 and higher you can do this for AS-i voltages of either 24 V or 30 V.
- Check whether the CM AS-i Master ST signals a duplicate address in spite of correct slave address assignment. If a duplicate address is signaled on the AS-i master even though the bus configuration is correct, this means that duplicate address detection cannot be used for this bus configuration. Should this occur, disable the duplicate address detection function.
- Note that when the duplicate address detection function is enabled, the presence of a duplicate address may not be detected, depending on the bus configuration.

Note

The activation status is saved in volatile memory of the AS-i master. After a startup or restart of the CM AS-i Master ST, duplicate address detection must be activated again via the user program, if required.

The CM AS-i Master ST signals a detected duplicate address as follows:

- The "CER" LED lights up to indicate a configuration error.
- The "SL_Xy (A)" and "SL_xY (B)" LEDs signal the AS-i address concerned.
- The message "AS-i address used multiple times" is output.

To rectify the fault, check and change the address of the affected AS-i slave, e.g. using the addressing unit. Via the online function of *STEP 7* it is not possible to change the AS-i address of an individual slave if there are multiple slaves with the same address on the AS-i cable.

See also

DS 100 Read setting for duplicate address detection (Page 174)

8.7 Diagnosis via the web server

Web server functionality

Many SIMATIC controllers provide integrated web server functionality. This enables access via a web browser to the data of the CPU and its connected components, e.g. the AS-i master.

A *STEP 7* library is available as a download for diagnosing the AS-i master via a web browser. It presents the most important diagnostic information in a clear overview. The package is based on the concept of user-defined web pages. You can obtain the package from the Siemens Service & Support Portal under the following link:

Service and support portal (http://support.automation.siemens.com/WW/view/en/50897766)

8.8 Fault indications/fault remedies

Fault indications/remedies for faults on the CM AS-i Master ST

Below are possible fault indications during operation of the AS-i master and potential remedial measures.

Table 8- 9 Fault indications and remedies for faults on the AS-i Master

Fault	Possible cause	Remedy
"AS-i fault" LED lights up red	The current consumption of the AS-i slaves is too high. Result: Voltage on the AS-i cable is too low.	Check the current consumption of the AS-i slaves.
	No voltage is present on the AS-i cable or the voltage is too low.	Check the connection with the AS-i power supply unit.
	Short-circuit on the AS-i cable	Check the AS-i cable and the connected AS-i slaves.
"DIAG" LED not lit	There is no supply over the communications bus.	Check whether the module is inserted correctly.
"DIAG" LED flashes green, but does not switch to constant green light	The AS-i master is not configured.	Configure the AS-i master in *STEP 7*.
"CER" LED is lit.	A configured AS-i slave has failed. • Evaluate the slave indication.	Replace the defective AS-i slave or configure the AS-i master again if the AS-i slave is not required.
	A non-configured AS-i slave was connected to the AS-i cable.	Remove the AS-i slave or configure the AS-i master again.
	An AS-i slave has been connected whose configuration data, e.g., IO code, ID codes, does not match the values of the configured AS-i slave.	Check whether an incorrect AS-i slave has been connected. Configure the AS-i master again, if necessary.
"CER" LED flashes erratically , i.e. a configured AS-i slave fails sporadically.	Loose connection	Check the connections of the AS-i slaves.
	Injection of interference on the AS-i cable.	Check that the grounding of the AS-i master and routing of the AS-i cable are correct. Check whether the shield of the AS-i power supply unit is connected correctly.
	The connected sensor is causing an overload.	Check the sensor and the sensor cable for damage.
The AS-i master does not switch from "configuration mode" to "protected operation".	An AS-i slave with address 0 is connected to the AS-i cable. The AS-i master is unable to switch to "protected operation" as long as this slave is connected.	Remove the AS-i slave with address 0 or set the correct address using the AS-i addressing device.
In *STEP 7* it is not possible to switch between "configuration mode" and "protected operation"	The automation system is in the "RUN" state.	Switch the automation system to the "STOP" state.
The AS-i master does not switch from "protected operation" to "configuration mode".	The automation system is in the "RUN" state.	Switch the automation system to the "STOP" state.

Fault	Possible cause	Remedy
Automatic address programming does not take place.	The configuration data, e.g., IO code, ID code, ID2 code, and ID1 code, of the replaced AS-i slave does not match the values of the original slave.	Check that the correct replacement slave was used. Compare the manufacturer's information with regard to configuration data. If the original slave is to be replaced by a different type, assign the address with the AS-i addressing device and configure the AS-i master again.
	Replaced AS-i slave does not have the address "0".	Set the address of the replaced slave with the AS-i addressing device.
	Replaced AS-i slave is not correctly connected or is defective.	Check the connections of the slave. Replace the slave, if necessary.
	The AS-i master is in "configuration mode".	Program the address of the new AS-i slave with the AS-i addressing device or via the command interface of the AS-i master.
	Several slaves with the same profile have failed.	Program the addresses of the new AS-i slaves with the AS-i addressing device.
No LEDs are lit, except possibly for the "DIAG" LED	The AS-i voltage is missing.	
"PF" LED is lit	One or more AS-i slaves signal a fault in the connected I/O.	Check the I/O components connected to the AS-i slaves and the cabling for wire break or short-circuit.

Reference

You will find further information about the LEDs on the AS-i master in Section "Meaning of the LEDs (Page 64)".

8.9 Data records for diagnostics

8.9.1 DS 92 Diagnostic data record (FW V1.1 and higher)

The operating status of the AS-i master, the connected AS-i network and the AS-i slave is stored as diagnostic data record DS 92 in the CM AS-i Master ST module.

Description

This data record provides information about the status of an AS-i network.

Table 8- 10 Structure of diagnostic data record DS 92, read

Byte	Description							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0 … 1	Reserved							
2	MA30V	MA24V	Res.	Res.	Res.	MADDR	PF	CER
3	Reserved				EFD	CM	CFGOK	DIAG
4	**Flags_1** (See Table "AS-i master flags")							
5	**Flags_2** (See Table "AS-i master flags")							
6	Reserved							
7	Reserved							
Slave diagnostics								
8 … 15	List of active slaves (see Table "Structure of bit fields")							
	Bit = 0	Slave is not in the list of active slaves.						
	Bit = 1	Slave is in the list of active slaves.						
16 … 23	List of failed slaves (see Table "Structure of bit fields")							
	Bit = 0	The configured slave has not failed.						
	Bit = 1	The configured slave has failed.						
24 … 31	List of incorrect slaves (see Table "Structure of bit fields")							
	Bit = 0	The profile of the connected slave is correct.						
	Bit = 1	The profile of the connected slave is incorrect.						
32 … 39	List of excess slaves (see Table "Structure of bit fields")							
	Bit = 0	The connected slave is configured or no slave is connected.						
	Bit = 1	The connected slave is not configured.						
40 … 47	List of multiple addressing (see Table "Structure of bit fields")							
	Bit = 0	The AS-i address is not assigned or is only assigned once.						
	Bit = 1	The AS-i address is assigned more than once.						
48 … 55	List of I/O errors (see Table "Structure of bit fields")							
	Bit = 0	The slave at the AS-i address does not have an I/O error.						
	Bit = 1	The slave at the AS-i address°has an I/O error.						

Byte	Description							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
56 … 63	List of configured ID = A (see Table "Structure of bit fields")							
	Bit = 0	A standard slave is configured at the AS-i address.						
	Bit = 1	An A/B slave is configured at the AS-i°address.						
64 … 71	List of actual ID = A (see Table "Structure of bit fields")							
	Bit = 0	A standard slave is connected at the AS-i address.						
	Bit = 1	An A/B slave is connected at the AS-i°address.						
72 … 79	List of detected slaves (see Table "Structure of bit fields")							
	Bit = 0	No slave detected at the AS-i°address.						
	Bit = 1	Slave detected at the AS-i°address.						
80 … 87	List of configured slaves (see Table "Structure of bit fields")							
	Bit = 0	No slave configured at the AS-i°address.						
	Bit = 1	Slave configured at the AS-i°address.						

Structure of the bit fields:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SLAVE 7/7A	SLAVE 6/6A	SLAVE 5/5A	SLAVE 4/4A	SLAVE 3/3A	SLAVE 2/2A	SLAVE 1/1A	SLAVE 0/Reserved
1	SLAVE 15/15A	SLAVE 14/14A	SLAVE 13/13A	SLAVE 12/12A	SLAVE 11/11A	SLAVE 10/10A	SLAVE 9/9A	SLAVE 8/8A
2	SLAVE 23/23A	SLAVE 22/22A	SLAVE 21/21A	SLAVE 20/20A	SLAVE 19/19A	SLAVE 18/18A	SLAVE 17/17A	SLAVE 16/16A
3	SLAVE 31/31A	SLAVE 30/30A	SLAVE 29/29A	SLAVE 28/28A	SLAVE 27/27A	SLAVE 26/26A	SLAVE 25/25A	SLAVE 24/24A
4	SLAVE 7B	SLAVE 6B	SLAVE 5B	SLAVE 4B	SLAVE 3B	SLAVE 2B	SLAVE 1B	Reserved
5	SLAVE 15B	SLAVE 14B	SLAVE 13B	SLAVE 12B	SLAVE 11B	SLAVE 10B	SLAVE 9B	SLAVE 8B
6	SLAVE 23B	SLAVE 22B	SLAVE 21B	SLAVE 20B	SLAVE 19B	SLAVE 18B	SLAVE 17B	SLAVE 16B
7	SLAVE 31B	SLAVE 30B	SLAVE 29B	SLAVE 28B	SLAVE 27B	SLAVE 26B	SLAVE 25B	SLAVE 24B

Explanation of status bits:

MA30V	= 0	Multiple address detection for AS-i 30 V is deactivated.
	= 1	Multiple address detection for AS-i 30 V is activated.
MA24V	= 0	Multiple address detection for Power24V is deactivated.
	= 1	Multiple address detection for Power24V is activated.
MADDR	= 0	No multiple addresses detected on the AS-i°cable.
	= 1	Multiple addressing detected for at least one AS-i address on the AS-i cable. This means that multiple slaves have the same AS-i address.
PF	= 0	No I/O errors detected.
	= 1	I/O errors detected.
CER	= 0	No AS-i configuration errors detected.
	= 1	AS-i configuration errors detected.
EFD	0 =	No ground fault detected
	1 =	Ground fault detected
CM	0 =	Master in protected operation
	1 =	Master in configuration mode
CFGOK	0 =	Configuration not OK or slave exists with address°0.
	1 =	Configuration OK
DIAG	0 =	No diagnostics pending
	1 =	Diagnostics pending. It is set when:

- The AS-i master is in "offline" mode.
- The AS-i voltage is not OK.
- Multiple addresses were detected.
- An I/O error was detected.
- A configuration error was detected.
- A slave with address°0 exists.

AS-i master flags:

Flag	Bit	Name of the bit	Meaning
Flag_1	0	Config_OK	The flag is set when the CONFIGURED configuration and the ACTUAL configuration match.
	1	LDS.0	The flag is set when an AS-i slave with address 0 is present. (List of Detected Slaves)
	2	Auto_Address_Assign	The flag is set if automatic address programming is possible. This means that AUTO_ADDR_ENABLE = 1 and no "incorrect" AS-i slaves is connected to AS-Interface.
	3	Auto_Address_Available	The flag is set when automatic address programming is performed as soon as a slave with a valid configuration is connected at address zero.
	4	Configuration_Active	The flag is set in "configuration mode" and reset in "protected operation".
	5	Normal_Operation_Active	The flag is set when the AS-i master is in "protected operation".
	6	APF	The flag is set when the voltage on the AS-i cable is too low, or a power down was detected during data transmission (AS-i Power Fail).
	7	Offline_Ready	The flag is set if the offline phase is active.
Flag_2	0	Periphery_OK	The flag is set if none of the AS-i slaves signal a peripheral fault. All bits in the LPF are zero.
	1	Data_Exchange_Active	Controlling: When the flag is set, data transfer starts between the master and slave.
	2	Off_Line	Controlling: When the flag is set, the device is switched "OFFLINE" or is "Offline".
	3	AUTO_ADDR_ENABLE	The flag is set when automatic address programming is enabled by the user.
	4	GROUND FAULT	The flag is set if a ground fault has been detected on the AS-i cable.
	5	EEPROM_OK	The flag is set if the test of the internal EEPROM was successful.
	6	EFD_Disable	The flag indicates whether ground fault detection is switched on (BIT = 0) or off (BIT = 1).
	7	Reserved	--

8.9.2 DS 96 Read AS-i master error counters and status messages (FW V1.1 and higher)

Meaning

This data record reads out error counters that pertain to the overall AS-i network.

If the AS-i power supply is missing, the overall device fails. This leads to all counters being reset. The count starts again each time the device is powered up.

Table 8- 11 Meaning of error counter

Count value / Information	Meaning
AS-i Power Fail	The count value is incremented when the AS-i power supply drops to a value that is too low.
Ground fault	The count value is increased when a ground fault has been detected on the AS-i cable.
Slave failure	The count value is increased when an active slave fails, that is, when process data transmission has been interrupted. An active slave only fails when it does not respond to six consecutive master calls.
Missing slave message frame	The count value is increased when a slave does not respond to a master call or the master does not receive the response. Process data transmission is not interrupted in this case.
Erroneous slave message frame	The count value is increased when the master receives an incomplete slave response, such as when slaves are added during operation. Process data transmission is not interrupted in this case.
I/O fault	The count value is increased when a slave signals an I/O error.
Protocol error	The count value is increased when the master detects a transmission error for a slave that needs multiple cycles for transmission of data, e.g. for analog data.
Erroneous master frame	The count value is incremented when a master call cannot be sent correctly, e.g. in the event of strong interfering signals on the AS-i cable. Process data transmission is not interrupted in this case.
Sent master frames	Number of master frames This counter counts all frames sent by the master, regardless of whether or not a slave response was received. The total number of master frames is calculated as follows: MT_CNT_TOTAL = (MT_CNT_HIGH x MT_CNT_BASE) + MT_CNT_LOW The error count starts over each time the device is powered up. By dividing the absolute values of the error counters by the number of master frames, it is possible to calculate the percentage of errors and thus the error frequency.

Table 8- 12 Structure of the data record

Byte	Meaning		
0	Reserved		High byte
1			Low byte
2	Summation counter: AS-i Power Fail		High byte
3			Low byte
4	Summation counter: Ground fault		High byte
5			Low byte
6	Summation counter: Slave failure		High word, high byte
7			High word, low byte
8			Low word, high byte
9			Low word, low byte
10	Summation counter: Missing slave frame		High word, high byte
11			High word, low byte
12			Low word, high byte
13			Low word, low byte
14	Summation counter: Erroneous slave frame		High word, high byte
15			High word, low byte
16			Low word, high byte
17			Low word, low byte
18	Summation counter: Slave peripheral fault		High word, high byte
19			High word, low byte
20			Low word, high byte
21			Low word, low byte
22	Summation counter: Slave protocol error (for slaves according to CTT1 ... CTT5)		High word, high byte
23			High word, low byte
24			Low word, high byte
25			Low word, low byte
26	Summation counter: Erroneous master frame		High word, high byte
27			High word, low byte
28			Low word, high byte
29			Low word, low byte
30 … 37	List of count values > 0 (see "Structure of bit fields")		
	Bit = 0	Count value = 0 for all error counters of the AS-i address	
	Bit = 1	Count value > 0 for at least one error counter of the AS-i address	
38	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)		High word, high byte
39			High word, low byte
40			Low word, high byte
41			Low word, low byte
42	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)		High word, high byte
43			High word, low byte
44			Low word, high byte
45			Low word, low byte

Byte	Meaning	
46	Summation counter: Sent master frames, factor (MT_CNT_BASE)	High word, high byte
47		High word, low byte
48		Low word, high byte
49		Low word, low byte
50	Reserved	Bit 0 = MADDR
51	Reserved	
52 … 59	List of multiple addressing (see Table "Structure of bit fields")	
	Bit = 0	The AS-i address is assigned once or is not present.
	Bit = 1	The AS-i address is assigned more than once.

The counters are integer values (2 bytes or 4 bytes).

Structure of the bit fields:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SLAVE 7/7A	SLAVE 6/6A	SLAVE 5/5A	SLAVE 4/4A	SLAVE 3/3A	SLAVE 2/2A	SLAVE 1/1A	SLAVE 0/Reserved
1	SLAVE 15/15A	SLAVE 14/14A	SLAVE 13/13A	SLAVE 12/12A	SLAVE 11/11A	SLAVE 10/10A	SLAVE 9/9A	SLAVE 8/8A
2	SLAVE 23/23A	SLAVE 22/22A	SLAVE 21/21A	SLAVE 20/20A	SLAVE 19/19A	SLAVE 18/18A	SLAVE 17/17A	SLAVE 16/16A
3	SLAVE 31/31A	SLAVE 30/30A	SLAVE 29/29A	SLAVE 28/28A	SLAVE 27/27A	SLAVE 26/26A	SLAVE 25/25A	SLAVE 24/24A
4	SLAVE 7B	SLAVE 6B	SLAVE 5B	SLAVE 4B	SLAVE 3B	SLAVE 2B	SLAVE 1B	Reserved
5	SLAVE 15B	SLAVE 14B	SLAVE 13B	SLAVE 12B	SLAVE 11B	SLAVE 10B	SLAVE 9B	SLAVE 8B
6	SLAVE 23B	SLAVE 22B	SLAVE 21B	SLAVE 20B	SLAVE 19B	SLAVE 18B	SLAVE 17B	SLAVE 16B
7	SLAVE 31B	SLAVE 30B	SLAVE 29B	SLAVE 28B	SLAVE 27B	SLAVE 26B	SLAVE 25B	SLAVE 24B

Explanation of the status bits

MADDR= 0 No multiple addressing detected on the AS-i°cable.

= 1 Multiple addressing detected for at least one AS-i address on the AS-i cable. This means that multiple slaves have the same AS-i address.

8.9.3 DS 97 Read and reset AS-i master error counters (FW V1.1 and higher)

Description

This data record functions in the same manner as the "DS 96 Read AS-i slave error counters" data record. After the DS 97 data record is read, all error counters in the AS-i master are reset to "0".

The structure of the DS 97 data record is identical to the structure of the DS 96 data record. For the meaning of the error counters, refer to Section "DS 96 Read AS-i master error counters and status messages (FW V1.1 and higher) (Page 86)".

8.9.4 DS 150 to DS 153 Read AS-i error counters

These data records read the error counters of the AS-i slaves. Data records DS 150 and DS 151 access the standard addresses and the A addresses. Data records DS 152 and DS 153 access the B addresses. The counters for addresses 16 / 16A exist identically in data records DS 150 and DS 151. The counters for address 16B exist identically in data records DS 152 and DS 153.

Error counter

The CM AS-i Master ST module manages several counters internally which log the number of master frames sent and the number of different error occurrences.

These counter values can be read out using data records DS 150 to DS 153:

- DS 150 contains counter values for slave addresses 1(A) to 16(A).
- DS 151 contains counter values for slave addresses 16(A) to 31(A).
- DS 152 contains counter values for slave addresses 1B to 16B
- DS 153 contains counter values for slave addresses 16B to 31B

Each data record also contains the total count of master frames sent. To determine a relative error rate, divide the count of error occurrences by the number of master frames sent.

The bus system allows the automatic sending of repeat message frames. This ensures that the process data is reliably transferred between master and slave in the industrial environment, even in the case of brief interruptions in transmission, e.g. due to switching operations. If the fault limit value is exceeded, or the slave is not functioning correctly due to a defect, communication to the slave cannot be performed within the defined time period. In this case, transmission of the process data is interrupted. The master signals failure of the slave address and tries to establish communication again.

Under error-free conditions, one master frame is sent to every available slave address for cyclic data transfer per AS-i bus cycle. The addressed slave responds with a corresponding slave frame. Depending on the configuration of the bus, between 1 and 31 slaves are addressed in each AS-i bus cycle. This results in a maximum bus cycle time of 5 ms. When two slaves with extended addressing have the same numerical address, but one is the A address and one the B address, these two slaves are automatically addressed in two consecutive bus cycles. It can be assumed that around 64 000 master frames are sent per second.

Table 8- 13 Meaning of error counter

Count value / Information	Meaning
Slave failure	The count value is increased when an active slave fails, that is, when process data transmission has been interrupted. An active slave only fails when it does not respond to six consecutive master calls.
Missing slave frame	The count value is increased when a slave does not respond to a master call or the master does not receive the response. Transmission of process data is not interrupted in this case.
Erroneous slave frame	The count value is increased when the master receives an incomplete slave response, such as when slaves are added during operation. Transmission of process data is not interrupted in this case.
I/O fault	The count value is increased when a slave signals an I/O error.
Protocol error	The count value is increased when the master detects a transmission error for a slave that needs multiple cycles for transmission of data, e.g. for analog data.
Erroneous master frame	The count value is incremented when a master call cannot be sent correctly, e.g. in the event of strong interfering signals on the AS-i cable. Transmission of process data is not interrupted in this case.
Sent master frames	Number of master frames This counter counts all frames sent by the master, regardless of whether or not a slave response was received. The total number of master frames is calculated as follows: MT_CNT_TOTAL = (MT_CNT_HIGH x MT_CNT_BASE) + MT_CNT_LOW The error count starts over each time the device is powered up. By dividing the absolute values of the error counters by the number of master frames, it is possible to calculate the percentage of errors and thus the error frequency.

Table 8- 14 Slave address structure of the counters

Byte	Counter	
0	Counter: Slave failure	High byte
1		Low byte
2	Counter: Missing slave frame	High byte
3		Low byte
4	Counter: Erroneous slave frame	High byte
5		Low byte
6	Counter: I/O fault	High byte
7		Low byte
8	Counter: Protocol error	High byte
9		Low byte
10	Counter: Erroneous master frame	High byte
11		Low byte

The counters are integer values (2 bytes).

Table 8- 15 Master frame structure of the counters

Byte	Meaning	
0	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)	High word, high byte
1		High word, low byte
2		Low word, high byte
3		Low word, low byte
4	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)	High word, high byte
5		High word, low byte
6		Low word, high byte
7		Low word, low byte
8	Summation counter: Sent master frames, factor (MT_CNT_BASE)	High word, high byte
9		High word, low byte
10		Low word, high byte
11		Low word, low byte

The counters are integer values (4 bytes).

8.9.4.1 DS 150 Read AS-i slave error counters 1/1A to 16/16A

Table 8- 16 Structure of data record DS 150

Byte	Meaning
0	Version High
1	Version Low
2 … 13	Counter for slave address 1 / 1A
14 … 25	Counter for slave address 2 / 2A
26 … 37	Counter for slave address 3 / 3A
38 … 49	Counter for slave address 4 / 4A
50 … 61	Counter for slave address 5 / 5A
62 … 73	Counter for slave address 6 / 6A
74 … 85	Counter for slave address 7 / 7A
86 … 97	Counter for slave address 8 / 8A
98 … 109	Counter for slave address 9 / 9A
110 … 121	Counter for slave address 10 / 10A
122 … 133	Counter for slave address 11 / 11A
134 … 145	Counter for slave address 12 / 12A
146 … 157	Counter for slave address 13 / 13A
158 … 169	Counter for slave address 14 / 14A
170 … 181	Counter for slave address 15 / 15A
182 … 193	Counter for slave address 16 / 16A
194 … 205	Master frame counter

8.9.4.2 DS 151 Read AS-i slave error counters 16/16A to 31/31A

Table 8- 17 Structure of data record DS 151

Byte	Meaning
0	Version High
1	Version Low
2 … 13	Counter for slave address 16 / 16A
14 … 25	Counter for slave address 17 / 17A
26 … 37	Counter for slave address 18 / 18A
38 … 49	Counter for slave address 19 / 19A
50 … 61	Counter for slave address 20 / 20A
62 … 73	Counter for slave address 21 / 21A
74 … 85	Counter for slave address 22 / 22A
86 … 97	Counter for slave address 23 / 23A
98 … 109	Counter for slave address 24 / 24A
110 … 121	Counter for slave address 25 / 25A
122 … 133	Counter for slave address 26 / 26A
134 … 145	Counter for slave address 27 / 27A
146 … 157	Counter for slave address 28 / 28A
158 … 169	Counter for slave address 29 / 29A
170 … 181	Counter for slave address 30 / 30A
182 … 193	Counter for slave address 31 / 31A
194 … 205	Master frame counter

8.9.4.3 DS 152 Read AS-i slave error counters 1B to 16B

Table 8- 18 Structure of data record DS152

Byte	Meaning
0	Version High
1	Version Low
2 … 13	Counter for slave address 1B
14 … 25	Counter for slave address 2B
26 … 37	Counter for slave address 3B
38 … 49	Counter for slave address 4B
50 … 61	Counter for slave address 5B
62 … 73	Counter for slave address 6B
74 … 85	Counter for slave address 7B
86 … 97	Counter for slave address 8B
98 … 109	Counter for slave address 9B
110 … 121	Counter for slave address 10B
122 … 133	Counter for slave address 11B
134 … 145	Counter for slave address 12B
146 … 157	Counter for slave address 13B
158 … 169	Counter for slave address 14B
170 … 181	Counter for slave address 15B
182 … 193	Counter for slave address 16B
194 … 205	Master frame counter

8.9.4.4 DS 153 Read AS-i slave error counters 16B to 31B

Table 8- 19 Structure of data record DS 153

Byte	Meaning
0	Version High
1	Version Low
2 … 13	Counter for slave address 16B
14 … 25	Counter for slave address 17B
26 … 37	Counter for slave address 18B
38 … 49	Counter for slave address 19B
50 … 61	Counter for slave address 20B
62 … 73	Counter for slave address 21B
74 … 85	Counter for slave address 22B
86 … 97	Counter for slave address 23B
98 … 109	Counter for slave address 24B
110 … 121	Counter for slave address 25B
122 … 133	Counter for slave address 26B
134 … 145	Counter for slave address 27B
146 … 157	Counter for slave address 28B
158 … 169	Counter for slave address 29B
170 … 181	Counter for slave address 30B
182 … 193	Counter for slave address 31B
194 … 205	Master frame counter

8.9.5 DS 154 Delete AS-i error counters (from V1.1)

Description

When writing this data record all the error counters are reset.

The content of the data record has to be filled with zero values.

Table 8- 20 Structure of DS 154 write

Byte	Meaning
0	0
1	0
2	0
3	0

Using the command interface

9

9.1 Introduction

You control the behavior of the AS-i master in your user program entirely through the command interface.

This chapter contains the information you need for accessing the command interface of the CM AS-i Master ST.

9.2 Command interface with SIMATIC S7

Instruction "ASI_CTRL"

The instruction "ASI_CTRL" is available for controlling the command interface. You will find this instruction in *STEP 7* in the task card "Instructions" under "Advanced instructions" > "Distributed I/O" > "Others" > "ASI".

For detailed instructions on using the instruction "ASI_CTRL", see: ASI_CTRL (http://support.automation.siemens.com/WW/view/en/51678777).

9.3 Command interface with controllers of other manufacturers

Functional principle

AS-i commands are read and written via the acyclic services of PROFINET/PROFIBUS. You use the "Read_data_record" and "Write_data_record" (data record 2) services in the user program of the IO controller/DP master for this.

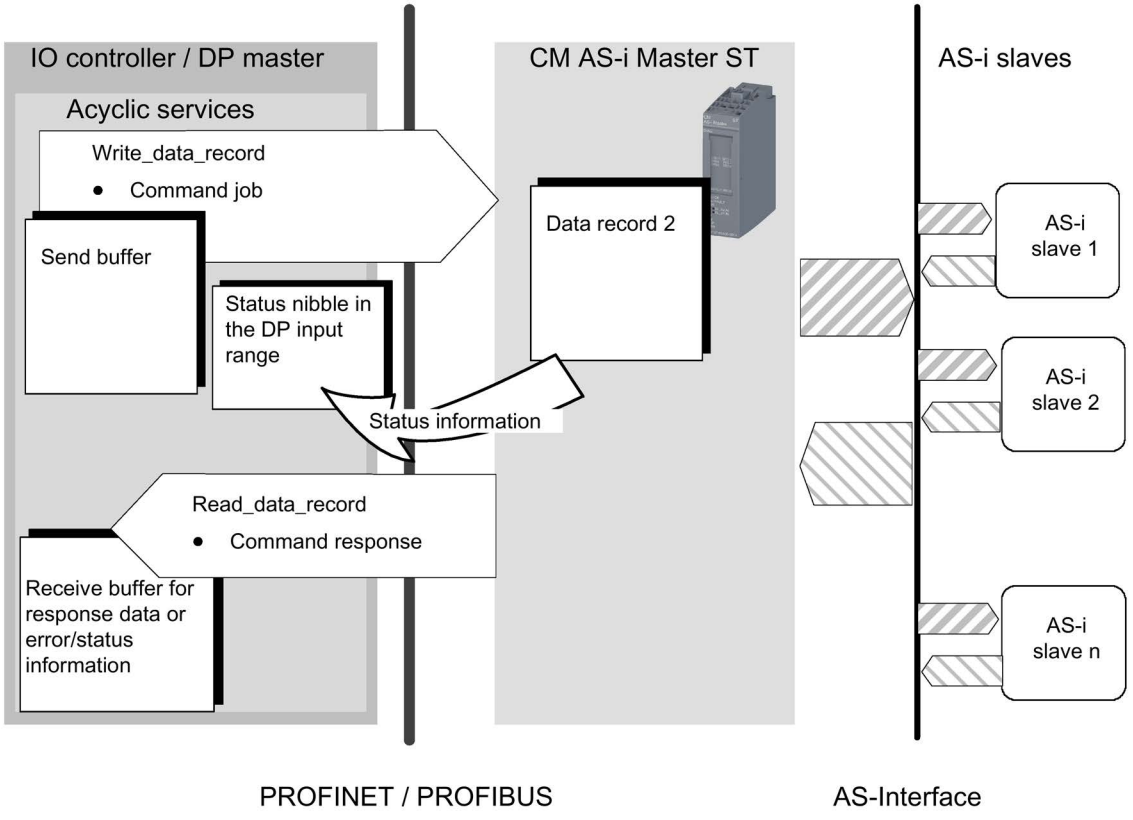


Figure 9-1 Functional principle

Job parameters

You assign parameters for the "Read_data_record" and "Write_data_record" jobs. The following parameters control the issuance of the commands:

- Index:

  Defines the data record number = 2

- Length:
  - With "Write_data_record", you specify the length of the send data depending on the command.
  - With "Read_data_record", the CM AS-i Master ST signals the length of the receive data via the status nibble.

Command processing in the user program

Structure the command processing in the user program as follows:

1. Specify the command call (Page 103) in a send buffer in the user program.
2. Send this data record call to the CM AS-i Master ST with Write_data_record (data record 2).
3. Then, query the status of the command processing in the input range for digital values (cyclic services). The status information is stored in the first byte reserved for it (byte 0) in bits 4 to 7 of the input range (status nibble).
4. Different reactions occur depending on the result of the status evaluation. You can find these in the following sequence chart. Details on the meaning of the status nibble can be found in the "Coding of the status nibble" table.

   To complete the command processing, you must always issue a Read_data_record (data record 2) job either to obtain further information or to apply the response data.

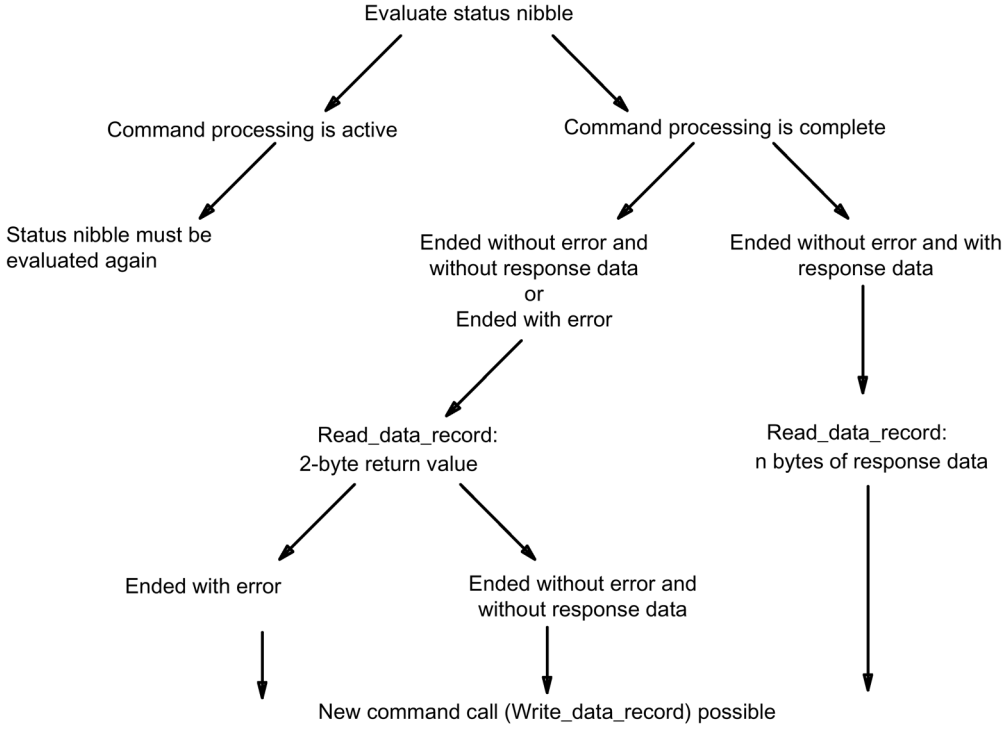


Figure 9-2 Flowchart

Table 9- 1 Coding of the status nibble

Status nibble (byte 1 of the digital input data)				Meaning
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
1	0	0	0	Startup detection 1: The status nibble switches between the values 1000_B and 1110_B following a startup/restart of the AS-i master. Initiation of a command by the user program is possible.
1	1	1	0	Startup detection 2: The status nibble switches between the values 1000_B and 1110_B following a startup/restart of the AS-i master. Initiation of a command by the user program is possible.
1	1	0	0	Reserved for SIMATIC S7 use FB ASI_CTRL Initiation of a command by the user program is possible.
0	0	1	0	The command processing is active Initiation of a command by the user program is not possible.
0	0	0	1	Command processing has ended. An asynchronous read access can be used to retrieve a **2-byte** return value from the AS-i master. Two cases are distinguished here: • The return value is 0: A command without response data has been ended without errors. • The return value is a value **other than 0**: The command has been ended **with error** (see "Return value in response buffer" table). Initiation of a new command by the user program is possible.
0	0	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **1 byte** of response data from the AS-i master. Initiation of a new command by the user program is possible.
0	1	0	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **4 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
0	1	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **14 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
1	0	0	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **16 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
1	0	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **32 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
1	1	0	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **56 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.

Status nibble (byte 1 of the digital input data)				Meaning
Bit 7	Bit 6	Bit 5	Bit 4	
1	1	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **221 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
0	1	0	0	Job processing is complete. The response data or return value of the previous job has already been read by the user. Initiation of a new command by the user program is possible.

Example

The table below indicates the behavior of the status nibble display as a result of the device status and the command processing in the user program:

	Action	Response in the status nibble
1.	Switching on the AS-i voltage of the CM AS-i Master ST.	1110_B … 1000_B … 1110_B …
2.	The user program transfers a command (e.g., Write_parameter) to the CM AS-i Master ST with an asynchronous write access.	0010_B (briefly; dependent on command)
3.	The AS-i master ends the command. The user program can read the return value	0001_B
4.	The user program reads the 2-byte return value with an asynchronous read access.	0100_B
5.	... Further program processing ...	…
6.	The user program transfers a command (e.g., Read_expanded_lists_and_flags) to the CM AS-i Master ST with an asynchronous write access.	0010_B (briefly, dependent on command)
7.	The AS-i master ends the command without errors. The user program can read the response data.	1011_B
8.	The user program reads 32 bytes of response data with an asynchronous read access.	1011_B

Return value

Processing errors are itemized in the return value of the response buffer, if necessary. An error indication exists when "ended without error and without response data or ended with error" is displayed in the status nibble (coding: 0001_H).

Table 9- 2 Return value in the response buffer

STATUS	Meaning
0000_H	**Job completed without errors**
8381_H	The AS-i slave address is incorrect.
8382_H	The AS-i slave is not activated (not in LAS).
8383_H	Error on the AS-Interface
8384_H	The command is not permitted in the current state of the AS-i master.
8385_H	An AS-i slave with address 0 exists.
8386_H	The AS-i slave has impermissible configuration data (IO, ID, ID2, or ID1 code).
$83A1_H$	The referenced AS-i slave was not found on the AS-Interface.
$83A2_H$	An AS-i slave with address 0 exists.
$83A3_H$	An AS-i slave with the new address already exists on the AS-Interface.
$83A4_H$	The AS-i slave address cannot be deleted.
$83A5_H$	The AS-i slave address cannot be set.
$83A6_H$	The AS-i slave address cannot be permanently saved.
$83A7_H$	Error while reading the ID1 code
$83A8_H$	The destination address is not plausible: e.g. a B slave address is used for a standard slave.
$83B1_H$	A length error occurred during the string transfer in accordance with Profile 7.4.
$83B2_H$	A protocol error occurred during the string transfer in accordance with Profile 7.4.
$83C0_H$	The AS-i slave has an invalid profile, e.g. the standard slave or A slave is configured at a B address.
$83C1_H$	The standard slave cannot be configured, because the B address is already assigned.
$83F8_H$	The job number or the job parameter is not known.
$83F9_H$	The AS-i master has detected an EEPROM error.

Note

Errors that occur during processing of acyclic services and are reported via call parameters, such as "Return Value", can be found in the documentation of the relevant programming interface.

9.4 Description of the AS-i commands

Overview

The commands that the user program can issue to the CM AS-i Master ST are described below. With these commands, the AS-i master makes available the complete functionality of the M4 master profile of the AS-i master specification.

Note

Adaptations when using existing user programs

Please observe the following adaptations when using existing user programs:

For some commands of the CM AS-i Master ST, the command numbers have been changed and the data structures belonging to the command have been optimized compared to other AS-i masters (e.g., DP/AS-i LINK Advanced).

The following table provides an overview of the modified command numbers:

Command name	Coding for DP/AS-i LINK Advanced	Coding for CM AS-i Master ST
Set_Permanent_Configuration (Page 111)	25_H	$A5_H$
Get_Permanent_Configuration (Page 112)	26_H	$A6_H$
Read_Actual_Configuration (Page 114)	28_H	$A8_H$
Set_LPS (Page 115)	29_H	$A9_H$
Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 121)	30_H	$B0_H$
Read_overall_configuration (Page 124)	39_H	$B9_H$
Write_overall_configuration (Page 130)	$3A_H$	BA_H
Get_LPF (Page 146)	$3E_H$	BE_H
Read_Error_Counter (Page 151)	$4A_H$	CA_H
Read_and_Delete_AS-i-Master_Error_Counter (Page 154)	$4B_H$	CB_H
Read_AS-i_error_counter (Page 154)	$4C_H$	CC_H
Read_and_delete_AS-i_Slave_error_counter (Page 156)	$4D_H$	CD_H

The following table lists the commands that can be executed with the CM AS-i Master ST.

Table 9- 3 AS-i commands

Name	Parameters	Return value	Coding
Set_Permanent_Parameter (Page 107)	Slave address, parameter	—	00_H
GET_Permanent_Parameter (Page 108)	Slave address	Parameter	01_H
Write_Parameter (Page 109)	Slave address, parameter	Optional: Parameter echo	02_H
Read_Parameter (Page 110)	Slave address	Parameter value	03_H
Store_Actual_Parameters (Page 110)	—	—	04_H
Set_Permanent_Configuration (Page 111)	Slave address, configuration data to be configured	—	$A5_H$
Get_Permanent_Configuration (Page 112)	Slave address	Configured configuration data	$A6_H$
Store_Actual_Configuration (Page 113)	—	—	07_H
Read_Actual_Configuration (Page 114)	Slave address	ACTUAL configuration	$A8_H$
Set_LPS (Page 115)	LPS	—	$A9_H$
SET_Offline_Mode (Page 116)	Mode	—	$0A_H$
Set_Auto_Address_Enable (Page 117)	Mode	—	$0B_H$
Set_Operation_Mode (Page 118)	Mode	—	$0C_H$
Change_AS-i-Slave_Address (Page 119)	Address 1, Address 2	—	$0D_H$
Read_Status (Page 120)	Slave address	Error data record of AS-i slave	$0F_H$
Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 121)	—	LDS, LAS, LPS, flags	$B0_H$
Read_overall_configuration (Page 124)	—	ACTUAL configuration data, actual parameters, LAS, flags	$B9_H$
Write_overall_configuration (Page 130)	Overall configuration	—	BA_H
Set_PI (Page 136)	Parameter list	—	$3C_H$
AS-i Parameter Echolist (Page 138)	—	Parameter echo list	33_H
Read_Write_CTT2_String (Page 140)	Slave address CTT2 string	CTT2 string	44_H
Read_Version (Page 141)	—	Version string	14_H
Read ID_Code (Page 142)	Slave address	ID code	17_H
Read_ID1-Code (Page 143)	Slave address	ID1 code	37_H
Write ID1-Code (Page 143)	ID1 code	—	$3F_H$
Read_ID2-Code (Page 144)	Slave address	ID2 code	38_H
Read_IO-Code (Page 145)	Slave address	IO code	18_H
Get_LPF (Page 146)	—	LPF	BE_H
Write_Parameter_String (Page 147)	Slave address, parameter string	—	40_H
Read_String (Page 148)	Slave address	Parameter string	41_H
Read_String (Page 149)	Slave address	Identification string	42_H
Read_String (Page 150)	Slave address	Diagnostics string	43_H

Name	Parameters	Return value	Coding
Read_Error_Counter (Page 151)	—	—	CA_H
Read_and_Delete_AS-i-Master_Error_Counter (Page 154)	—	—	CB_H
Read_AS-i_error_counter (Page 154)	Slave address	—	CC_H
Read_and_delete_AS-i_Slave_error_counter (Page 156)	Slave address	—	CD_H
Activate_ground fault detection (reset EFD) (Page 157)	Mode	—	13_H
Set_Configuration_Online (Page 158)	Slave address, configuration data to be configured, parameters	—	$D0_H$
AS-i-Slave_ID1_schreiben_mit_Zieladresse (Write ID1 code with destination address) (Page 159)	Address, ID1 code	—	$D1_H$

General structure of the send buffer

The basic structure of the send buffer for commands is shown below.

The length of the job data depends on the respective command. Some commands do not require any job data. In this case, the send buffer only has one byte (byte 0).

Table 9- 4 Basic structure of the send buffer for commands

Byte	Meaning
0	Number of the command
1	**Job data**
…	**Job data**

General structure of the receive buffer

The basic structure of the receive buffer for commands is shown below. The length of the response data depends on the respective command.

Some commands do not supply any response data. In this case, there is no receive buffer.

Table 9- 5 Basic structure of the receive buffer

Byte	Meaning
0	**Response data**
1	**Response data**
…	**Response data**

General operating state of the AS-i slave address

If an AS-i slave must be addressed in a command or in a response, it must be addressed as follows:

Table 9- 6 Structure of the AS-i slave address

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	Select bit	Slave address				

The Select bit for the selection of the slave type is specified as follows:

- Select bit = 0

  AS-i slave with standard-address (0 to 31) or AS-i slave with extended address in address area A (1A to 31A)

- Select bit = 1:

  AS-i slave with extended address in address area B (1B to 31B)

9.4.1 Set_Permanent_Parameter

Meaning

This command configures a parameter value for the specified AS-i slave in the AS-i master. The value is stored in the non-volatile EEPROM of the CM AS-i Master ST. The parameter value is additionally forwarded to the addressed AS-i slave.

However, the "parameter echo" of the AS-i slave cannot be read out with this command (see Write_Parameter (Page 109) command).

Note

Use of other Siemens AS-i masters

Other Siemens AS-i masters do not transfer the configured parameters to the AS-i slave immediately.

For AS-i slaves that meet the AS-i standard slave profile 7.4, this command is not permitted. For these slaves, the AS-i master itself administers the parameter assignment of the AS-i slave. In this case, the configured parameters are always equal to F_H.

Note

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

When this command is executed, the AS-i master switches to the offline phase and then switches back to "normal operation". The AS-i master restarts.

Structure of the job data in the send buffer

Table 9- 7 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Command number: 00_H			
1	Slave address			
2	0		Parameters	

9.4.2 GET_Permanent_Parameter

Significance

This command reads a slave-specific parameter value that has been saved in EEPROM of the CM AS-i Master ST.

Structure of the job data in the send buffer

Table 9- 8 Structure of the job data in the send buffer

Byte	Significance
0	Command number: 01_H
1	Slave address

Structure of the reply data in the receive buffer

Table 9- 9 Structure of the reply data in the receive buffer

Byte	Significance			
	Bit 7	Bit 4	Bit 3	Bit 0
0	0		Configured parameters	

9.4.3 Write_Parameter

Meaning of the command

The command transfers an AS-i slave parameter value. This is transferred to the addressed AS-i slave.

The parameter is only stored in volatile memory in the AS-i master and it is not transferred to the EEPROM as a configured parameter!

The AS-i slave transfers its current "Parameter echo" parameter value in the response. In accordance with the AS-i master specification "AS-Interface Complete Specification", this value can deviate from the value just written. The response from the AS-i slave is supplied in the response data as a parameter echo.

For AS-i slaves that meet the AS-i standard slave profile 7.4, this command is not permitted. For these slaves, the AS-i master itself administers the parameter assignment of the AS-i slave.

Structure of the job data in the send buffer

Table 9- 10 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Command number: 02_H			
1	Slave address			
2	0		Parameters	

Structure of the response data in the receive buffer

Table 9- 11 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	0		Parameter echo	

9.4.4 Read_Parameter

Meaning

This command returns the current "ACTUAL parameter" parameter value of an AS-i slave sent by the AS-i master.

You must not confuse this value with the parameter echo that the AS-i slave supplies as reply to Write_Parameter.

Structure of the job data in the send buffer

Table 9- 12 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 03_H
1	Slave address

Structure of the reply data in the receive buffer

Table 9- 13 Structure of the reply data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	0		Parameters	

9.4.5 Store_Actual_Parameters

Significance

This command overwrites the configured parameters stored on EEPROM with the current ACTUAL parameters stored in non-volatile memory. That is, the parameters of all AS-i slaves are configured.

The AS-i master parameterizes the AS-i slaves itself in the case of AS-i slaves that meet AS-i slave standard profile 7.4. The configured parameters for these AS-i slaves are always equal to F_H.

Structure of the job data in the send buffer

Table 9- 14 Structure of the job data in the send buffer

Byte	Significance
0	Command number: 04_H

9.4.6 Set_Permanent_Configuration

Meaning

With this command, the following configuration data are configured for the addressed AS-i slave:

- IO code
- ID code
- ID1 code
- ID2 code

The configuration data are stored in the non-volatile EEPROM of the CM AS-i Master ST. The AS-i master uses these configuration data as the specified expected configuration data for "protected operation". The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification".

If the addressed AS-i slave does not support ID code 1 or ID code 2, the value F_H must be specified for this in the command.

When this command is executed, the AS-i master switches to the offline phase and then switches back to "normal operation". The AS-i master restarts.

This command is not executed in "protected operation".

Note

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

Structure of the job data in the send buffer

Table 9- 15 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Command number: $A5_H$			
1	Slave address			
2	IO code		ID code	
3	ID1 code		ID2 code	

9.4.7 Get_Permanent_Configuration

Meaning

The configuration data (configured CONF data) of an addressed AS-i slave stored on the EEPROM of the AS-i master are read with this command:

- IO code
- ID code
- ID1 code
- ID2 code

The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification".

Structure of the job data in the send buffer

Table 9- 16 Structure of the job data in the send buffer

Byte	Meaning
0	Command number $A6_H$
1	Slave address

Structure of the response data in the receive buffer

Table 9- 17 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	IO code		ID code	
1	ID1 code		ID2 code	
2	0			
3	0			

9.4.8 Store_Actual_Configuration

Meaning

The following ACTUAL configuration data of all AS-i slaves is obtained from the AS-i master:

- Slave profile (IO, ID, ID2 codes)
- ID1 code

This command saves the obtained ACTUAL configuration data as CONF configuration data in the non-volatile EEPROM. The List of activated AS-i slaves (LAS) is also loaded into the List of configured AS-i slaves (LPS).

When this command is executed, the AS-i master switches to the offline phase and then switches back to "protected operation". The AS-i master restarts.

This command is not executed in "protected operation".

The slave parameter values in volatile memory of the AS-i master and the content of the non-volatile memory for the parameters are not changed. The "Set_Permanent_Parameter" command must be executed, if necessary.

Note

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

Structure of the job data in the send buffer

Table 9- 18 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 07_H

9.4.9 Read_Actual_Configuration

Meaning

This command reads the following configuration data of an addressed AS-i slave obtained from the AS-i master on the AS-Interface:

- IO code
- ID code
- ID1 code
- ID2 code

The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification".

Structure of the job data in the send buffer

Table 9- 19 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $A8_H$
1	Slave address

Structure of the response data in the receive buffer

Table 9- 20 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	IO code		ID code	
1	ID1 code		ID2 code	
2	Reserved			
3	Reserved			

9.4.10 Set_LPS

Meaning

This command transfers the list of configured AS-i slaves for non-volatile storage in the EEPROM of the master.

When this command is executed, the AS-i master switches to the offline phase and then switches back to "normal operation". The AS-i master restarts.

This command is not executed in "protected operation".

Note

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

Structure of the job data in the send buffer

Table 9- 21 Structure of the job data in the send buffer

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0	Command number: $A9_H$							
1	00_H							
2	Slave 7(A)	Slave 6(A)	Slave 5(A)	Slave 4(A)	Slave 3(A)	Slave 2(A)	Slave 1(A)	0
3	Slave 15(A)	Slave 14(A)	Slave 13(A)	Slave 12(A)	Slave 11(A)	Slave 10(A)	Slave 9(A)	Slave 8(A)
4	Slave 23(A)	Slave 22(A)	Slave 21(A)	Slave 20(A)	Slave 19(A)	Slave 18(A)	Slave 17(A)	Slave 16(A)
5	Slave 31(A)	Slave 30(A)	Slave 29(A)	Slave 28(A)	Slave 27(A)	Slave 26(A)	Slave 25(A)	Slave 24(A)
6	Slave 7B	Slave 6B	Slave 5B	Slave 4B	Slave 3B	Slave 2B	Slave 1B	0
7	Slave 15B	Slave 14B	Slave 13B	Slave 12B	Slave 11B	Slave 10B	Slave 9B	Slave 8B
8	Slave 23B	Slave 22B	Slave 21B	Slave 20B	Slave 19B	Slave 18B	Slave 17B	Slave 16B
9	Slave 31B	Slave 30B	Slave 29B	Slave 28B	Slave 27B	Slave 26B	Slave 25B	Slave 24B

The bits have the following meanings in the LPS data:

0: AS-i slave is not configured

1: AS-i slave is configured

9.4.11 SET_Offline_Mode

Meaning

This command switches between online and offline mode.

Online mode is the normal mode for the AS-i master. The following jobs are processed in online mode:

1. In the data exchange phase, the fields of the output data are transferred to the slave outputs for all AS-i slaves of the LAS. In error-free transmission, the addressed AS-i slaves transfer the values of the slave inputs to the master.
2. In the loading phase, a search is conducted for the existing AS-i slaves. Newly added AS-i slaves are inserted in the LDS or LAS.
3. In the management phase, jobs forwarded by the user, such as writing parameters, are executed.

In offline mode, the AS-i master only processes jobs from the user. Jobs that immediately activate an AS-i slave are rejected with an error. Cyclic data exchange is not performed with the AS-i slaves.

The bit OFFLINE=TRUE is not stored permanently. This means that after startup or restart, the AS-i master is in online mode again.

Structure of the job data in the send buffer

Table 9- 22 Structure of the job data in the send buffer

Byte	Meaning		
	Bit 7	Bit 1	Bit 0
0	Command number: $0A_H$		
1	0		Mode 0 = Online 1 = Offline

9.4.12 Set_Auto_Address_Enable

Meaning

This command enables or disables the "Automatic address programming" function.

The bit AUTO_ADDR_ENABLE is stored in non-volatile memory. It is retained even after startup or warm restart of the AS-i master.

Structure of the job data in the send buffer

Table 9- 23 Structure of the job data in the send buffer

Byte	Meaning		
	Bit 7	Bit 1	Bit 0
0	Command number: $0B_H$		
1	0		Value for AUTO_ADDR_ENABLE 1 = Automatic address programming enabled 0 = Automatic address programming disabled

9.4.13 Set_Operation_Mode

Meaning

This command chooses between "configuration mode" and "protected operation".

In **"protected operation"**, only the AS-i slaves that are flagged in the LPS and whose CONFIGURED and ACTUAL configurations match are activated. This is the case when the I/O code and the ID codes of the detected AS-i slaves are identical to the configured values.

In **"configuration mode"**, all the detected AS-i slaves are activated - with the exception of AS-i slave "0". This also applies to AS-i slaves that differ in their CONFIGURED and ACTUAL configurations.

The "OPERATING MODE" bit is saved in **non-volatile** memory. As a result, this bit is retained in the event of startup or restart.

On switching from "configuration mode" to "protected operation", the AS-i master restarts. It enters the offline phase and then switches to online mode.

Note

AS-i slave with address 0 prevents switchover to "protected operation"

If an AS-i slave with address 0 is present on the AS-i bus, the AS-i master cannot switch from "configuration mode" to "protected operation".

Structure of the job data in the send buffer

Table 9- 24 Structure of the job data in the send buffer

Byte	Meaning		
	Bit 7	Bit 1	Bit 0
0	Command number: $0C_H$		
1	0		Operating mode 0 = "Protected operation" 1 = "Configuration mode"

9.4.14 Change_AS-i-Slave_Address

Meaning of the command

This command changes the AS-i slave address of an AS-i slave.

This command is used predominantly for adding a new AS-i slave with the default address "0". In this case, the address is changed from "AS-i slave address, old" = 0 to "AS-i slave address, new".

The change is only executed if the following conditions are met:

1. An AS-i slave with "AS-i slave address, old" must exist.
2. If "AS-i address, old" is not equal to "0", an AS-i slave with the address "0" must not be connected at the same time.
3. "AS-i slave address, new" must have a valid value.
4. An AS-i slave with "AS-i slave address, new" must not already exist.

Note

When changing the AS-i slave address, the AS-i slave is not reset. The output data of the AS-i slave are retained until new data arrive for the new address.

Structure of the job data in the send buffer

Table 9- 25 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $0D_H$
1	Slave address, old
2	Slave address, new

9.4.15 Read_Status

Meaning

This command reads the status register for the addressed AS-i slave. The flags of the status register have the following meaning depending on the type of the AS-i slave:

Table 9- 26 Meaning of the flags of the status register depending on the type of the AS-i slave

Status bit	AS-i slave according to standard 2.0	AS-i slave according to standard 2.1
S0	**Address volatile**	**Address/ID code volatile**
	This flag is set if • The internal routine of the AS-i slave for permanent storage of the AS-i slave address is running. This can last up to 15 ms and must not be interrupted by another addressing call. • The internal address comparison of the AS-i slave determines that the permanently saved address is not identical to the entry in the address register.	
S1	**Parity error detected** This flag is set if the AS-i slave has detected a parity error in a receive frame since the last "Read and delete status" job.	**Peripheral fault detected** An AS-i slave can set this flag if it detects a fault, e.g. wire break, on the connected I/O.
S2	**End bit error detected** This flag is set if the AS-i slave has detected an end bit error in a message frame since the last "Read and delete status" job.	Reserved
S3	**Read error in non-volatile memory (EEPROM)** This bit is set if the AS-i slave has discovered a read error when reading the non-volatile memory.	

Structure of the job data in the send buffer

Table 9- 27 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $0F_H$
1	Slave address

Structure of the job data in the receive buffer

Table 9- 28 Structure of the response data in the receive buffer

Byte	Meaning					
	Bit 7	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0		S 3	S 2	S 1	S 0

9.4.16 Get_LPS, Get_LAS, Get_LDS, Get_Flags

Meaning

This command reads the following entries from the AS-i master:

- List of activated AS-i slaves, LAS
- List of detected AS-i slaves, LDS
- List of configured AS-i slaves, LPS
- The flags in accordance with the AS-i slave specification

Structure of the job data in the send buffer

Table 9- 29 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $B0_H$

Structure of the response data in the receive buffer

Table 9- 30 Structure of the response data in the receive buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	LAS Slave 7(A)	LAS Slave 6(A)	LAS Slave 5(A)	LAS Slave 4(A)	LAS Slave 3(A)	LAS Slave 2(A)	LAS Slave 1(A)	Reserved
1	LAS Slave 15(A)	LAS Slave 14(A)	LAS Slave 13(A)	LAS Slave 12(A)	LAS Slave 11(A)	LAS Slave 10(A)	LAS Slave 9(A)	LAS Slave 8(A)
2	LAS Slave 23(A)	LAS Slave 22(A)	LAS Slave 21(A)	LAS Slave 20(A)	LAS Slave 19(A)	LAS Slave 18(A)	LAS Slave 17(A)	LAS Slave 16(A)
3	LAS Slave 31(A)	LAS Slave 30(A)	LAS Slave 29(A)	LAS Slave 28(A)	LAS Slave 27(A)	LAS Slave 26(A)	LAS Slave 25(A)	LAS Slave 24(A)
4	LAS Slave 7B	LAS Slave 6B	LAS Slave 5B	LAS Slave 4B	LAS Slave 3B	LAS Slave 2B	LAS Slave 1B	Reserved
5	LAS Slave 15B	LAS Slave 14B	LAS Slave 13B	LAS Slave 12B	LAS Slave 11B	LAS Slave 10B	LAS Slave 9B	LAS Slave 8B
6	LAS Slave 23B	LAS Slave 22B	LAS Slave 21B	LAS Slave 20B	LAS Slave 19B	LAS Slave 18B	LAS Slave 17B	LAS Slave 16B
7	LAS Slave 31B	LAS Slave 30B	LAS Slave 29B	LAS Slave 28B	LAS Slave 27B	LAS Slave 26B	LAS Slave 25B	LAS Slave 24B
8	LDS Slave 7(A)	LDS Slave 6(A)	LDS Slave 5(A)	LDS Slave 4(A)	LDS Slave 3(A)	LDS Slave 2(A)	LDS Slave 1(A)	LDS Slave 0

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
9	LDS Slave 15(A)	LDS Slave 14(A)	LDS Slave 13(A)	LDS Slave 12(A)	LDS Slave 11(A)	LDS Slave 10(A)	LDS Slave 9(A)	LDS Slave 8(A)
10	LDS Slave 23(A)	LDS Slave 22(A)	LDS Slave 21(A)	LDS Slave 20(A)	LDS Slave 19(A)	LDS Slave 18(A)	LDS Slave 17(A)	LDS Slave 16(A)
11	LDS Slave 31(A)	LDS Slave 30(A)	LDS Slave 29(A)	LDS Slave 28(A)	LDS Slave 27(A)	LDS Slave 26(A)	LDS Slave 25(A)	LDS Slave 24(A)
12	LDS Slave 7B	LDS Slave 6B	LDS Slave 5B	LDS Slave 4B	LDS Slave 3B	LDS Slave 2B	LDS Slave 1B	Reserved
13	LDS Slave 15B	LDS Slave 14B	LDS Slave 13B	LDS Slave 12B	LDS Slave 11B	LDS Slave 10B	LDS Slave 9B	LDS Slave 8B
14	LDS Slave 23B	LDS Slave 22B	LDS Slave 21B	LDS Slave 20B	LDS Slave 19B	LDS Slave 18B	LDS Slave 17B	LDS Slave 16B
15	LDS Slave 31B	LDS Slave 30B	LDS Slave 29B	LDS Slave 28B	LDS Slave 27B	LDS Slave 26B	LDS Slave 25B	LDS Slave 24B
16	LPS Slave 7(A)	LPS Slave 6(A)	LPS S Slave 5(A)	LPS Slave 4(A)	LPS Slave 3(A)	LPS Slave 2(A)	LPS Slave 1(A)	Reserved
17	LPS Slave 15(A)	LPS Slave 14(A)	LPS Slave 13(A)	LPS Slave 12(A)	LPS Slave 11(A)	LPS Slave 10(A)	LPS Slave 9(A)	LPS Slave 8(A)
18	LPS Slave 23(A)	LPS Slave 22(A)	LPS Slave 21(A)	LPS Slave 20(A)	LPS Slave 19(A)	LPS Slave 18(A)	LPS Slave 17(A)	LPS Slave 16(A)
19	LPS Slave 31(A)	LPS Slave 30(A)	LPS Slave 29(A)	LPS Slave 28(A)	LPS Slave 27(A)	LPS Slave 26(A)	LPS Slave 25(A)	LPS Slave 24(A)
20	LPS Slave 7B	LPS Slave 6B	LPS Slave 5B	LPS Slave 4B	LPS Slave 3B	LPS Slave 2B	LPS Slave 1B	Reserved
21	LPS Slave 15B	LPS Slave 14B	LPS Slave 13B	LPS Slave 12B	LPS Slave 11B	LPS Slave 10B	LPS Slave 9B	LPS Slave 8B
22	LPS Slave 23B	LPS Slave 22B	LPS Slave 21B	LPS Slave 20B	LPS Slave 19B	LPS Slave 18B	LPS Slave 17B	LPS Slave 16B
23	LPS Slave 31B	LPS Slave 30B	LPS Slave 29B	LPS Slave 28B	LPS Slave 27B	LPS Slave 26B	LPS Slave 25B	LPS Slave 24B
24	Flag 1							
25	Flag 2							
26 … 31	Reserved							

Meaning of the bits in Byte 0 to 23

- Bit = 0:

  The AS-i slave is **not** activated, detected or configured.

- Bit = 1:

  The AS-i slave **is** activated, detected or configured.

Table 9- 31 Structure of flag 1 and flag 2

Flag 1			**Flag 2**	
Bit	**Meaning**		**Bit**	**Meaning**
0	Config_OK		0	Periphery_OK
1	LDS.0		1	Data_Exchange_Active
2	Auto_Address_Assign		2	Off_Line
3	Auto_Address_Available		3	AUTO_ADDR_ENABLE
4	Configuration_Active		4	Earth_Fault
5	Normal_Operation_Active		5	EEPROM_OK
6	APF		6	EFD-ENABLE
7	Offline_Ready		7	Reserved

Table 9- 32 Meaning of the flags

Flag	**Meaning**
Config_OK	The flag is set when the CONFIGURED configuration and the ACTUAL configuration match.
LDS.0	The flag is set when an AS-i slave with address 0 is present. (List of Detected Slaves)
Auto_Address_Assign	The flag is set if automatic address programming is possible. This means that AUTO_ADDR_ENABLE = 1 and no "incorrect" AS-i slaves are connected to AS-Interface.
Auto_Address_Available	The flag is set if automatic address programming can be performed. This means that one AS-i slave has failed.
Configuration_Active	The flag is set in "configuration mode" and reset in "protected operation".
Normal_Operation_Active	The flag is set when the AS-i master is in "protected operation".
APF	The flag is set when the voltage on the AS-i cable is too low (AS-i Power Fail).
Offline_Ready	The flag is set if the offline phase is active.
Periphery_OK	The flag is set if none of the AS-i slaves signal a peripheral fault.
Data_Exchange_Active	The "Data_Exchange_Active" flag is set when cyclic data exchange is in "protected operation".
Off_Line	The flag is set if the "OFFLINE" operating status is to be adopted or has already been adopted.
AUTO_ADDR_ENABLE	The flag indicates whether automatic address programming is disabled (BIT = 0) or enabled (BIT = 1) by the user.
Earth_Fault	The flag is set if a ground fault has been detected on the AS-i cable.
EEPROM_OK	The flag is set if the test of the internal EEPROM was successful.
EFD Disable	The flag indicates whether ground fault detection is enabled (BIT = 0) or disabled (BIT = 1) by the user.

9.4.17 Read_overall_configuration

Meaning

This command reads the following data from the AS-i master:

- List of activated AS-i slaves (LAS).

  It specifies which of the connected AS-i slaves are activated
- The current configuration data for the connected AS-i slaves:
  - IO code
  - ID code
  - ID1 code
  - ID2 code
- The current parameters of the AS-i slaves (ACTUAL parameters)
- The current status of the AS-i master (Flag 1, Flag 2)

After commissioning, you can use this command, for example, to determine the configuration of the stations connected to the AS-i cable. You can modify this read-in configuration data if required and store it as the CONFIGURED configuration in the AS-i master with the "Write_overall_configuration" command.

Write_overall_configuration (Page 130)

Structure of the job data in the send buffer

Table 9- 33 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $B9_H$

Structure of the response data in the receive buffer

Table 9- 34 Structure of the response data in the receive buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	00_H							
1	00_H							
2	LAS Slave 7(A)	LAS Slave 6(A)	LAS Slave 5(A)	LAS Slave 4(A)	LAS Slave 3(A)	LAS Slave 2(A)	LAS Slave 1(A)	Reserved
3	LAS Slave 15(A)	LAS Slave 14(A)	LAS Slave 13(A)	LAS Slave 12(A)	LAS Slave 11(A)	LAS Slave 10(A)	LAS Slave 9(A)	LAS Slave 8(A)
4	LAS Slave 23(A)	LAS Slave 22(A)	LAS Slave 21(A)	LAS Slave 20(A)	LAS Slave 19(A)	LAS Slave 18(A)	LAS Slave 17(A)	LAS Slave 16(A)

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
5	LAS Slave 31(A)	LAS Slave 30(A)	LAS Slave 29(A)	LAS Slave 28(A)	LAS Slave 27(A)	LAS Slave 26(A)	LAS Slave 25(A)	LAS Slave 24(A)
6	LAS Slave 7B	LAS Slave 6B	LAS Slave 5B	LAS Slave 4B	LAS Slave 3B	LAS Slave 2B	LAS Slave 1B	Reserved
7	LAS Slave 15B	LAS Slave 14B	LAS Slave 13B	LAS Slave 12B	LAS Slave 11B	LAS Slave 10B	LAS Slave 9B	LAS Slave 8B
8	LAS Slave 23B	LAS Slave 22B	LAS Slave 21B	LAS Slave 20B	LAS Slave 19B	LAS Slave 18B	LAS Slave 17B	LAS Slave 16B
9	LAS Slave 31B	LAS Slave 30B	LAS Slave 29B	LAS Slave 28B	LAS Slave 27B	LAS Slave 26B	LAS Slave 25B	LAS Slave 24B
10	IO code Slave 0				ID_CODE Slave 0			
11	ID1 Slave 0				ID2 Slave 0			
12	IO code Slave 1 / 1A				ID_CODE Slave 1 / 1A			
13	ID1 Slave 1 / 1A				ID2 Slave 1 / 1A			
14	IO code Slave 2 / 2A				ID_CODE Slave 2 / 2A			
15	ID1 Slave 2 / 2A				ID2 Slave 2 / 2A			
16	IO code Slave 3 / 3A				ID_CODE Slave 3 / 3A			
17	ID1 Slave 3 / 3A				ID2 Slave 3 / 3A			
18	IO code Slave 4 / 4A				ID_CODE Slave 4 / 4A			
19	ID1 Slave 4 / 4A				ID2 Slave 4 / 4A			
20	IO code Slave 5 / 5A				ID_CODE Slave 5 / 5A			
21	ID1 Slave 5 / 5A				ID2 Slave 5 / 5A			
22	IO code Slave 6 / 6A				ID_CODE Slave 6 / 6A			
23	ID1 Slave 6 / 6A				ID2 Slave 6 / 6A			
24	IO code Slave 7 / 7A				ID_CODE Slave 7 / 7A			
25	ID1 Slave 7 / 7A				ID2 Slave 7 / 7A			
26	IO code Slave 8 / 8A				ID_CODE Slave 8 / 8A			
27	ID1 Slave 8 / 8A				ID2 Slave 8 / 8A			
28	IO code Slave 9 / 9A				ID_CODE Slave 9 / 9A			
29	ID1 Slave 9 / 9A				ID2 Slave 9 / 9A			
30	IO code Slave 10 / 10A				ID_CODE Slave 10 / 10A			
31	ID1 Slave 10 / 10A				ID2 Slave 10 / 10A			
32	IO code Slave 11 / 11A				ID_CODE Slave 11 / 11A			
33	ID1 Slave 11 / 11A				ID2 Slave 11 / 11A			
34	IO code Slave 12 / 12A				ID_CODE Slave 12 / 12A			
35	ID1 Slave 12 / 12A				ID2 Slave 12 / 12A			
36	IO code Slave 13 / 13A				ID_CODE Slave 13 / 13A			
37	ID1 Slave 13 / 13A				ID2 Slave 13 / 13A			
38	IO code Slave 14 / 14A				ID_CODE Slave 14 / 14A			
39	ID1 Slave 14 / 14A				ID2 Slave 14 / 14A			
40	IO code Slave 15 / 15A				ID_CODE Slave 15 / 15A			
41	ID1 Slave 15 / 15A				ID2 Slave 15 / 15A			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
42	IO code Slave 16 / 16A				ID_CODE Slave 16 / 16A			
43	ID1 Slave 16 / 16A				ID2 Slave 16 / 16A			
44	IO code Slave 17 / 17A				ID_CODE Slave 17 / 17A			
45	ID1 Slave 17 / 17A				ID2 Slave 17 / 17A			
46	IO code Slave 18 / 18A				ID_CODE Slave 18 / 18A			
47	ID1 Slave 18 / 18A				ID2 Slave 18 / 18A			
48	IO code Slave 19 / 19A				ID_CODE Slave 19 / 19A			
49	ID1 Slave 19 / 19A				ID2 Slave 19 / 19A			
50	IO code Slave 20 / 20A				ID_CODE Slave 20 / 20A			
51	ID1 Slave 20 / 20A				ID2 Slave 20 / 20A			
52	IO code Slave 21 / 21A				ID_CODE Slave 21 / 21A			
53	ID1 Slave 21 / 21A				ID2 Slave 21 / 21A			
54	IO code Slave 22 / 22A				ID_CODE Slave 22 / 22A			
55	ID1 Slave 22 / 22A				ID2 Slave 22 / 22A			
56	IO code Slave 23 / 23A				ID_CODE Slave 23 / 23A			
57	ID1 Slave 23 / 23A				ID2 Slave 23 / 23A			
58	IO code Slave 24 / 24A				ID_CODE Slave 24 / 24A			
59	ID1 Slave 24 / 24A				ID2 Slave 24 / 24A			
60	IO code Slave 25 / 25A				ID_CODE Slave 25 / 25A			
61	ID1 Slave 25 / 25A				ID2 Slave 25 / 25A			
62	IO code Slave 26 / 26A				ID_CODE Slave 26 / 26A			
63	ID1 Slave 26 / 26A				ID2 Slave 26 / 26A			
64	IO code Slave 27 / 27A				ID_CODE Slave 27 / 27A			
65	ID1 Slave 27 / 27A				ID2 Slave 27 / 27A			
66	IO code Slave 28 / 28A				ID_CODE Slave 28 / 28A			
67	ID1 Slave 28 / 28A				ID2 Slave 28 / 28A			
68	IO code Slave 29 / 29A				ID_CODE Slave 29 / 29A			
69	ID1 Slave 29 / 29A				ID2 Slave 29 / 29A			
70	IO code Slave 30 / 30A				ID_CODE Slave 30 / 30A			
71	ID1 Slave 30 / 30A				ID2 Slave 30 / 30A			
72	IO code Slave 31 / 31A				ID_CODE Slave 31 / 31A			
73	ID1 Slave 31 / 31A				ID2 Slave 31 / 31A			
74	Reserved				Reserved			
75	Reserved				Reserved			
76	IO code Slave 1B				ID_CODE Slave 1B			
77	ID1 Slave 1B				ID2 Slave 1B			
78	IO code Slave 2B				ID_CODE Slave 2B			
79	ID1 Slave 2B				ID2 Slave 2B			
80	IO code Slave 3B				ID_CODE Slave 3B			
81	ID1 Slave 3B				ID2 Slave 3B			
82	IO code Slave 4B				ID_CODE Slave 4B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
83	ID1 Slave 4B				ID2 Slave 4B			
84	IO code Slave 5B				ID_CODE Slave 5B			
85	ID1 Slave 5B				ID2 Slave 5B			
86	IO code Slave 6B				ID_CODE Slave 6B			
87	ID1 Slave 6B				ID2 Slave 6B			
88	IO code Slave 7B				ID_CODE Slave 7B			
89	ID1 Slave 7B				ID2 Slave 7B			
90	IO code Slave 8B				ID_CODE Slave 8B			
91	ID1 Slave 8B				ID2 Slave 8B			
92	IO code Slave 9B				ID_CODE Slave 9B			
93	ID1 Slave 9B				ID2 Slave 9B			
94	IO code Slave 10B				ID_CODE Slave 10B			
95	ID1 Slave 10B				ID2 Slave 10B			
96	IO code Slave 11B				ID_CODE Slave 11B			
97	ID1 Slave 11B				ID2 Slave 11B			
98	IO code Slave 12B				ID_CODE Slave 12B			
99	ID1 Slave 12B				ID2 Slave 12B			
100	IO code Slave 13B				ID_CODE Slave 13B			
101	ID1 Slave 13B				ID2 Slave 13B			
102	IO code Slave 14B				ID_CODE Slave 14B			
103	ID1 Slave 14B				ID2 Slave 14B			
104	IO code Slave 15B				ID_CODE Slave 15B			
105	ID1 Slave 15B				ID2 Slave 15B			
106	IO code Slave 16B				ID_CODE Slave 16B			
107	ID1 Slave 16B				ID2 Slave 16B			
108	IO code Slave 17B				ID_CODE Slave 17B			
109	ID1 Slave 17B				ID2 Slave 17B			
110	IO code Slave 18B				ID_CODE Slave 18B			
111	ID1 Slave 18B				ID2 Slave 18B			
112	IO code Slave 19B				ID_CODE Slave 19B			
113	ID1 Slave 19B				ID2 Slave 19B			
114	IO code Slave 20B				ID_CODE Slave 20B			
115	ID1 Slave 20B				ID2 Slave 20B			
116	IO code Slave 21B				ID_CODE Slave 21B			
117	ID1 Slave 21B				ID2 Slave 21B			
118	IO code Slave 22B				ID_CODE Slave 22B			
119	ID1 Slave 22B				ID2 Slave 22B			
120	IO code Slave 23B				ID_CODE Slave 23B			
121	ID1 Slave 23B				ID2 Slave 23B			
122	IO code Slave 24B				ID_CODE Slave 24B			
123	ID1 Slave 24B				ID2 Slave 24B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
124	IO code Slave 25B				ID_CODE Slave 25B			
125	ID1 Slave 25B				ID2 Slave 25B			
126	IO code Slave 26B				ID_CODE Slave 26B			
127	ID1 Slave 26B				ID2 Slave 26B			
128	IO code Slave 27B				ID_CODE Slave 27B			
129	ID1 Slave 27B				ID2 Slave 27B			
130	IO code Slave 28B				ID_CODE Slave 28B			
131	ID1 Slave 28B				ID2 Slave 28B			
132	IO code Slave 29B				ID_CODE Slave 29B			
133	ID1 Slave 29B				ID2 Slave 29B			
134	IO code Slave 30B				ID_CODE Slave 30B			
135	ID1 Slave 30B				ID2 Slave 30B			
136	IO code Slave 31B				ID_CODE Slave 31B			
137	ID1 Slave 31B				ID2 Slave 31B			
138	Reserved				Parameter Slave 1 / 1A			
139	Parameter Slave 2 / 2A				Parameter Slave 3 / 3A			
140	Parameter Slave 4 / 4A				Parameter Slave 5 / 5A			
141	Parameter Slave 6 / 6A				Parameter Slave 7 / 7A			
142	Parameter Slave 8 / 8A				Parameter Slave 9 / 9A			
143	Parameter Slave 10 / 10A				Parameter Slave 11 / 11A			
144	Parameter Slave 12 / 12A				Parameter Slave 13 / 13A			
145	Parameter Slave 14 / 14A				Parameter Slave 15 / 15A			
146	Parameter Slave 16 / 16A				Parameter Slave 17 / 17A			
147	Parameter Slave 18 / 18A				Parameter Slave 19 / 19A			
148	Parameter Slave 20 / 20A				Parameter Slave 21 / 21A			
149	Parameter Slave 22 / 22A				Parameter Slave 23 / 23A			
150	Parameter Slave 24 / 24A				Parameter Slave 25 / 25A			
151	Parameter Slave 26 / 26A				Parameter Slave 27 / 27A			
152	Parameter Slave 28 / 28A				Parameter Slave 29 / 29A			
153	Parameter Slave 30 / 30A				Parameter Slave 31 / 31A			
154	Reserved				Parameter Slave 1B			
155	Parameter Slave 2B				Parameter Slave 3B			
156	Parameter Slave 4B				Parameter Slave 5B			
157	Parameter Slave 6B				Parameter Slave 7B			
158	Parameter Slave 8B				Parameter Slave 9B			
159	Parameter Slave 10B				Parameter Slave 11B			
160	Parameter Slave 12B				Parameter Slave 13B			
161	Parameter Slave 14B				Parameter Slave 15B			
162	Parameter Slave 16B				Parameter Slave 17B			
163	Parameter Slave 18B				Parameter Slave 19B			
164	Parameter Slave 20B				Parameter Slave 21B			

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
165	Parameter Slave 22B				Parameter Slave 23B			
166	Parameter Slave 24B				Parameter Slave 25B			
167	Parameter Slave 26B				Parameter Slave 27B			
168	Parameter Slave 28B				Parameter Slave 29B			
169	Parameter Slave 30B				Parameter Slave 31B			
170	Flag 1							
171	Flag 2							
172 … 218	Reserved							

Table 9- 35 Structure of flag 1 and flag 2

Flag 1			Flag 2	
Bit number	**Meaning**		**Bit number**	**Meaning**
0	Config_OK		0	Periphery_OK
1	LDS.0		1	Data_Exchange_Active
2	Auto_Address_Assign		2	Off_Line
3	Auto_Address_Available		3	AUTO_ADDR_ENABLE
4	Configuration_Active		4	Earth_Fault
5	Normal_Operation_Active		5	EEPROM_OK
6	APF		6	EFD-ENABLE
7	Offline_Ready		7	Reserved

For the meanings of flags, refer to Chapter:

Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 121)

9.4.18 Write_overall_configuration

Meaning

This command transfers the desired overall configuration of AS-Interface to the AS-i master and saves it as the CONFIGURED configuration in the non-volatile EEPROM. This configures the AS-i master.

When this command is executed, the AS-i master changes to the offline phase and then switches back over to "normal operation". The AS-i master restarts.

The "Protected operation" or "Configuration mode" operating mode of the AS-i master after execution of the command is determined by the "Configuration_Active" flag (see Table "Structure of Flag 1 and Flag 2").

This command is permissible both in "Protected operation" and "Configuration mode.

Note

Configuration data are overwritten

If you configure the AS-i slaves using *STEP 7*, there is normally no need to use the command described here. If you have configured proxy slaves, you can specify the configuration data of the proxy slaves with this command. To avoid the offline changeover, the configuration data of the proxy slaves can be specified preferentially with the "Set_Configuration_Online (Page 158)" command.

If you use this command, you will overwrite the corresponding configuration data that resulted from configuring the AS-i master using the "SET" button or configuring using *STEP 7*.

Specifically, the following data are transferred:

- List of configured AS-i slaves

  This specifies which AS-i slaves are permitted to be activated by the AS-i master in "protected operation".

- List of configuration data.

  This specifies the ID codes and the IO code that the connected AS-i slaves must have.

- The list of the AS-i slave parameters that have been configured in the AS-i master and stored in non-volatile memory. These parameters are transferred to the AS-i slaves when the AS-i master starts up.

- The flags that determine the operating state of the AS-i master after startup.

The AS-i master parameterizes the AS-i slaves itself in the case of AS-i slaves that comply with standard profile 7.4. For slaves in accordance with standard profile 7.4, the AS-i master ignores the parameter values specified in the command.

NOTICE
Note the size of the I/O image If you have configured the AS-i slaves in *STEP 7*, the size of the I/O image of the individual slaves is defined using *STEP 7*. When using this command, ensure that the I/O image of the individual slaves corresponds to the slaves configured using the command. If the size of the I/O image does not match, only the lower-order data will be transferred. The data that do not fit into the image are truncated or are filled with substitute value "0" in the case of digital values and with substitute value 7FFF (Hex) in the case of analog values.

Structure of the job data in the send buffer

Table 9- 36 Structure of the job data in the send buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Command number: BA_H							
1	00_H							
2	LPS Slave 7(A)	LPS Slave 6(A)	LPS Slave 5(A)	LPS Slave 4(A)	LPS Slave 3(A)	LPS Slave 2(A)	LPS Slave 1(A)	0
3	LPS Slave 15(A)	LPS Slave 14(A)	LPS Slave 13(A)	LPS Slave 12(A)	LPS Slave 11(A)	LPS Slave 10(A)	LPS Slave 9(A)	LPS Slave 8(A)
4	LPS Slave 23(A)	LPS Slave 22(A)	LPS Slave 21(A)	LPS Slave 20(A)	LPS Slave 19(A)	LPS Slave 18(A)	LPS Slave 17(A)	LPS Slave 16(A)
5	LPS Slave 31(A)	LPS Slave 30(A)	LPS Slave 29(A)	LPS Slave 28(A)	LPS Slave 27(A)	LPS Slave 26(A)	LPS Slave 25(A)	LPS Slave 24(A)
6	LPS Slave 7B	LPS Slave 6B	LPS Slave 5B	LPS Slave 4B	LPS Slave 3B	LPS Slave 2B	LPS Slave 1B	0
7	LPS Slave 15B	LPS Slave 14B	LPS Slave 13B	LPS Slave 12B	LPS Slave 11B	LPS Slave 10B	LPS Slave 9B	LPS Slave 8B
8	LPS Slave 23B	LPS Slave 22B	LPS Slave 21B	LPS Slave 20B	LPS Slave 19B	LPS Slave 18B	LPS Slave 17B	LPS Slave 16B
9	LPS Slave 31B	LPS Slave 30B	LPS Slave 29B	LPS Slave 28B	LPS Slave 27B	LPS Slave 26B	LPS Slave 25B	LPS Slave 24B
10	IO code Slave 0				ID_CODE Slave 0			
11	ID1 Slave 0				ID2 Slave 0			
12	IO code Slave 1 / 1A				ID_CODE Slave 1 / 1A			
13	ID1 Slave 1 / 1A				ID2 Slave 1 / 1A			
14	IO code Slave 2 / 2A				ID_CODE Slave 2 / 2A			
15	ID1 Slave 2 / 2A				ID2 Slave 2 / 2A			
16	IO code Slave 3 / 3A				ID_CODE Slave 3 / 3A			
17	ID1 Slave 3 / 3A				ID2 Slave 3 / 3A			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
18	IO code Slave 4 / 4A				ID_CODE Slave 4 / 4A			
19	ID1 Slave 4 / 4A				ID2 Slave 4 / 4A			
20	IO code Slave 5 / 5A				ID_CODE Slave 5 / 5A			
21	ID1 Slave 5 / 5A				ID2 Slave 5 / 5A			
22	IO code Slave 6 / 6A				ID_CODE Slave 6 / 6A			
23	ID1 Slave 6 / 6A				ID2 Slave 6 / 6A			
24	IO code Slave 7 / 7A				ID_CODE Slave 7 / 7A			
25	ID1 Slave 7 / 7A				ID2 Slave 7 / 7A			
26	IO code Slave 8 / 8A				ID_CODE Slave 8 / 8A			
27	ID1 Slave 8 / 8A				ID2 Slave 8 / 8A			
28	IO code Slave 9 / 9A				ID_CODE Slave 9 / 9A			
29	ID1 Slave 9 / 9A				ID2 Slave 9 / 9A			
30	IO code Slave 10 / 10A				ID_CODE Slave 10 / 10A			
31	ID1 Slave 10 / 10A				ID2 Slave 10 / 10A			
32	IO code Slave 11 / 11A				ID_CODE Slave 11 / 11A			
33	ID1 Slave 11 / 11A				ID2 Slave 11 / 11A			
34	IO code Slave 12 / 12A				ID_CODE Slave 12 / 12A			
35	ID1 Slave 12 / 12A				ID2 Slave 12 / 12A			
36	IO code Slave 13 / 13A				ID_CODE Slave 13 / 13A			
37	ID1 Slave 13 / 13A				ID2 Slave 13 / 13A			
38	IO code Slave 14 / 14A				ID_CODE Slave 14 / 14A			
39	ID1 Slave 14 / 14A				ID2 Slave 14 / 14A			
40	IO code Slave 15 / 15A				ID_CODE Slave 15 / 15A			
41	ID1 Slave 15 / 15A				ID2 Slave 15 / 15A			
42	IO code Slave 16 / 16A				ID_CODE Slave 16 / 16A			
43	ID1 Slave 16 / 16A				ID2 Slave 16 / 16A			
44	IO code Slave 17 / 17A				ID_CODE Slave 17 / 17A			
45	ID1 Slave 17 / 17A				ID2 Slave 17 / 17A			
46	IO code Slave 18 / 18A				ID_CODE Slave 18 / 18A			
47	ID1 Slave 18 / 18A				ID2 Slave 18 / 18A			
48	IO code Slave 19 / 19A				ID_CODE Slave 19 / 19A			
49	ID1 Slave 19 / 19A				ID2 Slave 19 / 19A			
50	IO code Slave 20 / 20A				ID_CODE Slave 20 / 20A			
51	ID1 Slave 20 / 20A				ID2 Slave 20 / 20A			
52	IO code Slave 21 / 21A				ID_CODE Slave 21 / 21A			
53	ID1 Slave 21 / 21A				ID2 Slave 21 / 21A			
54	IO code Slave 22 / 22A				ID_CODE Slave 22 / 21A			
55	ID1 Slave 22 / 22A				ID2 Slave 22 / 22A			
56	IO code Slave 23 / 23A				ID_CODE Slave 23 / 23A			
57	ID1 Slave 23 / 23A				ID2 Slave 23 / 23A			
58	IO code Slave 24 / 24A				ID_CODE Slave 24 / 24A			

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
59	ID1 Slave 24 / 24A				ID2 Slave 24 / 24A			
60	IO code Slave 25 / 25A				ID_CODE Slave 25 / 25A			
61	ID1 Slave 25 / 25A				ID2 Slave 25 / 25A			
62	IO code Slave 26 / 26A				ID_CODE Slave 26 / 26A			
63	ID1 Slave 26 / 26A				ID2 Slave 26 / 26A			
64	IO code Slave 27 / 27A				ID_CODE Slave 27 / 27A			
65	ID1 Slave 27 / 27A				ID2 Slave 27 / 27A			
66	IO code Slave 28 / 28A				ID_CODE Slave 28 / 28A			
67	ID1 Slave 28 / 28A				ID2 Slave 28 / 28A			
68	IO code Slave 29 / 29A				ID_CODE Slave 29 / 29A			
69	ID1 Slave 29 / 29A				ID2 Slave 29 / 29A			
70	IO code Slave 30 / 30A				ID_CODE Slave 30 / 30A			
71	ID1 Slave 30 / 30A				ID2 Slave 30 / 30A			
72	IO code Slave 31 / 31A				ID_CODE Slave 31 / 31A			
73	ID1 Slave 31 / 31A				ID2 Slave 31 / 31A			
74	0				0			
75	0				0			
76	IO code Slave 1B				ID_CODE Slave 1B			
77	ID1 Slave 1B				ID2 Slave 1B			
78	IO code Slave 2B				ID_CODE Slave 2B			
79	ID1 Slave 2B				ID2 Slave 2B			
80	IO code Slave 3B				ID_CODE Slave 3B			
81	ID1 Slave 3B				ID2 Slave 3B			
82	IO code Slave 4B				ID_CODE Slave 4B			
83	ID1 Slave 4B				ID2 Slave 4B			
84	IO code Slave 5B				ID_CODE Slave 5B			
85	ID1 Slave 5B				ID2 Slave 5B			
86	IO code Slave 6B				ID_CODE Slave 6B			
87	ID1 Slave 6B				ID2 Slave 6B			
88	IO code Slave 7B				ID_CODE Slave 7B			
89	ID1 Slave 7B				ID2 Slave 7B			
90	IO code Slave 8B				ID_CODE Slave 8B			
91	ID1 Slave 8B				ID2 Slave 8B			
92	IO code Slave 9B				ID_CODE Slave 9B			
93	ID1 Slave 9B				ID2 Slave 9B			
94	IO code Slave 10B				ID_CODE Slave 10B			
95	ID1 Slave 10B				ID2 Slave 10B			
96	IO code Slave 11B				ID_CODE Slave 11B			
97	ID1 Slave 11B				ID2 Slave 11B			
98	IO code Slave 12B				ID_CODE Slave 12B			
99	ID1 Slave 12B				ID2 Slave 12B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
100	IO code Slave 13B				ID_CODE Slave 13B			
101	ID1 Slave 13B				ID2 Slave 13B			
102	IO code Slave 14B				ID_CODE Slave 14B			
103	ID1 Slave 14B				ID2 Slave 14B			
104	IO code Slave 15B				ID_CODE Slave 15B			
105	ID1 Slave 15B				ID2 Slave 15B			
106	IO code Slave 16B				ID_CODE Slave 16B			
107	ID1 Slave 16B				ID2 Slave 16B			
108	IO code Slave 17B				ID_CODE Slave 17B			
109	ID1 Slave 17B				ID2 Slave 17B			
110	IO code Slave 18B				ID_CODE Slave 18B			
111	ID1 Slave 18B				ID2 Slave 18B			
112	IO code Slave 19B				ID_CODE Slave 19B			
113	ID1 Slave 19B				ID2 Slave 19B			
114	IO code Slave 20B				ID_CODE Slave 20B			
115	ID1 Slave 20B				ID2 Slave 20B			
116	IO code Slave 21B				ID_CODE Slave 21B			
117	ID1 Slave 21B				ID2 Slave 21B			
118	IO code Slave 22B				ID_CODE Slave 22B			
119	ID1 Slave 22B				ID2 Slave 22B			
120	IO code Slave 23B				ID_CODE Slave 23B			
121	ID1 Slave 23B				ID2 Slave 23B			
122	IO code Slave 24B				ID_CODE Slave 24B			
123	ID1 Slave 24B				ID2 Slave 24B			
124	IO code Slave 25B				ID_CODE Slave 25B			
125	ID1 Slave 25B				ID2 Slave 25B			
126	IO code Slave 26B				ID_CODE Slave 26B			
127	ID1 Slave 26B				ID2 Slave 26B			
128	IO code Slave 27B				ID_CODE Slave 27B			
129	ID1 Slave 27B				ID2 Slave 27B			
130	IO code Slave 28B				ID_CODE Slave 28B			
131	ID1 Slave 28B				ID2 Slave 28B			
132	IO code Slave 29B				ID_CODE Slave 29B			
133	ID1 Slave 29B				ID2 Slave 29B			
134	IO code Slave 30B				ID_CODE Slave 30B			
135	ID1 Slave 30B				ID2 Slave 30B			
136	IO code Slave 31B				ID_CODE Slave 31B			
137	ID1 Slave 31B				ID2 Slave 31B			
138	0				Parameter Slave 1 / 1A			
139	Parameter Slave 2 / 2A				Parameter Slave 3 / 3A			
140	Parameter Slave 4 / 4A				Parameter Slave 5 / 5A			

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
141	Parameter Slave 6 / 6A				Parameter Slave 7 / 7A			
142	Parameter Slave 8 / 8A				Parameter Slave 9 / 9A			
143	Parameter Slave 10 / 10A				Parameter Slave 11 / 11A			
144	Parameter Slave 12 / 12A				Parameter Slave 13 / 13A			
145	Parameter Slave 14 / 14A				Parameter Slave 15 / 15A			
146	Parameter Slave 16 / 16A				Parameter Slave 17 / 17A			
147	Parameter Slave 18 / 18A				Parameter Slave 19 / 19A			
148	Parameter Slave 20 / 20A				Parameter Slave 21 / 21A			
149	Parameter Slave 22 / 22A				Parameter Slave 23 / 23A			
150	Parameter Slave 24 / 24A				Parameter Slave 25 / 25A			
151	Parameter Slave 26 / 26A				Parameter Slave 27 / 27A			
152	Parameter Slave 28 / 28A				Parameter Slave 29 / 29A			
153	Parameter Slave 30 / 30A				Parameter Slave 31 / 31A			
154	0				Parameter Slave 1B			
155	Parameter Slave 2B				Parameter Slave 3B			
156	Parameter Slave 4B				Parameter Slave 5B			
157	Parameter Slave 6B				Parameter Slave 7B			
158	Parameter Slave 8B				Parameter Slave 9B			
159	Parameter Slave 10B				Parameter Slave 11B			
160	Parameter Slave 12B				Parameter Slave 13B			
161	Parameter Slave 14B				Parameter Slave 15B			
162	Parameter Slave 16B				Parameter Slave 17B			
163	Parameter Slave 18B				Parameter Slave 19B			
164	Parameter Slave 20B				Parameter Slave 21B			
165	Parameter Slave 22B				Parameter Slave 23B			
166	Parameter Slave 24B				Parameter Slave 25B			
167	Parameter Slave 26B				Parameter Slave 27B			
168	Parameter Slave 28B				Parameter Slave 29B			
169	Parameter Slave 30B				Parameter Slave 31B			
170	Flag 1							
171	Flag 2							

Table 9- 37 Structure of flag 1 and flag 2

Flag 1			Flag 2	
Bit number	**Meaning**		**Bit number**	**Meaning**
0	Config_OK		0	Periphery_OK
1	LDS.0		1	Data_Exchange_Active
2	Auto_Address_Assign		2	Off_Line
3	Auto_Address_Available		**3**	**AUTO_ADDR_ENABLE** 1)
4	**Configuration_Active** 1)		4	Earth_Fault
5	Normal_Operation_Active		5	EEPROM_OK
6	APF		6	EFD-ENABLE
7	Offline_Ready		7	Reserved

1) The "Configuration_Active" and "AUTO_ADDR_ENABLE" flags change the operating mode of the AS-i master. The values of the remaining flags are insignificant for the command "Set_LPS, Set_PCD, Set_PP, Set_Flags" and cannot be modified in the AS-i master by this call.

Configuration_Active	"0" means: After the command has been executed, the AS-i master will switch to "protected operation". "1" means: The AS-i master runs in "configuration mode" after completion of the job.
AUTO_ADDR_ENABLE	"0" means: Automatic address programming is disabled. "1" means: Automatic address programming is enabled.

For the meanings of flags, refer to Chapter:

Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 121)

9.4.19 Set_PI

Meaning

This command transfers parameters for all AS-i slaves to the AS-i master. It only transfers those parameters that have changed to the AS-i slaves, i.e. those that differ from the previously sent ACTUAL parameters.

Structure of the job data in the send buffer

Table 9- 38 Structure of the job data

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0	Command number: $3C_H$							
1	00_H							
2	0				Parameter Slave 1 / 1A			
3	Parameter Slave 2 / 2A				Parameter Slave 3 / 3A			
4	Parameter Slave 4 / 4A				Parameter Slave 5 / 5A			
5	Parameter Slave 6 / 6A				Parameter Slave 7 / 7A			
6	Parameter Slave 8 / 8A				Parameter Slave 9 / 9A			
7	Parameter Slave 10 / 10A				Parameter Slave 11 / 11A			
8	Parameter Slave 12 / 12A				Parameter Slave 13 / 13A			
9	Parameter Slave 14 / 14A				Parameter Slave 15 / 15A			
10	Parameter Slave 16 / 16A				Parameter Slave 17 / 17A			
11	Parameter Slave 18 / 18A				Parameter Slave 19 /19A			
12	Parameter Slave 20 / 20A				Parameter Slave 21 / 21A			
13	Parameter Slave 22 / 22A				Parameter Slave 23 /23A			
14	Parameter Slave 24 / 24A				Parameter Slave 25 / 25A			
15	Parameter Slave 26 / 26A				Parameter Slave 27 / 27A			
16	Parameter Slave 28 / 28A				Parameter Slave 29 / 29A			
17	Parameter Slave 30 / 30A				Parameter Slave 31 / 31A			
18	0				Parameter Slave 1B			
19	Parameter Slave 2B				Parameter Slave 3B			
20	Parameter Slave 4B				Parameter Slave 5B			
21	Parameter Slave 6B				Parameter Slave 7B			
22	Parameter Slave 8B				Parameter Slave 9B			
23	Parameter Slave 10B				Parameter Slave 11B			
24	Parameter Slave 12B				Parameter Slave 13B			
25	Parameter Slave 14B				Parameter Slave 15B			
26	Parameter Slave 16B				Parameter Slave 17B			
27	Parameter Slave 18B				Parameter Slave 19B			
28	Parameter Slave 20B				Parameter Slave 21B			
29	Parameter Slave 22B				Parameter Slave 23B			
30	Parameter Slave 24B				Parameter Slave 25B			
31	Parameter Slave 26B				Parameter Slave 27B			
32	Parameter Slave 28B				Parameter Slave 29B			
33	Parameter Slave 30B				Parameter Slave 31B			

9.4.20 AS-i Parameter Echolist

Meaning

This command outputs the echo values for all AS-i slaves. The echo values of an AS-i slave originate in the last parameter call sent to this AS-i slave.

Structure of the job data in the send buffer

Table 9- 39 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 33_H
1	00_H

Structure of the response data in the receive buffer

Table 9- 40 Structure of the job data in the receive buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved				Par.Echo Slave 1			
1	Par.Echo Slave 2				Par.Echo Slave 3			
2	Par.Echo Slave 4				Par.Echo Slave 5			
3	Par.Echo Slave 6				Par.Echo Slave 7			
4	Par.Echo Slave 8				Par.Echo Slave 9			
5	Par.Echo Slave 10				Par.Echo Slave 11			
6	Par.Echo Slave 12				Par.Echo Slave 13			
7	Par.Echo Slave 14				Par.Echo Slave 15			
8	Par.Echo Slave 16				Par.Echo Slave 17			
9	Par.Echo Slave 18				Par.Echo Slave 19			
10	Par.Echo Slave 20				Par.Echo Slave 21			
11	Par.Echo Slave 22				Par.Echo Slave 23			
12	Par.Echo Slave 24				Par.Echo Slave 25			
13	Par.Echo Slave 26				Par.Echo Slave 27			
14	Par.Echo Slave 28				Par.Echo Slave 29			
15	Par.Echo Slave 30				Par.Echo Slave 31			
16	Reserved				Par.Echo Slave 1B			
17	Par.Echo Slave 2B				Par.Echo Slave 3B			
18	Par.Echo Slave 4B				Par.Echo Slave 5B			
19	Par.Echo Slave 6B				Par.Echo Slave 7B			
20	Par.Echo Slave 8B				Par.Echo Slave 9B			
21	Par.Echo Slave 10B				Par.Echo Slave 11B			
22	Par.Echo Slave 12B				Par.Echo Slave 13B			
23	Par.Echo Slave 14B				Par.Echo Slave 15B			
24	Par.Echo Slave 16B				Par.Echo Slave 17B			
25	Par.Echo Slave 18B				Par.Echo Slave 19B			
26	Par.Echo Slave 20B				Par.Echo Slave 21B			
27	Par.Echo Slave 22B				Par.Echo Slave 23B			
28	Par.Echo Slave 24B				Par.Echo Slave 25B			
29	Par.Echo Slave 26B				Par.Echo Slave 27B			
30	Par.Echo Slave 28B				Par.Echo Slave 29B			
31	Par.Echo Slave 30B				Par.Echo Slave 31B			

9.4.21 Read_Write_CTT2_String

Meaning

This command sends a CTT2 request according to the AS-i slave profile "CombinedTransactionType2" to the AS-i master with a byte string. The master forwards the string bytes to the AS-i slave address specified in the send buffer.

This command transfers a send buffer with up to 222 bytes to the AS-i master. The AS-i master calculates the actual number of string bytes to be sent to the AS-i slave from byte 2 of the send buffer.

The addressed AS-i slave answers the CTT2 request with a CTT2 response. The AS-i master communicates this response as a byte string in the receive buffer. The strings are transmitted by the AS-i master with the response.

The structure of the CTT2 request or CTT2 response (code, index, etc.) starts with string byte 1 in each case. You will find details about this in the respective AS-i slave description.

Note

While transmission of the strings is being executed on AS-i, there is no cyclic data transfer with the addressed AS-i slave. The type of protocol used means that transfer of up to 200 bytes can take up to half a minute.

Structure of the job data in the send buffer

Table 9- 41 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 44_H
1	Slave address
2	Number of string bytes
3	String byte 1
4	String byte 2
…	—
n + 1	String byte n-1
n + 2	String byte n

Maximum value for n = 220

Structure of the response data in the receive buffer

Table 9- 42 Structure of the response data in the receive buffer

Byte	Meaning
0	Number of string bytes
1	String byte 1
2	String byte 2
…	…
m - 1	String byte m - 1
m	String byte m

Maximum value for m = 220

9.4.22 Read_Version

Meaning

This command reads the version ID for the firmware of the AS-i master.

Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 14_H

Structure of the reply data in the receive buffer

Table 9- 43 Structure of the reply data in the receive buffer

Byte	Meaning
0 … 31	Versions string [1)]

1) "Siemens AG CM ASi M V aa.bb.cc.dd"

9.4.23 Read ID_Code

Significance

This command reads the ID code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 9- 44 Structure of the job data in the send buffer

Byte	Significance
0	Command number: 17_H
1	Slave address

Structure of the reply data in the receive buffer

Table 9- 45 Structure of the reply data in the receive buffer

Byte	Significance			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Reserved		ID code	

9.4.24 Read_ID1-Code

Meaning

This command reads the ID1 code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 9- 46 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 37_H
1	Slave address

Structure of the response data in the receive buffer

Table 9- 47 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Reserved		ID1 code	

9.4.25 Write ID1-Code

Meaning

This command writes the ID1 code of an AS-i slave with the address "0" directly over the AS-i cable.

The AS-i master forwards the ID1 code to the AS-i slave without a plausibility check.

Structure of the job data in the send buffer

Table 9- 48 Structure of the job data in the send buffer

Byte	Meaning	
0	Command number: $3F_H$	
1	Not relevant	ID1 code

9.4.26 Read_ID2-Code

Meaning

This command reads the ID2 code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 9- 49 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 38_H
1	Slave address

Structure of the response data in the receive buffer

Table 9- 50 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Reserved		ID2 code	

9.4.27 Read_IO-Code

Meaning

This command reads the IO code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 9- 51 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 18_H
1	Slave address

Structure of the response data in the receive buffer

Table 9- 52 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Reserved		IO code	

9.4.28 Get_LPF

Meaning

This command reads the list of I/O faults (periphery faults) (LPF) signaled by the AS-i slaves from the AS-i master. The AS-i master updates the LPF cyclically. Refer to the description of the AS-i slave to learn whether the slave can detect a fault in the connected I/O, e.g. wire break, and when it signals the fault.

Structure of the job data in the send buffer

Table 9- 53 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: BE_H

Structure of the responses in the receive buffer

Table 9- 54 Structure of the responses in the receive buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Slave 7(A)	Slave 6(A)	Slave 5(A)	Slave 4(A)	Slave 3(A)	Slave 2(A)	Slave 1(A)	Reserved
1	Slave 15(A)	Slave 14(A)	Slave 13(A)	Slave 12(A)	Slave 11(A)	Slave 10(A)	Slave 9(A)	Slave 8(A)
2	Slave 23(A)	Slave 22(A)	Slave 21(A)	Slave 20(A)	Slave 19(A)	Slave 18(A)	Slave 17(A)	Slave 16(A)
3	Slave 31(A)	Slave 30(A)	Slave 29(A)	Slave 28(A)	Slave 27(A)	Slave 26(A)	Slave 25(A)	Slave 24(A)
4	Slave 7B	Slave 6B	Slave 5B	Slave 4B	Slave 3B	Slave 2B	Slave 1B	Reserved
5	Slave 15B	Slave 14B	Slave 13B	Slave 12B	Slave 11B	Slave 10B	Slave 9B	Slave 8B
6	Slave 23B	Slave 22B	Slave 21B	Slave 20B	Slave 19B	Slave 18B	Slave 17B	Slave 16B
7	Slave 31B	Slave 30B	Slave 29B	Slave 28B	Slave 27B	Slave 26B	Slave 25B	Slave 24B
8 … 13	Reserved							

The bits have the following meanings in the LPF data:

Bit = 0: The slave signals no I/O fault.

Bit = 1: The slave signals I/O fault.

9.4.29 Write_Parameter_String

Meaning

This command sends a parameter string in accordance with AS-i slave profile 7.4 to the AS-i master. The master forwards the parameter string to the AS-i slave address specified in the send buffer.

This command transfers a send buffer with up to 223 bytes to the AS-i master. The AS-i master calculates the actual number of parameter bytes to be sent to the AS-i slave from byte 2 of the send buffer.

The AS-i master does not evaluate any other information in the parameter string. It transfers this to the AS-i slave transparently. While transmission of the parameter string is being executed, there is no transfer of user data / analog data with the addressed AS-i slave.

Structure of the job data in the send buffer

Table 9- 55 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 40_H
1	Slave address
2	Number of parameter bytes
3	Parameter string byte 1
4	Parameter string byte 2
…	…
n + 1	Parameter string byte n - 1
n + 2	Parameter string byte n

Maximum value for n = 220

9.4.30 Read_String

Meaning

This command causes the AS-i slave to read a parameter string in accordance with AS-i slave profile 7.4 with the AS-i slave address specified in the send buffer.

The AS-i master supplies up to 221 bytes of response data. The AS-i master signals the actual number of parameter bytes sent by the AS-i slave in Byte 0 of the receive buffer.

If the AS-i slave sends a parameter string longer than 220 bytes, the AS-i master aborts string transfer and terminates the job with an error. The received data is not made available to the job program.

While transmission of the parameter string is being executed, there is no transfer of user data / analog data with the addressed AS-i slave.

Structure of the job data in the send buffer

Table 9- 56 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 41_H
1	Slave address

Structure of the response data in the receive buffer

Table 9- 57 Structure of the response data in the receive buffer

Byte	Meaning
0	Number of parameter bytes
1	Parameter string byte 1
2	Parameter string byte 2
…	…
n - 1	Parameter string byte n - 1
n	Parameter string byte n

Maximum value for n = 220

9.4.31 Read_String

Meaning

This command causes the AS-i slave to read an identification string in accordance with AS-i slave profile 7.4 with the AS-i slave address specified in the send buffer. The AS-i master supplies up to 221 bytes of reply data. The AS-i master signals the actual number of ID bytes sent by the AS-i slave in Byte 0 of the receive buffer.

If the AS-i slave sends an ID string longer than 220 bytes, the AS-i master aborts string transfer and terminates the job with an error. The received data is not made available to the user program.

As long as the transmission of the identification string is running, there is no transfer of user/analog data with the addressed AS-i slave.

Note

In a deviation from normal procedure, this command also transfers the bytes that contain the bits "Follows" and "Valid".

For further details, refer to AS-i slave profile 7.4

Structure of the job data in the send buffer

Table 9- 58 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 42_H
1	Slave address

Structure of the reply data in the receive buffer

Table 9- 59 Structure of the reply data in the receive buffer

Byte	Meaning
0	Number of ID bytes
1	ID string byte 1
2	ID string byte 2
…	…
n - 1	ID string byte n - 1
n	ID string byte n

Maximum value for n = 220

9.4.32 Read_String

Significance

This command causes the AS-i slave to read a diagnostics string in accordance with AS-i slave profile 7.4 with the AS-i slave address specified in the send buffer. The AS-i master supplies up to 221 bytes of reply data. The AS-i master signals the actual number of diagnostics bytes sent by the AS-i slave in Byte 0 of the receive buffer.

If the AS-i slave sends a diagnostics string longer than 220 bytes, the AS-i master aborts string transfer and terminates the job with an error. The received data is not made available to the user program.

While transmission of the diagnostics string is being executed, there is no transfer of user data / analog data with the addressed AS-i slave.

Structure of the job data in the send buffer

Table 9- 60 Structure of the job data in the send buffer

Byte	Significance
0	Command number: 43_H
1	Slave address

Structure of the reply data in the receive buffer

Table 9- 61 Structure of the reply data in the receive buffer

Byte	Significance
0	Number of diagnostics bytes
1	Diagnostic string byte 1
2	Diagnostic string byte 2
…	…
n - 1	Diagnostic string byte n - 1
n	Diagnostic string byte n

Maximum value for n = 220

9.4.33 Read_Error_Counter

Note

With Firmware V1.1 or higher, use data record "DS 96 Read AS-i master error counters and status messages (FW V1.1 and higher) (Page 86)" for reading out the error counters. The Read_AS-i_Master_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command reads out error counters that concern the overall AS-i network.

If the AS-i power supply is missing, the overall device fails. This leads to all counters being reset. The counting starts over each time the device is powered up.

For the meaning of the error counters, refer to Table "Table 8-11 Meaning of error counter (Page 86)".

Structure of the job data in the send buffer

Table 9- 62 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CA_H

Structure of the responses in the receive buffer

Table 9- 63 Structure of the data record

Byte	Meaning	
0	Summation counter: AS-i Power Fail	High byte
1		Low byte
2	Summation counter: Ground fault	High byte
3		Low byte
4	Summation counter: Slave failure	High word, high byte
5		High word, low byte
6		Low word, high byte
7		Low word, low byte
8	Summation counter: Missing slave frame	High word, high byte
9		High word, low byte
10		Low word, high byte
11		Low word, low byte

Byte	Meaning		
12	Summation counter: Erroneous slave frame		High word, high byte
13			High word, low byte
14			Low word, high byte
15			Low word, low byte
16	Summation counter: Slave peripheral fault		High word, high byte
17			High word, low byte
18			Low word, high byte
19			Low word, low byte
20	Summation counter: Slave protocol error (for slaves according to CTT1 ... CTT5)		High word, high byte
21			High word, low byte
22			Low word, high byte
23			Low word, low byte
24	Summation counter: Erroneous master frame		High word, high byte
25			High word, low byte
26			Low word, high byte
27			Low word, low byte
28 … 35	List of count values > 0 (see Table "Structure of bit fields")		
	Bit = 0	Count value = 0 for all error counters of the AS-i address	
	Bit = 1	Count value > 0 for at least one error counter of the AS-i address	
36	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)		High word, high byte
37			High word, low byte
38			Low word, high byte
39			Low word, low byte
40	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)		High word, high byte
41			High word, low byte
42			Low word, high byte
43			Low word, low byte
44	Summation counter: Sent master frames, factor (MT_CNT_BASE)		High word, high byte
45			High word, low byte
46			Low word, high byte
47			Low word, low byte
48	Reserved		Bit 0 = MADDR
49	Reserved		
50 … 57	List of multiple addressing (see Table "Structure of bit fields")		
	Bit = 0	The AS-i address is assigned once or is not present.	
	Bit = 1	The AS-i address is assigned more than once.	
58 ... 220	Reserved		

The counters are integer values (2 bytes or 4 bytes).

Multiple addressing has been detected for at least one AS-i address on the AS-i cable. This means that multiple slaves have the same AS-i address.

Structure of the bit fields

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SLAVE 7/7A	SLAVE 6/6A	SLAVE 5/5A	SLAVE 4/4A	SLAVE 3/3A	SLAVE 2/2A	SLAVE 1/1A	Reserved
1	SLAVE 15/15A	SLAVE 14/14A	SLAVE 13/13A	SLAVE 12/12A	SLAVE 11/11A	SLAVE 10/10A	SLAVE 9/9A	SLAVE 8/8A
2	SLAVE 23/23A	SLAVE 22/22A	SLAVE 21/21A	SLAVE 20/20A	SLAVE 19/19A	SLAVE 18/18A	SLAVE 17/17A	SLAVE 16/16A
3	SLAVE 31/31A	SLAVE 30/30A	SLAVE 29/29A	SLAVE 28/28A	SLAVE 27/27A	SLAVE 26/26A	SLAVE 25/25A	SLAVE 24/24A
4	SLAVE 7B	SLAVE 6B	SLAVE 5B	SLAVE 4B	SLAVE 3B	SLAVE 2B	SLAVE 1B	Reserved
5	SLAVE 15B	SLAVE 14B	SLAVE 13B	SLAVE 12B	SLAVE 11B	SLAVE 10B	SLAVE 9B	SLAVE 8B
6	SLAVE 23B	SLAVE 22B	SLAVE 21B	SLAVE 20B	SLAVE 19B	SLAVE 18B	SLAVE 17B	SLAVE 16B
7	SLAVE 31B	SLAVE 30B	SLAVE 29B	SLAVE 28B	SLAVE 27B	SLAVE 26B	SLAVE 25B	SLAVE 24B

9.4.34 Read_and_Delete_AS-i-Master_Error_Counter

Note

With Firmware V1.1 or higher, use data record "DS 97 Read and reset AS-i master error counters (FW V1.1 and higher) (Page 89)" for reading out the error counters. The Read_and_Reset_AS-i_Master_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command functions like the "Read_AS-i-Master_Error_Counter" command. In addition, the AS-i master then sets all error counters to 0.

Structure of the job data in the send buffer

Table 9- 64 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CB_H

Structure of the responses in the receive buffer

The receive buffer is identical to the receive buffer of the "Read_Error_Counter (Page 151)" command.

9.4.35 Read_AS-i_error_counter

Note

With Firmware V1.1 or higher, use data records "DS 150 to DS 153 Read AS-i error counters (Page 89)". The Read_AS-i_Slave_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command reads out AS-i slave-specific error counters. For the meaning of the error counters, refer to Section "Table 8-13 Meaning of error counter (Page 90)".

Structure of the job data in the send buffer

Table 9- 65 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CC_H
1	AS-i slave address

Structure of the responses in the receive buffer

Table 9- 66 Structure of the responses in the receive buffer

Byte	Meaning	
0	Counter: Slave failure	High byte
1		Low byte
2	Counter: Missing slave frame	High byte
3		Low byte
4	Counter: Faulty slave frame	High byte
5		Low byte
6	Counter: Peripheral fault	High byte
7		Low byte
8	Counter: Protocol error	High byte
9		Low byte
10	Counter: Faulty master frame	High byte
11		Low byte
12	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)	High word / high byte
13		High word / low byte
14		Low word / high byte
15		Low word / low byte
16	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)	High word / high byte
17		High word / low byte
18		Low word / high byte
19		Low word / low byte
20	Summation counter: Sent master frames, factor (MT_CNT_BASE)	High word / high byte
21		High word / low byte
22		Low word / high byte
23		Low word / low byte
24 … 31	Reserved	

9.4.36 Read_and_delete_AS-i_Slave_error_counter

Note

With Firmware V1.1 or higher, use data records "DS 150 to DS 153 Read AS-i error counters (Page 89)" and "DS 154 Delete AS-i error counters (from V1.1) (Page 96)". The Read_and_Reset_AS-i_Slave_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command reads out the error counters of the AS-i slaves. Data records DS 150 and DS 151 access the standard addresses and the A addresses. Data records DS 152 and DS 153 access the B addresses. The counters for addresses 16 / 16A exist identically in data records DS 150 and DS 151. The counters for address 16B exist identically in data records DS 152 and DS 153. Data record DS 154 resets all AS-i slave error counters.

Structure of the job data in the send buffer

Table 9- 67 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CD_H
1	AS-i slave address

Structure of the responses in the receive buffer

The receive buffer is identical to the receive buffer of the "Read_AS-i_error_counter (Page 154)" command.

9.4.37 Activate_ground fault detection (reset EFD)

Meaning

The setting for enabling the integrated ground fault detection is always made when configuring the CM AS-i Master.
This command is used to enable or disable the ground fault detection via the user program so as to overwrite the configured setting.
After a startup or restart, the configured setting is applied again.

Structure of the job data in the send buffer

Table 9- 68 Structure of the job data in the send buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Command number 13_H							
1	0							0 = Ground fault detection is enabled 1 = Ground fault detection is disabled

9.4.38 Set_Configuration_Online

Meaning

The following configuration data for the addressed AS-i slave is configured with this command:

- IO code
- ID code
- ID1 code
- ID2 code
- Parameter value

The configuration data is stored in the non-volatile EEPROM of the CM AS-i Master ST. The AS-i master uses this configuration data as the specified expected configuration for "protected operation". The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification". If the addressed AS-i slave does not support ID code 1 or ID code 2, the command must be specified in the value FH for this. When this command is executed, the AS-i master remains in the online phase. This means that the AS-i master is not restarted. The command can be executed in "Protected operation".

The command can be executed for any slaves including proxy slaves. Ensure that you have defined an adequate length for the I/O image when configuring the slave. If the the I/O image for the slave is not long enough, surplus input data are truncated and surplus output data are transmitted with substitute value 0. This applies to a digital I/O image and an analog I/O image.

If the value F (hex) is written to a proxy slave for all four codes (IO code, ID code, ID1 code and ID2 code), any slave type at this AS-i address is activated by the AS-i master.

Note

Configuration data are overwritten

If you use this command, you will overwrite the corresponding configuration data that resulted from configuring using the "SET" button or configuring using HW Config.

Note

The configuration data for all proxy slaves can be reset to value F (hex) in the CM AS-i Master ST module by configuring the AS-i slaves using the "SET" button with no slaves connected (see Section "Configuration of the AS-i slaves using the "SET" button (Page 35)").

Structure of the job data in the send buffer

Table 9- 69 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Command: $D0_H$			
1	Slave address			
2	IO code		ID code	
3	ID1 code		ID2 code	
4	0		Parameter	

9.4.39 AS-i-Slave_ID1_schreiben_mit_Zieladresse (Write ID1 code with destination address)

Meaning

This command writes the ID1 code of an AS-i slave with the specified address directly via the AS-i cable.

The AS-i master forwards the ID1 code to the AS-i slave without a plausibility check.

Requirements

- The AS-i slave at the target address must support writing of the ID1 code.
- There are no AS-i slaves on the AS-i bus with address "0".

Structure of the job data in the send buffer

Table 9- 70 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Command: $D1_H$			
1	AS-i slave address			
2	0		ID1 code	

Technical data

10

10.1 Technical specifications

Technical specifications of CM AS-i Master ST

		3RK7137-6SA00-0BC1
product designation		AS-Interface Master
Product-type designation		CM AS-i Master ST
Protection class IP		IP20
Design of the electrical connection of the AS-Interface		ET 200SP BaseUnit (Type C0), 20 mm
Type of voltage supply		Via AS-i and backplane bus
Operating condition separate power supply 24 V		No
Current consumed		
• from shaped cables of AS-Interface		
– at 24 V with AS-i Power24V maximum	A	0.07
– with external 24 V-supply voltage maximum	A	0.07
• from backplane bus		0.02
Resistive loss	W	1.7
Insulation voltage rated value	V	500
Product function adapted for AS-i Power24V		Yes
Product feature redundancy capability		No
Product function web-based management		No
Product function diagnosis via E-mail		No
Product function galvanic isolation		Yes
Type of projection of the AS-interface		Set pushbutton on device, STEP7, GSD, command interface
Version of the AS-interface specification		V 3.0
AS-interface masterprofile is supported		M4 (in acc. with AS-interface specification V 3.0)
Type of data transmission		ET 200SP backplane bus
Transfer rate of the AS-interface maximum	bit/s	167 000

		3RK7137-6SA00-0BC1
Number of interfaces		
• as AS-interface		1
• according to Industrial Ethernet		0
• according to PROFINET		0
• according to RS 485		0
• according to USB		0
• according to wireless		0
• others		1
Product component optical interface		No
Protocol is supported		
• ASIsafe(Safety at work) protocol		No
• PROFIBUS protocol		No
• PROFINET CBA protocol		No
• PROFINET IO protocol		No
• PROFIsafe protocol		No
• SNMP		No
• other bus systems		No
• TCP/IP		No
Standard for wireless communication IEEE 802.11		No
Number of inputs for AS Interface maximum		496
Number of outputs for AS Interface maximum		496
Number of AS-i slaves per AS-Interface maximum		62
Bus cycle time of the AS-interface		
• at 31 slaves	s	0.005
• at 62 slaves	s	0.01
Access to digital I/O data		via process diagram/peripheral addresses and data record transfer
Access to analog I/O data		via data record transfer
Width	mm	20
Height	mm	69.2
Depth	mm	53.6
Type of mounting		Pluggable in BaseUnit

		3RK7137-6SA00-0BC1
Ambient temperature		
• if installed on horizontal mounting rail		
– during operation	°C	0 60
• if installed on vertical mounting rail		
– during operation	°C	0 50
• during storage	°C	-40 70
• during transport	°C	-40 70
Relative humidity at 25 °C during operating maximum	%	95
Installation altitude at a height over sea level maximum	m	2 000
Module format		IP20
Type of display as status display by LED		DIAG, AS-i OK, AS-i FAULT, PF, CER, CM, AUP, PWR, SL_Xy (A), SL_xY (B)
Acceptability for application safety-related function		No
Explosion protection labeling for intrinsic safety of related operating resources		
• EEX ia		No
• EEX ib		No
Explosion protection category for gas		none
Explosion protection category for dust		none

You will find additional information in the manual ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521).

AS-Interface Protocol Implementation Conformance Statements

A

A.1 AS-Interface Protocol Implementation Conformance Statement (PICS)

PICS for the CM AS-i Master ST

Vendor	SIEMENS AG
Product name	CM AS-i Master ST
Article number	3RK137-6SA00-0BC1
Firmware version	V1.0, V1.1
Master profile	M4
Date	—

List of available master functions

Character	Meaning
X	Function available
—	Function not available

No.	Function or command to the host interface (symbolic representation)	M4	Remark / implementation of the function with
1	Image, Status = Read_IDI()	X	Through automation system access to the I/O data of the AS-i master
2	Status = Write_ODI(Image)	X	Through automation system access to the I/O data of the AS-i master
3	Status = Set_Permanent_Parameter (Addr, Param)	X	See Section "Description of the AS-i commands (Page 103)"
4	Param, Status = Get_Permanent_Parameter (Addr)	X	
5	Status, Param = Write_Parameter (Addr, Param)	X	
6	Status, Param = Read_Parameter(Addr)	X	
7	Status = Store_Actual_Parameters()	X	
8	Status = Set_Permanent_Configuration (Addr, Config)	X	
9	Status, Config = Get_Permanent_Configuration (Addr)	X	
10	Status = Store_Actual_Configuration()	X	In *STEP 7*, in the control panel, by pressing the "ACTUAL → CONFIGURED" button.

No.	Function or command to the host interface (symbolic representation)	M4	Remark / implementation of the function with
11	Status, Config = Read_Actual_Configuration (Addr)	X	See Section "Description of the AS-i commands (Page 103)". Access to data record 84.
12	Status = Set_LPS(List31)	X	
13	Status, LPS = Get_LPS()	X	
14	Status, LAS = Get_LAS()	X	
15	Status, LDS = Get_LDS()	X	
16.0	Status = Get_Flags()	X	
16.1	Status, Flag = Get_Flag_Config_OK()	X	
16.2	Status, Flag = Get_Flag_LDS.0()	X	
16.3	Status, Flag = Get_Flag_Auto_Address_Assign()	X	
16.4	Status, Flag = Get_Flag_Auto_Prog_Available()	X	
16.5	Status, Flag = Get_Flag_Configuration_Active()	X	
16.6	Status, Flag = Get_Flag_Normal_Operation_Active()	X	
16.7	Status, Flag = Get_Flag_APF()	X	CP error bit, LED indication (see Section "Description of the AS-i commands (Page 103)"). Access to data record 84.
16.8	Status, Flag = Get_Flag_Offline_Ready()	X	Access to data record 84.
16.9	Status, Flag = Get_Flag_Periphery_OK()	X	
17	Status = Set_Operation_Mode(Mode)	X	By pressing the "Configuration mode" or "Protected operation" button in the control panel of *STEP 7*.
18	Status = Set_Offline_Mode(Mode)	X	See section "Description of the AS-i commands (Page 103)"
19	Status = Activate_Data_Exchange(Mode)	-	Optional command; not implemented
20	Status = Change_Slave_Address (Addr1, Addr2)	X	See Section "Description of the AS-i commands (Page 103)".
21.1	Status = Set_Auto_Address_Enable	X	
21.2	Status = Get_Auto_Address_Enable	X	
22.1	Status, Resp = Cmd_Reset_ASI_Slave (Addr, RESET)	-	
22.2	Status, Resp = Cmd_Read_IO_Configuration (Addr, CONF)	X	
22.3	Status, Resp = Cmd_Read_Identification_Code(Addr, IDCOD)	X	
22.4	Status, Resp = Cmd_Read_Status (Addr, STAT)	X	
22.5	Status, Resp = Cmd_Read_Reset_Status (Addr, STATRES)	-	Not relevant for AS-i master acc. to profile M4; not implemented
22.6	Status, Resp = Cmd_Read_ID−Code_1(Addr, IDCOD1)	X	Not implemented
22.7	Status, Resp = Cmd_Read_ID−Code_2(Addr, IDCOD2)	X	
23	Status, S_List = Get_LPF()	X	See Section "Description of the AS-i commands (Page 103)". Access to data record 84.
24	Status = Write_ID−Code_11(S_ID−Code_1)	X	See Section "Description of the AS-i commands (Page 103)". Not implemented

No.	Function or command to the host interface (symbolic representation)	M4	Remark / implementation of the function with
25	AImage, Status = Read_AIDI()	X	See Section Description of the AS-i commands (Page 103). Through automation system access to the I/O data of the AS-i master
26	Status = Write_AODI(AImage)	X	
27	String, Status = Read_ParamStr(S_Addr)	X	See "Read_Parameter_String" in Section Description of the AS-i commands (Page 103)
28	Status = Write_ParamStr(S_Addr, String)	X	See Section Description of the AS-i commands (Page 103)
29	String, Status = Read_DiagStr(S_Addr)	X	See Section Description of the AS-i commands (Page 103)
30	String, Status = Read_IdentStr(S_Addr)	X	See Section Description of the AS-i commands (Page 103)
B	Supported slave profiles		
1	Support of extended address mode	X	—
2	Support of Combined transaction type 1 integrated (S−7.3 only)	X	—
3	Full support of Combined transaction type 1 integrated	X	Support for profiles 7.3 and 7.4 only.
4	Support of Combined transaction type 2 integrated	X	—
5	Support of Combined transaction type 3 integrated	X	—
6	Support of Combined transaction type 4 integrated	X	—
7	Support of Combined transaction type 5 integrated	X	—

Readme Open Source Software

B

B.1 Read_me OSS

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Data sets

C

C.1 DS 100 Switch duplicate address detection on/off

Description

The duplicate address detection function can be activated/deactivated via the user program by means of write access to data record DS 100.

For the CM AS-i Master firmware V1.0 the status is stored in the AS-i Master volatile memory, i.e. if the AS-i voltage fails, duplicate address detection is deactivated.

For the CM AS-i Master firmware V1.0 and higher, duplicate address detection is adopted according to the setting in HW Config or GSD after failure of the AS-i voltage.

Note

From firmware V1.1 onwards use the setting option via HW Config or GSD to activate duplicate address detection. Data record DS 100 continues to exist for compatibility reasons.

Table C- 1 Structure of DS 100 write

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0							
1	0							
2	0							0 / 1
3	0							

Bit 0 = 0 Duplicate address detection is activated.

= 1 Duplicate address detection is deactivated (default setting for FW V1.0).

The setting for which AS-i voltage duplicate address detection is activated (possible for FW V1.1 and higher) cannot be changed in this case.

See also

Duplicate address detection (Page 76)

C.2 DS 100 Read setting for duplicate address detection

Description

Via read access to data record DS 100 the enable status of duplicate address detection can be read back.

Table C- 2 Structure of DS 100 read

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 1	Reserved							
2	Reserved							0 / 1
3	Reserved							

Bit 0 = 0 Duplicate address detection is activated

= 1 Duplicate address detection is deactivated (default setting for FW V1.0).

The setting for which AS-i voltage duplicate address detection is activated (possible for FW V1.1 and higher) cannot be read out in this case.

See also

Duplicate address detection (Page 76)

C.3 DS 101 Read version identifier

Description

This data record reads the version identifier.

Table C- 3 Structure of data record DS 101

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 1	Reserved							

2 … 33	Version identifier as a string
	e. g.:
	`Siemens AG CM ASi M V01.00.00`
	`1.....1.....1.....1..`							

List of abbreviations

D

D.1 List of abbreviations

Meaning of abbreviations

Abbreviation	Meaning
APF	AS-i Power Fail (problem with the AS-i supply voltage)
AS-i	AS-Interface
ATEX	Atmosphere Explosive
AUP	Automatic address programming
AWP	Automation Web Pages
CER	Configuration error
CBA	Component Based Automation
CDI	Configuration Data Image
CFGOK	Configuration OK
CM	Configuration mode; Communication module
	Configuration mode activated
CPU	Central Processing Unit
CTT	Combined Transaction Type Glossary (Page 177)
DIAG	Diagnosis
	Diagnostics available
DIN	Deutsches Institut für Normierung e. V.
DP	Distributed peripherals
DS	Data record/data set
I/O	Input/Output
EEPROM	Electrically Erasable Programmable Read-Only Memory
EFD	Ground fault detection
EN	Europäische Norm (European standard)
FB	Function Block
FC	Function Code
GSD	Device master data
GSDML	Generic Station Description Markup Language
HSP	Hardware support package
HW	Hardware
HW ID	Hardware identifier
I&M	Identification and Maintenance
ID	Identifier (Identification number, e.g., ID1 code)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers

Abbreviation	Meaning
IO	Input Output
IP	Ingress Protection (enclosure class)
ISO	International Organization for Standardization
LAS	List of Activated Slaves
LDS	List of Detected Slaves
LED	Light Emitting Diode
LPF	List of peripheral faults (list of peripheral faults signaled by the AS-i slaves)
LPS	List of configured AS-i slaves (list of "projected" slaves)
MPO	Master Power On
NEC	National Electrical Code
NFPA	National Fire Protection Association
OB	Organization block
PIQ	Process Image Output
PII	Process image input
PCD	Permanent Configuration Data
PELV	Protective extra low voltage
PF	Peripheral fault
PI	Parameter Image
PP	Permanent Parameter
RDREC	Read record
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level
GF, CF	System fault
SFB	System function block
PLC	Programmable logic controller
SNMP	Simple Network Management Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
TIA	Totally Integrated Automation
USB	Universal Serial Bus
WRREC	Write record

Glossary

"Protected operation"

In "protected operation", the AS-i master only exchanges data with the configured AS-i slaves. "Configured" means that the slave addresses and configuration data stored in the AS-i master agree with the values of existing AS-i slaves.

APF

AS-i Power Fail. Flag or LED display that indicates that the supply voltage on the AS-i cable is too low or has failed, e.g., failure of the AS-i power supply unit.

AS-i (AS-Interface)

Actuator-Sensor-Interface. A networking system for the plant-floor automation layer. It is suitable for networking sensors and actuators with controllers.

AS-i analog slave

AS-i analog slaves are special AS-i standard slaves that exchange analog values with the AS-i master; see also CTT.

AS-i master

The AS-i master monitors and controls simple digital or analog sensors and actuators via AS-i modules or AS-i slaves.

AS-i slave

All devices that can be addressed by an AS-i master are referred to as AS-i slaves. AS-i slaves are distinguished according to their design (AS-i modules as well as sensors or actuators with integrated AS-i connection) and their addressing type (AS-i slave with standard address in the range 0 ... 31 and AS-i slave with A/B address in the range 0, 1A ... 31A, 1B, 31B) or their functionality (standard slave for non-safety-related data transmission and ASIsafe slave for safety-related data).

AS-i slave with A/B address

AS-i slaves with A/B address use extended addressing. A (numerical) address can thus be used by two slaves with A/B address, e.g., 1A and 1B. Based on the address organization, up to 62 slaves with A/B address can be connected to the AS-Interface.

For cyclic data transmission, the master accesses each (numerical) address once per AS-i cycle (max. 5 ms). If two slaves use a (numerical) address on the bus both as an A address and a B address, two consecutive AS-i cycles are required for their data transmission (max. 10 ms rms). If a (numerical) address is used only as an A address or as a B address on the bus, the data transmission for these slaves occurs in every AS-i cycle.

AS-i slave with standard address

Each AS-i slave with standard address occupies one address on the AS-Interface; based on the address organization, up to 31 AS-i slaves with standard address can therefore be connected to the AS-Interface. If a slave with standard address occupies an address, this address is no longer available for slaves with A/B address.

For cyclic data transmission, the master accesses each address once per AS-i cycle (max. 5 ms).

CER

Configuration Error (Indication of configuration errors). The configuration error is indicated by an LED if the actual bus configuration does not match the specified configuration.

CM

Communication module

Module for communication tasks that is used in an automation system as an interface expansion for the CPU.

CPU

Central Processing Unit

CTT

Combined Transaction Type. Special AS-i slave profile:

CTT slaves require several AS-i cycles or several AS-i addresses for updating process data between an AS-I slave and AS-i master.

The following CTT variants are defined:

CTT1: Slave profiles S-7.3, S-7.4

For cyclic data transmission of analog values or transparent data (up to 16 bits per channel).

Depending on the slave, the data transmission is in the direction of the input or output.

The S-7.1 and S-7.2 profiles are outdated profiles that are not managed automatically by the AS-i master (function blocks are required for decoding the process data).

CTT2: Slave profiles S-7.5.5, S-7.A.5, S-B.A.5

For transmission of data blocks similar to data record transmission in PROFIBUS/PROFINET.

The transmission can be initiated individually via the user program (acyclically, see "CTT2-Request_lesen_schreiben (Read_Write_CTT2_String)") or automatically by the master (cyclically, same as for analog values). Refer to the slave documentation.

The transmission process is managed automatically by the master and corresponds to a serial data transmission with approximately 12 bytes (or 6 bytes for A/B address with maximum configuration).

Depending on the slave, in parallel to the data block transmission, digital data of up to 2 DI / DO are also transmitted per AS-i cycle (5 ms or 10 ms for A/B address with maximum configuration).

CTT3: Slave profiles S-7.A.7, S-7.A.A

For cyclic transmission of digital data.

Slave profile S-7.A.7 transmits 4 DI / 4 DO using a slave with A/B address. Like for standard slaves, the inputs are transmitted in each AS-i cycle (5 ms or 10 ms for A/B address with maximum configuration). The outputs require double the transmission time.

Slave profile S-7.A.A transmits 8 DI / 8 DO using a slave with A/B address. The inputs and outputs are transmitted using four AS-i cycles.

CTT4: Slave profiles S-7.A.8, S-7.A.9

For cyclic transmission of analog values or transparent data (up to 16 bits per channel) in the input direction using a slave with A/B address.

Depending on the slave, in parallel to the data block transmission, digital data of up to 1 DO can also be transmitted per AS-i cycle (5 ms or 10 ms for A/B address with maximum configuration).

CTT5: Slave profile S-6.0.x, where x = 2 … 7, A … C

For cyclic transmission of analog values or transparent data (up to 16 bits) in the input and output direction.

The CTT5 types each occupy 2, 3, or 4 slave addresses simultaneously, depending on the data record, so that consistent transmission of the full data width occurs in each AS-i cycle (5 ms).

DIAG

Diagnosis

EFD

Ground fault detection

GSD file

Generic station description file for PROFIBUS or PROFINET devices

GSDML file

GSD file for PROFINET devices. As a generic station description, this file contains all of the properties of a PROFINET device necessary for its configuration.

HSP

The Hardware Support Package supplements the hardware catalog of *STEP 7*.

ID code

Fixed identification code saved in the AS-i slave; part of the slave profile.

See also: Slave profile

ID1 code

Also called: Extended ID1 code

Fixed or editable identification code saved in the AS-i slave.

See also: Slave profile

ID2 code

Also called: Extended ID2 code

Fixed identification code saved in the AS-i slave; part of the slave profile.

See also: Slave profile

Inspector window

The inspector window of *STEP 7* / TIA Portal displays additional information about a selected object or executed actions. The indicated properties and parameters of the selected object can be edited within the inspector window.

IO code

Also called: I/O configuration

Fixed identification code saved in the AS-i slave; part of the slave profile.

See also: Slave profile

LAS

List of Activated Slaves

LDS

List of Detected Slaves

LED

A light-emitting diode that is used to display the signal status.

LPF

List of periphery faults This list in the AS-i master designates the status of the peripheral fault of the activated slaves.

LPS

List of Projected Slave (list of configured slaves)

Nibble

A nibble is a unit of information that comprises four bits.

Option handling

Option handling allows the user program to activate optional functions during normal operation without the need for reconfiguration.

PF

Peripheral fault: Error message of an active AS-i slave to the master, e.g., overload at output (depending on slave, see documentation of the AS-i slave).

Slave profile

The slave profile classifies the basic properties of an AS-i slave. The slave profile consists of the IO code, ID code, and ID2 code, which are stored as fixed, uneditable codes in each slave. In addition, a slave has an ID1 code, which is saved in the slave as a fixed code or a code that is editable by the user (e.g., with an addressing device). The value of the ID1 code usually has no effect on the operating characteristics of the slave. In this case, the user should not change the value, so that compatibility problems do not occur if the device is replaced. Note the documentation of the slave for the ID1 setting.

Each of the four identification codes consists of a 4-bit value that is usually written in hexadecimal notation with a value range of 0 to F. On power-up, the AS-i master reads the codes automatically from each slave and saves this ACTUAL configuration in the volatile memory of the AS-i master.

If the AS-i master is in “protected operation”, it compares the ACTUAL configuration with a CONFIGURED configuration, which is normally stored in non-volatile memory in the AS-i master. Slaves whose ACTUAL configuration matches the CONFIGURED configuration are activated and then participate in the cyclic data exchange. Slaves without a match are not activated and do not exchange cyclic data. A configuration error is also signaled.

ID2 and ID1 are optional codes. That is, some slaves do not have these two codes. In this case, the master enters the hexadecimal value “F” as a substitute value in the ACTUAL configuration.

Slaves with extended addressing, the so-called A/B slaves, use only the three less significant bits of the ID1 code as the slave identification. The most significant bit of the ID1 code is reserved and is used by the AS-i system to distinguish between an A address or B address. The effective value range of the ID1 code is thus 0 ... 7. For the read-out of the ID code, only the 3 less significant bits or all 4 bits are displayed, depending on the system, so that the displayed ID1 code can be within the value range 8 to F for slaves with B address. The user or programmer can ignore the most significant bit of the ID1 code for A/B slaves since it is managed automatically by the system.

The slave profile is usually shown in the documentation with the S prefix and a hyphen (in some cases), followed by the IO, ID, and ID2 codes, each separated by a dot.

Example: S-7.0.F

Since the ID1 code is usually editable, the value is often not documented or documented only as a default value.

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SIEMENS

SIMATIC

ET 200SP
Digital input module
F-DI 8x24VDC HF
(6ES7136-6BA00-0CA0)

Manual

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07/2013

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

Note

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Security information

Siemens provides automation and drive products with industrial security functions that support the secure operation of plants or machines. They are an important component in a holistic industrial security concept. With this in mind, our products undergo continuous development. We therefore recommend that you keep yourself informed with respect to our product updates. Please find further information and newsletters on this subject at: (http://www.siemens.com/industrialsecurity)

To ensure the secure operation of a plant or machine it is also necessary to take suitable preventive action (e.g. cell protection concept) and to integrate the automation and drive components into a state-of-the-art holistic industrial security concept for the entire plant or machine. Any third-party products that may be in use must also be taken into account. Please find further information at: (http://support.automation.siemens.com)

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Documentation guide

1

1.1 Documentation guide for the F-DI 8x24VDC HF digital input module

Introduction

The documentation of the SIMATIC products has a modular design and includes topics concerning your automation system.

The complete documentation of the ET 200SP system consists of different modules divided into system manuals, function manuals and manuals.

The STEP 7 (online help) information system supports you in configuring and programming your automation system.

Overview of documentation for the fail-safe digital input module F-DI 8×24VDC HF

The table below lists additional documents that complement this description of the fail-safe digital input module F-DI 8×24VDC HF and are available on the Internet.

Table 1- 1 Documentation for the fail-safe digital input module F-DI 8×24VDC HF

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning • Approvals • TÜV certificate
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment to verification all the way to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/safety-services).

Please send your questions to us by e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-DI 8x24VDC HF

Order number

6ES7136-6BA00-0CA0

View of the module

Figure 2-1 View of the F-DI 8×24VDC HF module

Properties

- Technical properties
  - Fail-safe digital module
  - 8 inputs (SIL3/Cat.4/PLe)
  - 8 outputs for sensor supply
  - Use of various interconnection types (1oo1, 1oo2) is possible
  - Supply voltage L+
  - Sink input (P-reading)
  - Suitable for connection of 3/4-wire sensors according to IEC 61131, type 1
  - Channel-specific assignable input delay 0.4 ms to 20 ms
  - Internal short circuit proof sensor supplies for each input
  - External sensor supply possible
  - Diagnostic display (DIAG red/green LED)
  - Status display for each input (green LED)
  - Error display for each input (red LED)
  - Diagnostics, e.g., short circuit/wire break, channel-specific
  - Diagnostics, e.g., load voltage missing, module-specific
  - Channel-specific or passivation throughout the module
- Supported functions
  - Firmware update
  - I&M identification data
  - PROFIsafe

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires. The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 47).

Accessories

The following accessories, which are not included in the product package of the F-module, can be used with the F-module:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection

Additional information on accessories can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

Connecting

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment for F-DI 8×24VDC HF

Terminal assignment for F-DI 8×24VDC HF (6ES7136-6BA00-0CA0)						
Ter-minal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System*system manual

Note

The first BaseUnit must be a light BaseUnit.

Note

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

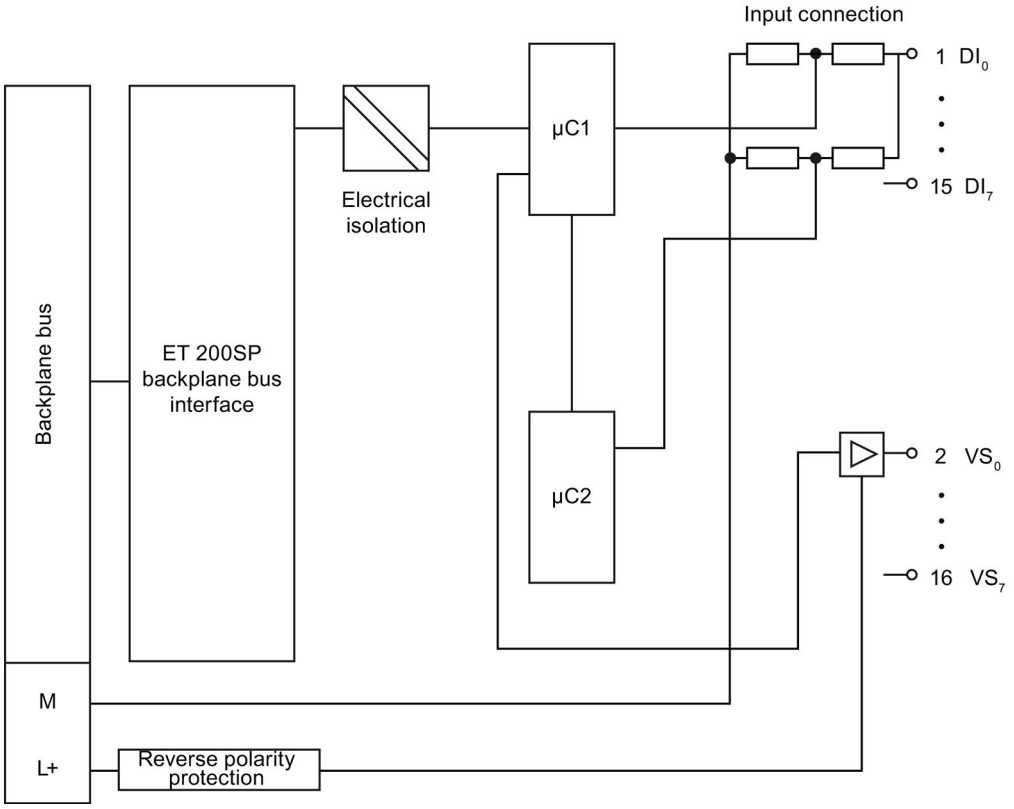


Figure 3-1 Block diagram of the F-DI 8×24VDC HF

Parameters/address space

4

4.1 Parameters

Parameters

⚠ WARNING
Diagnostic functions should be activated or deactivated in accordance with the application.

Table 4- 1 Parameters for F-DI 8×24VDC HF

Parameter	Value range	Parameter reassignment in RUN	Scope
F-parameters:			
Manual assignment of the F-monitoring time	• disable • enable	no	Module
F-monitoring time	1 to 65535 ms	no	Module
F-source address	1 to 65534	no	Module
F-destination address	1 to 65534	no	Module
F-parameter signature (without address)	0 to 65535	no	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	no	Module
F-I/O DB manual number assignment	• disable • enable	no	Module
F-I/O DB number	—	no	Module
F-I/O DB name	—	no	Module
DI parameters:			
Sensor supply			
Short circuit test	• disable • enable	no	Channel
Time for short circuit test	0.5 ms to 2 s	no	Channel
Startup time of the sensors after short circuit test	0.5 ms to 2 s	no	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Channel parameters			
Channel n, n+4			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non equivalent	no	Channel pair
Discrepancy behavior	• Supply 0 value • Supply last valid value	no	Channel pair
Discrepancy time	5 ms to 30 s	no	Channel pair
Reintegration after discrepancy error	• Test 0-signal not necessary • Test 0-signal necessary	no	Channel pair
Channel n			
Activated	• enable • disable	no	Channel
Sensor supply	• Sensor supply 0 to 7 • External sensor supply	no	Channel
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20 ms The provided value range depends on the parameter assignment of the employed sensor supply.	no	Channel
Pulse extension	• — • 0.5 s • 1 s • 2 s	no	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Chatter monitoring activated	• disable • enable	no	Channel
Number of signal changes	2 to 31	no	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	no	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

F-parameters

Information on F-parameters is available in the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.2 Parameters of the sensor supply

4.2.2.1 Short circuit test

Here you enable the short-circuit detection for the channels of the F-module for which "Internal sensor supply" is set.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply. For switches with power supply, for example, 3/4-wire proximity switches, a short-circuit test is not possible.

The short-circuit detection switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for sensor test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input of another channel when it has a 1 signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

During the execution time (Time for sensor test + Startup time of sensor after sensor test) of the short circuit test, the last valid value of the input before the start of the short circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

4.2.2.2 Time for short circuit test

Function

When the short-circuit test is enabled, the corresponding sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the assigned time, a diagnostic message is generated.

When assigning parameters, note that

- If the channel is passivated, this may be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance does not discharge within the assigned time, you need to adjust the "Time for sensor test" parameter.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

4.2.2.3 Startup time of sensors after short circuit test

Function

In addition to the off time ("Time for sensor test"), a startup time must be specified for performing the short circuit test. You use this parameter to notify the module how long the utilized sensor needs to start up after connecting the sensor supply. This prevents an undefined input state due to transient reactions in the sensor.

When assigning parameters, note that

- This parameter must be greater than the transient recovery time of the employed sensor.
- Because the assigned time affects the response time of the module, we recommend that you set the time as short as possible but long enough so that your sensor can settle safely.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short circuit test is enabled.

4.2.3 Parameters of the channel pairs

4.2.3.1 Activated

You hereby enable the corresponding channel for signal processing in the safety program.

4.2.3.2 Sensor evaluation

Overview

Select the type of sensor evaluation with the "Evaluation of the sensors" parameter:

- 1oo1 evaluation
- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent

1oo1 evaluation

The sensor is available once for 1oo1 evaluation.

1oo2 evaluation, equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- One two-channel sensor
- Two single-channel sensors
- One non-equivalent sensor

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly.

Discrepancy analysis

When using a two-channel sensor or two single-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non equivalence: the same levels). A check is made to determine whether the difference in levels (when testing for non equivalence: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

4.2.3.3 Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to fast response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown.. In the worst-case scenario, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

4.2.3.4 Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

4.2.3.5 Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-signal necessary"
- "Test 0-signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non equivalent"

"Test 0-signal necessary"

If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non equivalent", a 0-signal must be present again at the low order channel of the channel pair.

"Test 0-signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.4 Parameters of the channels

4.2.4.1 Sensor supply

Here you select one of the internal sensor supplies VS_0 to VS_n or an external sensor supply.

The selection of an internal sensor supply is required for using the short circuit test.

See also

Time for short circuit test (Page 19)

4.2.4.2 Input delay

Function

To suppress stray interference, you can set an input delay for the entire channel or channel pair.

Interference pulses whose pulse time is less than the set input delay (in ms) are suppressed. Suppressed interference pulses are invisible in the PII.

A high input delay suppresses longer interference pulses, but results in a longer response time.

The values available for the input delay depend on the "Startup time of sensors after short circuit test" and the "Time for short circuit test" of the configured sensor supply.

Note

Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Adapt the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the sensor supply.

See also

Technical specifications (Page 53)

Response times (Page 57)

4.2.4.3 Pulse extension

Function

Pulse extension is a function to change a digital input signal. A pulse on a digital input is extended to at least the assigned length. If the input pulse is already longer than the assigned length, the pulse is not changed.

The fail-safe electronic module only lengthens pulses with the value "0" because the basis of the safety concept is that there is a safe state for all process variables. For digital F-I/O, this is the value "0", which applies to sensors as well as to actuators.

With 1oo2 evaluation, the result of the evaluation of both sensors is used for the pulse extension.

4.2.4.4 Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

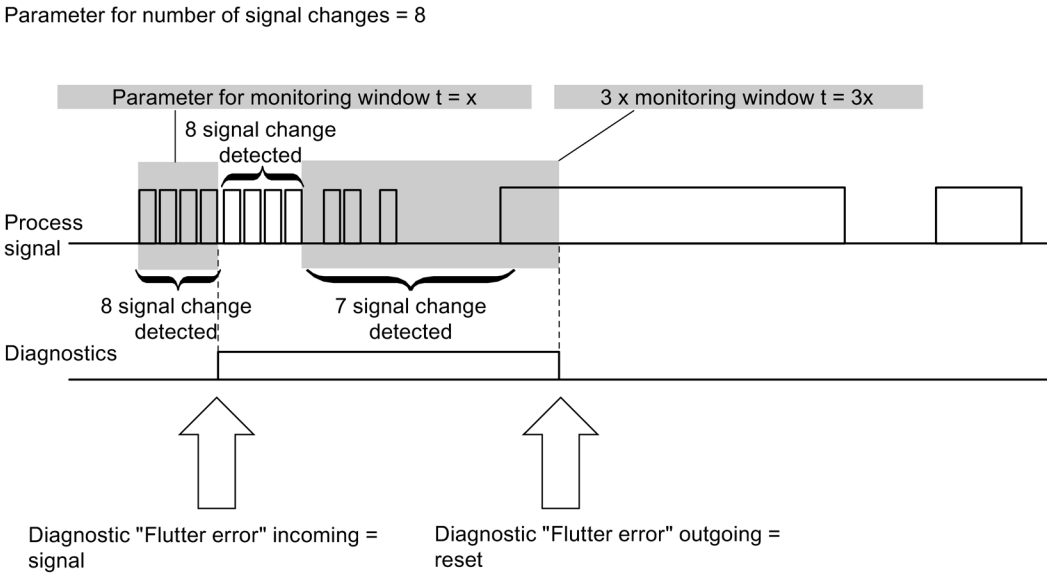


Figure 4-1 Figure chatter monitoring

Number of signal changes

Sets the number of signal changes after which a chatter error should be reported.

4.2.4.5 Monitoring window

Sets the time for the monitoring window of flutter monitoring.

You can set times of 1 s to 100 s in whole seconds for the monitoring window.

You can configure a monitoring window of 0.5 s when you set 0 s.

4.3 Address space

Address assignment of the digital input module F-DI 8×24VDC HF

The digital input module F-DI 8×24VDC HF occupies the following address areas in the F-CPU:

Table 4- 2 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
In input range	**In output range**
x + 0 to x + 5	x + 0 to x + 3

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 4- 3 Address assignment through user data

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	DI_7	DI_6	DI_5	DI_4	DI_3	DI_2	DI_1	DI_0
x + 1	Value status for DI_7	Value status for DI_6	Value status for DI_5	Value status for DI_4	Value status for DI_3	Value status for DI_2	Value status for DI_1	Value status for DI_0

x = Module start address

Note

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors you may only access the low order channel in the safety program.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

See also

Value status (Page 52)

Applications of the F-I/O module

5

5.1 Applications of the electronic module

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

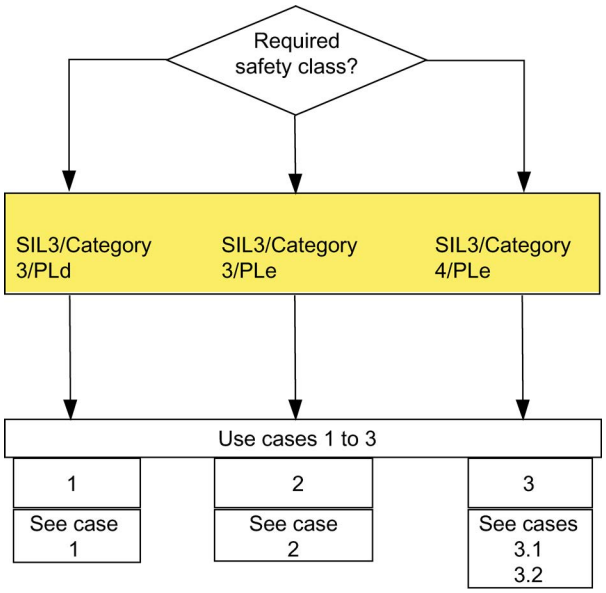


Figure 5-1 Selecting the application – digital input module F-DI 8×24VDC HF

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the proof-test interval in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 5- 1 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Any	3 / 3 / d
2	1oo2 equivalent	Internal, without short circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	External/internal, with short circuit test	

Note

You can operate the various inputs of an F-DI module simultaneously in SIL3/Cat.3/PLd **and** in SIL3/Cat.3 or Cat.4/PLe. You only have to interconnect the inputs and assign parameters as described in the following sections.

Sensor requirements

Information on safety-related use of sensors is available in the section Requirements for sensors and actuators for fail-safe modules in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.2 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is carried out on the matching BaseUnit (Page 13).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting one sensor via one channel

One sensor is connected via one channel (1oo1 evaluation) for each process signal. Any sensor supply of the module can be assigned to each input.

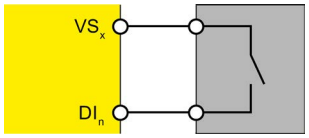


Figure 5-2 One sensor connected via one channel, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

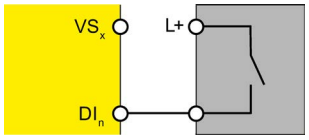


Figure 5-3 One sensor connected via one channel, external sensor supply

⚠ WARNING
To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 2 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Short circuit test	• disable • enable	disable
Sensor supply	• Sensor supply n • External sensor supply	External sensor supply*

*) Otherwise a diagnostic message will be generated when short circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 3 Fault detection

Fault	Fault detection		
	Internal sensor supply and short circuit test activated	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit of the input with other channels or other sensor supplies (short circuit with other channels is detected only if they use a different sensor supply)	yes*	no	no
Short circuit with L+ to DI_n	yes	no	no
Short circuit with M to DI_n	yes*	yes*	no
Discrepancy error	—	—	—
Short circuit with L+ to VS_n	yes	no	—
Short circuit with M to VS_n or defective	yes	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

⚠ WARNING

If the short circuit test is not activated or the sensor supply to digital inputs is set to "External sensor supply", the cable must be routed short circuit proof.

5.3 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs each to one input.

You can combine the following inputs:

- DI_0 and DI_4
- DI_1 and DI_5
- DI_2 and DI_6
- DI_3 and DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

Wiring

The wiring is carried out on the matching BaseUnit (Page 13).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting a two-channel sensor equivalent

A two-channel sensor is connected equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

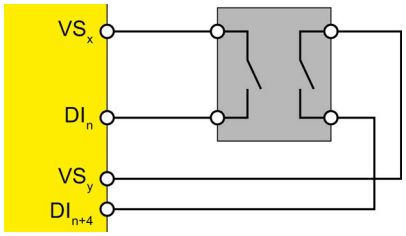


Figure 5-4 One two-channel sensor connected via two channels, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

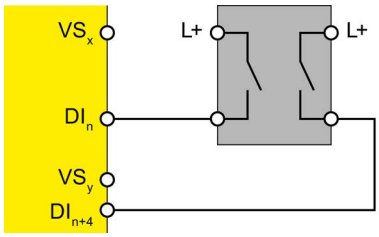


Figure 5-5 One two-channel sensor connected via two channels, external sensor supply

Wiring diagram – connecting two single-channel sensors via two channels

Two single-channel sensors that capture the same process value are connected to two inputs of the F-module for each process signal (1oo2 evaluation).

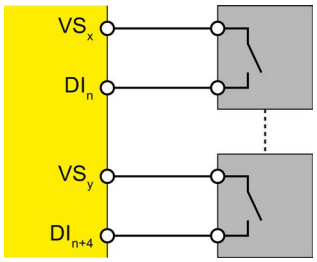


Figure 5-6 Two single-channel sensors connected via two channels, internal sensor supply

You can also supply the sensors by means of an external sensor supply.

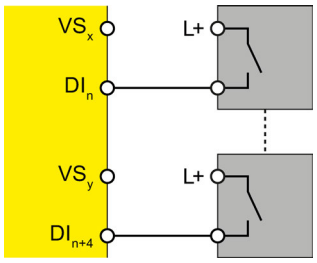


Figure 5-7 Two single-channel sensors connected via two channels, external sensor supply

WARNING
To achieve SIL3/Cat.3/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 4 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Short circuit test	• disable • enable	disable

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 5 Fault detection

Fault	Fault detection	
	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit within the channel pair	no	no
Short circuit with other channels or other sensor supplies	yes*	yes
Short circuit with L+ to DI_n	yes*	yes*
Short circuit with M to DI_n	yes*	yes*
Discrepancy error	yes	yes
Short circuit with L+ to VS_n	no	no
Short circuit with M to VS_n or defective	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.4 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs each to one input.

You can combine the following inputs:

- DI_0 with DI_4
- DI_1 with DI_5
- DI_2 with DI_6
- DI_3 with DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

Wiring

The wiring is carried out on the matching BaseUnit (Page 13).

Sensor supply

The sensor must be supplied internally by at least one channel for application 3.1.

The sensor can be supplied internally or externally for application 3.2.

Requirements for applications in machine protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed to state-of-the-art engineering and standards to prevent short circuits.
- The actuators must be wired as seen in sections Use case 3.1 (SIL3/Cat.4/PLe) (Page 38) or Use case 3.2 (SIL3/Cat.4/PLe) (Page 40). You only need to detect **one** short circuit because two faults are required to generate it. This means both signal cables in short circuit have an isolation fault. A multiple short circuit analysis is not required.

Procedures for locating all short circuits are also permitted if single short circuits are not located. One of the two conditions must be met for this purpose:

- Short circuits may not corrupt the read signals compared to the sensor signals.
- Short circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

5.4.1 Use case 3.1 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation).

Supply the sensors from two different sensor supplies.

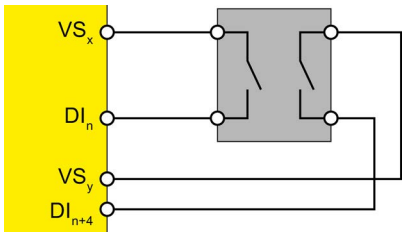


Figure 5-8 One two-channel sensor connected via two channels, internal sensor supply

You can also connect two single-channel sensors via two channels. In this case, the same process variable is acquired with two mechanically separate sensors.

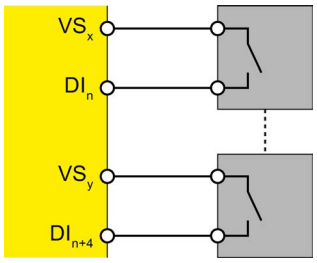


Figure 5-9 Two single-channel sensors connected via two channels, internal sensor supply

WARNING
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 6 Parameter assignment

Parameter	
Sensor evaluation	1oo2 evaluation, equivalent
Short circuit test	enable
Sensor supply	• Sensor supply n (internally by at least one channel) • External

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 7 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes*
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes
Short circuit with M to VS_n or defective	yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.4.2 Use case 3.2 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a nonequivalent sensor

A nonequivalent sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation, non equivalent).

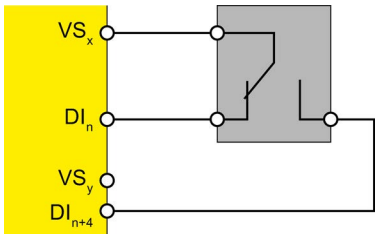


Figure 5-10 Nonequivalent sensor connected, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

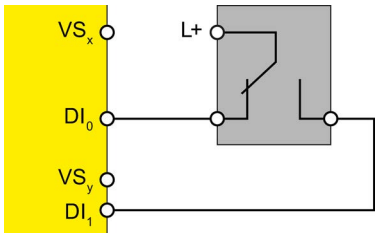


Figure 5-11 Nonequivalent sensor connected, external sensor supply

WARNING
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram – connecting two single-channel sensors nonequivalent

Two single-channel sensors are connected nonequivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

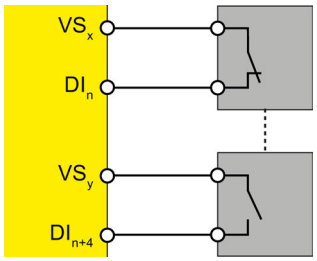


Figure 5-12 Two single-channel sensors connected nonequivalent, internal sensor supply

You can also supply the sensors by means of an external sensor supply.

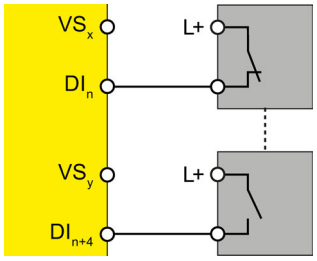


Figure 5-13 Two single-channel sensors connected nonequivalent, external sensor supply

WARNING
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 8 Parameter assignment

Parameter	
Sensor evaluation	1oo2 evaluation, non equivalent
Short circuit test	• disable • enable
Sensor supply	• Sensor supply n • External sensor supply

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 9 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes, if used
Short circuit with M to VS_n or defective	yes, if sensor supply is activated

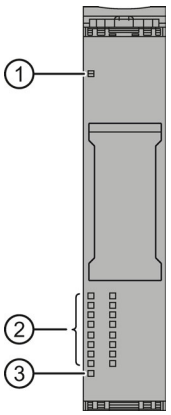
*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display



① DIAG (green/red)
② Channel status (green), channel fault (red)
③ PWR (green)

Figure 6-1 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 47).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the inputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

PWR LED

Table 6- 1 Meaning of the PWR LED

PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ available

DIAG LED

Table 6- 2 Meaning of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	Module parameters configured and module diagnostics

Channel status/channel fault LED

Table 6- 3 Meaning of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		Channel waiting for user acknowledgment

Channel status/DIAG/channel fault LED

Table 6- 4 Meaning of the channel status/DIAG/channel fault LED

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

6.2 Interrupts

Introduction

The F-DI 8×24VDC HF fail-safe digital input module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 47).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

Table 6- 5 Diagnostic interrupts of the F-DI 8×24VDC HF

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	1, 2, 3	F-module	No
Parameter assignment error	16_D			
Load voltage missing	17_D			
Access to retentive storage of F-address not possible	30_D			
Different destination address (F_Dest_Add)	64_D			
Invalid destination address (F_Dest_Add)	65_D			
Invalid source address (F_Source_Add)	66_D			
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D			
"F_SIL" parameter exceeds the application-specific SIL	68_D			
"F_CRC_Length" parameter does not match the generated CRC	69_D			

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Incorrect F-parameter version or F_Block_ID	70_D			
CRC1 error	71_D			
Inconsistent iParameters (iParCRC error)	75_D			
F_Block_ID not supported	76_D			
Internal error	256_D			
Time monitoring activated	259_D			
Internal supply voltage of the module failed	260_D			
Incorrect/inconsistent firmware present. Firmware update required	283_D			
Discrepancy error, channel status 0/0	768_D	2, 3	Channel	
Discrepancy error, channel status 0/1	769_D			
Discrepancy error, channel status 1/0	770_D			
Discrepancy error, channel status 1/1	771_D			
Input signal could not be clearly detected	773_D	1, 2, 3		
Short circuit of internal sensor supply to L+	774_D			Yes
Overload or short circuit of internal sensor supply to ground	775_D			
No pulse detected	778_D	1		
Sensor signal chatters	784_D			
Switching frequency too high	785_D			No
Undertemperature	786_D		F-module	
Fault in input circuit	787_D		Channel	
PROFIsafe communication error (timeout)	792_D		F-module	
PROFIsafe communication error (CRC)	793_D			
PROFIsafe address assignment error	794_D			
Input short-circuited to L+	796_D		Channel	Yes
Supply voltage too high	803_D		F-module	No
Supply voltage too low	804_D			

6.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 6- 6 Diagnostic messages of the F-DI 8×24VDC HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_D	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 53)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Parameter assignment error	16_D	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Load voltage missing	17_D	Missing or insufficient supply voltage L+	• Check supply voltage L+ at BaseUnit • Check BaseUnit type
Access to retentive storage of F-address not possible	30_D	The F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Different destination address (F_Dest_Add)	64_D	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Invalid destination address (F_Dest_Add)	65_D	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Invalid source address (F_Source_Add)	66_D	The PROFIsafe driver has detected an invalid F-source address.	
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D	The PROFIsafe driver has detected an invalid watchdog time.	
"F_SIL" parameter exceeds the application-specific SIL	68_D	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
"F_CRC_Length" parameter does not match the generated CRC	69_D	The PROFIsafe driver has detected a discrepancy in the CRC length.	

Diagnostic message	Fault code	Meaning	Remedy
Incorrect F-parameter version or F_Block_ID	70_D	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 error	71_D	The PROFIsafe driver has detected inconsistent F-parameters.	
Inconsistent iParameters (iParCRC error)	75_D	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76_D	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Internal error	256_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Internal supply voltage of the module failed	260_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the electromagnetic interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Incorrect/inconsistent firmware present. Firmware update required	283_D	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Discrepancy error, channel status 0/0	768_D	Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring.
Discrepancy error, channel status 0/1	769_D		
Discrepancy error, channel status 1/0	770_D		
Discrepancy error, channel status 1/1	771_D		

Diagnostic message	Fault code	Meaning	Remedy
Input signal could not be clearly detected	773_D	An error occurred in the plausibility check of the input signal between the processors. You must eliminate the error within 100 hours. If you do not eliminate the error within 100 hours, the F-module will become inoperative. Possible causes: • The input signal is faulty, e.g., as a result of impermissibly high electromagnetic interference. • A high-frequency input signal is present, e.g., due to mutual interference of sensors or the signal being above the sampling frequency of the input signal. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • The sensor/switch is bouncing.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Short circuit of internal sensor supply to L+	774_D	Possible causes: • There is a short circuit of the internal sensor supply with L+. • There is a short circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.
Overload or short circuit of internal sensor supply to ground	775_D	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.

Diagnostic message	Fault code	Meaning	Remedy
No pulse detected	778$_D$	A pulse with a length greater than or equal to "Minimum pulse time" has not occurred within the time configured with the "Pulse monitoring window" parameter. Possible causes: • The "Pulse monitoring window" parameter setting is too high. • The "Minimum pulse time" parameter setting is too low. • There is a wire break in the process wiring.	• Check the "Pulse monitoring window" parameter. • Check the "Minimum pulse time" parameter. • Check the process wiring.
Sensor signal chatters	784$_D$	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor/switch is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Switching frequency too high	785$_D$	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency. (see Technical specifications (Page 53))
Undertemperature	786$_D$	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 53))
Fault in input circuit	787$_D$	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate/reduce the electromagnetic interference. • Replace the F-module.
PROFIsafe communication error (timeout)	792$_D$	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • Bus faults are present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.

Diagnostic message	Fault code	Meaning	Remedy
PROFIsafe communication error (CRC)	793_D	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
PROFIsafe address assignment error	794_D	An error occurred during the automatic PROFIsafe address assignment.	Check the configuration.
Input short-circuited to L+	796_D	The input signal is short-circuited to L+.	Eliminate the short circuit.
Supply voltage too high	802_D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	803_D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage has recovered (level must remain above the specified value for at least 1 minute (see Technical specifications (Page 53) Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Behavior in case of cross circuit/short circuit to the sensor supply

When internal sensor supply is specified and short circuit test is deactivated, short circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is specified and short circuit test is enabled, short circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short circuit test and the sensor power supply. For this reason, tables on fault detection for the applications are presented under Applications of the F-I/O module (Page 29).

Generally applicable information on diagnostics

Information on diagnostics that pertains to all F-modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by the wire break check, short-circuit, chatter monitoring, pulse extension, and plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of inputs and outputs for the value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 27).

Reference

A detailed description of the evaluation and processing of the value status can be found in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications

7

Technical specifications of F-DI 8×24VDC HF

	6ES7136-6BA00-0CA0
Product type designation	F-DI 8x24VDC HF
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V12.0
STEP 7 configurable/integrated as of version	as of V5.5 SP3 / -
PROFINET as of GSD version/GSD revision	V2.31
Supply voltage	
Type of supply voltage	24 V DC
Rated value (DC)	24 V
Low limit of permissible range (DC)	20.4 V
High limit of permissible range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	75 mA; without load
Current consumption, max.	21 mA; from backplane bus
Sensor supply	
Number of outputs	8
Output current	
Up to 60 °C, max.	0.3 A
Short circuit protection	Yes; electronic (response threshold 0.7 A to 1.8 A)
24 V sensor supply	
24 V	Yes; min. L+ (-1.5 V)
Short circuit protection	Yes
Output current, max.	800 mA; total current of all sensors
Power	
Power consumption from the backplane bus	70 mW
Power loss	
Power loss, typ.	4 W

	6ES7136-6BA00-0CA0
Address space	
Address space per module	
Input	6 bytes
Output	4 bytes
Digital inputs	
Number of inputs	8
m/p-reading	Yes; p-reading
Input characteristic curve according to IEC 61131, Type 1	Yes
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
For "0" signal	-30 to +5 V
For "1" signal	+15 to +30 V
Input current	
For "1" signal, typ.	3.7 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Assignable	Yes
• For "0" to "1", min.	0.4 ms
• For "0" to "1", max.	20 ms
• For "1" to "0", min.	0.4 ms
• For "1" to "0", max.	20 ms
For counter/technological functions	
• Assignable	No
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes, see section "Interrupts/diagnostic messages" in the manual
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED

	6ES7136-6BA00-0CA0
Electrical isolation	
Electrical isolation channels	
Between channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC
Isolation	
Isolation test voltage	707 V DC (type test)
Standards, approvals, certificates	
SIL acc. to IEC 61508	SIL 3
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1	PLe
Low demand (PFD) acc. to SIL3	< 2.00E-05 1/h
High demand (PFH) acc. to SIL3	< 1.00E-09 1/h
Environmental conditions	
Operating temperature	
Min.	0 °C
Max.	60 °C
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Storage/transport temperature	
Min.	-40 °C
Max.	70 °C
Dimensions	
Width	15 mm
Weights	
Weight, approx.	49 g

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Response times

A

Introduction

The next section shows the response times of the digital input module F-DI 8×24VDC HF. The response time of the digital input module F-DI 8×24VDC HF is included in the calculation of the F-system response time.

Definition of response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Times required for the calculation

Maximum internal processing time: $T_{max.}$ = 20 ms

Maximum cycle time: T_{cycle} = 11.5 ms

Short circuit test time for the sensor supply configured for the channel = "Time for short circuit test" + "Startup time after short circuit test"

The input delay, short circuit test times, and discrepancy time are configured in STEP 7.

If you have configured "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

Maximum response time in the error-free case with 1oo1 evaluation

Maximum response time = T_{max} + Input delay + Short circuit test time for the sensor supply configured for the channel

Maximum response time in the error-free case with 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Maximum (short circuit test time for the sensor supply configured for channel n, short circuit test time for the sensor supply configured for channel n+4)

Maximum response time with external short circuits

Maximum response time = input delay + (n × T_{cycle}) + sum ("Time for short circuit test" + "Startup time after short circuit test" for sensor with activated short circuit test)

n = Number of sensor supplies with activated short circuit test

Maximum response time with discrepancy error and 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Discrepancy time + 2 × Maximum (short circuit test time for the sensor supply configured for channel n, short circuit test time for the sensor supply configured for channel n+4)

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SIMATIC

ET 200SP
Digital output module
F-DQ 4x24VDC/2A PM HF
(6ES7136-6DB00-0CA0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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℗ 08/2013 Technical data subject to change

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

Note

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Security information

Siemens provides automation and drive products with industrial security functions that support the secure operation of plants or machines. They are an important component in a holistic industrial security concept. With this in mind, our products undergo continuous development. We therefore recommend that you keep yourself informed with respect to our product updates. Please find further information and newsletters on this subject at: (http://support.automation.siemens.com)

To ensure the secure operation of a plant or machine it is also necessary to take suitable preventive action (e.g. cell protection concept) and to integrate the automation and drive components into a state-of-the-art holistic industrial security concept for the entire plant or machine. Any third-party products that may be in use must also be taken into account. Please find further information at: (http://www.siemens.com/industrialsecurity)

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Documentation guide

1

1.1 Documentation guide for F-DQ 4x24VDC/2A PM HF digital output module

Introduction

The documentation of the SIMATIC products has a modular design and includes topics concerning your automation system.

The complete documentation of the ET 200SP system consists of different modules divided into system manuals, function manuals and manuals.

The STEP 7 (online help) information system supports you in configuring and programming your automation system.

Overview of documentation for the fail-safe digital output module F-DQ 4×24VDC/2A PM HF

The table below lists additional documents that complement this description of the fail-safe digital output module DQ 4×24VDC/2A PM HF and are available on the Internet.

Table 1- 1 Documentation for the fail-safe digital output module F-DQ 4×24VDC/2A PM HF

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning • Approvals • TÜV certificate
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment to verification all the way to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/safety-services).

Please send your questions to us by e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-DQ 4x24VDC/2A PM HF

Order number

6ES7136-6DB00-0CA0

View of the module

Figure 2-1 View of the F-DQ 4×24VDC/2A PM HF module

Properties

- Technical properties
  - Fail-safe digital module
  - 4 outputs, PM-switching (SIL3/Cat.4/PLe)
  - Supply voltage L+
  - Output current per output 2 A
  - Source output (PM-switching)
  - Suitable for solenoid valves, DC contactors and signal lamps
  - Diagnostic display (DIAG red/green LED)
  - Status display for each output (green LED)
  - Fault display for each output (red LED)
  - Diagnostics, e.g., short circuit/wire break/load voltage missing, channel-specific
  - Channel-specific or passivation throughout the module
  - Direct interconnection to F-DI possible (single channel: SIL1, two-channel: SIL3)
- Supported functions
  - Firmware update
  - I&M identification data
  - PROFIsafe

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires. The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 38).

Accessories

The following accessories, which are not included in the product package of the F-module, can be used with the F-module:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection

Additional information on accessories can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

Passivation of fail-safe outputs over a long period of time

⚠ WARNING

Unintentional activation of F-I/O with fail-safe outputs

If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus place the F-system in a dangerous state.

Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.

One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.

The required measures are standardized for plants with product standards.

For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Property of the individual shutdown of F-modules with fail-safe outputs:

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Connecting

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment for F-DQ 4×24VDC/2A PM HF

Terminal assignment for F-DQ 4×24VDC/2A PM HF (6ES7136-6DB00-0CA0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DQ-P_0	**2**	DQ-P_1	• DQ-P_n: Output signal, channel n, P-switching • DQ-M_n: Ground for output signal, channel n, M-switching	A0	 CC02 6ES7193-6CP02-2MA0
3	DQ-P_2	**4**	DQ-P_3			
5	DQ-P_0	**6**	DQ-P_1			
7	DQ-P_2	**8**	DQ-P_3			
9	DQ-M_0	**10**	DQ-M_1			
11	DQ-M_2	**12**	DQ-M_3			
13	DQ-M_0	**14**	DQ-M_1			
15	DQ-M_2	**16**	DQ-M_3			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System*system manual

Note

The first BaseUnit must be a light BaseUnit.

Note

The fuse integrated in BaseUnit type A1 can trigger with the digital output module which renders the terminals useless.

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

Switching of grounded loads

The F-DQ 4×24VDC/2A PM HF can switch loads with a connection between chassis and ground of at least 100 kΩ. Otherwise a short circuit is detected.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection.

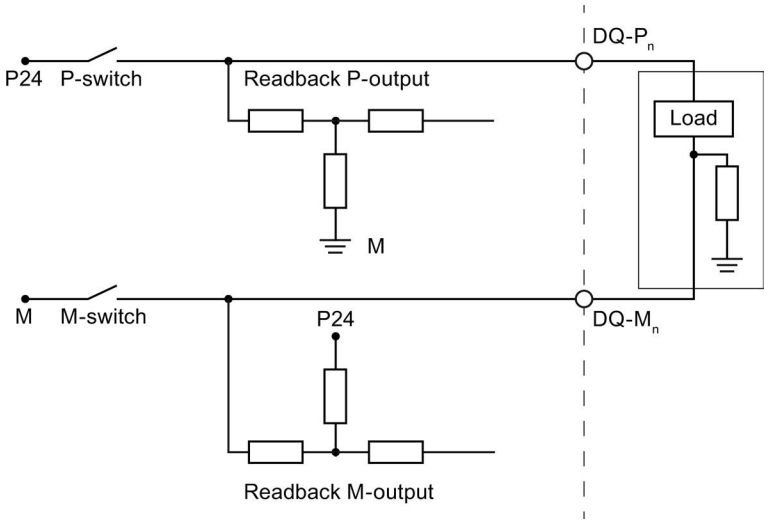


Figure 3-1 Switching of grounded loads (resistance between chassis and ground)

Alternatively, you can use F-PM-E 24VDC/8A PPM ST power module in which the output is configured as a PP-switching output.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

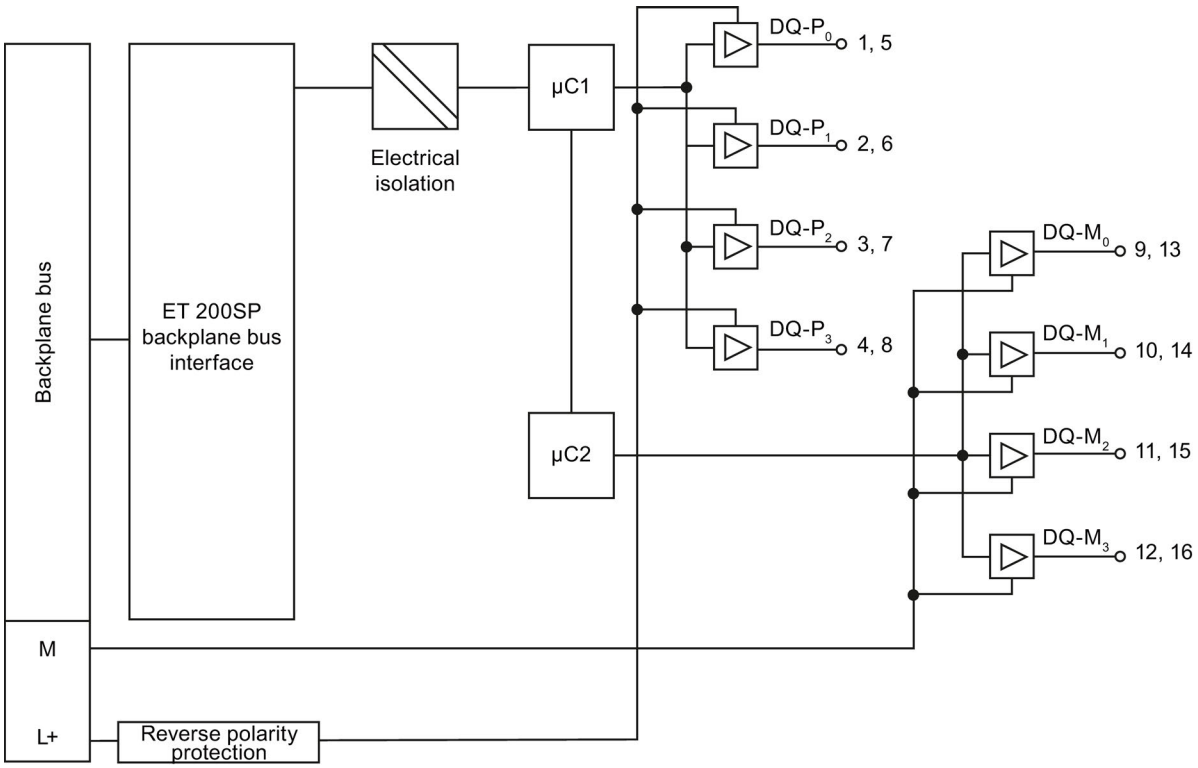


Figure 3-2 Block diagram F-DQ 4×24VDC/2A PM HF

Parameters/address space

4

4.1 Parameters

Parameters

⚠ WARNING
Diagnostic functions should be activated or deactivated in accordance with the application.

Table 4- 1 Parameters for F-DQ 4×24VDC/2A PM HF

Parameter	Value range	Parameter reassignment in RUN	Scope
F-parameters:			
Manual assignment of the F-monitoring time	• disable • enable	no	Module
F-monitoring time	1 to 65535 ms	no	Module
F-source address	1 to 65534	no	Module
F-destination address	1 to 65534	no	Module
F-parameter signature (without address)	0 to 65535	no	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	no	Module
F-I/O DB manual number assignment	• disable • enable	no	Module
F-I/O DB number	—	no	Module
F-I/O DB name	—	no	Module
DQ parameters:			
Maximum test period	• 100 s • 1000 s	no	Module

Parameter	Value range	Parameter reassignment in RUN	Scope
Channel parameters:			
Channel n			
Activated	• disable • enable	no	Channel
Max. readback time dark test	0.6 to 400.0 ms	no	Channel
Disable dark test for 48 hours	• disable • enable	no	Channel
Max. readback time switch on test	0.6 to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnosis: Wire break	• disable • enable	no	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

F-parameters

Information on F-parameters is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.2 Parameters of the channels

4.2.2.1 Maximal test period

With this parameter, you specify the time within which the light, dark and switch on tests (complete bit pattern test) should be performed throughout the module. When this time expires, the tests are repeated. In case of a fault, the test time is reduced to 60 seconds.

- Use "1000 s", for example, to conserve your actuators.
- Use "100 s" to detect faults more quickly.

4.2.2.2 Activated

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

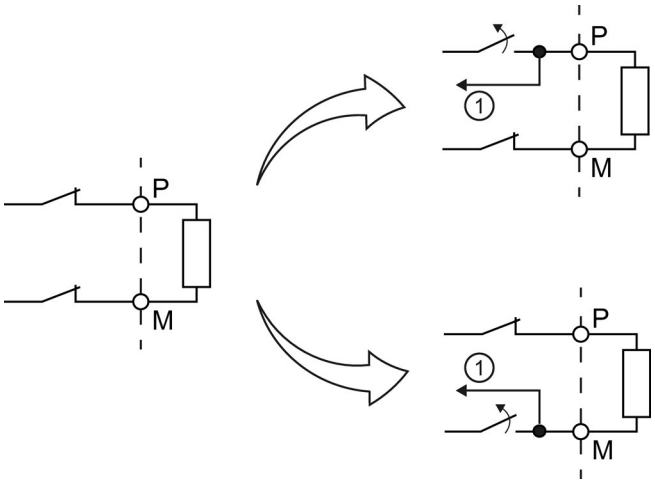
You can deactivate an unused channel with this parameter.

4.2.2.3 Max. readback time dark test

Function

Dark tests are shutdown tests with bit pattern test.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 4-1 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the response time of the F-module.

⚠ WARNING

Through the configured readback time dark test, short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured readback time dark test) Hz cannot be recognized (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting readback time dark test

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you set the readback time dark test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads.

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the readback time light test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time dark test so that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

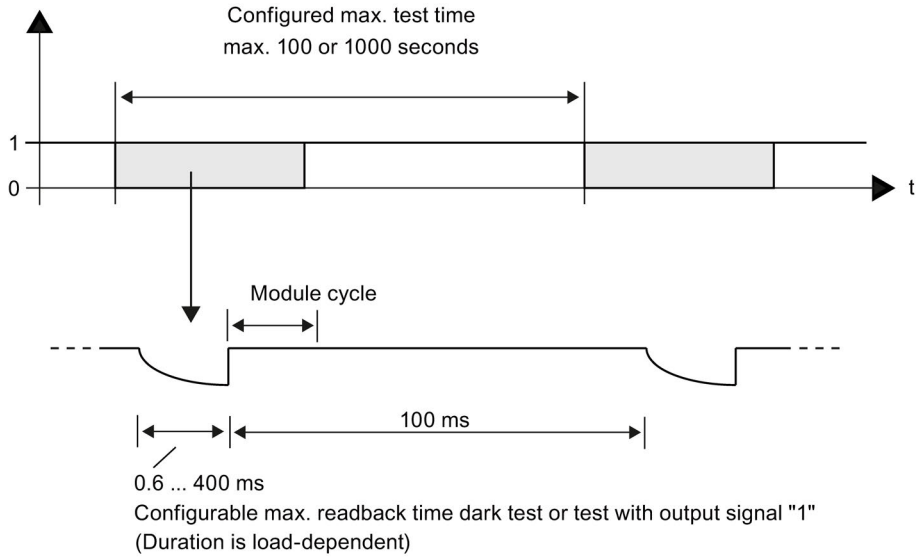


Figure 4-2 Test pulses of the dark test

The interval between two test pulses is 100 ms.

4.2.2.4 Disable dark test for 48 hours

This option allows you to suppress the dark test.

If the channel is permanently active (1) for 48 hours, a single dark test pulse is directed to this channel once the time has expired.

You must provide the signal change from 1 to 0 at the channel yourself within 48 hours to prevent the dark test pulse. This also applies to the operating time if the operating time is < 48 hours. The dark test is suspended for another 48 hours after the signal change from 0 to 1.

The dark test is permanently suppressed if the following condition is met:

- A signal change from 1 to 0 takes place before the 48 hours have expired.

⚠ WARNING

If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated but all outputs are shut down and the module is passivated. This is necessary because a complete bit pattern test is not performed within 48 hours, which means an undetected error burst may not be ruled out.

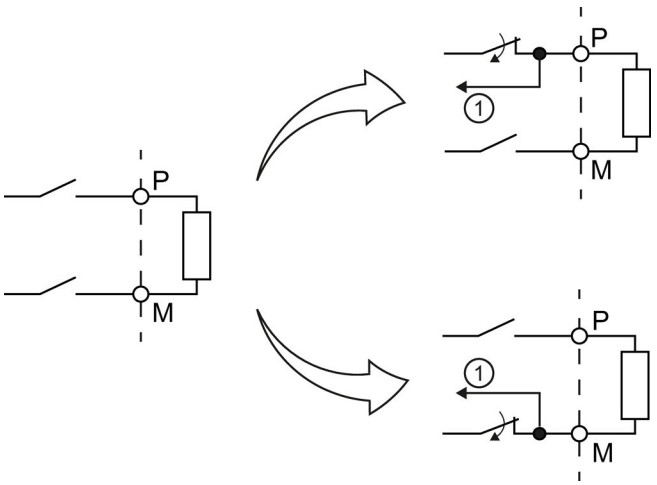
Consult the respective requirements of your product standards regarding error detection time.

4.2.2.5 Max. readback time switch on test

Function

The switch on test is part of the bit pattern test.

During the switch on test, the P-switch and M-switch of the output channel are alternately closed and read back when the output channel is inactive (output signal "0"). Contrary to the light test, no power flows through the connected load during the switch on test.



① Readback

Figure 4-3 Functional principle of the switch on test (PM switching)

This parameter allows you to set the time for the readback. If the signal was not read back correctly once the time has expired, the output channel is passivated.

The switch on test detects the following faults:

- Short circuit to L+ with output signal "0"
- Short circuit to ground with output signal "0"

⚠ WARNING

Through the configured readback time, short circuits (cross-circuits) to an interfering signal with a frequency > 1 / (2 x configured readback time) Hz can be suppressed (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

Setting readback time

Because the fault reaction time is extended by the length of the set readback time, we recommend that you set the readback time by trial and error as low as possible but high enough that the output channel is not passivated.

To determine the readback time required for your actuator, refer to the diagram in the section Switching capacitive loads.

If the capacitance of the actuator is not known, you may have to determine the required value for the readback time switch-on test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time switch on test in such a way that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time switch on test.
- If the output channel is passivated, the readback time is too small for a connected capacitive load. The charge of the capacitive load cannot take place during the configured readback time. Increase the readback time.

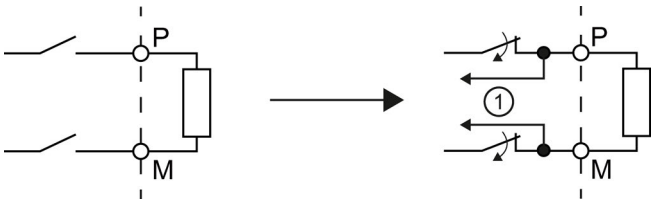
If you have set the readback time to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

4.2.2.6 Activated light test

Function

Overload and wire break are detected with a 0 signal at the output.

For a light test, a test signal is switched to the output channel while the output channel is inactive (output signal "0"). The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.



① Readback

Figure 4-4 Functional principle of the light test (PM switching)

In contrast to the switch on test, the P-switch and the M-switch switch at the same time during the light test and power flows through the connected load.

If the readback signals are incorrect, the signal is present for the configured readback time at the output channel before the fault causes passivation of the output channel.

If the signal was not read back correctly once the maximum readback time switch on test has expired, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time switch on test for the light test increases the response time of the F-module.

Test pulses of the light test

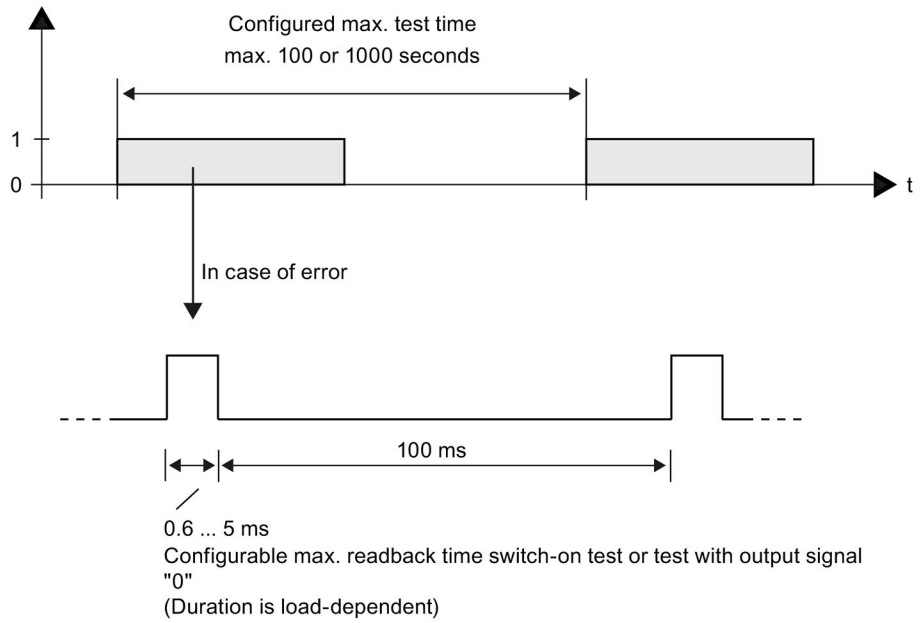


Figure 4-5 Test pulses of the light test

A light pulse with the configured duration takes place within the configured maximum test time per output channel.

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after 100 ms. If the fault is still present, the maximum test time is automatically reduced to 60 seconds and a diagnostic message is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

4.2.2.7 Diagnosis: Wire break

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

You also have to activate the light test to detect a wire break with an output signal "0".

4.3 Address space

Address assignment of the digital output module F-DQ 4×24VDC/2A PM HF

The digital output module F-DQ 4×24VDC/2A PM HF occupies the following address areas in the F-CPU:

Table 4- 2 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
In input range	**In output range**
x + 0 to x + 4	x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of digital output module F-DQ 4×24VDC/2A PM HF

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital output module F-DQ 4×24VDC/2A PM HF:

Table 4- 3 Address assignment of user data **in the input range**

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0

x = Module start address

Table 4- 4 Address assignment of user data **in the output range**

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

Note

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

See also

Value status (Page 42)

Applications of the F-I/O module

5

5.1 Applications of the F-DQ 4x24VDC/2A PM HF

You achieve SIL3/Cat.4/PLe with the following applications.

The wiring is carried out on the matching BaseUnit (Page 13).

5.2 Application: Wiring a load to each digital output

Each of the four fail-safe digital output consists of a P-switch DQ-P_n and an M-switch DQ-M_n. You connect the load between the P-switch and the M-switch. The two switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

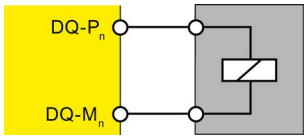


Figure 5-1 Wiring diagram for 1 relay each at 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

5.3 Application: Connection of loads to L+ and M at each digital output

You can connect two relays using one fail-safe digital output. The following conditions should be kept in mind:

- Same reference potential
- The normally open contacts of the two relays must be connected in series.

This configuration achieves SIL3/Cat.4/PLe (process status readback required).

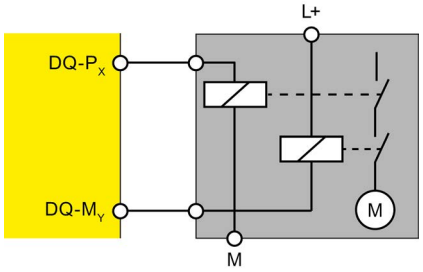


Figure 5-2 Wiring diagram for connecting 2 relays each to 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

WARNING

When two relays are connected to one digital output, as shown in the figure above, the "wire break" and "overload" faults are detected only at the P-switch of the output (not at the M-switch).

WARNING

With a cross circuit between P-switch and M-switch of the output, the module detects the fault and switches off the output. But the actuator is still supplied with power due to the external fault.

To avoid cross circuits between the P-switch and M-switch of a fail-safe digital output, you should always install the cables for the connection of the relays to the P-switch and M-switch separately to prevent any cross circuits (for example, as separately sheathed cables or in separate cable ducts).

Note

The digital output module F-DQ 4×24VDC/2A PM HF performs a bit pattern test depending on the parameter assignment. For this, the module outputs up to 5 ms pulses depending on the parameter assignment. This test (switch-on test) is run with a time offset between the P-switch and M-switch to prevent the actuator from being activated. This pulse may cause the corresponding relay to operated, which may reduce its service life.

We therefore recommend adhering to the wiring scheme described below.

5.4 Application: Wiring two loads in parallel to each digital output

To protect against cross-circuits between P-switch and M-switch in fail-safe digital outputs, we recommend the following wiring scheme. This circuit achieves SIL3/Cat.4/PLe.

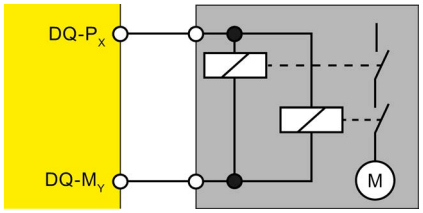


Figure 5-3 Wiring diagram for 2 relays each parallel at 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

Note

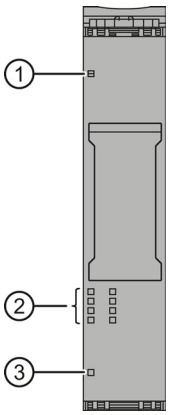
With a parallel connection of two relays on one digital output (as shown above) the "wire break" fault is only detected if the wire break disconnects both relays from P or M. This diagnostics is not safety-related.

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display



① DIAG (green/red)
② Channel status (green), channel fault (red)
③ PWR (green)

Figure 6-1 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 38).

WARNING
The DIAG LED and the channel status and channel fault LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

PWR LED

Table 6- 1 Meaning of the PWR LED

PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ available

DIAG LED

Table 6- 2 Meaning of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	Module parameters configured and module diagnostics

Channel status/channel fault LED

Table 6- 3 Meaning of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		Channel waiting for user acknowledgment

Channel status/DIAG/channel fault LED

Table 6- 4 Meaning of the channel status/DIAG/channel fault LED

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

6.2 Interrupts

Introduction

The F-DQ 4x24VDC/2A PM HF fail-safe digital output module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 38).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 38).

Table 6- 5 Diagnostic interrupts of the F-DQ 4x24VDC/2A PM HF

Diagnostic interrupt	Fault code	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	F-module	No
Parameter assignment error	16_D		
Load voltage missing	17_D		
Access to retentive storage of F-address not possible	30_D		
Different destination address (F_Dest_Add)	64_D		
Invalid destination address (F_Dest_Add)	65_D		
Invalid source address (F_Source_Add)	66_D		
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D		
"F_SIL" parameter exceeds the application-specific SIL	68_D		
"F_CRC_Length" parameter does not match the generated CRC	69_D		
Incorrect F-parameter version or F_Block_ID	70_D		
CRC1 error	71_D		
Inconsistent iParameters (iParCRC error)	75_D		
F_Block_ID not supported	76_D		

Diagnostic interrupt	Fault code	Scope of diagnostic interrupt	Configurable
Internal error	256_D		
Time monitoring activated	259_D		
Internal supply voltage of the module failed	260_D		
Output short-circuited to L+	261_D	Channel	Yes
Output short-circuited to ground	262_D		
Wire break	265_D		
Incorrect/inconsistent firmware present. Firmware update required	283_D	F-module	No
Switching frequency too high	785_D	Channel	
Undertemperature	786_D	F-module	
PROFIsafe communication error (timeout)	792_D	F-module	
PROFIsafe communication error (CRC)	793_D	F-module	
PROFIsafe address assignment error	794_D	F-module	
		Channel	No
Output defective	797_D		
Readback error	798_D	Channel	
Overload	800_D	Channel	
Supply voltage too high	802_D	F-module	
Supply voltage too low	803_D	F-module	

6.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

Note

You can connect two actuators per output.

The diagnostics of the two actuators influenced each other in the case of duplicate wiring.

This means:

- a wire break is only signaled if both actuators are affected
- a single short circuit affects both actuators.

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 6- 6 Diagnostic messages of the F-DQ 4×24VDC/2A PM HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_D	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 43)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_D	Possible causes: • There is an interrupted cable between the module and actuator. • The channel is not connected (open). • There is a short circuit between channels with different signals.	• Establish a cable connection. • Disable the wire break detection for the channel in the parameter assignment. • Eliminate the short circuit.
Parameter assignment error	16_D	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Load voltage missing	17_D	Missing or insufficient supply voltage L+	• Check supply voltage L+ at BaseUnit • Check BaseUnit type

Diagnostic message	Fault code	Meaning	Remedy
Access to retentive storage of F-address not possible	30_D	The F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Different destination address (F_Dest_Add)	64_D	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Invalid destination address (F_Dest_Add)	65_D	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Invalid source address (F_Source_Add)	66_D	The PROFIsafe driver has detected an invalid F-source address.	
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D	The PROFIsafe driver has detected an invalid watchdog time.	
"F_SIL" parameter exceeds the application-specific SIL	68_D	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
"F_CRC_Length" parameter does not match the generated CRC	69_D	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Incorrect F-parameter version or F_Block_ID	70_D	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 error	71_D	The PROFIsafe driver has detected inconsistent F-parameters.	
Inconsistent iParameters (iParCRC error)	75_D	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76_D	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Internal error	256_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Internal supply voltage of the module failed	260_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the electromagnetic interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Output short-circuited to L+	261_D	Short circuit to L+ can mean: • The output cable is short-circuited to L+. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).

Diagnostic message	Fault code	Meaning	Remedy
Output short-circuited to ground	262_D	Short circuit to ground can mean: • The output cable is short-circuited to ground. • The output signal is short-circuited to ground. • There is a short circuit between two output channels. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).
Incorrect/inconsistent firmware present. Firmware update required	283_D	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Switching frequency too high	785_D	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency. (see Technical specifications (Page 43))
Undertemperature	786_D	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 43))
PROFIsafe communication error (timeout)	792_D	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • Bus faults are present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
PROFIsafe communication error (CRC)	793_D	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
PROFIsafe address assignment error	794_D	An error occurred during the automatic PROFIsafe address assignment.	Check the configuration.
Output defective	797_D	The F-module has detected an internal error. Possible causes: • The capacitive load is too high. • Short circuit to L+ or M • The F-module is defective	• Increase the test times (dark, light, switch-on tests). • Check the wiring. • Replace the F-module.

Diagnostic message	Fault code	Meaning	Remedy
Readback error	798D	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The capacitive load is too high. • The F-module is defective.	• Increase the test times (dark, light, switch-on tests). • If the error persists, replace the F-module.
Overload	800D	The maximum permissible output current has been exceeded. The output stage has been switched off. Possible causes: • A short circuit exists.	Check the process wiring.
Supply voltage too high	802D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	803D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute (see Technical specifications (Page 43) Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by the wire break check, short-circuit, chatter monitoring, pulse extension, and plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 27).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications

7

Technical specifications of F-DQ 4×24VDC/2A PM HF

	6ES7136-6DB00-0CA0
Product type designation	F-DQ 4x24VDC HF
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V12.0
STEP 7 configurable/integrated as of version	as of V5.5 SP3 / -
PROFINET as of GSD version/GSD revision	V2.31
Supply voltage	
Type of supply voltage	24 V DC
Rated value (DC)	24 V
Low limit of permissible range (DC)	20.4 V
High limit of permissible range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	75 mA; without load
Current consumption, max.	21 mA; from backplane bus
Output voltage	
Rated value (DC)	24 V
Power	
Power consumption from the backplane bus	70 mW
Power loss	
Power loss, typ.	4 W
Address space	
Address space per module	
Input	5 bytes
Output	5 bytes

	6ES7136-6DB00-0CA0
Digital outputs	
Number of outputs	4
Digital outputs, configurable	Yes
Short circuit protection	Yes
• Response threshold, typ.	> 3.3 A
Wire break detection	Yes
• Response threshold, typ.	8 mA
Overload protection	Yes
• Response threshold, typ.	2.9 A
Voltage induced on current interruption limited to	typ. 2*47V
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	10 W
Load resistance range	
Low limit	12 Ω
High limit	2000 Ω
Output voltage	
Type of output voltage	DC
For "1" signal, min.	24 V; L+ (-0.5 V)
Output current	
For "1" signal, rated value	2 A
For "0" signal, residual current, max.	0.5 mA
Switching frequency	
With resistive load, max.	30 Hz; symmetrical
With inductive load, max.	0.1 Hz; acc. to IEC 947-5-1, DC13, symmetrical
With lamp load, max.	10 Hz; symmetrical
Total current of outputs	
Max. current per channel	2 A; (note derating data in the manual)
Max. current per module	6 A; (note derating data in the manual)
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m
Interrupts/diagnostics/status information	
Fail-safe values can be switched to	No
Interrupts	
Diagnostic interrupt	Yes
Diagnostic messages	
Diagnostics	Yes, see section "Interrupts/diagnostic messages" in the manual

	6ES7136-6DB00-0CA0
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	
Between channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC
Isolation	
Isolation test voltage	707 V DC (type test)
Standards, approvals, certificates	
SIL acc. to IEC 61508	SIL 3
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1	PLe
Low demand (PFD) acc. to SIL3	< 2.00E-05 1/h
High demand (PFH) acc. to SIL3	< 1.00E-09 1/h
Environmental conditions	
Operating temperature	
Min.	0 °C
Max.	60 °C
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Storage/transport temperature	
Min.	-40 °C
Max.	70 °C

	6ES7136-6DB00-0CA0
Dimensions	
Width	15 mm
Weights	
Weight, approx.	57 g

Temperature characteristic values

Mounting position	Maximum temperature	Total current across all channels
Horizontal	40 °C	6 A
	50 °C	5 A
	60 °C	4 A
Vertical	50 °C	4 A

Note

Because of the small size of the modules, pay attention to the development of heat between adjacent modules when output modules are exposed to elevated loads. If overtemperature occurs in an output module exposed to an elevated load, shutdown may result and reduce the plant availability. If you fully load an output module, the average total current of the modules directly adjacent to it should not exceed 75% of the values listed in the technical specifications. If you load directly adjacent modules with their maximum total current, reduce the maximum total current of the output module by 1 A (e.g., for horizontal installation up to 60 °C → total current of 3 A across all channels).

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Response times

A

Introduction

The next section shows the response times of the digital output moduleF-DQ 4×24VDC HF. The response times of digital output module F-DQ 4×24VDC HF are included in the calculation of the F-system response time.

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation

Maximum cycle time: T_{cycle} = 15.5 ms

You assign the dark test time and switch-on time in STEP 7.

Maximum response time in the error-free case

The maximum response time for fail-safe digital outputs in the error-free case is equal to:

Maximum response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with error and change of user data

Maximum response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with detection by bit pattern test

Maximum response time = T_{cycle} + Maximum(dark test time, switch-on time) + configured test time

Switching of loads

B

B.1 Connecting capacitive loads

If an F-DQ 4×24VDC HF digital output module is interconnected with loads that require little current and have capacitance, this can lead to detection of a short circuit or overload. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The typical trend shown in the diagram below represents the correlation between load impedance and maximum switched load capacitance at a supply voltage of 24 V DC.

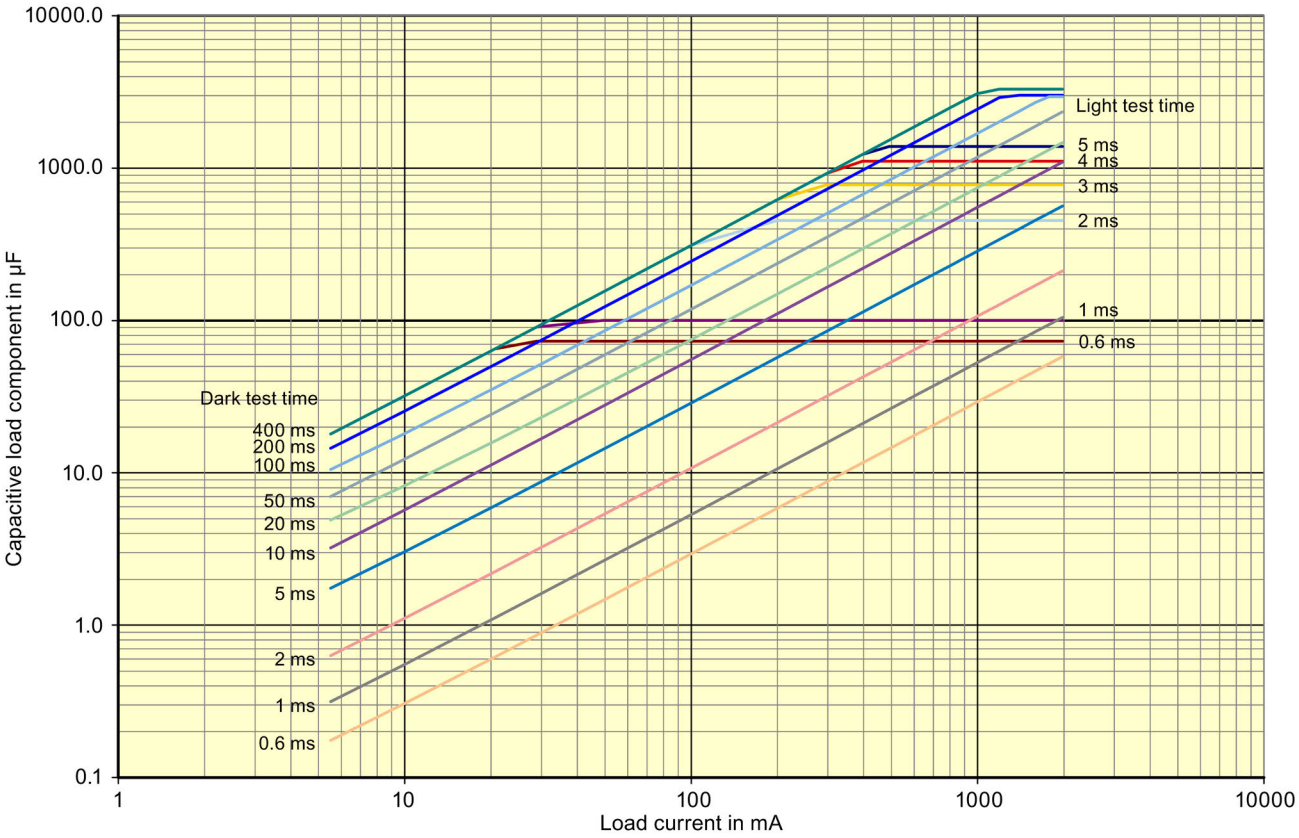


Figure B-1 Switching of capacitive loads for the F-DQ 4×24VDC HF digital output module depending on the configured dark and light test times

Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

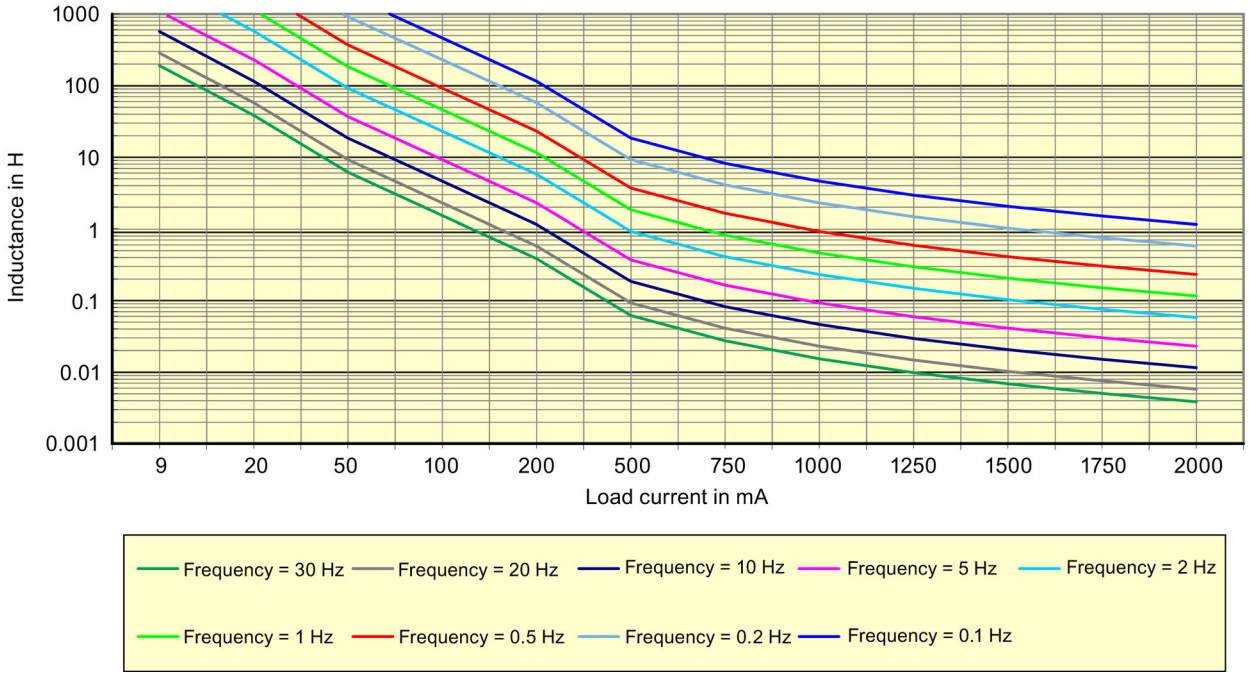


Figure B-2 Switching of inductive loads for the F-DQ 4x24VDC/2A PM HF digital output module depending on the load current and switching frequency

SIEMENS

SIMATIC

ET 200SP
Digital output module
F-RQ 1x24VDC/24..230VAC/5A
(6ES7136-6RA00-0BF0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Preface

Purpose of this documentation

This manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information in this manual and the system manual supports you when commissioning the ET 200SP system.

Conventions

Pay particular attention to notes highlighted as follows::

Note

A note contains important information on the product described in the documentation, on handling the product or on the part of the documentation to which you should pay special attention.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Guide to the documentation

1

1.1 Guide to the documentation for the digital output module F-RQ 1x24VDC/24..230VAC/5A

Introduction

The documentation of the SIMATIC products has a modular structure and includes topics relating to your automation system.

The complete documentation of the ET 200SP system consists of different modules made up of system manuals, function manuals and device manuals.

The STEP 7 (online help) information system supports you when configuring and programming your automation system.

Overview of the documentation for the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A

The table below lists additional documents that complement this description of the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A and that are available on the Internet.

Table 1- 1 Documentation for the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting up • Commissioning • Approvals • TÜV certificates
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment and verification right through to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/automation/service&support).

Please e-mail any queries you may have e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-RQ 1x24VDC/24..230VAC/5A

Article number

6ES7136-6RA00-0BF0

View of the module

Figure 2-1 View of the F-RQ 1x24VDC/24..230VAC/5A module

Properties

- Technical properties
  - Digital module with 1 relay output (2 isolated NO contacts)
  - Safety class SIL3/category 4/PLecan be achieved if the F-RQ module is controlled by a fail-safe output (for example F-module F-DQ 4x24VDC/2A PM HF)
  - Control voltage 24 VDC
  - Total current for both NO contacts 5 A max.
  - Isolated from control voltage
  - Suitable for solenoid valves, DC contactors and signal lamps
- Supported system functions
  - I&M identification data
  - Firmware update

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a service life of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the module in question from the BaseUnit or switch off its supply voltage before 100 hours are up.

Accessories

The following components can be used with the module:

- Labeling strips
- Color identification labels
- Reference identification labels

Connecting up

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment for F-RQ 1x24VDC/24..230VAC/5A

Terminal assignment for F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**	**Color identification label (terminals 1 to 16)**
1	RQ_{01}+ [13]	**2**	RQ_{01}- [14]	• RQ_n+, RQ_n-: Channel n • IN: Control input • OUT: Control input for loop-through	BU20-P8+A4+0B	 CC42 6ES7193-6CP42-2MB0
3	RQ_{02}+ [23]	**4**	RQ_{02}- [24]			
5	—	**6**	—			
7	—	**8**	—			
9	IN P	**10**	OUT P			
11	IN M	**12**	OUT M			
13	AUX	**14**	AUX			
15	AUX	**16**	AUX			

3.2 Block diagram

Block diagram

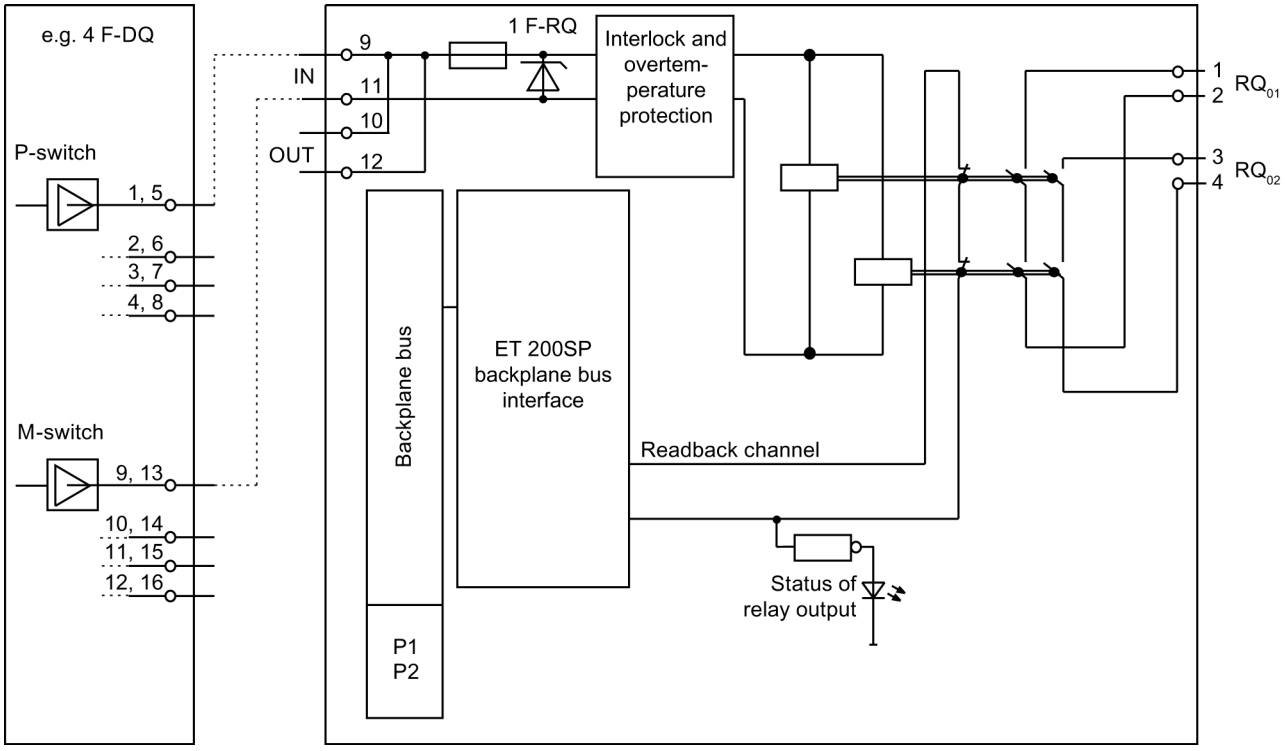


Figure 3-1 Block diagram F-RQ 1x24VDC/24..230VAC/5A

Addressing

4

4.1 Address space

Address assignment of the digital output module F-RQ 1x24VDC/24..230VAC/5A

The digital output module F-RQ 1x24VDC/24..230VAC/5A occupies the following address ranges in the F-CPU:

Table 4- 1 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
in input range	in output range
x.0 and x.1	—

x = Module start address

Address assignment of the user data of the digital output module F-RQ 1x24VDC/24..230VAC/5A

Of the occupied addresses of the digital output module F-RQ 1x24VDC/24..230VAC/5A, the user data occupies the following addresses in the F-CPU:

Table 4- 2 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-RQ module:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	RQ_1 Inverted readback channel (corresponds to process signal at IN)	RQ_0 Readback channel

x = Module start address

The user data is in the standard process image of the inputs and is not transferred to the F-CPU in safety-related communication. The readback channel in the user program is therefore displayed as a non-failsafe variable.

Note

With migration projects from the ET 200S product family, note the following:

The readback channel RQ_0 (bit 0) allows direct interconnection with the FDBACK instruction (F-block F_FDBACK) to its FEEDBACK input without additional inversion.

The readback channel RQ_1 (bit 1) is inverted.

Additional information

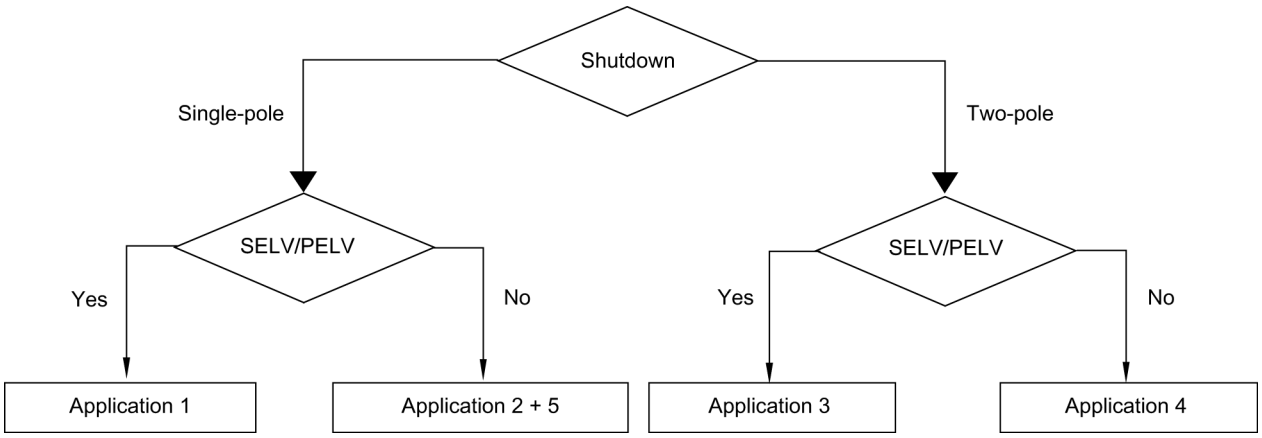
For detailed information about F-I/O access, refer to the SIMATIC Safety, Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module

5

5.1 Applications of the F-RQ 1x24VDC/24..230VAC/5A

You can achieve SIL3/category 4/PLe in the following applications if the activating F-module supports SIL3/category 4/PLe.



The wiring is carried out on the suitable BaseUnit (http://support.automation.siemens.com/WW/view/en/58532597/133300).

Wiring the 24 VDC power supply

Apply the 24 VDC control voltage to IN P (terminal 9) and IN M (terminal 11). The 24 VDC supply line is usually connected via a sourcing/sinking fail-safe output (e.g. digital output module F-DQ 4x24VDC/2A PM HF). Wire the P output (sourcing) of the F-DQ to the IN P of the F-RQ module and the M output (sinking)to the IN M of the F-RQ module.

As an alternative, you can also connect to a sourcing-sourcing fail-safe output. However, note that external short-circuits to P at the P input cannot be controlled. In this case, IN M would be connected directly to the control voltage ground.

NOTICE
Connecting the control voltage to the IN P and IN M inputs with the reverse polarity will destroy the F-module.

Wiring the load voltage and the load

The connectors of the relay output are electrically isolated NO contacts. This means that power must be supplied to these contacts from an external source. Connect the load supply (supply 1) and the load (load 1) in series to the RQ_{01} connectors (terminals 1;2). This ensures that the NO contacts of the relay interrupt the current flow of the power supply through the load. Due to the two relay contacts connected in series, the current flow can still be interrupted if one of the two relays has a fault..

The second circuit is independent of the first. They are logically interconnected by the common control. This means that the potential in the RQ_{02} (terminals 3;4), supply 2 and load 2 circuit may be different.

⚠ WARNING
If you connect a non-SELV/PELV power supply to one channel, you must not use the other channel.

Parameter assignment of the digital output module F-DQ 4x24VDC/2A PM HF

Assign the following parameters for the channel of the F-DQ 4x24VDC/2A PM HF digital output module to be activated:

Table 5- 1 Parameter assignment

Parameter	
Max. readback time dark test	1 ms
Max. readback time switch on test	1 ms

As the relays are highly inductive, you have the option of activating "Diagnostics: wire break" *or "*enable light test".

5.2 Application 1: 2 loads, single-pole switch-off

Wiring diagram

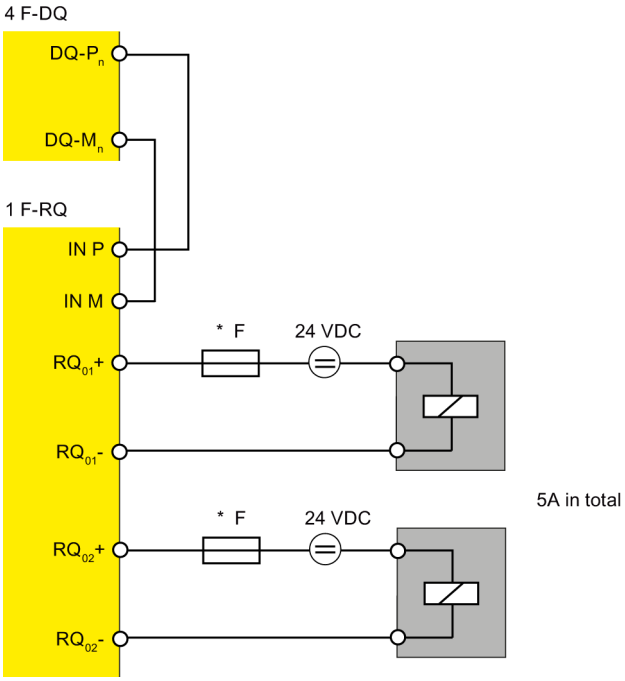


Figure 5-1 Wiring diagram of the F-RQ 1x24VDC/24..230VAC/5A to an F-DQ module

In this application, you can use one F-RQ module for single-pole switching of two loads with a total of 5A and one/two SELV/PELV power supplies.

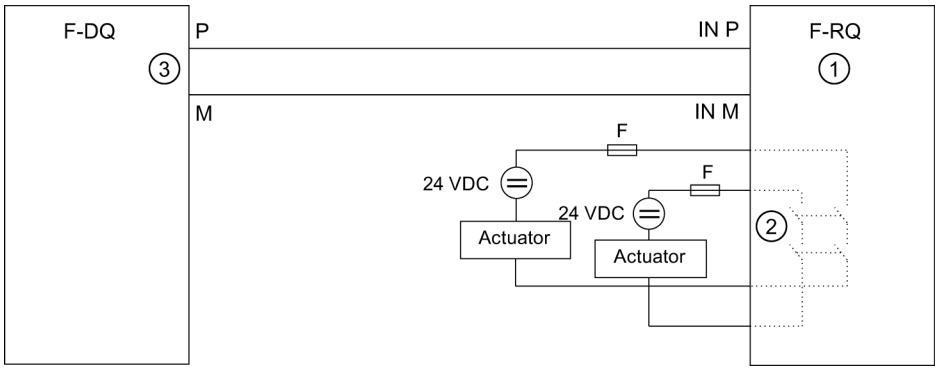
⚠ WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 5-2 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

Note

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

5.3 Application 2: 1 load, single-pole switch-off

Wiring diagram

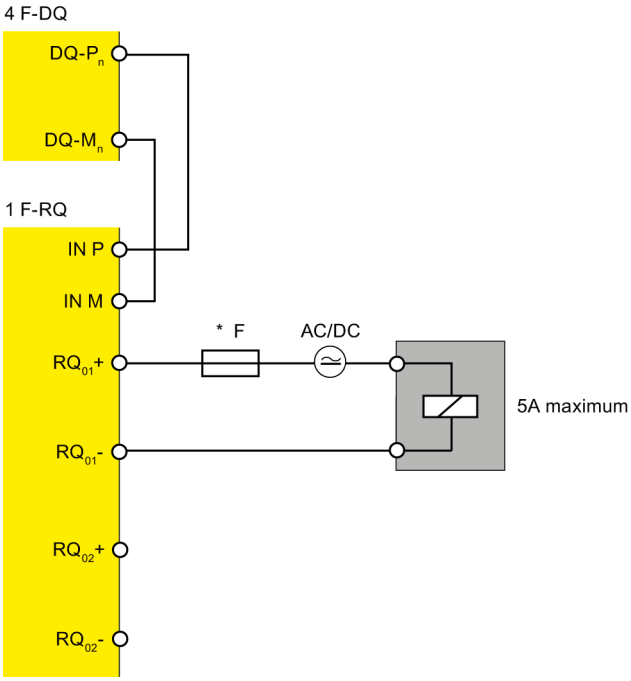


Figure 5-3 Wiring diagram of the F-RQ 1x24VDC/24..230VAC/5A to an F-DQ module

This application allows single-pole switching of one load with a total of 5A with one F-RQ module.

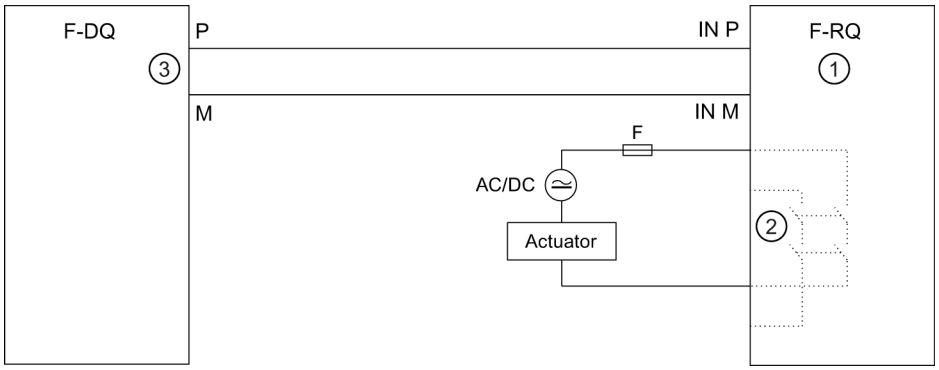
⚠ WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Please note that for applications in accordance with EN 50156-1, the specified rated current of the overcurrent protective device must be multiplied by the safety factor 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 5-4 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

Note

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

5.4 Application 3: 1 load, two-pole switch-off with 1 F-RQ module

Wiring diagram

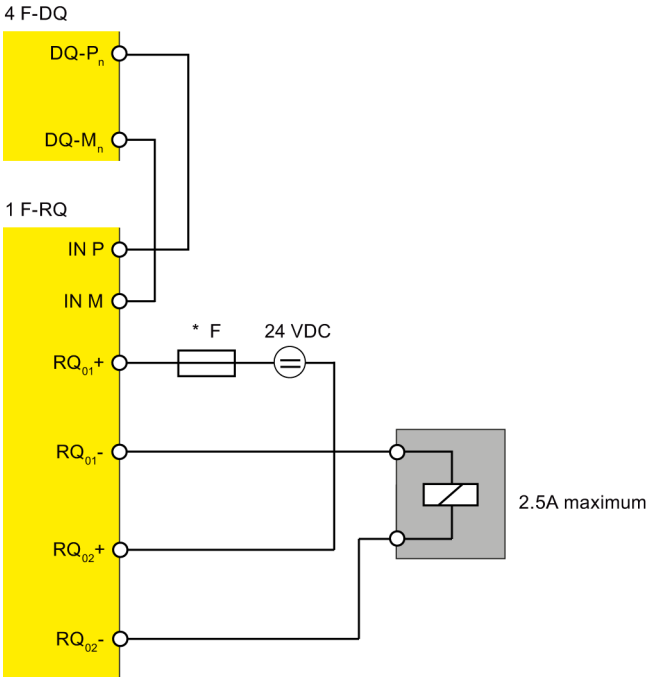


Figure 5-5 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

This application allows two-pole switching with one F-RQ module of one load with a maximum of 2.5A and an SELV/PELV power supply.

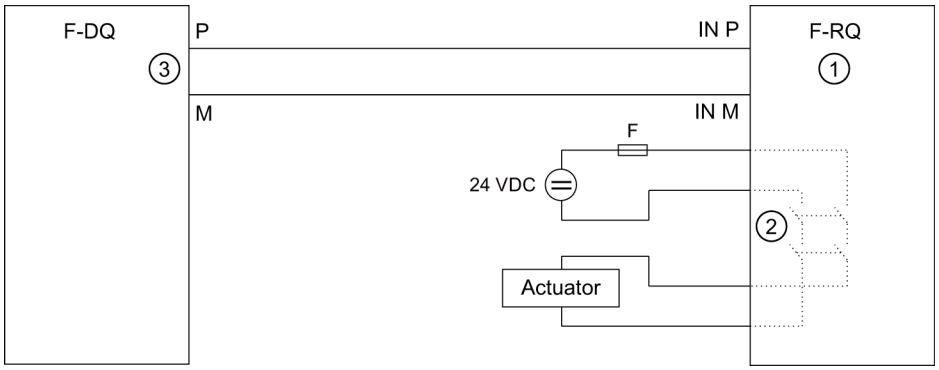
⚠ WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 5-6 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

Note

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

5.5 Application 4: 1 load, two-pole switch-off with 2 F-RQ modules

Wiring diagram

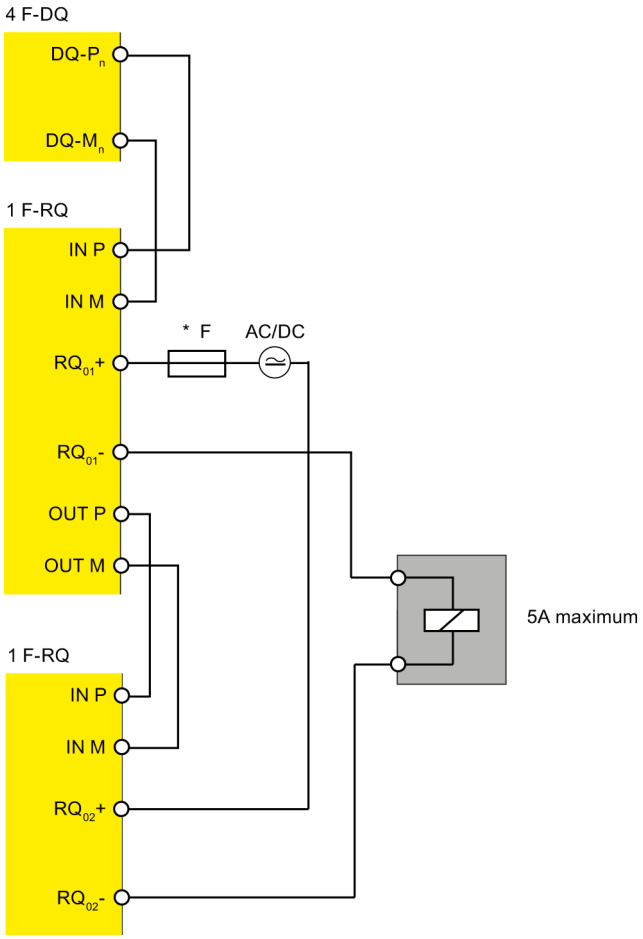


Figure 5-7 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

This application allows two-pole switching of one load with a max. of 5A with two F-RQ modules.

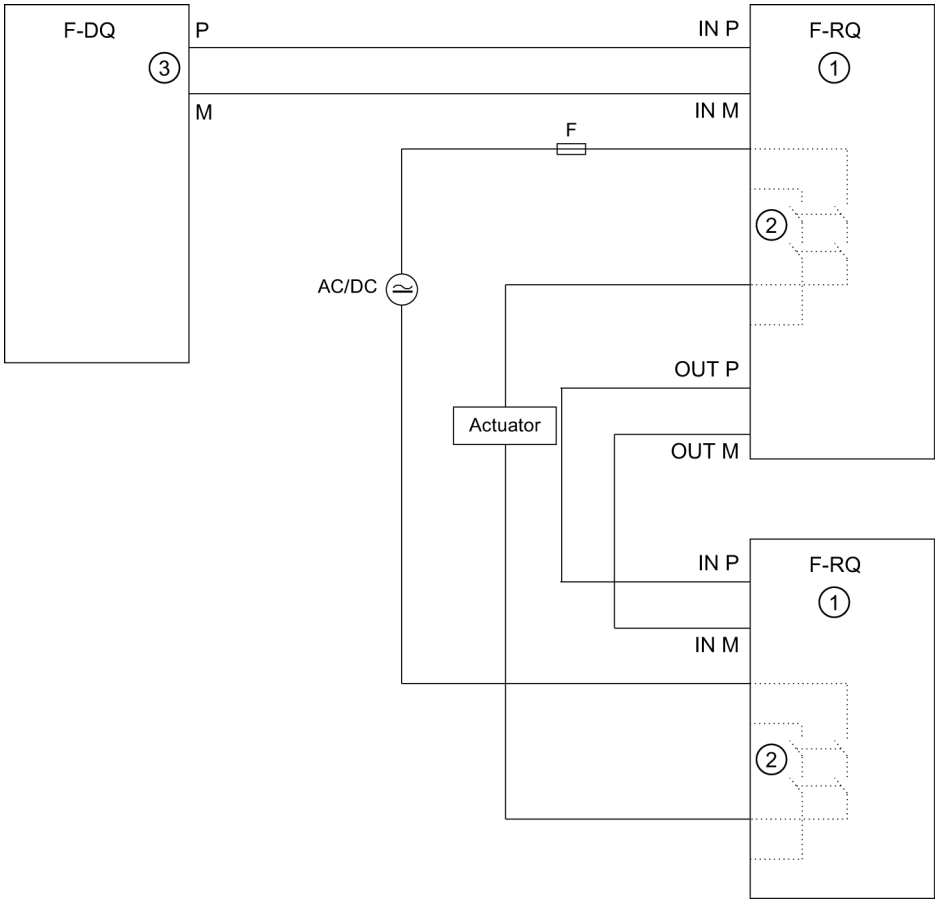
WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 5-8 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

Note

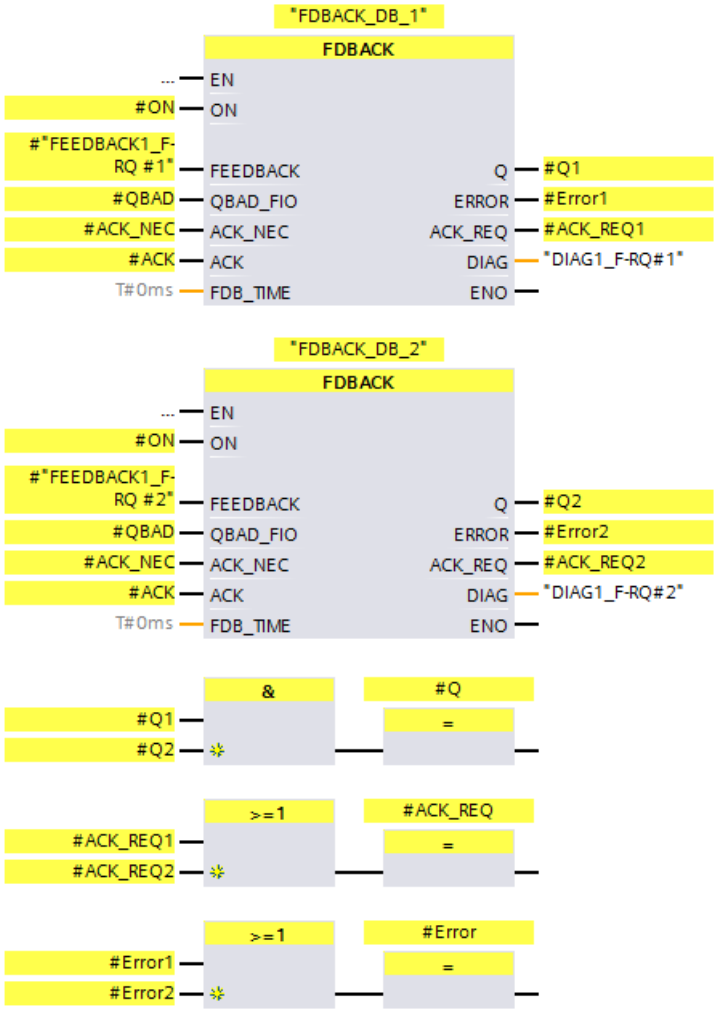
SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

Program example

For this application, program an FDBACK instruction for each F-RQ module as follows:



5.6 Application 5: 2 loads, single-pole switch-off with 2 F-RQ modules

Wiring diagram

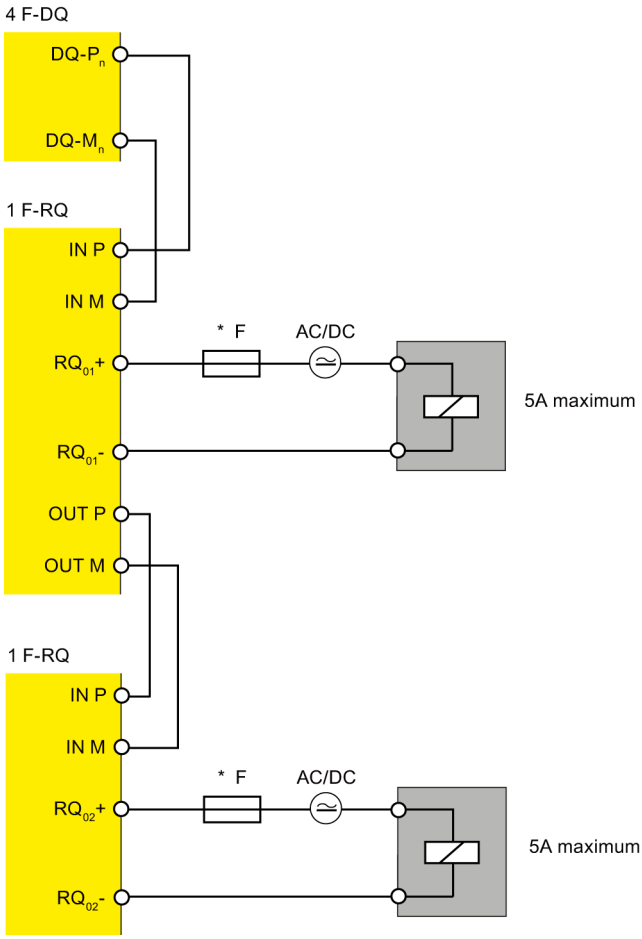


Figure 5-9 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

This application allows the single-pole switching of two loads with 5A each with two F-RQ modules. One power supply is not SELV/PELV.

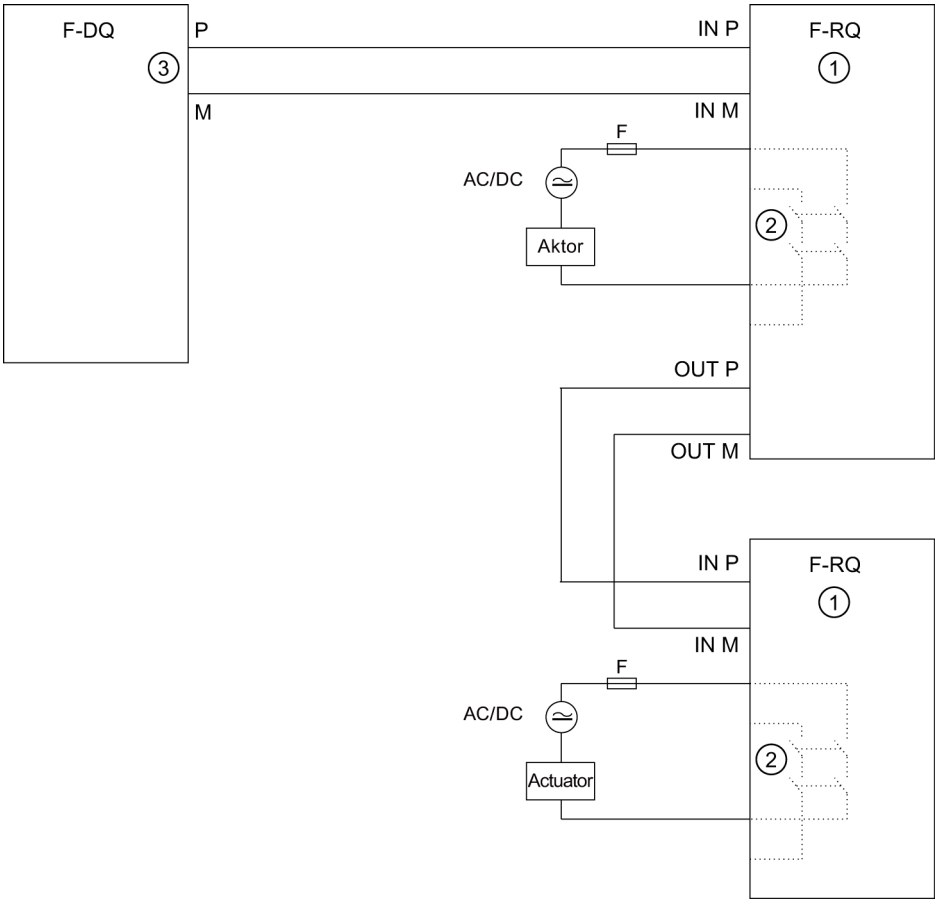
WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 5-10 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

Note

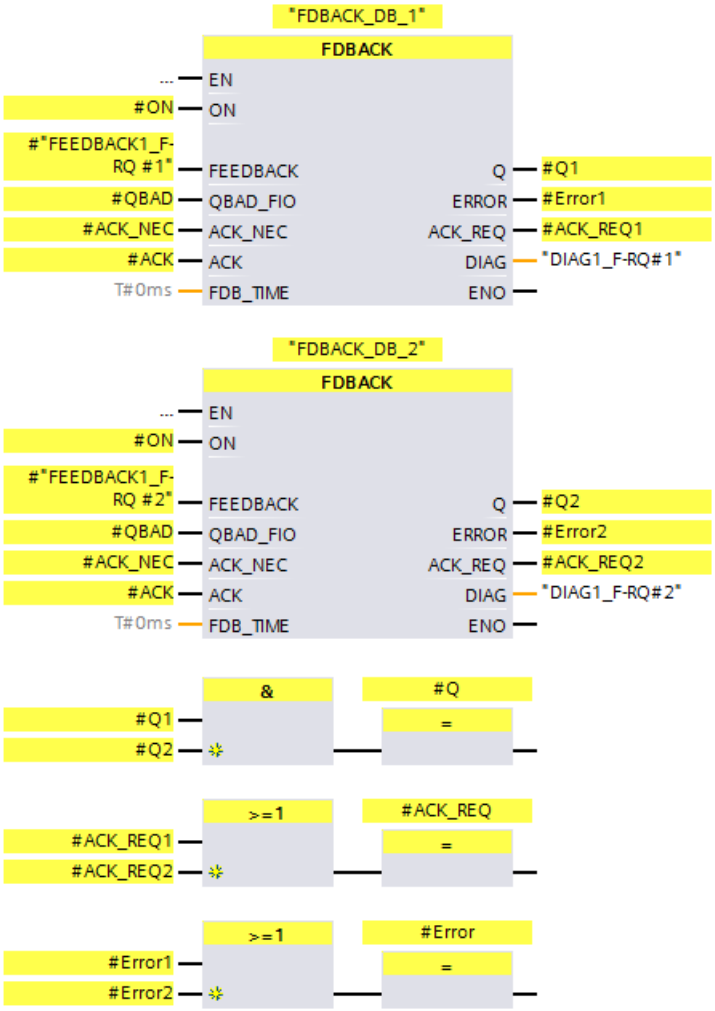
SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

Program example

For this application, program an FDBACK instruction for each F-RQ module as follows:

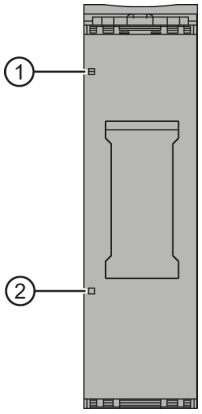


Status and error display

6

6.1 Status and error display

LED display



① DIAG (green/red)
② Channel status (green)

Figure 6-1 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays.

WARNING
The DIAG LED and the channel status LED of the output are not designed as safety-related LEDs and therefore must not be evaluated for safety-related activities.

DIAG LED

Table 6- 1 Meaning of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashing	Module parameters not set
On	Module parameters set and no module diagnostics

Channel status LED

Table 6- 2 Meaning of the channel status LED

Status	Meaning
Off	Process signal = 0
On	Process signal = 1

Technical specifications

7

7.1 Technical specifications

Technical specifications of F-RQ 1×24VDC/24...230VAC/5A

	6ES7136-6RA00-0BF0
Product type designation	F-RQ 1x24VDC/24 ... 230VAC/5A
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V13
STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
Installation type/mounting	
Rail mounting possible	Yes; standard mounting rail
Supply voltage	
Type of supply voltage	24 VDC
Rated value (DC)	24 V; coil voltage
Low limit of permitted range (DC)	20.4 V
High limit of permitted range (DC)	28.8 V
Power	
Power consumption from the backplane bus	100 mW
Power loss	
Power loss, typ.	1 W
Address range	
Address space per module	
Input	1 byte
Digital outputs	
Number of outputs	1
Voltage induced on current interruption limited to	No
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	5 A
With lamp load, max.	25 W

	6ES7136-6RA00-0BF0
Switching frequency	
With resistive load, max.	2 Hz
With inductive load, max.	0.1 Hz; see information in the manual
With inductive load (to IEC 60947-5-1, DC13), max.	0.1 Hz
With inductive load (to IEC 60947-5-1, AC15), max.	2 Hz
Total current of the outputs (per module)	
Horizontal installation	
• Up to 40 °C, max.	5 A; note derating information in the manual
• Up to 50 °C, max.	4 A; note derating information in the manual
• Up to 60 °C, max.	3 A; note derating information in the manual
Vertical installation	
• Up to 50 °C, max.	3 A; note derating information in the manual
Relay outputs	
Number of relay outputs	1; 2 NO contacts
Rated input voltage of relay coil L+ (DC)	24 V
Current consumption of relays (coil current of all relays), max.	70 mA
External fuse for relay outputs	Yes, 6 A, see information in the manual
Relay approved acc. to UL 508	Yes; Pilot Duty B300 R300
Switching capacity of contacts	
• With inductive load, max.	See additional description in the manual
• With resistive load, max.	See additional description in the manual
• Thermal continuous current, max.	5 A
• Contact rating, min.	1 mA
• Contact rating after exceeding 300 mA, min.	10 mA
• Contact rating after exceeding 300 mA, max.	5 A
• Rated switching voltage (DC)	24 V
• Rated switching voltage (AC)	230 V
Length of cable	
Cable length, shielded, max.	500 m; for load contacts
Cable length unshielded, max.	300 m; for load contacts
Control cable (input), max.	10 m
Interrupts/diagnostics/status information	
Diagnostics messages	
Diagnostics	Yes, firmware update
Diagnostics display LED	
RUN LED	Yes; green/red DIAG LED
Channel status display	Yes; green LED

	6ES7136-6RA00-0BF0
Electrical isolation	
Electrical isolation, channels	
Between channels	Yes; only with SELV / PELV
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between channels and backplane bus/supply voltage	250 VAC (reinforced insulation)
Between backplane bus and supply voltage	60 VAC/75 VDC
Insulation	
Insulation test voltage	2545 VDC 2 s (routine test)
Overvoltage category	III
Tested with	
Between channels and backplane bus/supply voltage	2545 VDC 2s (routine test), surge voltage test 7200 VDC/5 positive and 5 negative pulses (type test)
Between backplane bus and supply voltage	707 VDC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1:2008	PLe
Category according to ISO 13849-1:2008	4
SIL according to IEC 61508:2010	SIL 3
Low demand (PFD) acc. to SIL2	<1.00E-04, proof test interval 1 year
Low demand (PFD) acc. to SIL3	<1.00E-05, proof test interval 1 month
High demand (PFH) acc. to SIL2	<1.00E-08 1/h, proof test interval 1 year
High demand (PFH) acc. to SIL3	<6.00E-09 1/h, proof test interval 1 month
Dimensions	
Width	20 mm
Weights	
Weight, approx.	56 g

Supplement to the technical specifications

Technical specifications	
Relay outputs	
Current consumption of relays (coil current of all relays), min.	20 mA
Permitted potential difference	
• Between NO contacts	75 VDC / 60 VAC
Insulation tested	
• Between the NO contacts	707 VDC (type test)

Derating

Note

As the modules are small, you need to monitor the heat build-up between adjacent modules if output modules are subject to high loads. A temperature rise in an output module exposed to a high load can result in shutdown and reduce plant availability. If the operating voltage > 25 VDC, the average total current of the modules directly adjacent should not exceed 50% of the levels listed in the technical specifications, and the ambient temperature should not exceed 50 °C.

If the ambient temperature exceeds 50 °C, supply voltage L+ must not exceed 25 VDC.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

7.2 Mechanical and climatic ambient conditions

In contrast to the specifications for mechanical environmental conditions and mechanical environmental conditions testing in the "Mechanical and climatic ambient conditions" section of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual, the following applies to this F-module:

Mechanical ambient conditions

The following table shows the mechanical ambient conditions in the form of sinusoidal vibrations.

Table 7- 1 Mechanical ambient conditions

Frequency band	ET 200SP with BusAdapter BA 2×FC	ET 200SP with BusAdapter BA 2×RJ45/ BA 2xSCRJ
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude	
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration	

Tests of mechanical ambient conditions

The following table provides important information about the type and scope of the tests for ambient mechanical conditions.

Table 7- 2 Tests of mechanical ambient conditions

Check for ...	Test standard	Comment
Vibration	Vibration test according to IEC 60068-2-6 (sinus)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each of three vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes

7.3 Switching capacity and service life of contacts

Switching capacity and service life of contacts

You can extend the service life beyond the value indicated in the tables below by installing an external protective circuit.

The tables below show the switching capacity and service life of the contacts.

Table 7- 3 Switching capacity and service life of contacts with resistive load

Voltage	Current	Duty cycles (typ.) NO contact
24 VDC	5.0 A	350000
	3.0 A	500000
	2.0 A	750000
	1.0 A	1800000
	0.5 A	4000000
230 VAC	5.0 A	100000
	3.0 A	150000
	2.0 A	200000
	1.0 A	400000
	0.5 A	800000

Table 7- 4 Switching capacity and service life of contacts **with inductive load according to IEC 947-5-1 DC 13/ AC15**

Voltage	Current	Duty cycles (typ.) NO contact
24 VDC	1.0 A	100000
	0.5 A	200000
230 VAC	1.0 A	200000
	0.5 A	350000

Table 7- 5 B10d values

AC	750000
DC	10000000

Response times

A

A.1 Response times

Introduction

The section below shows the response times of the digital output module F-RQ 1x24VDC/24..230VAC/5A. The response times of digital output module F-RQ 1x24VDC/24..230VAC/5A are included in the calculation of the F-system response time.

Definition of response time for fail-safe relay outputs

The response time defines the interval between controlling by means of a fail-safe digital output module until the signal change at the relay output.

Maximum response time without errors

The maximum response time for fail-safe relay outputs when there are no errors is equal to:

Max. response time = 16 ms

Readback response time

The readback response time for fail-safe relay outputs is equal to:

Readback response time = 30 ms

Maximum response time until error detection

Max. response time = cycle time of the safety program + max. readback time of the FDBACK instruction + max. response time of the F-DQ module + max. response time of the F-RQ module + 12.8 ms

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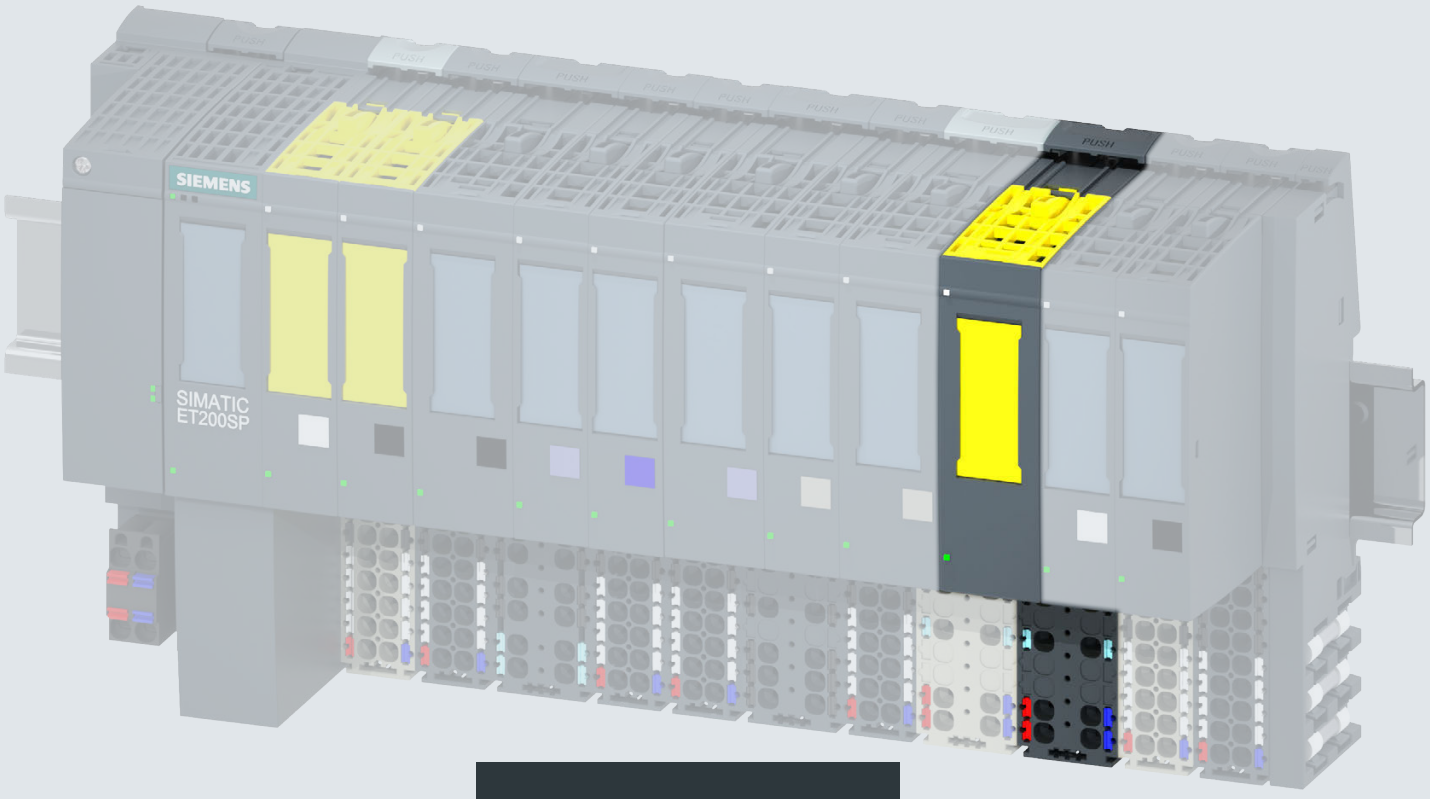

Manual

SIMATIC

ET 200SP

Fail-safe Modul F-CM AS-i Safety ST
3RK7136-6SC00-0BC1

Edition 03/2017

siemens.com

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ET 200SP
Fail-safe Module
F-CM AS-i Safety ST
(3RK7136-6SC00-0BC1)

Manual

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03/2017

A5E03957059020A/RS-AB/002

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual complements the ET 200SP distributed I/O system system manual. General functions of the ET 200SP are listed in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

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Documentation guide

1

Introduction

The following paragraph gives you an overview of the additional documentation you need to use the F-CM AS-i Safety ST.

Documentation for the distributed I/O system ET 200SP with the F-CM AS-i Safety ST

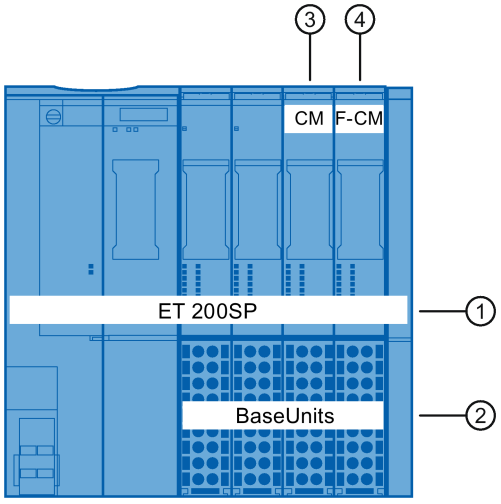


Figure 1-1 Example of a system structure

Table 1- 1 Documentation for the distributed I/O system ET 200SP with the F-CM AS-i Safety ST

No.	Component	Documentation	Most important contents
①	System	Fail-safe modules: Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en) ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)	• Application planning • Installation • Connecting • Commissioning • Technical specifications
		Fail-safe system: Programming and Operating Manual S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en) Programming and Operating Manual SIMATIC Safety (http://support.automation.siemens.com/WW/view/en/54110126/0/en)	• Configuration • Programming

No.	Component	Documentation	Most important contents
②	BaseUnits	SIMATIC ET 200 SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521/0/en)	• Connecting • Technical specifications
③	CM AS-i Master ST	Manual CM AS-i Master ST for SIMATIC ET 200SP (http://support.automation.siemens.com/WW/view/en/71756485)	• Commissioning • Technical specifications
④	ET 200SP F-CM AS-i Safety ST fail-safe module	Device manual ET 200SP F-CM AS-i Safety ST fail-safe module (3RK7136-6SC00-0BC1)	• Installation • Connecting • Configuration

Safety instructions

2

Important safety instructions

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

For operation in Pollution Degree 2 environment.

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

When used in hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or an enclosure. To comply with EU Directive 94/9 (ATEX 95), this enclosure must meet the requirements of at least IP54 according to EN 60529.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Wires must not be connected to the device or disconnected from the device within a flammable or combustible environment.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not disconnect live wires from the device if it cannot be ensured that an explosive atmosphere is not present in the environment.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Replacement of components may impair suitability for Class I, Division 2 or Zone 2.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not open the device when the supply voltage is switched on.

WARNING

Connection only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to an AS-i power supply unit that meets the conditions indicated in the Section "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

For this reason, you are only permitted to connect safety extra-low voltage (SELV) with limited power source (LPS) according to IEC 60950-1, EN 60950-1, VDE 0805-1 to the supply connections.

The supply of the device must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

Take measures to prevent transient overvoltages of more than 40% of the rated voltage. You can ensure this by using only AS-i power supply units that meet the requirements indicated in Section Terminal assignment (Page 27) in "Power supply units for AS-Interface". Transient overvoltages are not permitted to exceed 119 V under any circumstances. This will ensure compliance with an ATEX requirement.

CAUTION

Failure to observe this information may result in property damage and bodily injury

This device is only suitable for use in areas defined as Class I, Division 2, Groups A, B, C, and D and is not suitable for use in hazardous areas.

WARNING

To be operated by experienced users only

Improper operation may result in death, severe injury, and serious property damage. Users must be familiar with ASIsafe and the safety system used, e.g., SIMATIC, Distributed Safety, SIMATIC Safety Advanced.

Only an experienced user is permitted to teach the code sequences of safe AS-i slaves (organizational specification).

CAUTION

Failure to observe this information may result in property damage and bodily injury

This equipment is only suitable for use in areas defined as Class I, Zone 2, Group IIC and in non-hazardous areas.

NOTICE

Checking parameters

Check that all parameters are correctly set before final acceptance.

NOTICE

Reaction to faults in fail-safe modules

If you are using the module in safety-critical applications, the PROFIsafe mechanism of passivation and reintegration is enabled and must be used.

Observe the information concerning passivation and other fault reactions in the documentation for the ET 200SP Distributed I/O System, see Section Documentation guide (Page 7).

NOTICE

Single-channel use of safe AS-i input slaves

The values in the PROFIsafe process image input have Safety Integrity Level SIL 3.

If two-channel interconnection is not used for a safe AS-i input slave, the application has a maximum safety integrity level of SIL 2 or less. The configuration tool / STEP 7 cannot detect this.

You must ensure that the signals are correctly processed in the safety application.

NOTICE

Ensure that the plant is functioning correctly in productive operation

Carry out a function test before the system goes into productive operation.

Important note for maintaining the operational safety of the system

Note

Newsletter containing information on product development and product features

Owners of systems with safety-related characteristics must ensure compliance with special operational safety requirements. Suppliers are required to comply with special product monitoring measures. For this reason, Siemens publishes a special newsletter containing information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective. A newsletter keeps you constantly up to date in this regard. A subscription to the newsletter is necessary so that you can make any needed changes to your system. To sign up for the newsletter, go to:

Internet (https://www.industry.siemens.com/newsletter)

Select "Service & Support" > "Industry Online Support" > "Automation Technology" > "AS-Interface". Select the "Update" entry type.

See also

References (Page 101)

Product overview

3

3.1 Properties of the F-CM AS-i Safety ST

Item number

3RK7136-6SC00-0BC1

View of the module

Figure 3-1 View of the F-CM AS-i Safety ST module

Use of the module

The F-CM AS-i Safety ST module is a communication module for use in the SIMATIC ET 200SP Distributed I/O System.

The F-CM AS-i Safety ST module features a 20 mm wide ET 200SP module housing. A BaseUnit (BU) is required for use in the ET 200SP. The F-CM AS-i Safety ST module can be plugged in to:

- BaseUnit Type C0
- BaseUnit Type C1

The F-CM AS-i Safety ST fail-safe communication module expands a standard AS-Interface network to include safety-related communication.

The F-CM AS-i Safety ST module reads the input states of safety-related AS-Interface input modules and provides these states to a fail-safe F-CPU for further evaluation.

In the opposite direction, the F-CM AS-i Safety ST module receives safe output states of an F-CPU and outputs them for control of safety-related outputs on AS-Interface.

The F-CM AS-i Safety ST fail-safe module supports safety-related applications up to SIL 3 according to EN 62061 or safety category up to PL e according to EN 13849-1. The input and output values of the safety-related AS-i slaves are addressed using the safe cyclic process image. You need an F-CPU for safe processing.

The F-CM AS-i Safety ST module has no AS-i master functionality. For operation of the AS-i network, you need a CM AS-i Master ST module (3RK7137-6SA00-0BC1) or another AS-i master conforming to AS-i Specification V3.0.

You can plug several F-CM AS-i Safety ST modules into one SIMATIC ET 200SP station. An F-CM AS-i Safety ST occupies 16 input bytes and 8 output bytes in the I/O address space. The number of F-CM AS-i Safety ST modules that can be plugged in depends on:

- The maximum address space of the utilized interface module (IM) of the ET 200SP
- The amount of address space occupied by other modules

Up to five module combinations of CM AS-i Master ST (32 input bytes/32 output bytes) and F-CM AS-i Safety ST (16 input bytes/8 output bytes) can be plugged in to one SIMATIC ET 200SP station with standard interface module IM 155-6 PN ST having a maximum address space of 256 input bytes/256 output bytes. If other modules are present in the ET 200SP station, the available address space and the maximum number of AS-i modules are reduced.

In a SIMATIC ET 200SP station with High Feature Interface Module IM 155-6 PN HF and a maximum address space of 1 440 input bytes/1 440 output bytes, a correspondingly greater number of modules can be plugged in.

You can find additional information in ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

Properties

- Technical properties
  - Gateway between PROFIsafe and ASIsafe, without master functionality
  - Expands a standard AS-i network to include safety-related communication (ASIsafe)
  - Transfer of safety-related digital I/O values in the cyclic process image
  - Monitoring of up to 31 safety-related input slaves
  - Control of up to 16 safety-related AS-i output slaves or switch-off groups
  - Power supplied from the AS-i voltage
  - Use of various interconnection types (1oo1 and 1oo2) is possible
  - Input delay of 0 ms to 150 ms can be assigned for each channel
  - Startup test can be activated for each channel
  - Discrepancy monitoring can be configured for each channel
  - Sequence monitoring can be set for each channel
  - Channel-wise passivation
  - Test for 0 signal before reintegration
  - 8 LED displays for status and error diagnostics
- Supported functions
  - I&M identification data
  - PROFIsafe V2.4
  - Firmware update

NOTICE
Max. proof test interval When the proof test interval has expired, you must replace the device; see "Technical specifications (Page 93)".

- New properties as from FW V1.0.1
  As from product version 02, the module is shipped with FW V1.0.1 (or higher).
  - Extended functions (diagnostic texts)
  - New messages
  - New diagnostics data record 206

For more information, see Section "Parameterizing (Page 41)".

Accessories

The following components can be used with the module:

- Labeling strips
- Reference identification label

Ease of maintenance

The following features support maintenance:

- Code sequences are saved in the coding element. As a result, teaching of the code sequences does not have to be repeated after an F-CM AS-i Safety ST module is replaced.
- Use is automated to the greatest extent possible. This applies, in particular, to the teaching of the code sequences of safe AS-i slaves.
- An F-address that has already been assigned is stored in the coding element. This means that there is no need to repeat teaching-in after replacing the F-CM AS-i Safety ST module.
- The module/BaseUnit concept allows you to easily replace defective hardware. Remove the defective module from the rack and plug in the new module.

Further information can be found in the Section "Code sequences (Page 75)".

Certifications

More detailed information regarding certifications can be found in the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

3.2 Operating modes of the F-CM AS-i Safety ST

3.2.1 Standard mode

Self test during device startup

After the AS-i voltage is switched on (PWR LED shows steady green light), the F-CM AS-i Safety ST module performs a comprehensive self-test. During this test, all LEDs are lit for approximately 3 seconds. Exception: the "DIAG" LED is controlled directly by the ET 200SP backplane bus and indicates the communication status for the ET 200SP system.

Checking of the F-address

After the self-test, the module checks the F-address. If no valid F-address is available, the "DIAG" and "PROFIsafe" LEDs flash red (the status LED flashes green). You must then assign the F-address, see Section "F-parameters (Page 44).

Downloading of the module parameters

The F-CM AS-i Safety ST then begins to read in code sequences of the safe AS-i slaves on the connected AS-i bus. At the same time, the module downloads the module parameters that were stored in the PLC CPU. The module parameters can only be downloaded when the operating voltage is applied to the interface module of the ET 200SP and the parameters have been made available by the PLC CPU during startup of the ET 200SP station.

The "Status" LED flashes green until the module parameters are completely downloaded or the PLC CPU is in STOP state, or the PLC communication is interrupted.

Cyclic data exchange of safe input/output data

When a valid set of module parameters has been downloaded and the PLC CPU is in "RUN" state, the safe input/output data is evaluated according the parameter assignment and exchanged with the PLC CPU.

The PROFIsafe protocol is used for the data exchange.

The "Status" LED is lit green during cyclic data exchange.

If the F-CM AS-i Safety ST module starts cyclic data exchange directly after startup, but communication cannot yet be established on the AS-i bus, the F-CM AS-i Safety ST module supplies the substitute value "0" in the input image. Passivation is delayed by a maximum of 30 s in this case. As a result, communication can start on the AS-i bus within this time window without passivation. After this time window, the input/output channels are passivated if there is no AS-i communication.

3.2.2 Error statuses

Note

Statuses not considered to be errors

The F-CM AS-i Safety ST module does not consider the following statuses to be errors, i.e. no alarm and no passivation is triggered:

- Waiting for start-up test
- Input/output with value = 0 in the process image without error condition, e.g. normal opening of the input contacts by pressing an emergency stop button or opening a protective door.

Diagnostic information can be read out in the user program using data records. For information, please refer to Section "Data records for diagnostics (Page 57)".

3.2.2.1 Serious device fault

Description

Examples of conditions that trigger a serious device fault are:

- Fault in the electronics
- Repeated synchronization error

You can read the following pattern on the LEDs:

Table 3- 1 LED display for a serious device fault

LED	Display
"Status"	☐ "Off"
"Error"	■ Red "On"
"CFG"	■ Red "On"
"PSF"	■ Red "On"

In the event of a serious device fault, communication with the F-CM AS-i Safety ST module, e.g., reading a data record, is not possible. The substitute value "0" is processed for inputs and outputs, and all channels are passivated.

1. Switch off the module.
2. Wait for the module to cool down, if necessary.
3. Switch on the device again.
4. If the error persists after the module is switched on, the module must be replaced.

3.2.2.2 Device fault

Description

Examples of conditions that trigger a device fault are:

- Device fault (e.g. sporadic synchronization error, see also DS92)
- Configuration error (e.g. problem with contact to backplane bus, coding plug missing, see also DS92)

You can read the following pattern on the LEDs:

Table 3- 2 LED display for device faults

LED	Display
"Status"	☐ "Off"
"Error"	✳ Red "flashes"
"CFG"	☐ "Off"
"PSF"	☐ "Off"

In the event of a device fault of this type, communication with the F-CM AS-i Safety ST module is only possible. e.g., for reading out additional diagnostic information via data records. The substitute value "0" is processed for inputs and outputs, and all channels are passivated.

- Make sure that the station is properly grounded.
- Check whether the coding element is present or replace it if necessary.
- Plug the module into the BaseUnit in an untwisted position.

Switch off the module. If the error persists after the module is switched on and no external error cause can be found, the module must be replaced.

3.2.2.3 Process signal error

Description

Examples of conditions that trigger a process signal error are:

- Discrepancy error at the inputs of a safe AS-i input slave
- Sequence error at the inputs of a safe AS-i input slave
- Sporadic code sequence error (from FW V1.0.1), e.g. fault caused by EMC in the input circuit
- Code sequence error at a safe AS-i input slave, e.g. due to cross-circuit at the inputs
- Failure of a safe AS-i input slave

You can read the following pattern on the LEDs:

Table 3- 3 LED display for discrepancy error or sequence error

LED	Display
"Status"	■ Green "On"
"Error"	□ "Off"
"CFG"	□ "Off"
"PSF"	✳ Red "flashes"

Table 3- 4 LED display for code sequence errors (e.g. due to cross-circuit) or for slave failure

LED	Display
"Status"	■ Green "On"
"Error"	□ "Off"
"CFG"	✳ Red "flashes"
"PSF"	✳ Flashes red if the CPU is in RUN "off" if the CPU is in STOP.

In the event of a process signal error, the F-CM AS-i Safety ST module remains in cyclic data exchange. Only at the safe input slave involved in each case is the substitute value "0" processed and the channel passivated. After the cause of the error has been eliminated, the channel can be reintegrated via the safety program.

The "PSF" LED goes out only after all channels have been reintegrated.

The "DIAG" LED switches from flashing red to green as soon as all errors that led to a passivation of the individual channels have been cleared.

Communication with the F-CM AS-i Safety ST module is possible, for example, for reading out additional diagnostic information via data records.

Response to code sequence errors

- **Sporadic code sequence error**
  Momentary interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable.
  Behavior as from firmware V1.0.1:
  - Sporadic code sequence error leads to passivation of the channel, which must then be reintegrated.
  - Safety input bit of the channel is reset to substitute value 0 until the channel is reintegrated.
  - The resetting to the substitute value 0 takes place without any delay.
  - Diagnostic alarm is triggered (after a short delay, in order to distinguish between sporadic code sequence errors and general code sequence errors).
  - **Response to FW V1.0.0**
  - No message as diagnostic alarm in FW V1.0.0 and no passivation of the channel.
  - Safety input bit of the channel is reset to substitute value 0 without a delay and automatically switches to the process value 0 or 1 if there is no interference to the code sequence.
- **Code sequence error (general)**
  Permanent interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable or code sequence corruption after replacement of the fail-safe input module.
  Behavior (identical for firmware V1.0.0 and V1.0.1 or higher):
  - Code sequence error leads to passivation of the channel, which must then be reintegrated.
  - Safety input bit of the channel is reset to substitute value 0 until the channel is reintegrated.
  - The reset to the substitute value 0 takes place without a delay, while the diagnostic alarm is triggered after a short delay (delay necessary in order to distinguish between sporadic code sequence errors and general code sequence errors).

3.2.2.4 Parameter assignment error

Description

In the event of invalid configuration data, the cyclic data exchange will not start.

You can read the following pattern on the LEDs:

Table 3- 5 LED display for parameter assignment errors

LED	Display
"Status"	✳ Green "flashing"
"Error"	☐ "Off"
"CFG"	☐ "Off"
"PSF"	✳ Red "flashes"

1. Check the hardware configuration in *STEP 7*.
2. Perform a compilation.
3. Download the configuration data to the PLC CPU.

3.3 Firmware update

Performing a firmware update

Information about updating the firmware can be found in the ET 200SP System Manual.

Note

Noting the firmware version

After a firmware update, mark the current firmware version on the housing of the F-CM AS-i Safety ST.

Note

Requirement for the firmware update

Always perform the firmware update of the F-CM AS-i Safety ST in a separate ET 200SP rack. Ensure that no other modules besides the interface module (IM), the F-CM AS-i Safety ST, and the terminating server module are located in the ET 200SP rack.

During the firmware update of the F-CM AS-i Safety ST module, the associated CPU must be in the STOP operating state. To do this, switch the CPU to the STOP state before starting the firmware update.

Note

If the FW V1.0.0 is replaced by another FW version, then an intermediate step is necessary. If you would like to replace a higher FW version with FW version V1.0.0, then this intermediate step is also necessary.

As an intermediate step, the Bootloader Version (B1.0.0) of the firmware must be loaded before the actual firmware V1.x.x.

NOTICE

Observe references to the download page for executing the firmware change
Failure to do so can result in the destruction of the device.

The firmware versions are made available in the Online Support:
Online Support (https://support.industry.siemens.com/cs/ww/en/view/109743655)

NOTICE

Checking the firmware version for F-permission

Before using a new firmware version, check whether it is permitted for use in the respective module.

The permissible firmware version is specified in the appendices of the F-CM AS-i Safety ST Safety certificate.

See also:

Certificate for failsafe module F-CM AS-i Safety ST (3RK7136-6SC00-0BC1)
(https://support.industry.siemens.com/cs/ww/en/view/90477145)

Certificate for ET 200SP modules
(http://support.automation.siemens.com/WW/view/en/49368678/134200)

Handling of the F-address and the code sequences

Note

Saving of the F-address in the coding element

During a firmware update, the F-address that is saved in the coding element is retained. Observe the information in the description of the firmware version.

Note

Saving of the code sequences in the coding element

During a firmware update, the ASIsafe code sequences that are saved in the coding element are retained. Observe the information in the description of the firmware version.

LED behavior during a firmware update

During a firmware update, the LEDs exhibit the following behavior:

- "DIAG" LED flashes red.
- "ADDR" LED flashes green.
- "PWR" LED lights up green.
- The rest of the LEDs are Off.

Note

Supply voltage during a firmware update

The AS-i voltage and the supply voltage of the ET 200SP station must not be switched off during a firmware update.

On successful completion of a firmware update, the module performs a hot restart. It is not necessary to switch off the voltage.

After the restart, the LEDs indicate the status of the F-CM AS-i Safety ST same as after a device startup.

If the firmware update cannot be completed, switch the AS-i voltage off and back on again and repeat the firmware update.

See also

Error statuses (Page 17)

Connection 4

4.1 Terminal assignment

Requirement

For connecting, you require a BaseUnit:

- Type C1 (dark BaseUnit, e.g., item number 6ES7193-6BP20-0BC1)
- Type C0 (light BaseUnit, e.g., item number 6ES7193-6BP20-0DC0)

Note that, within a BaseUnit group for AS-i consisting of light and dark BaseUnits, only the AS-i modules CM AS-i Master ST and F-CM AS-i Safety ST may be combined. Other module types of the ET 200SP must always be separated from the BaseUnit group for AS-i using light BaseUnits.

⚠ WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to AS-i power supply units that meet the requirements given in Section "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

Variants

Use with light BaseUnit Type C0

If the F-CM AS-i Safety ST module is connected to an AS-i network whose AS-i master is located outside the ET 200SP station, use the light BaseUnit Type C0.

If the AS-i master is located within the ET 200SP station, you can also use the light BaseUnit. However, you must wire the AS-i network explicitly using the connecting terminals.

The light BaseUnit Type C0 has no internal connection to the module plugged in on the left.

Use with dark BaseUnit Type C1

If you are using a combination of CM AS-i Master ST and F-CM AS-i Safety ST on the same AS-i network, use the dark BaseUnit. In this case, plug the CM AS-i Master ST module into a light BaseUnit Type C0. Next to it on the right, plug the F-CM AS-i Safety ST module into a dark BaseUnit Type C1.

In this case, connect the AS-i network to the light BaseUnit. The dark BaseUnit does not have to be connected to the AS-i network because the connection is made automatically via the BaseUnit group.

In contrast to other BaseUnit types, for the BaseUnits Type C0 and Type C1, the P1 and P2 busbars of the BaseUnit are electrically isolated from the front panel connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-). An electrical connection is made in each case via the plugged-in CM AS-i Master ST module or F-CM AS-i Safety ST module.

The AS-i voltage connected to the light BaseUnit Type C0 is applied through the plugged CM AS-i Master ST module to the busbars. The busbars of the BaseUnit group are connected-through. The F-CM AS-i Safety ST module is supplied with AS-i voltage via the busbars of the dark BaseUnit Type C1. It is not permitted to continue the AS-i voltage from the front panel connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) of the dark BaseUnit because this type of current draw can cause an overload in the modules.

If you want to maintain the voltage supply of the F-CM AS-i Safety ST module when the CM AS-i Master ST module is unplugged from the light BaseUnit, you can wire an external connection of the connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) between the light BaseUnit Type C0 and the dark BaseUnit Type C1.

Grouping of a light BaseUnit Type C0 with several dark BaseUnits Type C1

The use of a single F-CM AS-i Safety ST module on an AS-i network is generally sufficient. If several F-CM AS-i Safety ST modules are being used on an AS-i network by means of series connected dark BaseUnits Type C1, you must wire an external connection of the connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) between the light BaseUnit Type C0 and a dark BaseUnit Type C1. This will prevent an overload of the modules. A current draw from the dark BaseUnit is not allowed. Additional information about this can be found in "Use with dark BaseUnit Type C1".

General terminal assignment

Table 4- 1 Terminal assignment of the F-CM AS-i Safety ST

Terminal	Assignment	Description
1	TEACH1	Connection of the "TEACH" button (optional) See Section Code sequences (Page 75).
2	TEACH2	
3	RES	Reserved
4	RES	Reserved
5	RES	Reserved
6	RES	Reserved
1L, 2L[1)]	ASI+	Dark BaseUnit Type C1: optional connection of the AS-i cable, positive polarity Light BaseUnit Type C0: connection of the AS-i cable, positive polarity
1N, 2N [1)]	ASI-	Dark BaseUnit Type C1: optional connection of the AS-i cable, negative polarity Light BaseUnit Type C0: connection of the AS-i cable, negative polarity

1) The terminals are connected through in the BaseUnit.

Connecting an external "TEACH" button

You can connect a "TEACH" button to the "TEACH1" and "TEACH2" terminals of the F-CM AS-i Safety ST module. The "TEACH" button enables the transfer of code sequences of the connected safe AS-i input slaves. This function is activated by closing the button contact on the TEACH1 and TEACH2 terminals.

The maximum cable length between the terminal and "TEACH" button is 0.5 m.

Use two wires routed in parallel for connecting the button (not included in the scope of delivery).

Additional rules and instructions for operating the ET 200SP with fail-safe modules

Observe generally the information in Section "Connecting" in the following documentation:

- Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
- Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en)

The conditions for connecting sensors and actuators to the modules of the ET 200SP also apply generally to the connecting of sensors and actuators to the slaves and modules of the AS-i network.

In addition, the information in the documentation of the AS-i component applies.

Ensure that all components of the AS-i network are connected in such a way that the voltage applied to the safety-related AS-i modules is limited to a maximum of 40 V.

The ET 200SP modules CM AS-i Master ST and F-CM AS-i Safety ST have internal safe electrical isolation from the backplane bus of the ET 200SP.

Power supply units for AS-Interface

A connected power supply unit must have the following properties:

- Rated output voltage 30 V DC (AS-Interface Standard) or 24 V DC (AS-i Power24V)
- PELV/SELV (Protective/Safety Extra-Low Voltage) standard
- Residual ripple < 250 mVpp
- Limiting of output voltage to a maximum of 40 V in the event of a fault, including a second fault.

The Siemens power supply units for AS-Interface meet these requirements. For additional information, refer to the operating instructions of the power supply unit.

Use an AS-Interface power supply unit with integrated data decoupling or a combination of a power supply unit that meets the above-indicated requirements and an AS-i data decoupling unit.

In the following text, the expression "AS-i power supply unit" stands, unless described otherwise, for an AS-Interface power supply unit with integrated data decoupling or a combination of a power supply unit and an AS-i data decoupling unit.

When AS-i Power24V is used, there are limitations on the cable length (max. 50 m AS-i cable) and usability of AS-i components and connected sensors/actuators due to the reduced voltage.

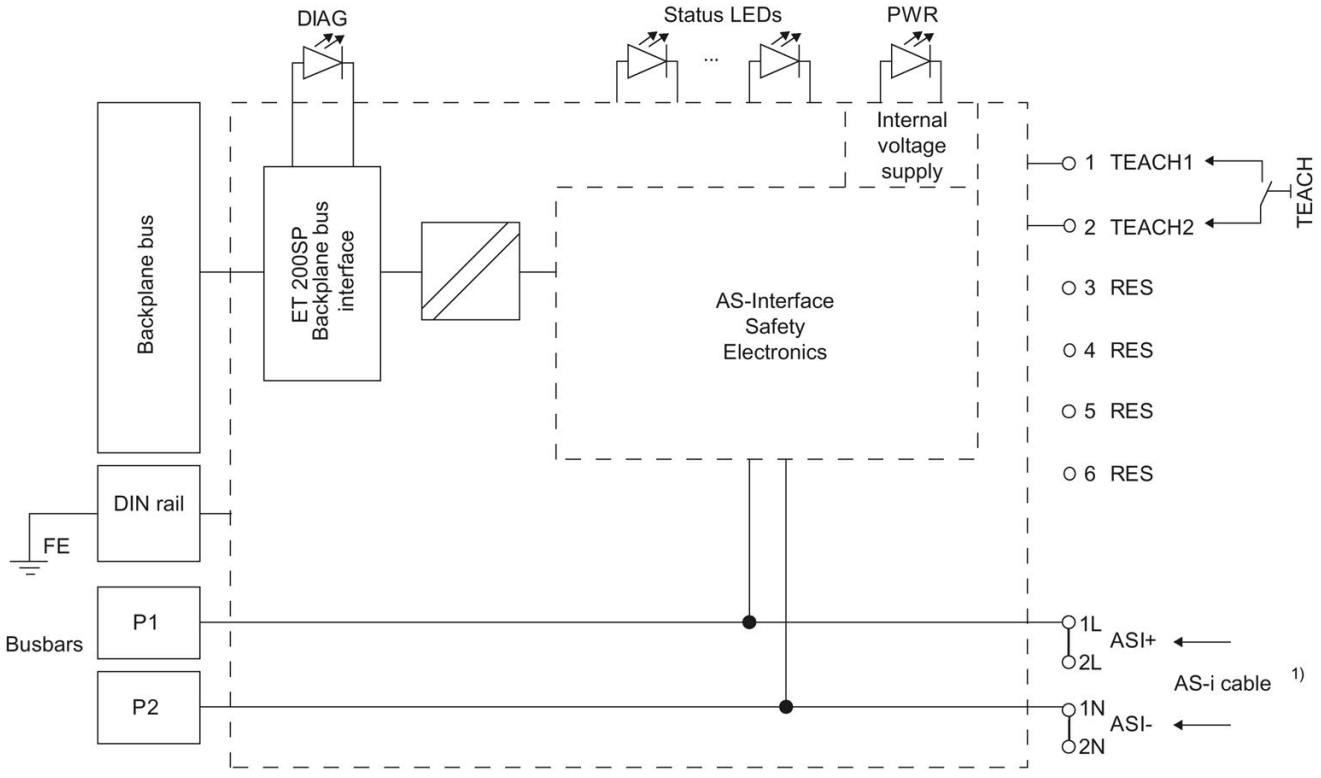
Use a PELV / SELV power supply when operating the F-CM AS-i Safety ST module on PROFIsafe.

Additional notes:

- AS-Interface System Manual (http://support.automation.siemens.com/WW/view/en/26250840/0/en)
- FAQ "Compatibility for AS-i Power24V" (http://support.automation.siemens.com/WW/view/en/20025980/133000)

4.2 Schematic circuit diagram

Schematic circuit diagram



1) AS-i cable: Connection not applicable for dark BaseUnit

Figure 4-1 Schematic diagram of F-CM AS-i Safety ST

Connection to busbars

Requirement:

- An AS-i power supply unit is connected to the light BaseUnit Type C0 of the BaseUnit group.
- A CM AS-i Master ST module is plugged into the light BaseUnit.

If you plug an F-CM AS-i Safety ST module into a dark BaseUnit Type C1, the F-CM AS-i Safety ST module will be automatically supplied with AS-i voltage via the busbars.

It is not permitted to continue the AS-i voltage from the front panel connecting terminals 1L, 2L (ASI+) and 1N, 2N (ASI-) of the dark BaseUnit because this type of current draw can cause an overload of the modules.

Note the additional explanations in Section Terminal assignment (Page 27).

Configuring

5

5.1 Configuring the F-CM AS-i Safety ST

Notes on configuration

You configure the ET 200SP station and its F-CM AS-i Safety ST module and assign their parameters with *STEP 7*.

There is currently no provision for configuration via a GSD file, because the GSD configuration procedure does not permit safety-related parameter assignment (according to PROFIsafe Specification V2.4).

Note

F-CM AS-i Safety ST in the hardware catalog of *STEP 7*

If the F-CM AS-i Safety ST module is not listed in the hardware catalog of *STEP 7* , you will need a "Hardware Support Package". This HSP can be obtained from the Internet using the corresponding function in *STEP 7*.

Note

Operation under S7 F systems is not approved.

Note

The data exchange with "F-DX-MOD" is not supported.

Software for configuration of the F-CM AS-i Safety ST

Configuration software	Requirements	Installation information
STEP 7 (classic) V5.5 SP3 HF4 or higher with Distributed Safety	Hardware Support Package HSP 2093[1)] Internet	Online Help for *STEP 7*
STEP 7 (classic) V5.5 SP4 or higher with Distributed Safety		
STEP 7 (TIA Portal) V13 or higher with Safety Advanced	Hardware Support Package HSP 70[1)] Internet (http://support.automation.siemens.com/WW/view/en/29156492/133100)	
STEP 7 (TIA Portal) V14 or higher with Safety Advanced / Basic		

[1)] Download optional, if not already contained in the hardware catalog

Note

Observe the online help on *STEP 7*.

The "S7 F-Configuration Pack" can be found on the Internet (http://support.automation.siemens.com/WW/view/en/15208817).

Procedure

1. Assign the parameters of the F-CM AS-i Safety ST module according to your safety application.
2. Configure the AS-i Master in such a way that it includes all AS-i slaves in the communication – including the control addresses for safe AS-i outputs that are activated in the F-CM AS-i Safety ST module.
3. Download the hardware configuration to the PLC-CPU.
4. Assign the associated F-address to the F-CM AS-i Safety ST module.
5. Start the teaching and transferring of the code sequences of the safe AS-i input slaves.
6. Create the safety program in the F-CPU.
7. Test your application.

Information concerning these steps can be found in the following sections and in the manuals of the utilized devices.

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage
Observe instructions in the programming and operating manuals

Observe the instructions in the manuals.

- Programming and Operating Manual SIMATIC Safety - Programming and Configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
- Programming and Operating Manual S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

See also

HSP WinCC "classic" (http://support.automation.siemens.com/WW/view/en/23183356)

5.2 Safety-related communication with AS-Interface

5.2.1 Operating principle of code sequences of safe AS-i slaves

For realization of safety-related communication, each safe AS-i input slave sends a code sequence over the AS-i bus. To prevent a mix-up of the AS-i input slaves on an AS-i bus, each AS-i input slave sends a different code sequence. The code sequences are permanently stored in the AS-i input slave.

The F-CM AS-i Safety ST module checks every code sequence for correct data content. Depending on the result of the evaluation, the module sets the the safe input image.

During initial commissioning, the F-CM AS-i Safety ST module must teach the code sequences of all safe AS-i input slaves present on the AS-i bus and transfer them to non-volatile memory. In so doing, the module detects both the slaves for which input monitoring is activated as well as the other safe input slaves.

After replacement of a safe AS-i input slave, the new code sequence must be taught and saved.

If the code sequence is not saved for a safe AS-i input slave, or if the code sequence does not correspond to the saved code sequence, the input channel will be passivated and assigned the substitute value "0".

As soon as the F-CM AS-i Safety ST module detects a new code sequence, the code sequences are automatically taught. Confirm the transfer of the code sequences into the memory to prevent unauthorized changes to the AS-i component.

You will find more information about teaching code sequences, and the LED behavior, in Section "Code sequences (Page 75)".

You can find a description of the individual parameters in the Section "Process signal errors (Page 20)".

5.2.2 Operating principle of the safe AS-i outputs

Safety-related communication for safe AS-i outputs also uses code sequences. However, they have a different data structure compared to the code sequences of safe AS-i input slaves. The code sequences for safe AS-i outputs do not have to be taught and transferred.

For the function of a safe AS-i output, you need the following components:

- A control unit
- An evaluation unit

Control unit

The control unit outputs safety-related IN or OUT control commands to the AS-i bus. The control unit is integrated in the F-CM AS-i Safety ST module. The control unit assumes an active position in the communication. It acts like an AS-i slave and has an AS-i address that must be called by the AS-i master. The values in the output data of the AS-i master are not relevant in this case. The F-CM AS-i Safety ST module inserts the safety-related control data into the communication data.

Besides controlling the OFF state according to specification, a control unit can control up to four different output switching states: F-OUT 1, F-OUT 2, F-OUT 3, and F-OUT 4. The F-CM AS-i Safety ST module, however, makes available only the output switching state F-OUT 1, i.e., The OFF and ON states are controlled.

In addition to the switching states, a control unit can send out two different auxiliary signals: AUX1 and AUX2. You can use these auxiliary signals for error acknowledgement in the evaluation unit. For technical reasons, the AUX1 and AUX2 signals are mapped in the safe process image output. The auxiliary signals are not safety-related signals, however. During control by the safety program, the F-CM AS-i Safety ST module sends a sequence from each auxiliary signal one after the other on the AS-i bus. Up to 16 different control units can be activated in the F-CM AS-i Safety ST module. The control units are managed in the F-CM AS-i Safety ST module as switching group 0 to switching group 15.

If you want to use more than 16 different control units, you can plug two F-CM AS-i Safety ST modules into the ET 200SP station.

Observe the information on the bus configuration in Section AS-i bus configuration with multiple F-CM AS-i Safety ST modules (Page 38).

NOTICE
Uniqueness of the AS-i address on the AS-i bus
Carefully check the AS-i addresses for the control of the safe AS-i outputs. Ensure that the assigned AS-i address exists only once on the AS-i bus. This is particularly important when you are using multiple devices that can control safe AS-i outputs on the same AS-i bus. If this is not observed, reliable shutdown of a safe output module is not guaranteed.

Evaluation unit

The evaluation unit reads the safety-related control commands ON or OFF on the AS-i bus and passes corresponding switching commands, e.g., to switching contacts. In case of error, e.g., communication error on the AS-i bus, the evaluation unit switches off. The evaluation unit is integrated in the safe AS-i output module to which, for example, drive contactor coils are connected. The evaluation unit behaves as a passive unit in the AS-i communication. The master does not detect the evaluation unit and does not call it. The evaluation unit monitors the communication of the AS-i address of the control unit and reacts to its safety-related control signals.

You set the AS-i address (see Section "Control unit") the evaluation unit is to monitor.

You can set multiple evaluation units to the same address so that a control unit can control multiple safe output modules simultaneously.

NOTICE
Bus cycle time for safe AS-i outputs An evaluation unit requires a minimum AS-i bus cycle time. Ensure that at least 5 AS-i addresses are present on the AS-i bus. Otherwise, the control unit goes to error state. When A/B slaves are used, at least 5 different numerical AS-i addresses must be present. That is, a combination of slave addresses 1A and 1B count as 1 numerical address. The F-CM AS-i Safety ST module does not have a monitoring function for this configuration rule.

5.3 AS-i bus configuration with multiple F-CM AS-i Safety ST modules

The F-CM AS-i Safety ST module generates an additional physical bus load on the AS-i cable.

To avoid faults due to too low levels of the communication signals on the AS-i cable, the entire bus load on the AS-i cable must not exceed a maximum value.

The following rules apply to the determination of the physical bus load on the AS-i cable:

Device type	Bus load value
Slave with A/B address	0.5
Slave with standard address	1.0
F-CM AS-i Safety ST module	2.5
---	---
Maximum value as sum of all devices	35.0
---	---

Determine the total bus load by adding the bus load values of the components connected to the AS-i cable. You do not have to include the standard AS-i master and AS-i power supply unit system components when calculating the bus load.

To avoid disturbances, the maximum bus load must not exceed the value 35.

The bus load value of the F-CM AS-i Safety ST module remains unchanged if switching groups are activated in the F-CM AS-i Safety ST module for control of safe outputs. In other words, the internally generated AS-i addresses do not influence the bus load value.

If you connect additional components, e.g., an MSS 3RK3 modular safety system, to the AS-i cable, you must take into consideration the bus load values of these components. For more detailed information, refer to the relevant manual.

When a repeater is used, this yields multiple cable segments for which the bus load can be determined separately.

The following configuration examples result from the table:

- In a fully expanded AS-Interface network configuration (with 31 slaves with standard address), you can install 1 F-CM AS-i Safety ST module.
- In an AS-Interface network configuration with 30 slaves with standard address, you can install 2 F-CM AS-i Safety ST modules.

5.4 Configuring with STEP 7 (classic)

With *STEP 7* (classic) the F-CM AS-i Safety ST module is configured independently of the configuration of further ET 200SP modules, e.g. CM AS-i Master ST.

If a safe AS-i slave, which is not available on the connected AS-i network, is configured on the F-CM AS-i Safety ST module, then this configuration error is not recognized when compiling the configuration. The F-CM module does not report that the slave cannot be detected until operation is in progress or code sequences are being read.

5.5 Configuring with the TIA Portal

TIA Portal V13 SP1

With TIA Portal V13 SP1, an F-CM AS-i Safety module can only be configured in combination with an AS-i master, necessitating the configuration of the AS-i slaves in STEP 7.

The AS-i subnet of the AS-i master, including the configured AS-i slaves, must be linked to the configuration with the F-CM.

The safety parameters of the AS-i input slaves are set in the properties window of the AS-i slaves.

TIA Portal V14 or higher

From TIA Portal V14 onwards, an F-CM AS-i Safety module can be configured:

- In combination with an AS-i Master, necessitating the configuration of the AS-i slaves in STEP 7. The AS-i subnet of the AS-i master, including the configured AS-i slaves, must be linked to the configuration with the F-CM.
  The safety parameters of the AS-i input slaves are set in the properties window of the AS-i slaves.
- Regardless of an AS-i master, i.e. no configuration of the AS-i slaves in STEP 7 is required. In this case, the parameters of the AS-i input slaves are set in the properties window of the F-CM AS-i Safety ST module.

In the case of safe inputs/outputs, the "Configuration status" output field in the properties of the F-CM reports whether the configuration of the F-CM is compatible with the configuration of the connected AS-i subnet. If a safe AS-i slave, which is not available on the connected AS-i network, is configured on the F-CM module, then the compilation of the configuration is nevertheless still possible. During operation or when reading the code sequences, however, the F-CM module reports that the slave cannot be detected.

The affected input address is passivated.

Configuration of safe AS-i outputs

The F-CM module contains a control unit for the safe AS-i outputs, see Section "Functional principle of the safe AS-i outputs (Page 36)".

TIA Portal V13 SP1

When configuring with TIA Portal V13 SP1, this control unit is not visible in the network view on the AS-Interface subnet of the AS-i master. The configuration of the F-CM module, however, is always combined with the AS-i master.

TIA Portal V14 or higher

In TIA Portal V14 or higher, the control unit must additionally be configured as a virtual slave on the AS-i subnet of the master, in the event that the AS-i slaves are configured in STEP 7.

A virtual slave is inserted automatically if a safe AS-i output is activated in the properties of the F-CM module and the F-CM module is already linked with the AS-i subnet. If necessary, by using the "Add AS-i Slave to AS-i network" button, the virtual slave can be inserted in the properties of the F-CM module under "Safe outputs". If no AS-i subnet is connected to the F-CM when the "Add AS-i slave to AS-i network" button is actuated, a subnet is automatically inserted.
The virtual slave can be managed like any other slave on the subnet, which means that all AS-i slave addresses existing in the AS-i subnet are visible. The virtual slave can be deleted if the control of the safe AS-i output is no longer required.

If necessary, the virtual slave can also be inserted straight from the hardware catalog (3RK7136-6SC00-0BC1F-DQ) into the subnet of the master.

Note

The virtual slave 3RK7136-6SC00-0BC1F-DQ is not a hardware module that is connected to the AS-i cable, but only a tool for the configuration of the AS-i master. The AS-i address assigned to the virtual slave 3RK7136-6SC00-0BC1F-DQ is emulated in the F-CM AS-i Safety module as soon as the corresponding safe output is activated in the properties of the F-CM.

If the AS-i master is engineered without configuring the AS-i slaves in STEP 7, i.e. either configuration of the AS-i slaves via the "SET" button or via the control panel in the TIA Portal, then the secure outputs in the F-CM must be configured and must have been loaded into the station before the configuration of the AS-i slaves is read into the master by means of the "SET" button or via the control panel in the TIA Portal.

Assigning parameters / Setting the address space 6

6.1 Parameters

List of parameters

Table 6- 1 F-parameters

Parameter	Value range	Default setting	Parameter reassignment in RUN	Scope
F-monitoring time (ms)	1 … 65534 ms	150 ms	No	F-CM AS-i Safety ST
F-source address	1 … 65534	Assigned by the F-system	No	F-CM AS-i Safety ST
F-destination address	1 … 65534	Is suggested by the F-system	No	F-CM AS-i Safety ST

For information on the F-parameters and the assignment of the F-address, refer to the Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

Table 6- 2 Potential group / AS-i network

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
BaseUnit with AS-i voltage supply	Potential group: The AS-i network of the left module (dark BaseUnit) is used New potential group: New AS-i network (light BaseUnit)	The AS-i network of the left module (dark BaseUnit) is used	No	F-CM AS-i Safety ST

Table 6- 3 Module parameters: Behavior after channel faults

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Behavior after channel faults	Passivate the channel (setting cannot be changed).	Passivate the channel	-	F-CM AS-i Safety ST

Safe inputs

Up to 31 safe AS-i input slaves are monitored. Open the settings for each required AS-i address. Activate the input monitoring and assign the parameters.

Table 6- 4 Module parameters: Safe inputs, AS-i address 1 to 31

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Activate input monitoring	• Disable • Enable	Disable	No	If this parameter is not activated, none of the following settings are possible.
I address	Output field, value is calculated automatically	-	No	Channel / safe AS-i input slave
Input delay (ms)	0 ms, 50 ms … 150 ms[1)]	0 ms	No	Channel / safe AS-i input slave
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent	1oo2 evaluation	No	Channel / safe AS-i input slave
Startup test	• Disable • Enable	Disable	No	Channel / safe AS-i input slave
Discrepancy monitoring	• Disable • Enable	• "Disable" if 1oo1 evaluation • "Enable" if 1oo2 evaluation	No	Channel / safe AS-i input slave
Discrepancy behavior	Supply "0" value[2)]	Supply "0" value	-	Channel / safe AS-i input slave
Discrepancy time infinite	• Disable • Enable	Disable	No	Channel / safe AS-i input slave
Discrepancy time (ms)	0 ms … 60 000 ms	500 ms	No	Channel / safe AS-i input slave
Sequence monitoring	• Deactivated • In ascending order (input 1 before input 2 at HIGH state) • In descending order (input 2 before input 1 at HIGH state)	Deactivated	No	Channel / safe AS-i input slave

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Reintegration after discrepancy error	Test 0 signal necessary on both channels[2)]	Test 0 signal necessary on both channels	-	F-CM AS-i Safety ST
Configuration status	-	-	-	(read-only)

1) In increments of 10 ms

2) The setting cannot be changed.

Safe outputs

You can activate up to 16 safe AS-i switching groups Open the settings for each required switching group. Activate the output control and set the associated AS-i address.

Table 6- 5 Safe outputs: Switching group 0 to 15

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Activate output control	• Disable • Enable	Disable	No	If this parameter is not activated, none of the following settings are possible.
AS-i address	1 … 31		No	Channel / safe AS-i output slave
AS-i address switching output	Output field, value is calculated automatically	-	No	Channel / safe AS-i output slave
AS-i address error acknowledgement	Output field, value is calculated automatically	-	No	Channel / safe AS-i output slave
Configuration status	-	-	-	(read-only)

You will find additional information in the Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

6.2 Explanation of the parameters

6.2.1 F-parameters

Specify F-destination address for F-I/O of the PROFIsafe address type 2

The F-destination address of F-I/O of the PROFIsafe address type 2 is automatically assigned for every F-CPU.

F-source address

With the parameter "Central F-source address" you specify the F-source address for the F-I/O of the PROFIsafe address type 2 assigned to this F-CPU. The F-source address must be unique throughout the network.

Note

A change to the parameter "Central F-source address" results in a modification to the safety program when it is recompiled. A new acceptance may therefore be required, as this centrally modifies the F-source address of all F-I/O devices of address type 2 retrospectively.

See also

S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126/0/en)

6.2.2 Potential group / AS-i network

Here, you set:

- The BaseUnit you are using.
- How the F-CM AS-i Safety ST I/O module is connected to the AS-i network.

The module can be connected to the AS-i cable by external wiring or automatically via the module plugged in on the left.

- Enable new AS-i network (light BaseUnit)
- Use AS-i network of the left module (dark BaseUnit)

BaseUnit with voltage supply

Enable new AS-i network (light BaseUnit)

Select this option if the module is plugged into a light BaseUnit.

Connect the module to the AS-i cable (ASI+ / ASI-) via the BaseUnit. The module is supplied with voltage from the AS-i cable. Connect the AS-i cable to an AS-i power supply unit or to a combination of a data decoupling unit and a suitable power supply unit.

There is no module-internal connection of the AS-i cable to the module plugged in on the left.

With TIA Portal or with STEP 7 (classic) the F-CM AS-i Safety module is configured independently of the configuration of the module inserted on the left (normally: CM AS-i Master ST).

WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to AS-i power supply units that meet the requirements named in Section Terminal assignment (Page 27), "Power supply units for AS-Interface". Connection to higher voltage may result in death, severe injury, and serious property damage.

Use AS-i network of the left module (dark BaseUnit)

Select this option if the module is plugged into the dark BaseUnit.

The module inserted on the left must be a CM AS-i Master ST module (normal situation) or another F-CM AS-i Safety ST module (special case).

The module is connected to the AS-i cable of the module plugged in on the left and supplied with voltage via the module-internal connection.

The module-internal connection is designed only for supplying power to the F-CM AS-i Safety ST I/O module. If several dark BaseUnits are connected in series, a direct connection of the dark BaseUnits to the AS-i cable using external wiring is additionally recommended.

Supplying power to AS-i modules, e.g., AS-i slaves, via the terminals of the dark BaseUnit is not permitted.

With TIA Portal, the F-CM AS-i Safety ST module uses the same AS-Interface subnet as the module inserted on the left (normally: CM AS-i Master ST).

With STEP 7 (classic) the F-CM AS-i Safety module is configured independently of the configuration of the module inserted on the left (as a rule: CM AS-i Master ST).

WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to AS-i power supply units that meet the requirements named in Section Terminal assignment (Page 27), "Power supply units for AS-Interface". Connection to higher voltage may result in death, severe injury, and serious property damage.

6.2.3 Module parameters - General

Behavior after channel faults

This parameter is permanently set to "Passivate the channel".

After channel faults have occurred, only the faulty PROFIsafe channels are passivated. The PROFIsafe channel corresponds to the safe input and output address in the process image.

6.2.4 Module parameters - Safe inputs

Configuration status

A valid evaluation is only possible if a compatible safe AS-i slave is actively operating on the network.
Input monitoring where there is a missing safe input or a missing AS-i slave causes a passivation of the input address. If no configuration of the slaves is saved in the STEP 7 project, the settings of the AS-i master must ensure that the connected compatible safe AS-i slave is actively operating, for example, using the "SET" button of the master.

Input monitoring activated

With activation of the input monitoring, you activate the corresponding AS-i slave as an input channel for signal processing in the safety program. The AS-i address must be assigned to a safe AS-i input slave.

When the input monitoring is activated, the value of the input channel is calculated based on the input states of the assigned safe AS-i input slave and the evaluation conditions specified by the parameter assignment. If a fault occurs, the substitute value "0" is transferred and the channel is passivated.

If input monitoring is deactivated, the substitute value "0" is transferred. The channel is not passivated.

If required, the AS-i slave can be monitored by another evaluation module, e.g., by another F-CM AS-i Safety ST module, the 3RK3 Modular Safety System. This applies both when input monitoring is deactivated and when it is activated.

Note

Call of the AS-i slave

The AS-i slave must be called by the AS-i master. Set up the configuration of the AS-i master in such a way that the communication of the AS-i master with the AS-i address functions properly.

Note

Slave profile

A safe AS-i input slave has the slave profile (IO.ID) = 0.B or 7.B.

I address

The input bit address of the input channel for the signal processing in the safety program is indicated here. It is calculated automatically from the start of the inputs entered on the "Addresses" tab.

Input delay

To suppress coupled-in interference or brief switching pulses, you can set an input delay for each AS-i slave. This will suppress interference pulses whose pulse time is less than the set input delay, in ms. The input delay applies to both channels of the channel pair of the AS-i slave.

Note

Time of fault suppression shortened by up to 75 ms

It can take 15 AS-i cycles until the valid code sequence is detected. As a result, the time of the fault suppression is shortened by up to 75 ms compared to the set value.

A long input delay suppresses longer interference pulses but results in a longer response time.

Range of values:	0 to 150 ms
Default	0 ms

The values 0, 50 to 150 ms can be selected in 10 ms increments.

The input delay time acts in addition to the system response time. Suppressed interference pulses are not visible in the safety program.

Evaluation of the sensors

This parameter specifies how the connected sensors are to be evaluated.

1oo1 evaluation

In 1oo1 evaluation, the sensor exists once and is connected to the first input of the safe AS-i slave via a single channel. You jumper the second input of the AS-i slave. Instead of the jumper, you can also connect another single-channel sensor to the second input. Only when both inputs supply an ON signal does the F-CM AS-i Safety ST module transfer the "1" value to the safety program (the two inputs are ANDed).

The individual states of the two inputs of the AS-i slave are not visible in the safety program.

A discrepancy analysis is not performed in 1oo1 evaluation.

1oo2 evaluation, equivalent

In 1oo2 (2v2) evaluation, equivalent, both inputs of the safe AS-i slave are occupied by one two-channel sensor or by two single-channel sensors. The two single-channel sensors then belong together functionally as a pair.

The input signals are compared internally for equivalence. The two inputs of the AS-i slave are combined to form a channel pair.

A discrepancy analysis is possible in 1oo2 evaluation, equivalent.

Discrepancy analysis

If you are using a two-channel sensor or two single-channel sensors that acquire the same physical process variable, the sensors will, for example, respond with a delay due to the limited accuracy of their arrangement to each other. For fail-safe inputs, the discrepancy analysis for equivalence is used to infer errors from the time characteristic of two signals of the same functionality. For two associated input signals, if different levels are detected after the input delay time has expired, the discrepancy analysis is started. A check is made to determine if the difference has disappeared after expiration of an assignable time period, the so-called discrepancy time. If not, there is a discrepancy error.

Startup test

If the "Startup test" parameter is activated, after startup of the channel or after a cross-circuit error (code sequence error), the value transferred to the safety program is kept at the substitute value "0" until the connected sensor has been correctly actuated at least once. Afterwards, the value of the input channel is calculated according to the set functionality.

The actuation of the sensor is defined to mean that both inputs of the safe AS-i slave must supply an ON signal, e.g., both switching contacts of the sensor are closed. Then, they must supply an OFF signal, e.g., switching contacts open. Finally, an ON signal must be supplied again, e.g., switching contacts closed. During the sensor actuation phase, none of the following errors may occur:

- Discrepancy error
- Sequence error
- Cross-circuit error (code sequence error)

After reintegration is complete, you must perform a startup test. For this purpose, you actuate the sensor to be monitored once.

A discrepancy error or a sequence monitoring error does not trigger a new startup test.

Discrepancy monitoring

If the discrepancy monitoring is activated, a discrepancy analysis is performed. This is the normal setting for 1oo2 evaluation, equivalent, in order to achieve high error uncovering.

You can deactivate the discrepancy monitoring for special situations. This corresponds in principle to 1oo1 evaluation of sensors. Check whether the lower error uncovering is sufficient for the required safety level. You may possibly use a sensor with integrated error uncovering. If required, you can activate the sequence monitoring.

When 1oo2 evaluation of the sensors is set, discrepancies in signal states between input 1 and input 2 are monitored.

When discrepancy monitoring is activated, the discrepancy time starts to elapse as soon as a difference is detected between the signal on input 1 and the signal on input 2. If the set discrepancy time is exceeded and the difference continues to exist, a discrepancy error is triggered.

Before switch-on, the signal value 0 must be present at both inputs, even when a discrepancy error has not occurred or the discrepancy time has not been set to "infinite".

If the "Evaluation of the sensors" parameter has been assigned with 1oo1, discrepancy monitoring is not performed.

Discrepancy behavior

This parameter is permanently set to "Supply 0 value".

The discrepancy behavior determines the value that is made available to the safety program in the F-CPU during the discrepancy, i.e., while the discrepancy time is running.

After expiration of the set input delay time, once an "OFF" signal is detected at one of the two input channels of the channel pair involved, this parameter setting causes the value "0" to be provided to the safety program in the F-CPU. This setting does not affect the sensor-actuator response time as a result of the discrepancy time.

Discrepancy time infinite

If you activate "Discrepancy time infinite", the time period for the discrepancy analysis never expires. As a result, a time-related discrepancy error will not be detected.

Nevertheless, the following switch-on condition applies: After a channel has been switched off, a "0" signal must be read in simultaneously at both input channels of the relevant channel pair before the channel can be switched on again.

If this condition is not satisfied, especially in the event of a single-channel switch-off (i.e., signal OFF at only one of the two input channels of the relevant channel pair) followed by a change to signal ON at both input channels, a discrepancy error will be detected at the time of the change to signal ON (at both input channels) even though the time for the discrepancy analysis has not expired. In data record 202, the bit 0.2 "= 1" is set in the status of the input monitoring of AS-i address n.

A discrepancy error is only detected if both input channels of the affected channel pair have not received the "0" signal simultaneously.

If "Discrepancy time infinite" is deactivated, the discrepancy analysis uses the value set for the "Discrepancy time" parameter.

Discrepancy time

You can specify the discrepancy time in the range of 0 to 60 000 ms for each channel pair.

The following settings are required:

- "Sensor evaluation": 1oo2 evaluation, equivalent
- "Discrepancy monitoring": Active
- "Discrepancy time infinite": Deactivated

In most cases, the discrepancy time is started but does not completely elapse, because the signal differences are evened out again after a short time.

Select a large enough discrepancy time so that in error-free cases, the difference between the two signals always disappears before the discrepancy time expires.

If the input signals do not match after expiration of the assigned discrepancy time, e.g., due to a mechanical defect of the sensor or sensor wire break, a discrepancy error is detected.

When discrepancy time is running, the switch-on condition also applies that after a channel has been switched off, a "0" signal must be read in simultaneously at both input channels of the relevant channel pair before the channel can be switched on again. If this condition is not satisfied, especially in the event of brief switch-off of a channel (due to signal OFF at only one of the two input channels) followed by a change to signal ON at both input channels, a discrepancy error will be detected at the time of the change to signal ON (at both input channels) if the time for the discrepancy analysis has not expired.

A detected discrepancy error indicates to the user that the switch-on condition is not satisfied.

Assign a discrepancy time that is greater than the input delay time.

Sequence monitoring

Overview

The sequence monitoring monitors the sequence of the signals of the channel pair when there is a signal change OFF >>> ON at the inputs of the safe AS-i slave.

The following settings are possible:

- Deactivated: The sequence is not a condition that has to be satisfied for switching on the function output.
- Ascending order: Input 1 before input 2 at "HIGH" state
- Descending order: Input 2 before input 1 at "HIGH" state

If the sequence is violated, the "Sequence condition violated" error is detected. The value transferred to the safety program is kept at "0" until the "OFF" signal is read in at both input channels. Switch-on condition is, for example, both switching contacts of the sensor open. The inputs must be switched on one after the other in the assigned sequence and must not switch on simultaneously.

You can activate the sequence monitoring if 1oo2 evaluation, equivalent, is set for the sensor evaluation. In this case, the discrepancy monitoring can be activated or deactivated.

Deactivated

The sequence of the inputs is not monitored.

Ascending order: Input 1 before input 2 at "HIGH" state

For switch-on of the channel, input channel 1 must first read in and hold an "ON" signal followed by input channel 2.

When the channel is switched off, the sequence of the input channels is not monitored.

Descending order: Input 2 before input 1 at "HIGH" state

For switch-on of the channel, input channel 2 must first read in and hold an "ON" signal followed by input channel 1.

When the channel is switched off, the sequence of the input channels is not monitored.

Reintegration after discrepancy error

This parameter is permanently set to: "Test 0-signal necessary on both channels".

A discrepancy error is not considered to be rectified until an "OFF" signal is present again at both input channels. Reintegration of the PROFIsafe channel is then possible.

6.2.5 Module parameters - Safe outputs

Configuration status

For operation of the switching group the AS-i master must activate communication with the associated AS-i address of the control unit in the F-CM. For this reason the configuration of the AS-i network must include a virtual AS-i slave with the profile IO.ID.ID2 = 6.B.D and ID1 = 0. If the slaves are not configured, the AS-i master must be set such that the AS-i address of the control unit in the F-CM is actively operating, for example, using the "SET" button of the master while the F-CM module is being configured and connected to the AS-i master.

Activate output control

With this parameter, you activate the corresponding switching group and the associated AS-i address of the control unit in the F-CM AS-i Safety ST module.

You will find additional information in Section Operating principle of the safe AS-i outputs (Page 36), "Operating principle of the safe AS-i outputs."

When output control is activated, the control unit in the F-CM AS-i Safety ST module is switched on so that the F-CM AS-i Safety ST module generates an additional AS-i address on the AS-i Bus. The associated value is output from the safe process image via this AS-i address.

When output control is deactivated, the corresponding control unit in the F-CM AS-i Safety ST module is switched off, and an AS-i slave is not emulated on the AS-i bus.

AS-i address

Here, you set the AS-i address within the range of 1 to 31 that the F-CM AS-i Safety ST module is to use for control of a safe AS-i output.

WARNING

Uniqueness of the AS-i address on the AS-i bus

Carefully check the AS-i addresses for the control of the safe AS-i outputs. Ensure that the assigned AS-i address exists only once on the AS-i bus. This is particularly important when you are using multiple devices that can control safe AS-i outputs on the same AS-i bus. If this is not observed, reliable shutdown of a safe output module is not guaranteed.

Note

Communication of the AS-i master with the AS-i address

The AS-i address of the control unit must be called by the AS-i master. Set up the communication of the AS-i master in such a way that communication with the AS-i address of the control unit functions properly.

Note

Slave profile of the control unit in the F-CM AS-i Safety ST module (control of a safe AS-i output)

The AS-i address of the control unit corresponds to a slave with slave profile (IO.ID.ID2) = 6.B.D and ID1 = 0.

Q address switching output

The output bit address is displayed here. It determines the switching state of the safe output (control signal F-OUT 1). Interconnect the "Q address switching output" in your safety program according to the required safety logic.

The output bit address is calculated automatically from the start of the outputs entered on the "Addresses" tab.

Q address error acknowledgment

The output bit address that sends an acknowledgment signal to the safe output is displayed here.

The output bit address is calculated automatically from the start of the outputs entered on the "Addresses" tab.

A positive edge (0 >>> 1) triggers the F-CM AS-i Safety ST module to first send the AUX1 auxiliary signal to the safe output followed by the AUX2 auxiliary signal. Another positive edge is necessary for sending another sequence of auxiliary signals.

The auxiliary signals are used, in general, for acknowledging an error state at the safe output. Refer to the AS-Interface (http://support.automation.siemens.com/WW/view/en/26250840/0/en) System Manual and the Operating Instructions of the safe output module (http://support.automation.siemens.com/WW/view/en/43666143/0/en) used to find out which functions the auxiliary signals are used for.

Note

"Q address error acknowledgment"

The "Q address error acknowledgment" does not trigger an error acknowledgment in the F-CM AS-i Safety ST module. Rather, as described above, it sends an acknowledgement signal to the safe output module on the AS-i bus.

See also

ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)

6.3 Address space

6.3.1 Address assignment for user data and value status of the F-CM AS-i Safety ST module

Input and output address assignment

Of the assigned addresses of the F-CM AS-i Safety ST module, the user data occupy the following addresses in the F-CPU:

Table 6- 6 Input address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
x + 0	DI0.7 AS-i address 7	DI0.6 AS-i address 6	DI0.5 AS-i address 5	DI0.4 AS-i address 4	DI0.3 AS-i address 3	DI0.2 AS-i address 2	DI0.1 AS-i address 1	DI0.0 Reserved
x + 1	DI1.7 AS-i address 15	DI1.6 AS-i address 14	DI1.5 AS-i address 13	DI1.4 AS-i address 12	DI1.3 AS-i address 11	DI1.2 AS-i address 10	DI1.1 AS-i address 9	DI1.0 AS-i address 8
x + 2	DI2.7 AS-i address 23	DI2.6 AS-i address 22	DI2.5 AS-i address 21	DI2.4 AS-i address 20	DI2.3 AS-i address 19	DI2.2 AS-i address 18	DI2.1 AS-i address 17	DI2.0 AS-i address 16
x + 3	DI3.7 AS-i address 31	DI3.6 AS-i address 30	DI3.5 AS-i address 29	DI3.4 AS-i address 28	DI3.3 AS-i address 27	DI3.2 AS-i address 26	DI3.1 AS-i address 25	DI3.0 AS-i address 24
x + 4	Value status for DI0.7	Value status for DI0.6	Value status for DI0.5	Value status for DI0.4	Value status for DI0.3	Value status for DI0.2	Value status for DI0.1	Reserved
x + 5	Value status for DI1.7	Value status for DI1.6	Value status for DI1.5	Value status for DI1.4	Value status for DI1.3	Value status for DI1.2	Value status for DI1.1	Value status for DI1.0
x + 6	Value status for DI2.7	Value status for DI2.6	Value status for DI2.5	Value status for DI2.4	Value status for DI2.3	Value status for DI2.2	Value status for DI2.1	Value status for DI2.0
x + 7	Value status for DI3.7	Value status for DI3.6	Value status for DI3.5	Value status for DI3.4	Value status for DI3.3	Value status for DI3.2	Value status for DI3.1	Value status for DI3.0
x + 8	Value status for DQ0.7	Value status for DQ0.6	Value status for DQ0.5	Value status for DQ0.4	Value status for DQ0.3	Value status for DQ0.2	Value status for DQ0.1	Value status for DQ0.0
x + 9	Value status for DQ1.7	Value status for DQ1.6	Value status for DQ1.5	Value status for DQ1.4	Value status for DQ1.3	Value status for DQ1.2	Value status for DQ1.1	Value status for DQ1.0
x + 10	Reserved							
...								
x + 15	Reserved							

X = Module start address

NOTICE
Process value "0" is transmitted as a non-safety related value Based on the transfer principle of the code sequences, the process value "1" is transferred via AS-Interface as a safe value, so that the enable for switching on a machine can be issued in a safety-related manner. If an error occurs during transfer of the value "1", this error is detected and substitute value "0" is used. The process value "0" is transferred via AS-interface as an unsafe value. That is, a faulty transmission of the "0" value cannot be detected. The "0" value must therefore not be used as safety-related information that initiates a dangerous action (e.g. feedback "0" of a switch position).

Table 6- 7 Output address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
x + 0	DQ0.7 Switching group 7	DQ0.6 Switching group 6	DQ0.5 Switching group 5	DQ0.4 Switching group 4	DQ0.3 Switching group 3	DQ0.2 Switching group 2	DQ0.1 Switching group 1	DQ0.0 Switching group 0
x + 1	DQ1.7 Switching group 15	DQ1.6 Switching group 14	DQ1.5 Switching group 13	DQ1.4 Switching group 12	DQ1.3 Switching group 11	DQ1.2 Switching group 10	DQ1.1 Switching group 9	DQ1.0 Switching group 8
x + 2	Error acknowledgment for DQ0.7	Error acknowledgment for DQ0.6	Error acknowledgment for DQ0.5	Error acknowledgment for DQ0.4	Error acknowledgment for DQ0.3	Error acknowledgment for DQ0.2	Error acknowledgment for DQ0.1	Error acknowledgment for DQ0.0
x + 3	Error acknowledgment for DQ1.7	Error acknowledgment for DQ1.6	Error acknowledgment for D1.5	Error acknowledgment for DQ1.4	Error acknowledgment for DQ1.3	Error acknowledgment for DQ1.2	Error acknowledgment for DQ1.1	Error acknowledgment for DQ1.0
x + 4	Reserved							
...								
x + 7	Reserved							

X = Module start address

The error acknowledgment bit initiates the AUX1 and AUX2 signals one after the other.

Note

Use of the error acknowledgment bit of a safe AS-i output

The values in the PROFIsafe process output image have Safety Integrity Level SIL 3. In addition to the switching states, a control unit can send out two different auxiliary signals to a safe AS-i output: AUX1 and AUX2. These auxiliary signals are not safety-related signals. You can use the auxiliary signals for error acknowledgement in the evaluation unit. For technical reasons, these error acknowledgment bits are mapped in the safe process output image. If error acknowledgment bits are sent to a safe AS-i output, the *STEP 7* or SIMATIC Manager configuration tool is unable to detect that the error acknowledgment bits are not safe. This means: No warnings or faults will be output for it when the safety application is generated. The user is responsible for the correct processing of these signals in the safety application.

6.3.2 Value status

Properties

For each input signal and output signal, the F-CM AS-i Safety ST module provides information about the signal's validity, i.e., the "value status". Like the input signal, the value status is stored in the process image.

Value status for the digital input and output modules

The value status is binary supplementary information of a digital input or output signal. It is entered in the process input image simultaneously with the process signal. The value status provides information regarding the validity of the input or output signal.

The value status is influenced by the following:

- Code sequence errors, e.g, caused by a permanent fault on the AS-i bus, wiring error, etc.
- Missing safe AS-i input slaves
- Channel faults
- Replacement of a safe AS-i slave by a non-safe AS-i slave
- Discrepancy error
- Sequence error

Value status = 1: A valid process value is output for the channel.

Value status = 0: A substitute value is output for the channel or the channel is deactivated.

Assignment of the inputs and outputs to the value status in the process image

A value status is assigned to each channel of the F-CM AS-i Safety ST module in the process input image.

Additional information

A detailed description of the evaluation and processing of the value status can be found in the Programming and Operating Manual SIMATIC Safety - Programming and Configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

See also

Address assignment for user data and value status of the F-CM AS-i Safety ST module (Page 54)

6.4 Data records for diagnostics

For diagnostic purposes, you can read out the following data records via your user program. In firmware V1.0.1 or higher the diagnostics data record 206 is available. This data record contains a summary of the information that is relevant for a comprehensive diagnosis via your user program.

Note

Use of the DS 206 for diagnostic purposes is recommended (firmware V1.0.1 or higher).

The data records 92, 202 and 204 are required for the diagnosis via the user program for a module with firmware V1.0.0. For reasons of compatibility, these data records also remain available in firmware V1.0.1 or higher.

See also

Firmware update (Page 24)

6.4.1 DS 92 Device-specific diagnostics

Meaning

Note

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

Data record 92 contains device-specific messages and information on the device function states of the F-CM AS-i Safety ST module.

For some events, the F-CM AS-i Safety ST module generates a diagnostic alarm.

The following applies for diagnostic alarms of the F-CM AS-i Safety ST module with firmware V1.0.0:

- The "Error code" column in the table below indicates which events are relevant here. If the associated bit changes in the data record, a diagnostic alarm with the indicated error code is generated (incoming alarm when bit changes to value "1" and outgoing alarm when bit changes to value "0").
- The text inside parentheses after the error code corresponds to the error text that is specified for the given error code according to the PROFIBUS Standard. Several error codes can be output. If no error code is specified ("-"), a diagnostic alarm is not generated.
- The diagnostic alarms in firmware V1.0.1 or higher are described in Section "DS 206 Diagnostic Data Record (Page 69)".

Table 6- 8 DS 92 device-specific diagnostics

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
0.0 … 0.7	Reserved	-	-
1.0 … 1.7	Reserved	-	-
2.0 … 2.7	Reserved	-	-
3.0 … 3.7	Reserved	-	-
4.0 … 4.7	Reserved	-	-
5.0 … 5.7	Reserved	-	-
6.0 … 6.7	Reserved	-	-
7.0 … 7.7	Reserved	-	-
8.0 … 8.7	Reserved	-	-
9.0 … 9.7	Reserved	-	-
10.0 … 10.7	Reserved	-	-
11.0 … 11.7	Reserved	-	-
12.0	Serious device fault	9 ("Error")	See Section Error statuses (Page 17)
12.1	Group error	24 ("Switch-off")	At least one error is present.
12.2	AS-i communication error	19 ("Communication error")	Failure of an AS-i slave configured in the F-CM AS-i Safety ST module or code sequence error
12.3	Group_Message_Device	-	At least one message about the device state is present, e.g., configuration missing.
12.4	Group_Message_Application	-	At least one message about the application state is present, e.g., startup test necessary, safety sensor tripped (Emergency Stop, protective door, etc.).

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
12.5 … 12.7	Reserved	-	-
13.0	Reserved	-	-
13.1	Device fault	24 ("Switch-off") 27 ("Unclear error")	See Section Error statuses (Page 17)
13.2	Parameter assignment error	24 ("Switch-off") 16 ("Parameter assignment error")	Parameter not permitted in configuration.
13.3	Process signal error	24 ("Switch-off") 27 ("Unclear error")	See Section Error statuses (Page 17)
13.4	Code sequence error	24 ("Switch-off") 26 ("External error")	A code sequence error can occur, for example, in case of: • Cross-circuit at the inputs • EMC problem Bit 18.0 is additionally set.
13.5	Logic error	24 ("Switch-off") 25 ("Safety-related switch-off")	A logic error can occur, for example, in case of: • Discrepancy error • Sequence error Bit 18.0 is additionally set.
13.6 … 13.7	Reserved	-	-
14.0	Downloading of module parameters is not yet complete	-	-
14.1	Reserved	-	-
14.2	Cyclic data exchange is active	-	-
14.3 … 14.7	Reserved	-	-
15 … 17	Reserved	-	-
18.0	Group error code sequence_Logic	24 ("Switch-off")	A code sequence error or logic error is present for at least one safe input. Bytes 90 … 91 contain the AS-i address of the first safe input for which the error is present.
18.1	Reserved	-	-
18.2	Group_Message_Input_Triggered	-	At least one monitored safe input has value status "0". Possible cause: • Startup test necessary • Safety sensor triggered Bytes 94 … 95 contain the AS-i address of the first safe input for which the value status "0" is present.
18.3 … 18.7	Reserved	-	-

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
19 … 21	Reserved	-	-
22.0 … 22.1	Reserved	-	-
22.2	Timeout	24 ("Switch-off") 8 ("Lower limit undershot")	An internal data processing error has occurred. The F-CM AS-i Safety ST module signals a device fault. Bit 13.2 is additionally set.
22.3 … 22.6	Reserved	-	-
22.7	AS-i slave failure	26 ("External error")	No communication is detected in the case of at least one monitored safe input slave or control unit for a safe AS-i output.
23.0 … 23.7	Reserved	-	-
24 … 25	Reserved	-	-
26.0 … 26.3	Reserved	-	-
26.4	Coding element error	24 ("Switch-off") 27 ("Unclear error")	A data error occurred or coding element is missing when a coding element is accessed. The F-CM AS-i Safety ST module signals a device fault.
26.5 … 26.7	Reserved	-	-
27 … 28	Reserved	-	-
29.0 … 29.7	Reserved	-	-
30 … 33	Reserved	-	-
34 … 35	Parameter assignment error object	-	Object number for which a parameter assignment error was detected. 0 = No error 1 … 31 = The number corresponds to the AS-i address of a safe input. 32 … 47 = A number 32 … 47 corresponds to the number of the switching group 0 … 15
36 … 37	Reserved	-	-
38.0	AS-i bus error	26 ("External error")	The AS-i data communication is interrupted, substitute values in the interconnection logic

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
38.1	AS-i parameter assignment error	26 ("External error")	In addition, the AS-i address of the affected AS-i slave with the lowest address is entered in byte 55. If an AS-i address of an output switching group is not included by the AS-i master in the data communication, this bit is set. A substitute value will be used instead.
38.2	AS-i configuration error	-	In addition, the AS-i address of the affected AS-i slave with the lowest address is entered in byte 39. This bit is set when SET ≠ ACTUAL on the AS-i bus, when, for example, an AS-i slave is missing. A substitute value will be used instead.
38.3	AS-i voltage too low	-	If the AS-i voltage is too low during operation, a serious device fault results.
38.4	Reserved	-	-
38.5	AS-i communication okay	-	-
38.6 … 38.7	Reserved	-	-
39	Incorrect AS-i address	-	AS-i address of the AS-i slave that the device has identified as faulty: 0 = No error 1 … 31 = AS-i slave address
40 … 47	Reserved	-	-
48.0	ASIsafe safe input active	-	As soon as safe AS-i slaves become monitored, this bit is set.
48.1	ASIsafe safe output active	-	If safe AS-i outputs are controlled, this bit is set.
48.2 … 48.7	Reserved	-	-
49.0	ASIsafe code sequences missing	26 ("External error")	Safe input In addition, the AS-i address is entered in byte 50.
49.1	ASIsafe code sequences duplicated	24 ("Switch-off") 19 ("Communication error")	In addition, the AS-i address is entered in byte 50.
49.2	ASIsafe code sequences new	-	New code sequences are available for transfer. In addition, the AS-i address is entered in byte 50.
49.3	ASIsafe code sequences known	-	The code sequences are taught and saved in the coding element.
49.4	ASIsafe code sequence error	24 ("Switch-off") 19 ("Communication error")	In addition, the AS-i address is entered in byte 50.

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
49.5	ASIsafe code sequence teaching active	-	The code sequences are being collected. When the code sequences for all safe AS-i input slaves detected on the bus are taught, this bit is reset.
49.6 … 49.7	Reserved	-	-
50	Code sequence error object	-	This bit contains the lowest AS-i address for which a code sequence problem has occurred. Code sequence problems are: • 49.0 ASIsafe code sequences missing (Prio 3) • 49.1 ASIsafe code sequences duplicated (Prio 1) • 49.2 ASIsafe code sequences new (Prio 4) • 49.4 ASIsafe code sequence error (Prio 2)
51 … 54	Reserved	-	-
55	Switching group error object	-	This byte contains the lowest AS-i address that is configured for an output switching group but is not addressed by the master. Correct the slave configuration of the master.
56 … 61	Reserved	-	-
62.0	F_Dest_Adr does not match	24 ("Switch-off") 19 ("Communication error") 64 ("Different destination address")	-
62.1	F_Dest_Adr invalid	24 ("Switch-off") 19 ("Communication error") 65 ("Invalid destination address")	The coding element does not contain an F-address.
62.2	F_Source_Adr invalid	24 ("Switch-off") 19 ("Communication error") 66 ("Invalid source address")	-
62.3	F_WD-Time_0	24 ("Switch-off") 19 ("Communication error") 67 ("Watchdog time is 0 ms")	F_WD-Time value is 0 ms.
62.4	F_SIL value	24 ("Switch-off") 19 ("Communication error") 68 ("Parameter 'F_SIL' exceeds the appl. SIL")	F_SIL value exceeds SIL value of the specified device application

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
62.5	F_CRC_Length	24 ("Switch-off") 19 ("Communication error") 69 ("Parameter 'F_CRC_Length' does not match …")	F_CRC_Length value does not match the actual CRC length.
62.6	F_Par_Version	24 ("Switch-off") 19 ("Communication error") 70 ("Incorrect F-parameter version or F_Block_ID")	F_Par_Version does not match the F-parameter set or F-Block_ID is invalid Block_ID
62.7	CRC1 error	24 ("Switch-off") 19 ("Communication error") 71 ("CRC1 error")	-
63.0 … 63.2	Reserved	-	-
63.3	iPAR_CRC error	24 ("Switch-off") 19 ("Communication error") 75 ("Inconsistent I-parameters [iParCRC error]")	-
63.4	Operator acknowledge requested	-	Channel is ready for reintegration
63.5 … 63.7	Reserved	-	-
64 … 65	Reserved	-	-
70 … 89	Reserved	-	-
90 … 91	Object_Code_Sequence_Logic	-	AS-i address of the first safe AS-i slave for which a code sequence error or logic error i present. See also bit 18.0. 0 = No error 0 = No error 1 … 31 = AS-i slave address ≥32 = Internal error numbers
92 … 93	Reserved	-	-
94 … 95	Object_input_triggered	-	AS-i address of the first safe AS-i slave for which the input_triggered message is present. See also bit 18.2. 0 = No error 1 … 31 = AS-i slave address ≥32 = Internal error numbers
96 … 199	Reserved	-	-

6.4.2 DS 202 Status safe inputs/outputs

Description

Note

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

DS 202 contains non-safety-related status information for the safe input slaves and for the control of the safe output slaves.

The status information for the control of the safe output slaves relates either to the control units activated in the F-CM AS-i Safety ST module or to data of external control units for safe output slaves that is also read on the AS-i bus.

Table 6- 9 DS 202 Status safe inputs/safe outputs

Byte	Description
0 … 1	Reserved
2 … 5	Status input monitoring AS-i address 1
6 … 9	Status input monitoring AS-i address 2
10 … 13	Status input monitoring AS-i address 3
14 … 17	Status input monitoring AS-i address 4
18 … 21	Status input monitoring AS-i address 5
22 … 25	Status input monitoring AS-i address 6
26 … 29	Status input monitoring AS-i address 7
30 … 33	Status input monitoring AS-i address 8
34 … 37	Status input monitoring AS-i address 9
38 … 41	Status input monitoring AS-i address 10
42 … 45	Status input monitoring AS-i address 11
46 … 49	Status input monitoring AS-i address 12
50 … 53	Status input monitoring AS-i address 13
54 … 57	Status input monitoring AS-i address 14
58 … 61	Status input monitoring AS-i address 15
62 … 65	Status input monitoring AS-i address 16
66 … 69	Status input monitoring AS-i address 17
70 … 73	Status input monitoring AS-i address 18
74 … 77	Status input monitoring AS-i address 19
78 … 81	Status input monitoring AS-i address 20
82 … 85	Status input monitoring AS-i address 21
86 … 89	Status input monitoring AS-i address 22
90 … 93	Status input monitoring AS-i address 23
94 … 97	Status input monitoring AS-i address 24
98 … 101	Status input monitoring AS-i address 25

Byte	Description
102 … 105	Status input monitoring AS-i address 26
106 … 109	Status input monitoring AS-i address 27
110 … 113	Status input monitoring AS-i address 28
114 … 117	Status input monitoring AS-i address 29
118 … 121	Status input monitoring AS-i address 30
122 … 125	Status input monitoring AS-i address 31
126 … 129	Status output control switching group 0
130 … 133	Status output control switching group 1
134 … 137	Status output control switching group 2
138 … 141	Status output control switching group 3
142 … 145	Status output control switching group 4
146 … 149	Status output control switching group 5
150 … 153	Status output control switching group 6
154 … 157	Status output control switching group 7
158 … 161	Status output control switching group 8
162 … 165	Status output control switching group 9
166 … 169	Status output control switching group 10
170 … 173	Status output control switching group 11
174 … 177	Status output control switching group 12
178 … 181	Status output control switching group 13
182 … 185	Status output control switching group 14
186 … 189	Status output control switching group 15
190 … 199	Reserved

Table 6- 10 Input monitoring: Structure of the status information in DS 202

Byte.Bit	Message bit		Remark
0.0	Value = 1:	Startup test necessary	-
0.1	Value = 1:	Sequence condition violated	-
0.2	Value = 1:	Discrepancy condition violated	-
0.3	Value = 1:	Safety sensor triggered	-
0.4 … 0.7	Reserved		-
1.0	Value = 1:	Code sequence error	Cross-circuit at input
1.1 … 1.7	Reserved		-
2.0	Reserved		-
2.1	Value = 1:	Switch-on condition not met	-
2.2 … 2.7	Reserved		-
3.0 … 3.7	Reserved		

Table 6- 11 Output control: Structure of the status information in DS 202

Byte.Bit	Message bit	Remark
0.0	Output active	The control unit of the switching group sends the "F-OUT 1" control signal.
0.1 … 0.7	Reserved	-
1.0 … 1.3	Reserved	-
1.4	Auxiliary signal AUX1 sent	Auxiliary control signal AUX1 was transferred with value "1." If the error acknowledgment bit in the output process image has the value "0", the message is reset.
1.5	Auxiliary signal AUX2 sent	Auxiliary control signal AUX2 was transmitted with value "1." If the error acknowledgment bit in the output process image has the value "0", the message is reset.
1.6 … 1.7	Reserved	-
2.0 … 2.7	Reserved	-
3.0 … 3.7	Reserved	-

6.4.3 DS 204 Status code sequences

Description

Note

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

The DS 204 contains the statuses of all AS-i slaves that are known to the F-CM AS-i Safety ST module.

Table 6- 12 DS 204: Status code sequence for an AS-i address in DS 204

Byte	Description
0 … 13	Reserved
14 … 17	Status code sequence for AS-i address 1
18 … 21	Status code sequence for AS-i address 2
22 … 25	Status code sequence for AS-i address 3
26 … 29	Status code sequence for AS-i address 4
30 … 33	Status code sequence for AS-i address 5
34 … 37	Status code sequence for AS-i address 6
38 … 41	Status code sequence for AS-i address 7
42 … 45	Status code sequence for AS-i address 8
46 … 49	Status code sequence for AS-i address 9
50 … 53	Status code sequence for AS-i address 10
54 … 57	Status code sequence for AS-i address 11

Byte	Description
58 … 61	Status code sequence for AS-i address 12
62 … 65	Status code sequence for AS-i address 13
66 … 69	Status code sequence for AS-i address 14
70 … 73	Status code sequence for AS-i address 15
74 … 77	Status code sequence for AS-i address 16
78 … 81	Status code sequence for AS-i address 17
82 … 85	Status code sequence for AS-i address 18
86 … 90	Status code sequence for AS-i address 19
90 … 91	Status code sequence for AS-i address 20
94 … 97	Status code sequence for AS-i address 21
98 … 101	Status code sequence for AS-i address 22
102 … 105	Status code sequence for AS-i address 23
106 … 109	Status code sequence for AS-i address 24
110 … 113	Status code sequence for AS-i address 25
114 … 117	Status code sequence for AS-i address 26
118 … 121	Status code sequence for AS-i address 27
122 … 125	Status code sequence for AS-i address 28
126 … 129	Status code sequence for AS-i address 29
130 … 133	Status code sequence for AS-i address 30
134 … 137	Status code sequence for AS-i address 31
138 … 199	Reserved

Table 6- 13 Assignment of the bits of an AS-i address in the "Status code sequence" data structure

Byte	Bit	Description	Setting	Meaning of the setting
0	0 … 2	Status of the slave	= 0	No slave present
			= 1	Standard slave (not safety-related)
			= 2	Safe slave, but the code sequence type safe input/safe output is not yet decoded.
			= 3	Code sequence type safe output
			= 4	Code sequence type safe input
			= 5 … 7	Reserved
	3	-	Reserved	-
	4 … 6	Status of parameter assignment	= 0	No safe AS-i output slave or AS-i input slave is configured.
			= 1	Reserved
			= 2	Safe AS-i slave is configured The detected slave corresponds to the activation.
			= 3	Safe AS-i slave is configured The detected slave does not correspond to the activation.
			= 4 … 7	Reserved
	7	-	Reserved	-
1	0 … 2	Status of the code sequence	= 0	Code sequence irrelevant: No activation or no slave is present.
			= 1	Code sequence missing: No code sequence is taught or transferred.
			= 2	Code sequence duplicated: At least one other slave has the same code sequence.
			= 3	Code sequence new: The taught code sequence does not correspond to the transferred code sequence.
			= 4	Code sequence known: The taught code sequence does not correspond to the transferred code sequence.
			= 5 … 7	Reserved
	3	-	Reserved	-
	4 … 5	Status of the safe input 1	= 0	The input is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Input signal = 0: The contact is open.
			= 3	Input signal = 1: The contact is closed.
	6 … 7	Status of the safe input 2	= 0	The input is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Input signal = 0: The contact is open.
			= 3	Input signal = 1: The contact is closed.

Byte	Bit	Description	Setting	Meaning of the setting
2	0 … 1	Status of the "F-OUT 1" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	2 … 3	Status of the "F-OUT 2" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	4 … 5	Status of the "F-OUT 3" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	6 … 7	Status of the "F-OUT 4" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
3	0 … 1	Status of the auxiliary signal 1	= 0	The signal is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Auxiliary signal = 0
			= 3	Auxiliary signal = 1
	2 … 3	Status of the auxiliary signal 2	= 0	The signal is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Auxiliary signal = 0
			= 3	Auxiliary signal = 1
	4 … 7	-	Reserved = 0	-

6.4.4 DS 206 Diagnostic data record

Meaning

Note

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

Data record 206 contains a summary of the information that is relevant for a comprehensive diagnosis of the F-CM AS-i Safety ST module via your user program.

For some events, the F-CM AS-i Safety ST module generates a diagnostic alarm.

The following applies for diagnostic alarms of the F-CM AS-i Safety ST module with firmware V1.0.1 or higher:

- The "Error code" column in the table below indicates which events are relevant here.
- If the associated bit changes in the data record, a diagnostic alarm with the indicated error code is generated (incoming alarm when bit changes to value "1" and outgoing alarm when bit changes to value "0").
- If no error code is specified ("-"), a diagnostic alarm is not generated.
- The diagnostic alarms for firmware V1.0.0 are described in Section "DS 92 Device-specific diagnosis (Page 57)".

Table 6- 14 DS 206 Diagnosis

Byte.Bit	**Description** In the case of binary values, the description declares the status "1"	**FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm**	**Remark**
0	Version High	-	-
1	Version Low	-	-
2.0	Overtemperature	1048	Maximum operating temperature exceeded
2.1	Undertemperature	786	Ambient temperature too low
2.2	Incorrect parameter value	16	Configuration data contains errors
2.3	Incorrect or inconsistent firmware	283	Firmware is faulty Firmware update necessary
2.4	Supply voltage too high	1038	AS-i voltage too high
2.5	Supply voltage too low	1039	AS-i voltage too low
2.6	Program cycle time exceeded	259	Internal cycle time exceeded
2.7	Device fault	1059	Self-test has determined a device fault. For details, see further error messages.
3.0	Serious device fault	9	Serious device fault. No communication possible
3.1	Teaching necessary	1055	New code tables are available for transfer.
3.2	Normal operation	-	Cyclic I/O data exchange active
3.3	Startup	-	Parameters are loaded No cyclic I/O data exchange
3.4	Serious device fault	-	Serious device fault. No communication possible
3.5	I/O device signal error	-	One or more channels are passivated
3.6	Code sequence cannot be read correctly	-	A code sequence is non-existent or incomplete
3.7	Reintegration necessary	-	Error is cleared, but at least one channel is still passivated
4.0	Access to device settings	-	Assignment of the F-address Acceptance of the code sequences Firmware update

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
4.1	ASIsafe code table teaching active	-	Teach LED flashes yellow; code sequences are collected. Is reset when the code tables for all safe AS-i input slaves detected on the bus have been taught.
4.2	Diagnostic memory overflow	33	Too many simultaneous error messages
4.3	Change of parameters not permissible	-	Modification of parameter data is rejected in normal mode
4.4 ... 4.7	Reserved	-	-
5.0	Status LED flashes green	-	-
5.1	Status LED lit green	-	-
5.2	Error LED flashes red	-	-
5.3	CFG LED flashes red	-	-
5.4	PSF LED flashes red	-	-
5.5	Teach LED flashes yellow	-	-
5.6	Teach LED lit yellow	-	-
5.7	ADDR LED flashes green	-	-
6.0	No access possible to the retentive storage of the F-address	781	The coding element (type H) in the BaseUnit is missing or there is an access error
6.1	Different destination address (F_Dest_Add)	64	The PROFIsafe driver has detected a different F-destination address.
6.2	Invalid target address (F_Dest_Add)	65	The PROFIsafe driver has detected an inadmissible F-destination address.
6.3	Invalid source address (F_Source_Add)	66	The PROFIsafe driver has detected an inadmissible F-source address.
6.4	Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67	The PROFIsafe driver has detected an inadmissible watchdog time.
6.5	Parameter "F_SIL" exceeds the application-specific SIL	68	The PROFIsafe driver has detected a discrepancy between the communication SIL setting and the application SIL setting.
6.6	Parameter "F_CRC_Length" does not match the generation	69	The PROFIsafe driver has detected a discrepancy in the CRC length.
6.7	Incorrect F-parameter version or F_Block_ID	70	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.
7.0	CRC1 error	71	The PROFIsafe driver has detected inconsistent F-parameters.
7.1	Inconsistent i-parameters (iParCRC error)	75	The PROFIsafe driver has detected inconsistent i-parameters.
7.2	PROFIsafe communication error (timeout)	92	
7.3	PROFIsafe communication error (CRC)	F93	

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
7.4	PROFIsafe address assignment error	F94	Coding element contains inadmissible data
7.5 ... 7.7	Reserved	-	-
8	Configured AS-i address for output switching group 0	-	-
9	Configured AS-i address for output switching group 1	-	-
10	Configured AS-i address for output switching group 2	-	-
11	Configured AS-i address for output switching group 3	-	-
12	Configured AS-i address for output switching group 4	-	-
13	Configured AS-i address for output switching group 5	-	-
14	Configured AS-i address for output switching group 6	-	-
15	Configured AS-i address for output switching group 7	-	-
16	Configured AS-i address for output switching group 8	-	-
17	Configured AS-i address for output switching group 9	-	-
18	Configured AS-i address for output switching group 10	-	-
19	Configured AS-i address for output switching group 11	-	-
20	Configured AS-i address for output switching group 12	-	-
21	Configured AS-i address for output switching group 13	-	-
22	Configured AS-i address for output switching group 14	-	-
23	Configured AS-i address for output switching group 15	-	-
24 ... 27	Status AS-i address 1	-	-
28 ... 31	Status AS-i address 2	-	-
32 ... 35	Status AS-i address 3	-	-
36 ... 39	Status AS-i address 4	-	-
40 ... 43	Status AS-i address 5	-	-
44 ... 47	Status AS-i address 6	-	-
48 ... 51	Status AS-i address 7	-	-
52 ... 55	Status AS-i address 8	-	-

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
56 ... 59	Status AS-i address 9	-	-
60 ... 63	Status AS-i address 10	-	-
64 ... 67	Status AS-i address 11	-	-
68 ... 71	Status AS-i address 12	-	-
72 ... 75	Status AS-i address 13	-	-
76 ... 79	Status AS-i address 14	-	-
80 ... 83	Status AS-i address 15	-	-
84 ... 87	Status AS-i address 16	-	-
88 ... 91	Status AS-i address 17	-	-
92 ... 95	Status AS-i address 18	-	-
96 ... 99	Status AS-i address 19	-	-
100 ... 103	Status AS-i address 20	-	-
104 ... 107	Status AS-i address 21	-	-
108 ... 111	Status AS-i address 22	-	-
112 ... 115	Status AS-i address 23	-	-
116 ... 119	Status AS-i address 24	-	-
120 ... 123	Status AS-i address 25	-	-
124 ... 127	Status AS-i address 26	-	-
128 ... 131	Status AS-i address 27	-	-
132 ... 135	Status AS-i address 28	-	-
136 ... 139	Status AS-i address 29	-	-
140 ... 143	Status AS-i address 30	-	-
144 ... 147	Status AS-i address 31	-	-

Table 6- 15 Status AS-i addresses: Structure of the status information

Byte.Bit	Description	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
0.0	Reserved	-	-
0.1	Discrepancy error, channel status 0/1	1041	When the error occurs, the pair of channels at input 1 has the status "0" and at input 2 the status "1".
0.2	Discrepancy error, channel status 1/0	1042	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "0".
0.3 ... 0.4	Reserved	-	-
0.5	Sequence error, channel status 0/1	1045	When the error occurs, the pair of channels at input 1 has the status "0" and at input 2 the status "1".

Byte.Bit	Description	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
0.6	Sequence error, channel status 1/0	1046	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "0".
0.7	Sequence error, channel status 1/1	1047	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "1".
1.0	Input slave missing or of the incorrect type	1050	-
1.1	Control unit of the output switching group not in cyclic data exchange	1051	The AS-i master does not address the configured AS-i address of the output switching group.
1.2	Code sequence error (systematic fault)	1054	Permanent interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable or code sequence corruption after replacement of the safe input module.
1.3	Code sequence missing in the memory of the F-CM	1056	-
1.4	ASIsafe code sequences duplicated	1057	Identical code sequence occurs several times
1.5	Sporadic code sequence error	1058	Momentary interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable.
1.6 ... 1.7	Reserved	-	-
2.0	Safety sensor triggered	-	-
2.1	Switch-on condition not met		The safe input value has been reset to the status "0"
2.2	Startup test necessary	-	Test of the input is necessary: Both inputs of the channel pair must assume the status "0".
2.3	Status of process image (user data)	-	-
2.4	Value status	-	Value status = 1: A valid process value is output for the channel. Value status = 0: A substitute value is output for the channel (error on channel or the channel is deactivated).
2.5... 2.7	Reserved	-	-
3.0	Safe AS-i input slave configured	-	-
3.1	Safe AS-i output slave configured	-	-
3.2	Unsafe slave detected	-	-
3.3	Safe slave detected, type unknown	-	-
3.4	Safe slave detected, type input slave	-	-
3.5	Safe slave detected, type output slave	-	-
3.6	Slave is located in cyclic data exchange	-	-
3.7	Reserved	-	-

Code sequences

7

The principle of the ASIsafe code sequences is briefly explained in Section Safety-related communication with AS-Interface (Page 35).

The F-CM AS-i Safety ST module manages the code sequences of the safe AS-i slaves in two steps. First, the F-CM AS-i Safety ST module reads all code sequences on the AS-i bus and checks whether the respective code sequence is plausible. This operation is referred to as "teaching the code sequences". The code sequences taught in this way are in volatile memory. The taught code sequences are transferred to the non-volatile memory after a request by the user.

Initial commissioning

During initial commissioning, the F-CM AS-i Safety ST module must teach the code sequences of all safe AS-i input slaves present on the AS-i bus and transfer them to non-volatile memory. In so doing, the module detects both the slaves for which input monitoring is activated as well as the other safe input slaves.

Replacement of a safe AS-i input slave

After replacement of a safe AS-i input slave, the new code sequence must be taught and saved.

If the code sequence is not saved for a safe AS-i input slave, or if the code sequence does not correspond to the saved code sequence, the input channel will be passivated and assigned the substitute value "0".

As soon as the F-CM AS-i Safety ST module detects a new code sequence, the code sequences are automatically taught. Confirm the transfer of the code sequences into the memory to prevent unauthorized changes to the AS-i component.

For the transfer of the code sequences to the non-volatile memory, you can open the "Teach ASIsafe" dialog by pressing the "Teach ..." button.

Alternatively, the transfer is also possible by pressing the optional "TEACH" button (at least 3 s).

Replacement of the F-CM AS-i Safety ST module

The non-volatile memory is located in the BaseUnit. The transferred code sequences are retained in this memory after replacement of the F-CM AS-i Safety ST module.

Below is a description of the options offered by the F-CM AS-i Safety ST module for transferring code sequences.

See also

Connection (Page 27)

7.1 Transferring code sequences via STEP 7 online access

When code sequence are managed via *STEP 7* online access, you have the option of monitoring the status of the existing code sequences in a graphic overview. In particular, the graphic overview offers advantages for initial commissioning. In addition, you can use the graphic overview for transferring the code sequences of replaced slaves during operation. You can open the graphic overview for diagnostic purposes without changing the saved code sequences. The transfer of taught code sequences is possible but not mandatory.

In order to open this dialog, there must be an online connection to the controller or to the F-CM AS-i Safety ST module. Load the hardware configuration into the modules of the controller before teaching the code sequences so that the online configuration of the F-CM AS-i Safety ST module matches the offline configuration.

7.1.1 "Teach ASIsafe code sequences" dialog

The "Teach ASIsafe code sequences" dialog contains an overview of the code sequences of the existing safety-related AS-i slaves. In this dialog, you start the transfer of the code sequences read in on the AS-i bus into the memory of the F-CM AS-i Safety ST module.

The "Teach ASIsafe code sequences" dialog does not make any changes to the module configuration. You can open the dialog for information purposes during operation. The information displayed in the dialog are obtained online from the F-CM AS-i Safety ST module. There is no comparison with the offline configuration in this case.

Within the "AS-i addresses 0…15" and "AS-i adresses 16…31", you see the following information for each AS-i address:

- Slave status
- Code sequence
- F-IN 1 … 2
- F-OUT 1 ... 4

For the AS-i address 0, only information about the slave status can be displayed because a slave with the address 0 does not exchange cyclic input/output data.

Below this information you see:

- The "Transfer taught code sequences" button
- The "Progress of teaching operation" display

By double-clicking the "Close" button, you can exit the dialog at any time. If the button is actuated, the data will not be changed. If the code sequences have not been transferred or have only been partially transferred, a corresponding notice appears.

"Slave Status" column

The "Slave status" column shows the following information about the AS-i address via a color code:

Gray	The address does not exist on the AS-i bus. It is not needed in the configuration of the F-CM AS-i Safety ST module (input monitoring control / output monitoring control deactivated)
Green (without check mark)	The address belongs to a slave that exists on the AS-i bus. However, the slave is not needed in the configuration of the F-CM AS-i Safety ST module (input monitoring control / output monitoring control deactivated). The slave on the AS-i bus is a safe slave or a standard slave. It is available for use by the AS-i master or another module.
Green (with check mark)	The address is present on the AS-i bus and corresponds to the configuration of the F-CM AS-i Safety ST module (input monitoring or output monitoring is activated).
Yellow	An error has been detected: The address is present on the AS-i bus but does not correspond to the configuration of the F-CM AS-i Safety ST module (input monitoring control or output monitoring control is activated). Check the slave. Replace the slave with the required slave or change the configuration.
Red	An error has been detected: The address is not present on the AS-i bus but is needed in the configuration of the F-CM AS-i Safety ST module (input monitoring or output monitoring is activated). • Check whether the slave exists on the AS-i bus and has been included in the communication by the AS-i master. • Check whether the slave is contained in the configuration of the AS-i master. Correct the configuration of the AS-i bus, if required.

"Code sequence" column

The "Code sequence" column shows the following information about the AS-i address via a color code:

Gray	No code sequence is needed for the address.
Green (without check mark)	A code sequence was taught but not transferred to the memory. Start the transfer of the code sequence by double-clicking the "Transfer taught code sequences" button.
Green (with check mark)	The code sequence was transferred to the non-volatile memory. Note: This status is also displayed when the output control is activated for this address. The code sequences for safe outputs are automatically predefined in the F-CM AS-i Safety ST module. They are not transferred to the non-volatile memory of the code sequences.
Yellow	An error has been detected: A code sequence was taught that is already being used by another slave. The code sequence cannot be used. Replace the slave with a different slave.
Red	Warning or error: The address is sending an incomplete or invalid code sequence. Check whether both inputs of the safe input slave are assigned with the "ON" signal. If required, actuate the associated safety contacts. The contacts must be closed. • Check whether a cross-circuit exists at the inputs. If necessary, correct the wiring of the inputs.

"F-IN 1 ... 2" column

The "F-IN 1 ... 2" column shows the following information about the AS-i address via a color code:

The numbers 1 to 2 designate the number of the input channel.

Gray	The input channel is not present. A safe input slave was not detected at the address.
Green	The input channel shows the value 1 ("ON" status).
White	The input channel shows the value 0 ("OFF" status).
Yellow	The input channel shows the value 0 ("OFF" state) or is not present. Note: The status indication is unambiguous once the code sequence has been taught for a safe input slave (both inputs assigned with "ON" signal), or when an "ON" signal has been read in for an externally controlled safe output slave.
Red	An error was detected, e.g., a code sequence error: The status of the input channel cannot be read in. Substitute value 0 is used.

"F-OUT 1 ... 4" column

The "F-OUT 1 ... 4" column shows the following information about the AS-i address via a color code:

The numbers 1 to 4 designate the number of the output channel.

Gray	The output channel is not present. A safe output channel was not detected at the address.
Green	The output channel shows the value 1 ("ON" status).
White	The output channel shows the value 0 ("OFF" status).
Yellow	The output channel shows the value 0 ("OFF" state) or is not present. Note: The status indication is unambiguous once the code sequence has been taught for a safe input slave (both inputs assigned with "ON" signal), or when an "ON" signal has been read in for an externally controlled safe output slave.
Red	An error was detected, e.g., a code sequence error: The status of the output channel cannot be read in.

If the output control is activated for the address, the F-CM AS-i Safety ST module can control the status for F-OUT 1. The F-CM AS-i Safety ST module cannot control F-OUT 2 … 4. The value 0 is output here.

If an external control unit uses the output address, the dialog shows the statuses for F-OUT 1 … 4 read in on the AS-i bus.

7.1.2 Transferring taught code sequences

In order for the input data of a safe AS-i input slave to be evaluated and made available to the safety program, the taught code sequences must be transferred to the non-volatile memory.

To do so, click the "Transfer taught code sequences..." button.

A dialog opens prompting you whether the code sequences are to be transferred. With "Yes" you confirm that you are addressing the correct module. For checking purposes, the "ADDR" LED flashes green on the front of the F-CM AS-i Safety ST module The code sequences are transferred to the non-volatile memory. The input data of the safe AS-i input slaves are then evaluated. Reintegration in the safety program is enabled.

With "No" you cancel the prompt without transferring the code sequence.

WARNING

The switching on of plant components may result in death, severe injury, and serious property damage.

Depending on the safety program, the transfer of code sequences may cause plant components to be switched on. Before transferring the code sequences, ensure that no personal injury or property damage can occur. After transferring the code sequences, check the safety equipment for proper functioning.

The "Transfer taught code sequences" button is deactivated when all taught code sequences have already been transferred to the non-volatile memory.

7.1.3 "Progress of teaching operation" display

You can track the progress of the teaching operation.

Progress bar "Teaching in progress":

If at least one safe slave is detected on the AS-i bus whose code sequence has not yet been taught an active progress bar and the text "Teaching in progress" is displayed. Check the displays in the "Code sequences" column and ensure that the safe slaves send their code sequences.

For further information, refer to the "'Code sequence' column".

Taught slaves:

The "Taught slaves" output field shows the number of already transferred code sequences in relation to the number of code sequences that must still be transferred. You will additionally see the numerical ratio as a percentage. When 100% is indicated, all code sequences have been transferred to the non-volatile memory.

You will find additional information in the section "Accept taught code sequences".

7.2 Transferring code sequences with the "TEACH" button.

The use of the "TEACH" button provides an easy way of transferring taught code sequences.

The "TEACH" button can be used, for example, to transfer code sequences of replaced modules during operation. However, it is also suitable for initial commissioning.

To learn how to connect the button to the BaseUnit, refer to Section "Connecting". You can track the progress of the code sequence transfer via the LEDs.

Press the "TEACH" button for at least 3 s. This action causes all currently taught code sequences that are unique and consistent to be transferred to the non-volatile memory. The input data of the safe AS-i input slaves are then evaluated. Reintegration in the safety program is enabled.

⚠ WARNING

The switching on of plant components may result in death, severe injury, and serious property damage.

Depending on the safety program, the transfer of code sequences may cause plant components to be switched on. Before transferring the code sequences, ensure that no personal injury or property damage can occur. After transferring the code sequences, check the safety equipment for proper functioning.

When the transfer of the code sequences has been ended successfully, the "TEACH" LED goes out and you can release the "TEACH" button.

If you press the "TEACH" button before all code sequences are taught, the code sequences received up to then will be transferred.

7.3 Final steps

7.3.1 Reintegrating passivated input channels

The input channels of the F-CM AS-i Safety ST module for which no valid code sequences are saved supply the substitute value "0" and are passivated.

After the transfer of the code sequences, the passivated channels must be reintegrated so that the application can work with the real process values.

The procedure for this can be found in the following Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

After transferring the code sequences, check the safety equipment for proper functioning.

Alarm, fault, and system events

8

8.1 Overview

Diagnostics options

The following diagnostics options are available for the F-CM AS-i Safety ST module:

- LEDs on the module
- Diagnostics in *STEP 7*:
  - Diagnostic buffer
- Alarm messages in user program

See also

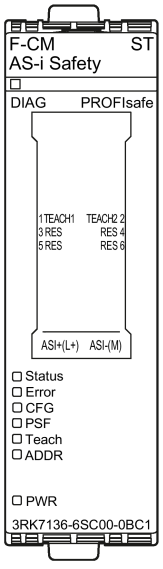
Meaning of the LEDs (Page 85)

8.2 LED statuses

8.2.1 Arrangement of the LEDs on the F-CM AS-i Safety ST

Introduction

LEDs on the front plate of the respective module display module-internal and module-external faults. The LEDs and their evaluation are described in the manuals for the relevant modules of the SIMATIC devices.



DIAG	Diagnosis
STATUS	Operating state of the module
Error	Operating state of the module
CFG	Fault on the AS-i bus
PSF	Process signal error, e.g.,channel fault on AS-i-F input slave
Teach	Teaching: Teaching of code sequences
ADDR	Addressing of the F-CM AS-i Safety ST module. F-addressing and teaching. The LED indicates whether the module is conducting safety-relevant communication with the software tool.
PWR	Supply voltage

Figure 8-1 LEDs of F-CM AS-i Safety ST

8.2.2 Meaning of the LEDs

The "F-CM AS-i Safety ST" module has 8 LEDs on the front:

LED "DIAG"

The "DIAG" LED displays the general status of the ET 200SP module

Table 8- 1 Meaning of the "DIAG" LED

"DIAG"	Meaning
☐ Off	The voltage is not OK.
✳ Green flashes	The F-CM AS-i Safety ST module is not ready for operation. The module parameters are not assigned.
■ Green ON	The F-CM AS-i Safety ST module is parameterized and error-free. No diagnostic alarms of the F-CM AS-i Safety ST are active.
✳ Red flashes	The F-CM AS-i Safety ST module is parameterized and indicates a diagnostic fault, or a firmware update is in progress.
✳✳ The two-color LED alternately flashes red/green	The position (ping) is displayed for 3 seconds.

LED "Status"

The "Status" and "Error" LEDs indicate the operating state of the device.

Table 8- 2 Meaning of the "Status" LED

"Status"	Meaning
■ Green ON	• The F-CM AS-i Safety ST module is OK. • Cyclic I/O data exchange active
✳ Green flashes	• The system is powering up. • No cyclic I/O data exchange

LED "Error"

The "Status" and "Error" LEDs indicate the operating state of the device.

Table 8- 3 Meaning of the "Error" LED

"Error"	Meaning
■ Red ON	**Serious device fault, e.g.,** • Fault in the electronics • Overtemperature
✳ Red flashes	**Device fault, e.g.,** • Intermittent data processing error (EMC problem) • Contact problem with the backplane bus • Missing coding element in the BaseUnit • Missing firmware update
□ Off	No error

LED "CFG"

The "CFG" LED indicates errors on the AS-i bus.

Table 8- 4 Meaning of the "CFG" LED

"CFG"	Meaning
■ Red ON	The AS-i bus is OK, but a code sequence error exists.
✳ Red flashes	Fault on the AS-i bus: • A code sequence does not exist or it is incomplete.
□ "Off"	All code sequences are completely transferred.

LED "PSF"

The "PSF" LED indicates process signal errors at one or more channels of the module.

Table 8- 5 Meaning of the "PSF" LED

LED "PSF"	Meaning
■ Red ON	PROFIsafe channel fault for the complete F-CM AS-i Safety ST module, e.g. fault on F-CM AS-i input slave
✳ Red "flashes"	• Discrepancy error at the inputs of a safe AS-i input slave • Sequence error at the inputs of a safe AS-i input slave • Code sequence error at a safe AS-i input slave, e.g., due to cross-circuit at inputs or an EMC problem • Failure of a safe AS-i input slave The channel involved is passivated. The "PSF" LED goes out only after all channels have been reintegrated.
□ "Off"	No process signal error

LED "TEACH"

This LED indicates teaching of safe AS-i slaves. The "TEACH" LED indicates the progress of the teaching operation.

Table 8- 6 Meaning of the "TEACH" LED

LED "TEACH"	Meaning
■ Yellow ON	The code sequences have been successfully taught, but have not yet been accepted. Transfer the code sequences either via the STEP 7 online dialog or by pressing the optional "TEACH" button (for at least 3 s). For more information, see the Section "Code sequences (Page 75)".
✳ Yellow flashes	Teaching of code sequences in progress.
□ "Off"	The code sequences are completely transferred.

LED "ADDR"

The "ADDR" LED indicates that the device is conducting safety-relevant communication with a software tool.

Table 8- 7 Meaning of the "ADDR" LED

LED "ADDR"	Meaning
✳ Green flashes	Feedback that the module is addressed: • For assignment of the F-address • For transfer of the code sequences • Firmware update in progress
☐ Off	Not relevant

LED "PWR"

The "PWR" LED indicates the status of the voltage supply.

Table 8- 8 Meaning of the "PWR" LED

LED "PWR"	Meaning
■ Green ON	AS-i voltage is applied.
☐ "Off"	Insufficient AS-i voltage is applied.

8.3 Diagnostic messages

The F-CM AS-i Safety ST module generates one or more alarms when various events occur.

Note

When replacing an F-CM AS-i Safety module with firmware V1.0.0, the following must be observed:

With firmware V1.0.1 or higher, the F-CM AS-i Safety ST module generates a modified range of alarm messages compared with V1.0.0.

If the user program evaluates the error numbers of the generated alarms directly, the user program may have to be adapted if the firmware version is changed (e.g. when changing a device). If necessary, the firmware version of a replacement device can be modified to the previously used firmware version (see Section "Firmware update (Page 24)").

It is expected that the upgrading of the firmware version from V1.0.0 to V1.0.1 will not usually have any influence on the user program. The safety functionality of the F-CM AS-i Safety ST module does not change when the firmware is replaced.

If, after the replacement of a device, an alarm message of the F-CM AS-i Safety module appears in the message system (e.g. on an HMI panel), which contains an error code instead of a message text, then the assigned message texts are not known to the message system. In order to update the message texts, the project must be re-compiled with a current version of the TIA Portal / STEP 7 and loaded into the controller or into the message system. The function of the message system can be checked by generating an alarm (e.g. by removing an assigned AS-i safety slave).

Diagnostic messages for firmware V1.0.0

The following applies for firmware V1.0.0: Which events lead to which alarm messages is indicated in the description of data record DS 92 "Device-specific diagnostics" (Page 57).

The alarms use the diagnostic codes 0 to 31 according to the PROFIBUS Standard.

Diagnostic messages as from firmware V1.0.1

The following applies as from firmware V1.0.1: Which events lead to which alarm messages is indicated in the description of data record DS 206 "Data record diagnostics" (Page 69).

The alarms use diagnostic codes in the extended range of values according to the PROFINET Standard. The alarms allow a meaningful system diagnosis to be made, specifying the type of error and the AS-i address affected.

8.4 Replacement of defective devices

8.4.1 Replacing a safe AS-i input slave

Replace a failed safe AS-i input slave with a new device of the same type and assign the correct AS-i address to the slave. This address assignment can be performed automatically by the AS-i master (see manual of the AS-i master) or manually, e.g., with the AS-i addressing device (1904-2AB02).

Close the contacts on the inputs of the safe AS-i input slave so that the slave sends the code sequences.

The F-CM AS-i Safety ST module detects a new code sequence automatically and teaches it. For reintegration, the taught code sequence must be transferred.

The transfer can be started from the STEP 7 online dialog or by pressing the optional "TEACH" button (at least 3 s). For more information, see Section Code sequences (Page 75).

Observe the "CFG" and "TEACH" LEDs, see Section Meaning of the LEDs (Page 85).

To exclude impermissible duplicate code sequences for two safe input slaves, code sequences from all safe input slaves present on the AS-i bus must be transferred, regardless of whether the monitoring is activated or deactivated.

8.4.2 Replacing the safe AS-i output module (evaluation unit)

After replacement of a safe AS-i output module (evaluation unit), no setting is necessary on the F-CM AS-i Safety ST module.

Observe the operating instructions of the AS-i output module, and set the correct F-address for the AS-i output module and the AS-i address of any integrated standard slave.

An error acknowledgment for the affected output switching group must be performed, if necessary. See Section 6.3 Address space.

Non-safety related AS-i slaves (standard slaves) are not evaluated by the F-CM AS-i Safety ST module. Observe the replacement instructions in the operating instructions of the AS-i master or the slave.

8.4.3 Replacing the F-CM AS-i Safety ST module

When the F-CM AS-i Safety ST module is replaced, the new device automatically receives all necessary settings from the head module (IM) of the ET 200SP and the coding element in the BaseUnit.

When replacing an F-CM AS-i Safety module with firmware V1.0.0, the instructions in Section "DS 206 Diagnostic data record (Page 69)" must be observed.

For more information, see Manual "ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293/0/en)

Technical specifications

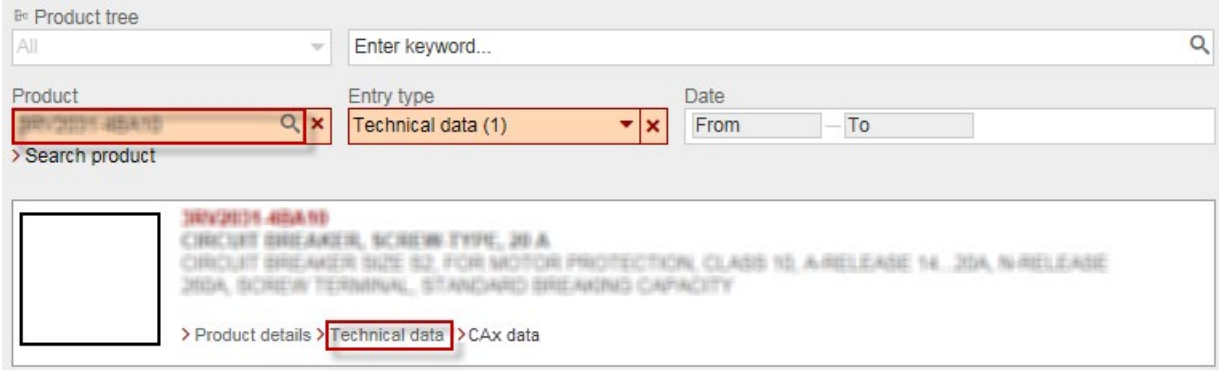
9

9.1 Technical data in Siemens Industry Online Support

Technical data sheet

You can also find the technical data of the product at Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/15757/td).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "Technical data link.



9.2 Configuration software

Information on the configuration software that you can use can be found in the Table "Software for configuration of the F-CM AS-i Safety ST" in Section Configuring the F-CM AS-i Safety ST (Page 33).

9.3 Safe technical specifications

Safety characteristics

Table 9- 1 Maximum achievable safety class in safety mode

Standard	Designation	Value
SIL according to IEC 61508	SIL	3
EN ISO 13849-1[1)]	PL	e
	Category	4

1) Performance Level

Table 9- 2 **Safety characteristics**

Characteristic	Designation	Value
High Demand according to SIL 3[1)]	PFH_D	$1.00 \times 10^{-9} \times 1 / h$
Total value for AS-i system with the F-CM AS-i Safety ST module[2)]		$1.89 \times 10^{-9} \times 1 / h$
Individual value for F-CM AS-i Safety ST	PFH_D	$0.89 \times 10^{-9} \times 1 / h$
Individual value for AS-Interface transfer procedure	PFH_D	$1.00 \times 10^{-9} \times 1 / h$
Individual value for AS-Interface slave[2)]	PFH_D	0
Proof test interval	T1	20 years
Low Demand according to SIL 3[3)]	PFD	2.00×10^{-5}
Total value for AS-i system with the F-CM AS-i Safety ST module[2)]		1.55×10^{-5}
Individual value for F-CM AS-i Safety ST	PFD	0.55×10^{-5}
Individual value for AS-Interface transfer procedure	PFD	1.00×10^{-5}
Individual value for AS-Interface slave[2)]	PFD	0
Mean Time To dangerous Failure	$MTTF_d$	≥100 years (37 000 years) High (according to EN ISO 13849-1)
Diagnostic Coverage level	DC	>99 %
Common Cause Failure	CCF	75 points (requirements met according to EN ISO 13849-1)

1) Probability of a dangerous failure in the case of an operating mode with high or continuous demand rate

2) Value "0" as an approximation for the individual value for AS-Interface slave applies only under the assumption that the PFH_D or PFD value of the AS-i slave is comparatively low and, thus, the PFH_D or PFD value of the AS-i slave does not contributed significantly to the PFH_D or PFD value of the total system. For this, observe the technical specifications of the safe AS-i slaves and use the specific values of the manufacturer.

3) Probability of a dangerous failure in the case of an operating mode with lower demand rate

9.4 Response times

The response times specified below represent worst case specifications. The response times relate to the switch-off operation (status change "1" → "0").

The response times for the switch-on operation (status change "0" → "1") can be longer but are not relevant for the given safety-related examination.

Maximum response time in the input direction

The maximum response time in the input direction results from the calculation of the response time from the safe AS-i input slave up to the head module (IM) of the ET 200SP:

max.	5 ms	AS-i bus cycle with maximum configuration
max.	5 ms	Disturbance in AS-i bus cycle with maximum configuration
max.	20 ms	Module-internal processing
max.	2 ms	Transfer ET 200SP backplane bus
max.	32 ms	Total response time in input direction (with 0 ms input delay)

WARNING

Increased response time

If an input delay time > 0 is assigned for a safe input, this input delay time must be added to the total response time.

In the total response time indicated above, external influencing variables are **not** included:

- Response time of the sensor
- Additional response time in the safe AS-i input slave (see operating instructions)
- Bus response time between the head module (IM) of the ET 200SP and the controller
- Response time of the controller
- Timeout time (F-monitoring time) of the controller in case of PROFIsafe failure

These influencing variables must be taken into consideration when calculating the system response time of the total system.

In the above-indicated total response time, it is taken into consideration that a maximum of 4 AS-i bus cycle times elapse between a safe input slave failure and detection of an error.

Maximum response time in the output direction

The maximum response time in the output direction results from the calculation of the response time from the head module (IM) of the ET 200SP to the safe AS-i input slave (evaluation unit).

max.	2 ms	Transfer ET 200SP backplane bus
max.	20 ms	Module-internal processing
max.	5 ms	AS-i bus cycle with maximum configuration
max.	5 ms	Disturbance in AS-i bus cycle with maximum configuration
max.	32 ms	Total response time in output direction (for disturbance-free PROFIsafe transmission)

WARNING

Increased response time

In case of PROFIsafe failure, the total response time in the output direction increases by the set timeout time of the F-CM AS-i Safety ST module (see F-parameters, F-monitoring time).

In the total response time indicated above, external influencing variables are **not** included:

- Response time of the controller
- Bus response time between the controller and the head module (IM) of the ET 200SP
- Response time in the safe AS-i output module (evaluation unit), see operating instructions
- For response time of the safe AS-i output module (evaluation unit) in case of AS-i failure, see operating instructions
- Response time of the actuator (e.g., contactor)

These influencing variables must be taken into consideration when calculating the system response time of the total system.

Additional information

Further information is provided in

System Manual SIMATIC Industrial Software Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443/0/en)

For calculation of response times, the following aid is available on the Internet:

- For S7 Distributed Safety, the Excel file S7fcotia.xls (http://support.automation.siemens.com/WW/view/en/25412441)

9.5 Calculation of monitoring times and response times

The Excel file S7fcotia.xls for S7 Distributed Safety is available on the Internet to aid the approximate calculation of the runtime of the F-runtime group, the minimum F-monitoring time, and the maximum response time of the safety program:

S7fcotia (http://support.automation.siemens.com/WW/view/en/25412441)

Additional information is available in Manual "Safety Engineering in SIMATIC S7".

You can download this free of charge on the Internet at:

Safety Engineering in SIMATIC S7
(http://support.automation.siemens.com/WW/view/en/12490443/0/en)

Notes on completing the Excel file S7fcotia.xls (when used without IE/PB Link)

Tab "max. runtime F-run-time group"

Enter the number of modules (in the relevant F-runtime group) in the "F-CM AS-i Safety ST" row under "ET 200SP fail-safe modules".

Tab "min. F-Monitoring times"

In the "Configuring the PROFIsafe monitoring time" section, select one of the following variants depending on which head module (IM) of the ET 200SP is being used.

- Variant 3 (distributed F-I/O via PROFINET IO)

Use the values from the following table.

Table 9- 3 Values for calculating the minimum F-monitoring times

Description	Designation	Value
Max. acknowledgment time of the F-CM AS-i Safety ST	T_DAT	20 ms
F-I/O with inputs and outputs	-	Yes

Tab "max. response times"

In the "Input" section, select one of the following variants for the relevant signal flow of the safety function depending on which head module (IM) of the ET 200SP is being used:

- Variant 3 (distributed F-I/O via PROFINET IO)

Use the values from the following table.

Table 9- 4 Values for calculating the max. response times

Description	Designation	Value
Max. discrepancy time (Note: The safe value 0 is supplied while the discrepancy time is running)	T_DIS	0
Maximum response time in error-free operation	T_WCDT	20 ms
Maximum response time when an error is present	T_OFDT	20 ms
Max. acknowledgment time of the F-I/O	T_DAT	20 ms
Configured PROFIsafe monitoring time	T_PSTO, conf.	F_WD_TIME (see the setting on the PROFISAFE tab of the properties dialog)
Max. response time of sensor Note: For T_Sensor_DLY, the part of the system starting from the F-CM AS-i Safety ST module up to the sensor, including the AS-i bus, is considered.	T_Sensor_DLY	10 ms (signal flow of AS-i Bus) + Assigned input delay + Response time of the sensor + Additional response time in the safe AS-i input slave

List of abbreviations

A

A.1 List of abbreviations

Meaning of abbreviations

Abbreviation	Meaning
ADDR	Addressing
AS-i	AS-Interface
ATEX	Atmosphere Explosive
AUX	Auxiliary
BF	AS-i bus error
BU	BaseUnit
CFG	Configuration
CM	Communication Module
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
DI	Digital Input
DIAG	Diagnosis
DP	Distributed peripherals
DS	Data record/data set
I/O	Input/Output
EMC	Electromagnetic compatibility
EN	Europäische Norm (European standard)
F-	Fail-safe
GSD	Generic Station Description
GSDML	Generic Station Description Markup Language
HF	High Feature
HSP	Hardware support package
HW	Hardware
HW ID	Hardware identifier
I&M	Identification and Maintenance
ID	Identifier
IEC	International Electrotechnical Commission
IM	Interface module
IO	Input Output
IP	Ingress Protection (enclosure class)
ISO	International Organization for Standardization
LED	Light Emitting Diode
LPS	List of configured AS-i slaves (list of "projected" slaves)

Abbreviation	Meaning
NEC	National Electrical Code
NFPA	National Fire Protection Association
PIQ	Process Image Output
PII	Process image input
PELV	Protective extra low voltage
PF	Peripheral fault
PFD	Probability of dangerous failure on demand (from IEC 61508)
PFH_D	Probability of dangerous failure per hour (from IEC 61508)
PL	Performance Level
PSF	Process signal error
PWR	Power
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level
GF, CF	System fault
PLC	Programmable logic controller

References

B

B.1 References

Additional documentation

Further information is available in the following documents:

Document type	Internet link
System Manual	ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
Manual	ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521/0/en)
System Manual	ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
Product Information	Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en)
Programming and Operating Manual	SIMATIC Safety - Programming and configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
Programming and Operating Manual	S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)
Manual	CM AS-i Master ST for SIMATIC ET 200SP (http://support.automation.siemens.com/WW/view/en/71756485)
System Manual	AS-Interface System Manual (http://support.automation.siemens.com/WW/view/en/26250840/0/en)
FAQ	FAQ "Compatibility for AS-i Power24V" (http://support.automation.siemens.com/WW/view/en/20025980/133000)
IEC 61508 standard	-
System Manual	SIMATIC Industrial Software Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443/0/en)

Glossary

1oo1 evaluation

Type of sensor evaluation. With 1oo1 evaluation, the sensor exists once. The sensor is connected to the F-module over a single channel.

1oo2 evaluation, equivalent

Type of sensor evaluation. With 1oo2 evaluation, two input channels are occupied by one two-channel sensor or by two single-channel sensors. The input signals are compared internally for equivalence.

AS-i (AS-Interface)

Actuator-sensor interface. A networking system for the lowest field level of the automation level. The networking system is suitable for networking sensors and actuators with control devices (previous designation: SINEC S1).

AS-i A/B slave

AS-i A/B slaves use the extended address range. You can assign two A/B slaves as a pair to an address on AS-Interface. Because of the address organization, you can therefore connect up to 62 AS-i A/B slaves to AS-Interface.

AS-i analog slave

AS-i analog slaves are AS-i slaves that exchange analog values with the AS-i master.

AS-i master

The AS-i master monitors and controls binary or analog sensors and actuators via AS-i modules or AS-i slaves.

AS-i slave

All devices that can be addressed by an AS-i master are referred to as AS-i slaves. AS-i slaves are distinguished according to their design (AS-i modules as well as sensors or actuators with integrated AS-i connection) and their addressing mode (AS-i standard slave and AS-i A/B slave with extended addressing mode).

AS-i standard slave

The AS-i standard slave occupies one address on AS-Interface; because of to the address organization, up to 31 AS-i standard slaves can therefore be connected to AS-Interface.

ASIsafe®

The AS-Interface Safety at Work concept allows the integration of safety-related components in an AS-Interface network, e.g.:

- EMERGENCY STOP switch
- Protective door switch
- Safety light grid

These safety-related components are fully compatible, according to EN 50 295, with the well-known AS-Interface components, e.g., master, slaves, power supply unit, etc. They can be operated together on the yellow AS-Interface cable. Siemens supplies all components for configuring a safe AS-Interface network.

CM

Communication Module

Module for communication tasks that is used in an automation system as an interface expansion for the CPU.

CPU

Central Processing Unit

CRC

Cyclic Redundancy Check is a test procedure for checking the integrity of data. A generator polynomial is used to calculate a checksum over the data to be monitored. This checksum is, in the signature sense, characteristic of the data concerned. The generator polynomial can be calculated according to various algorithms.

DIAG

Diagnosis

Distributed Safety

Siemens-specific addition to PROFIsafe. The Distributed Safety fail-safe system with F-Configuration Pack supports implementation of safety concepts for machine and personal protection.

With Distributed Safety, passivation of selective channels has possible since PROFIsafe V2.0. The quality bits transferred in the process image are used to enter a substitute value in the process image for the channel concerned. The quality bits for the inputs and outputs are subsequently transferred in the process image to the actual process data. The same mechanism that PROFIsafe uses for reintegration of the module is used for reintegration of passivated channels.

F-address

Each fail-safe module has an F-address. For the F-CM AS-i Safety ST module, the F-address must initially be assigned online using *Step 7*. You specify the F-address in the configuration.

Fail-safe systems

Fail-safe systems are characterized in that, when certain failures occur, the system remains in a safe state or changes over directly to another safe state.

F-parameters

The fail-safe parameters are safety-relevant parameters. They are needed for communication via PROFIsafe.

I-parameters

Individual parameters for revising the AS-i functionality. The I-parameters are safety-relevant.

LED

A light-emitting diode that is used to display the signal status.

Nibble

A nibble is a unit of information that comprises four bits.

Passivation

When a fail-safe I/O device detects an error, it switches the affected channel, or all channels, to the safe state. That is, the channels of these fail-safe I/O devices are passivated. The fail-safe I/O device signals the detected fault to the F-CPU.

In the case of passivation of a fail-safe I/O device with inputs, the fail-safe system provides the safety program with substitute value "0" instead of the process values that are present at the fail-safe inputs.

In the case of passivation of a fail-safe I/O device with outputs, the fail-safe system transfers substitute value "0" to the fail-safe outputs instead of the output values supplied by the safety program.

PROFIsafe

Safety-related bus profile of PROFINET IO for communication between the safety program and the fail-safe I/Os in a fail-safe system.

Proof test interval

Time interval after which a component must be put into error-free state. The component is replaced or proof is furnished that it is entirely free of errors.

Safe state

The basis of the safety concept in fail-safe systems is that a safe state exists for all process variables.

Safety class

Safety Integrated Level (SIL) acc. to IEC 61508. The higher the safety integrity level, the stronger the measures for avoiding systematic failures as well as for overcoming intermittent failures and hardware failures.

Fail-safe modules used in safety mode can achieve up to safety class SIL 3.

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SIEMENS

SIMATIC

ET 200SP
Power Module
F-PM-E 24VDC/8A PPM ST
(6ES7136-6PA00-0BC0)

Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

Note

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you should pay special attention.

Security information

Siemens provides automation and drive products with industrial security functions that support the secure operation of plants or machines. They are an important component in a holistic industrial security concept. With this in mind, our products undergo continuous development. We therefore recommend that you keep yourself informed with respect to our product updates. Please find further information and newsletters on this subject at: (http://support.automation.siemens.com)

To ensure the secure operation of a plant or machine it is also necessary to take suitable preventive action (e.g. cell protection concept) and to integrate the automation and drive components into a state-of-the-art holistic industrial security concept for the entire plant or machine. Any third-party products that may be in use must also be taken into account. Please find further information at: (http://www.siemens.com/industrialsecurity)

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Documentation guide

1

1.1 Documentation Guide for Power Module F-PM-E 24VDC/8A PPM ST

Introduction

The documentation of the SIMATIC products has a modular design and includes topics concerning your automation system.

The complete documentation of the ET 200SP system consists of different modules divided into system manuals, function manuals and manuals.

The STEP 7 (online help) information system supports you in configuring and programming your automation system.

Overview of documentation for the F-PM-E 24VDC/8A PPM ST fail-safe power module

The table below lists additional documents that complement this description of the F-PM-E 24VDC/8A PPM ST fail-safe power module and are available on the Internet.

Table 1- 1 Documentation for the F-PM-E 24VDC/8A PPM ST fail-safe power module

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning • Approvals • TÜV certificate
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment to verification all the way to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/safety-services).

Please send your questions to us by e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-PM-E 24VDC/8A PPM ST

Order number

6ES7136-6PA00-0BC0

View of the module

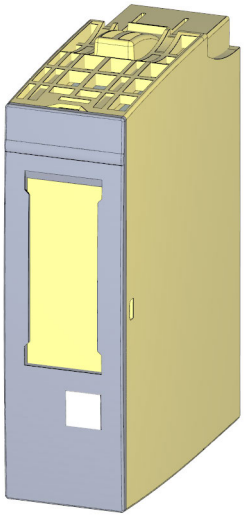


Figure 2-1 View of the F-PM-E 24VDC/8A PPM ST module

Properties

- Technical properties
  - Fail-safe digital module
  - 2 inputs (SIL3/Cat.4/PLe)
  - 1 output PM-switching or PP-switching, output current 8 A (SIL3/Cat.4/PLe)
  - 2 outputs for sensor supply
  - Sink input (P-reading)
  - Source output (PM/PP-switching)
  - Supply voltage L+
  - Suitable for connection of 2-wire sensors to IEC 61131, type 1
  - Channel-specific assignable input delay 0.4 ms to 20 ms
  - Diagnostic display (DIAG red/green LED)
  - Status display for each input or output (green LED)
  - Fault display for each input or output (red LED)
  - Diagnostics, e.g., short circuit/wire break, channel-specific
  - Diagnostics, e.g., load voltage missing, module-specific
  - Channel-specific or passivation throughout the module
- Supported functions
  - Firmware update
  - I&M identification data
  - PROFIsafe

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires. The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 69).

Accessories

The following accessories, which are not included in the product package of the F-module, can be used with the F-module:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection

Additional information on accessories can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

Safety-related shutdown of standard DQ modules by the F-PM-E 24VDC/8A PPM ST

This cost-effective solution allows for full and simultaneous shutdown of all affected outputs of the standard DQ modules when a fault is detected in the process or on the F-PM-E 24VDC/8A PPM ST power module.

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

You can use the F-PM-E 24VDC/8A PPM ST power module with all standard DQ modules within a potential group. Additional information is available in Applications for safety-related shutdown of standard modules (Page 59).

Passivation of fail-safe outputs over a long period of time

⚠ WARNING

Unintentional activation of F-I/O with fail-safe outputs

If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus place the F-system in a dangerous state.

Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.

One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.

The required measures are standardized for plants with product standards.

For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Connecting

3

3.1 Terminal assignment

General terminal assignment

Table 3- 1 Terminal assignment for F-PM-E 24VDC/8A PPM ST

Terminal assignment for F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n • DQ-P_0: Output signal, channel 0, P-switching • DQ-M_0: Ground for output signal, channel 0, M-switching • AUX: Protective conductor connection or voltage bus for SELV/PELV circuits	C0	 CC52 6ES7193-6CP52-2MC0
3	VS_0	**4**	VS_1			
5	DQ-P_0	**6**	DQ-M_0			
7	AUX	**8**	AUX			
L+	DC24V	**N**	M			
L+	DC24V	**N**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System*system manual

Note

Make sure that you only use the power module with BaseUnit type C0 during commissioning.

Digital output

The digital output switches the voltage L+ and M using two electronic switches (see Block diagram (Page 16)). The switched voltage and chassis are conducted to the internal voltage buses P1 and P2. The switched voltage and chassis is also available at the BaseUnit at DQ-P_0 and DQ-M_0.

This results in two connection options that can be used at the same time, if desired:

- One load can be wired directly to the BaseUnit (see Applications for the output DQ/P1 and P2 (Page 39)).
- The standard modules can be supplied and switched off safety-related by means of the internal voltage buses P1 and P2. You can, in turn, connect loads to the standard modules (see Applications for safety-related shutdown of standard modules (Page 59)).

⚠ WARNING

It is no longer possible to shut down an actuator if a cross circuit has developed between L+ and DQ. To prevent cross circuits between L+ and DQ, you must route the cables used to connect the actuators in a cross-circuit proof manner (for example, as separate, sheathed cables or in separate cable ducts).

Redundant ground conductor required

⚠ WARNING

The ground conductor to the BaseUnit for F-PM-E 24VDC/8A PPM ST must be installed twice for safety reasons. Any interruption of a single ground conductor would prevent the safety-related shutdown of voltage bus P2.

Property of the individual shutdown of F-modules with fail-safe outputs

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Switching of loads with ground if the F-module is configured PM-switching

If the following two conditions are met, F-PM-E 24VDC/8A PPM ST detects a short circuit:

- If loads that have a connection between chassis and ground are switched by the F-PM-E 24VDC/8A PPM ST , for example, to improve the EMC properties.
- If chassis and ground are connected at the power supply unit.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection (refer to the diagram below as an example for an F-PM-E 24VDC/8A PPM ST).

Remedy:

- Use the F-PM-E 24VDC/8A PPM ST configured as a PP-switching module.
- Increase the value of the resistance between chassis and ground at the load end to more than 100 kΩ.
- Reduce the capacitance value between chassis and ground at the load end to less than 2 µF.

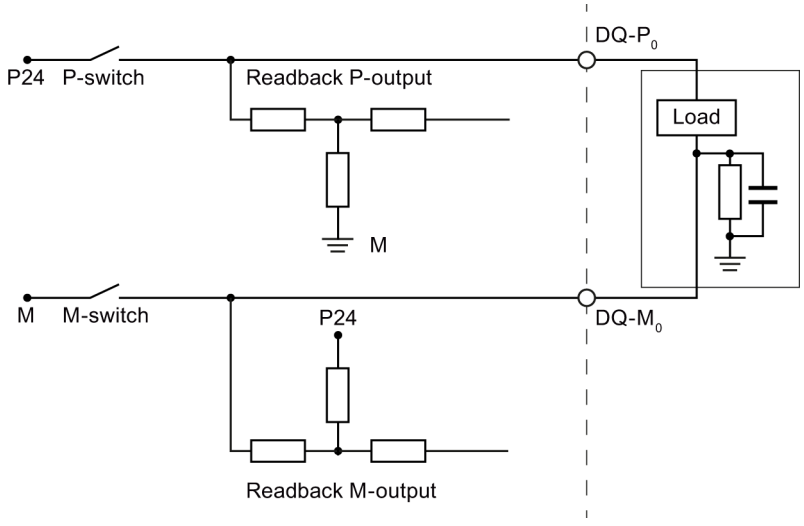


Figure 3-1 Switching of grounded loads (resistance between chassis and ground)

WARNING

During startup, the F-PM-E 24VDC/8A PPM ST carries out a switch-on test of approximately 3 ms. The capacitance between chassis and ground at the load end is charged by way of the load resistance. This low charging current may briefly trigger sensitive load circuits.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

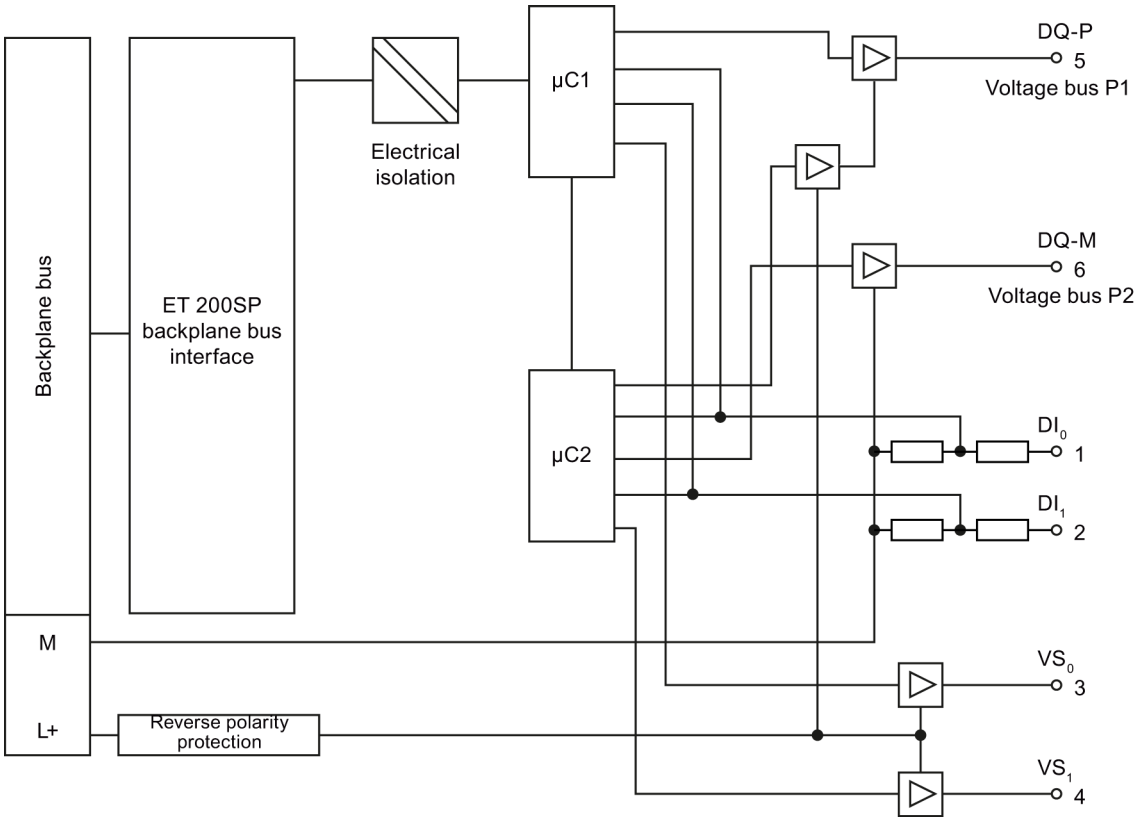


Figure 3-2 Block diagram F-PM-E 24VDC/8A PPM ST

Parameters/address space

4

4.1 Parameters

Parameters

⚠ WARNING
Diagnostic functions should be activated or deactivated in accordance with the application.

Table 4- 1 Parameters for power module

Parameter	Value range	Parameter reassignment in RUN	Scope
F-parameters:			
Manual assignment of the F-monitoring time	• disable • enable	no	Module
F-monitoring time	1 to 65535 ms	no	Module
F-source address	1 to 65534	no	Module
F-destination address	1 to 65534	no	Module
F-parameter signature (without address)	0 to 65535	no	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	no	Module
F-I/O DB manual number assignment	• disable • enable	no	Module
F-I/O DB number	—	no	Module
F-I/O DB name	—	no	Module
PM-parameters:			
Maximum test period	• 100 s • 1000 s	no	Module
Sensor supply:			
Short circuit test	• disable • enable	no	Channel
Time for short circuit test	0.5 ms to 2 s	no	Channel
Startup time of the sensors after short circuit test	0.5 ms to 2 s	no	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Inputs:			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent	no	Channel pair
Discrepancy behavior	• Supply last valid value • Supply 0 value	no	Channel pair
Discrepancy time	5 ms to 30 s	no	Channel pair
Reintegration after discrepancy error	• Test 0-signal necessary • Test 0-signal not necessary	no	Channel pair
Activated	• disable • enable	no	Channel
Sensor supply	• Sensor supply 0 • Sensor supply 1 • External sensor supply	no	Channel
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20 ms The provided value range depends on the parameter assignment of the employed sensor supply.	no	Channel
Pulse extension	• — • 0.5 s • 1 s • 2 s	no	Channel
Chatter monitoring activated	• disable • enable	no	Channel
Number of signal changes	2 to 31	no	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	no	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Output:			
Activated	• disable • enable	no	Channel
Control of the output	• F-CPU • F-CPU and onboard F-DI	no	Module
Output type	• PM switching • PP switching	no	Channel
Max. readback time dark test	0.8 to 400.0 ms	no	Channel
Disable dark test for 48 hours	• disable • enable	no	Channel
Max. readback time switch on test	0.8 to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnosis: Wire break	• disable • enable	no	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

F-parameters

Information on F-parameters is available in the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.2 PM-parameters

4.2.2.1 Maximum test period

Here you specify the time within which the light and dark tests (in all combinations) should be performed throughout the module. When this time expires, the tests are repeated.

The "Maximum test period" parameter is a module parameter, which means the test cycle for the entire fail-safe output module is performed within the configured maximum test time. If the bit pattern test is not performed within the configured time (or the shortened test time of 60 seconds in case of an error), the module goes into the error state.

4.2.3 Parameters of the sensor supply

4.2.3.1 Short circuit test

Here you enable the short-circuit detection for the channels of the F-module for which "Internal sensor supply" is set.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply. For switches with power supply, for example, 3/4-wire proximity switches, a short-circuit test is not possible.

The short-circuit detection switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for sensor test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input of another channel when it has a 1 signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

During the execution time (Time for sensor test + Startup time of sensor after sensor test) of the short circuit test, the last valid value of the input before the start of the short circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

4.2.3.2 Time for short circuit test

Function

When the short-circuit test is enabled, the corresponding sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the assigned time, a diagnostic message is generated.

When assigning parameters, note that

- If the channel is passivated, this may be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance does not discharge within the assigned time, you need to adjust the "Time for sensor test" parameter.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

4.2.3.3 Startup time of sensors after short circuit test

Function

In addition to the off time ("Time for sensor test"), a startup time must be specified for performing the short circuit test. You use this parameter to notify the module how long the utilized sensor needs to start up after connecting the sensor supply. This prevents an undefined input state due to transient reactions in the sensor.

When assigning parameters, note that

- This parameter must be greater than the transient recovery time of the employed sensor.
- Because the assigned time affects the response time of the module, we recommend that you set the time as short as possible but long enough so that your sensor can settle safely.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short circuit test is enabled.

4.2.4 Parameters of the inputs

4.2.4.1 Sensor evaluation

Overview

Select the type of sensor evaluation with the "Sensor evaluation" parameter:

- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent

1oo2 evaluation equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- One single-channel sensor
- One non-equivalent sensor
- One two-channel sensor
- Two single-channel sensors

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly.

Discrepancy analysis

When using a two-channel sensor or two single-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non-equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same levels). A check is made to determine whether the difference in levels (when testing for non equivalence: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

Achievable safety class

The following safety class can be achieved depending on the selected sensor evaluation:

- SIL3/Cat.4/PLe with "1oo2 evaluation equivalent/non-equivalent"

4.2.4.2 Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to fast response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown.. In the worst-case scenario, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

4.2.4.3 Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

4.2.4.4 Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-signal necessary"
- "Test 0-signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non equivalent"

"Test 0-signal necessary"

If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non equivalent", a 0-signal must be present again at the low order channel of the channel pair.

"Test 0-signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.4.5 Activated

You hereby enable the corresponding channel for signal processing in the safety program.

4.2.4.6 Sensor supply

Here you select one of the internal sensor supplies VS_0 to VS_n or an external sensor supply.

The selection of an internal sensor supply is required for using the short circuit test.

See also

Time for short circuit test (Page 20)

4.2.4.7 Input delay

Function

To suppress stray interference, you can set an input delay for the entire channel or channel pair.

Interference pulses whose pulse time is less than the set input delay (in ms) are suppressed. Suppressed interference pulses are invisible in the PII.

A high input delay suppresses longer interference pulses, but results in a longer response time.

The values available for the input delay depend on the "Startup time of sensors after short circuit test" and the "Time for short circuit test" of the configured sensor supply.

Note

Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Adapt the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the sensor supply.

See also

Technical specifications (Page 77)

4.2.4.8 Pulse extension

Function

Pulse extension is a function to change a digital input signal. A pulse on a digital input is extended to at least the assigned length. If the input pulse is already longer than the assigned length, the pulse is not changed.

The fail-safe electronic module only lengthens pulses with the value "0" because the basis of the safety concept is that there is a safe state for all process variables. For digital F-I/O, this is the value "0", which applies to sensors as well as to actuators.

With 1oo2 evaluation, the result of the evaluation of both sensors is used for the pulse extension.

4.2.4.9 Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

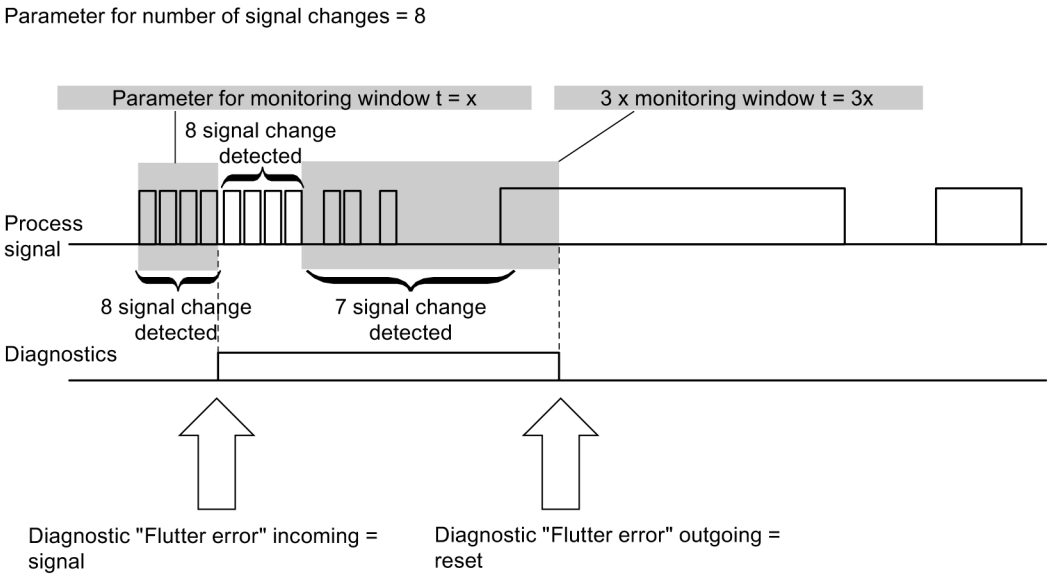


Figure 4-1 Figure chatter monitoring

Number of signal changes

Sets the number of signal changes after which a chatter error should be reported.

4.2.4.10 Monitoring window

Sets the time for the monitoring window of flutter monitoring.

You can set times of 1 s to 100 s in whole seconds for the monitoring window.

You can configure a monitoring window of 0.5 s when you set 0 s.

4.2.5 Parameters of the output

4.2.5.1 Activated

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

You can deactivate an unused channel with this parameter.

4.2.5.2 Controlling the output

Activates the internal evaluation.

Additional information on internal evaluation is available in the chapter "Application for internal evaluation" (Page 57).

4.2.5.3 Output type

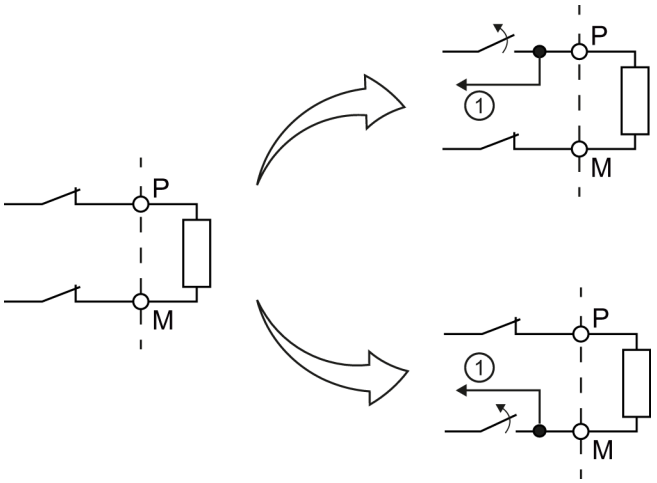
The parameter specifies if the output switches PM or PP.

4.2.5.4 Max. readback time dark test

Function

Dark tests are shutdown tests with bit pattern test.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 4-2 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the response time of the F-module.

⚠ WARNING

Through the configured readback time dark test, short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured readback time dark test) Hz cannot be recognized (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting readback time dark test

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you set the readback time dark test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads (Page 85).

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the readback time light test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time dark test so that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

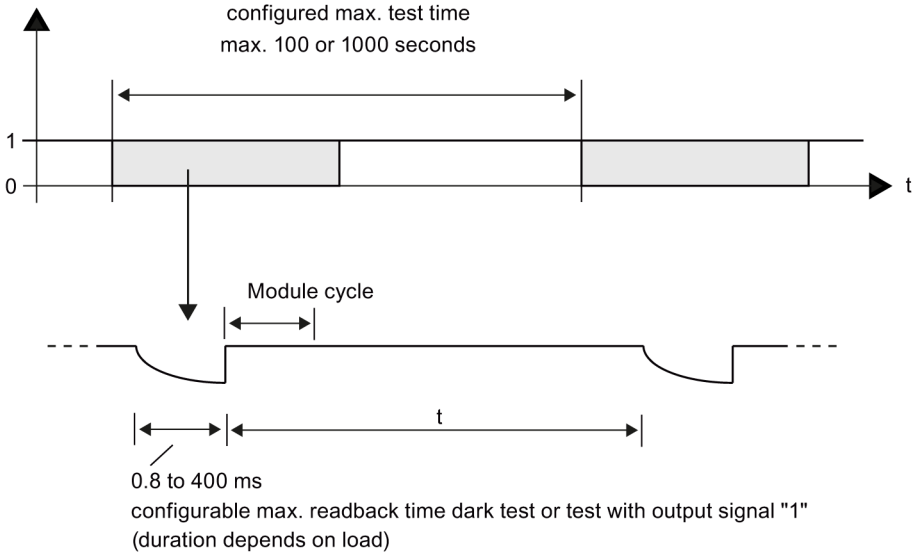


Figure 4-3 Test pulses of the dark test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance of test pulses (Page 84).

4.2.5.5 Disable dark test for 48 hours

This option allows you to suppress the dark test.

If the channel is permanently active (1) for 48 hours, 2 dark test pulses (PP switching) or 3 dark test pulses (PM switching) are directed to this channel once the time has expired.

You must provide the signal change from 1 to 0 at the channel yourself within 48 hours to prevent the dark test pulse. The dark test is suspended for another 48 hours after the signal change from 0 to 1.

The dark test is permanently suppressed if the following condition is met:

- A signal change from 1 to 0 takes place before the 48 hours have expired.

⚠ WARNING

The output is passivated if an error caused by a short-circuit is recognized when the safety-function is executed (output turned off). This is necessary because a complete bit pattern test is not performed within 48 hours, which means an undetected error burst may not be ruled out.

If the channel can retain signal 0 for 48 hours and longer, the function "Disable dark test for 48 hours" must not be used.

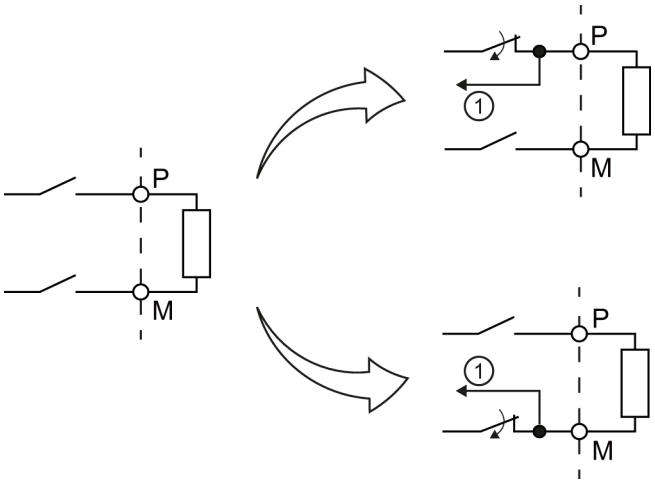
Consult the respective requirements of your product standards regarding error detection time.

4.2.5.6 Max. readback time switch on test

Function

The switch on test is part of the bit pattern test.

During the switch on test, the P-switch and M-switch of the output channel are alternately closed and read back when the output channel is inactive (output signal "0"). Contrary to the light test, no power flows through the connected load during the switch on test.



① Readback

Figure 4-4 Functional principle of the switch on test (PM switching)

This parameter allows you to set the time for the readback. If the signal was not read back correctly once the time has expired, the output channel is passivated.

The switch on test detects the following faults:

- Short circuit to L+ with output signal "0"
- Short circuit to ground with output signal "0"

⚠ WARNING

Through the configured readback time, short circuits (cross-circuits) to an interfering signal with a frequency > 1 / (2 x configured readback time) Hz can be suppressed (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

Setting readback time

Because the fault reaction time is extended by the length of the set readback time, we recommend that you set the readback time by trial and error as low as possible but high enough that the output channel is not passivated.

To determine the readback time required for your actuator, refer to the diagram in the chapter Switching capacitive loads (Page 85).

If the capacity of the actuator is not known, it may be necessary for you to determine the required value for the readback time by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time switch on test in such a way that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time switch on test.
- If the output channel is passivated, the readback time switch on test is too small for a connected capacitive load. The charge of the capacitive load cannot take place within the configured readback time switch on test. Increase the readback time.

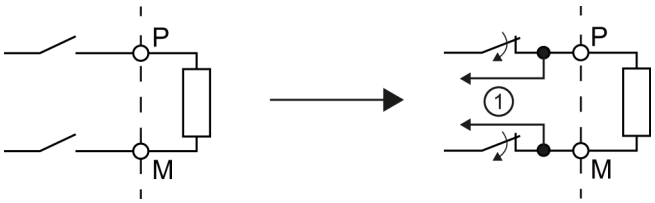
If you have set the readback time to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

4.2.5.7 Activated light test

Function

Overload and wire break are detected with a 0 signal at the output.

For a light test, several test signals are switched to the output channel while the output channel is inactive (output signal "0"). The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.



① Readback

Figure 4-5 Functional principle of the light test (PM switching)

In contrast to the switch on test, the P-switch and the M-switch switch at the same time during the light test and power flows through the connected load.

If the readback signals are incorrect, the signal is present for the configured readback time at the output channel before the fault causes passivation of the output channel.

If the signal was not read back correctly once the maximum readback time switch on test has expired, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time switch on test for the light test increases the response time of the F-module.

Test pulses of the light test

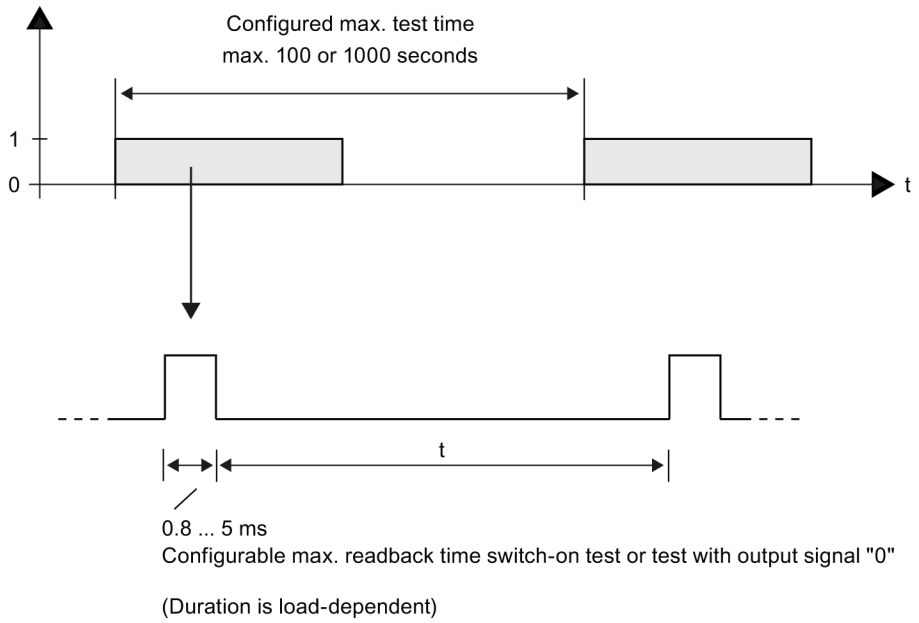


Figure 4-6 Test pulses of the light test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance of test pulses (Page 84).

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after t. If the fault is still present, the maximum test time is automatically reduced to 60 seconds and a diagnostic message is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

4.2.5.8 Diagnosis: Wire break

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

Wire break is signaled when the following conditions are met:

- Wiring to the actuator is interrupted.
- A module that is disabled in fail-safe mode by the F-PM module has been removed.

You also have to activate the light test to detect a wire break with an output signal "0".

4.3 Address space

Address assignment of power module F-PM-E 24VDC/8A PPM ST

The F-PM-E 24VDC/8A PPM ST power module occupies the following address areas in the F-CPU:

Table 4- 2 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
In input range	In output range
x + 0 to x + 6	x + 0 to x + 4

x = Module start address

Address assignment of the user data and value status of power module F-PM-E 24VDC/8A PPM ST

Of the assigned addresses of power module F-PM E 24VDC/8A PPM ST, the user data occupy the following addresses in the F-CPU:

Table 4- 3 Address assignment of user data **in the input range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	DI_1	DI_0
x + 1	—	—	—	—	—	—	Value status for DI_1	Value status for DI_0
x + 2	—	—	—	—	—	—	—	Value status DQ_0

x = Module start address

Table 4- 4 Address assignment of user data **in the output range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	—	DQ_0

x = Module start address

Note

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors you may only access the low order channel in the safety program.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

See also

Value status (Page 75)

Applications of the F-I/O module

5

5.1 Applications for the output DQ/P1 and P2

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving the various safety categories.

Table 5- 1 Conditions for achieving SIL/Cat./PL

F-PM-E 24VDC/8A PPM ST		Achievable safety class
Digital output DQ	Without standard DQ modules	SIL3/Cat.4/PLe
	With standard DQ modules	SIL2/Cat.3/PLd

5.1.1 Applications: Safety mode up to SIL3/Cat.4/PLe

Wiring

The wiring is carried out on the matching BaseUnit (Page 13).

5.1.1.1 Application: Wiring a load to the digital output, PM switching

The fail-safe digital output consists of two P-switches for DQ-P_0 and one M-switch for DQ-M_0. They connect the load between the P-switches DQ-P_0 and the M-switch DQ-M_0. The two P-switches and the M-switch are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

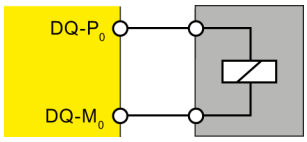


Figure 5-1 Wiring diagram of power module F-PM-E 24VDC/8A PPM ST

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 5- 2 Parameters

Parameter	
Output type	PM switching

5.1.1.2 Application: Wiring a load to the digital output, PP switching

The fail-safe digital output consists of two P-switches for DQ-P_0 and one M-switch for DQ-M_0. You connect the load between the P-switch DQ-P_0 and chassis in this case. The two P-switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

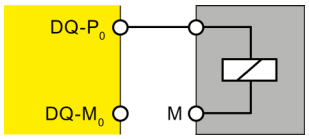


Figure 5-2 Wiring diagram of power module F-PM-E 24VDC/8A PPM ST

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 5- 3 Parameters

Parameter	
Output type	PP switching

5.1.1.3 Application: Wiring two loads in parallel to the digital output, PM switching

You achieve SIL3/Cat.4/PLe with the following wiring variant.

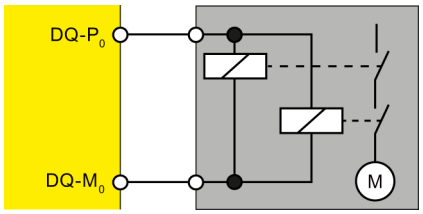


Figure 5-3 Wiring diagram for connecting two relays each in parallel to F-DQ of power module F-PM-E 24VDC/8A PPM ST

Note

When two relays are connected in parallel to one digital output (as shown above), a wire break is only detected if the wire break disconnects both relays from P or M. The diagnostics generated in the process is not safety-related.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 5- 4 Parameters

Parameter	
Output type	PM switching

5.1.1.4 Application: Wiring two loads in parallel to the digital output, PP switching

You achieve SIL3/Cat.4/PLe with the following wiring variant.

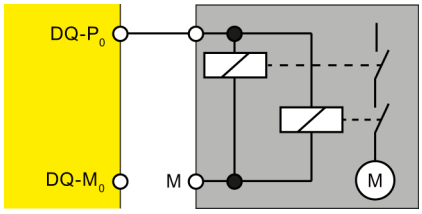


Figure 5-4 Wiring diagram for connecting two relays each in parallel to F-DQ of power module F-PM-E 24VDC/8A PPM ST

Note

When two relays are connected in parallel to one digital output (as shown above), a wire break is only detected if the wire break disconnects both relays from P or M. The diagnostics generated in the process is not safety-related.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 5- 5 Parameters

Parameter	
Output type	PP switching

5.2 Applications for inputs

5.2.1 Applications of the electronic module

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

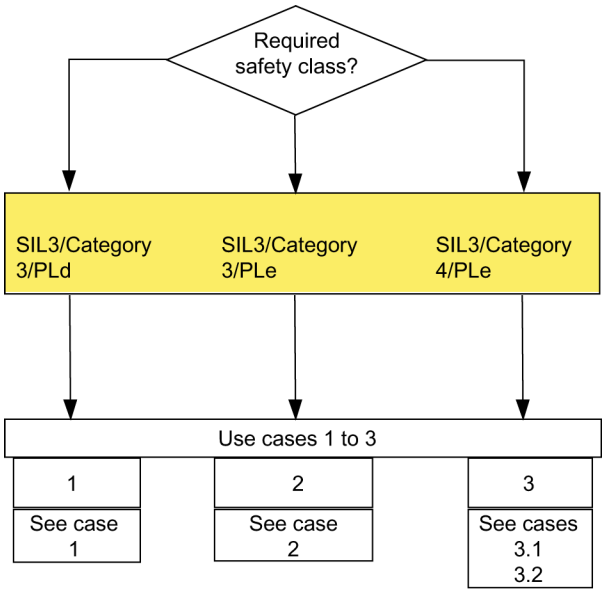


Figure 5-5 Selecting the application – digital inputs of the F-PM-E 24VDC/8A PPM ST

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the proof-test interval in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 5- 6 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Any	3 / 3 / d
2	1oo2 equivalent	Internal, without short circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	External/internal, with short circuit test	

Sensor requirements

Information on safety-related use of sensors is available in the section Requirements for sensors and actuators for fail-safe modules in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.2.2 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is carried out on the matching BaseUnit (Page 13).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting one sensor via one channel

One sensor is connected via one channel (1oo1 evaluation) for each process signal. Any sensor supply of the module can be assigned to each input.

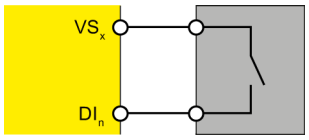


Figure 5-6 One sensor connected via one channel, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

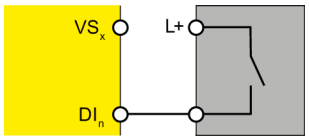


Figure 5-7 One sensor connected via one channel, external sensor supply

⚠ WARNING
To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 7 Parameter assignment

Parameters	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Short circuit test	• disable • enable	disable
Sensor supply	• Sensor supply n	External sensor supply*

*) Otherwise a diagnostic message will be generated when short circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 8 Fault detection

Fault	Fault detection		
	Internal sensor supply and short circuit test activated	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit with other channels or other sensor supplies (short circuit with other channels is detected only if they use a different sensor supply)	yes*	no	no
Short circuit with L+ to DI_n	yes	no	no
Short circuit with M to DI_n	yes*	yes*	no
Discrepancy error	—	—	—
Short circuit with L+ to VS_n	yes	no	—
Short circuit with M to VS_n or defective	yes	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

⚠ WARNING

If the short circuit test is not activated or the sensor supply to digital inputs is set to "External sensor supply", the wiring between the sensor and the input channel must be short circuit proof.

5.2.3 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The F-PM-E 24VDC/8A PPM ST power module has two fail-safe inputs, DI_0 and DI_1 (SIL3). You can combine the two inputs into one input.

The process signal is supplied by channel DI_0.

Wiring

The wiring is carried out on the matching BaseUnit (Page 13).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

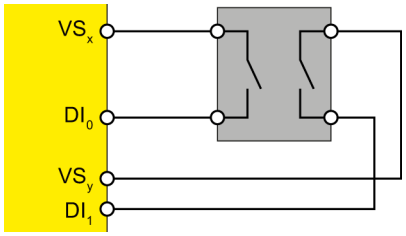


Figure 5-8 One two-channel sensor connected via two channels, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

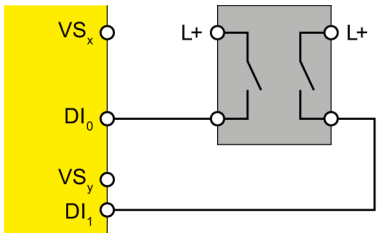


Figure 5-9 One two-channel sensor connected via two channels, external sensor supply

Wiring diagram – connecting two single-channel sensors via two channels

Two single-channel sensors that capture the same process value are connected to two inputs of the F-module for each process signal (1oo2 evaluation).

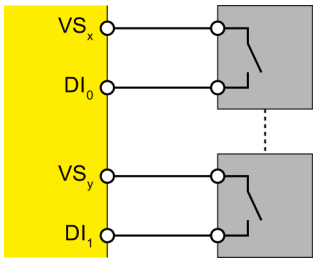


Figure 5-10 Two single-channel sensors connected via two channels, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

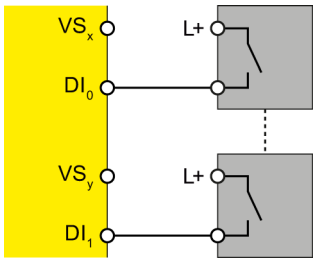


Figure 5-11 Two single-channel sensors connected via two channels, external sensor supply

WARNING
To achieve SIL3/Cat.3/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 9 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Short circuit test	• disable • enable	disable

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 10 Fault detection

Fault	Fault detection	
	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit within the channel pair, with other channels or other sensor supplies	no	no
Short circuit with L+ to DI_n	yes*	yes*
Short circuit with M to DI_n	yes*	yes*
Discrepancy error	yes	yes
Short circuit with L+ to VS_n	no	no
Short circuit with M to VS_n or defective	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.2.4 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The F-PM-E 24VDC/8A PPM ST power module has two fail-safe inputs, DI_0 and DI_1 (SIL3). You can combine the two inputs into one input.

The process signal is supplied by channel DI_0.

Wiring

The wiring is carried out on the matching BaseUnit (Page 13).

Sensor supply

The sensor must be supplied **internally** for application 3.1 (Page 52).

The sensor can be supplied internally or externally for application 3.2 (Page 54).

Requirements for applications in machine protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed to state-of-the-art engineering and standards to prevent short circuits.
- All short circuits listed in Table 5-12 Fault detection (Page 53) and Table 5-14 Fault detection (Page 56) must be detected. You only need to detect **one** short circuit because two faults are required to generate it. This means both signal cables in short circuit have an isolation fault. A multiple short circuit analysis is not required.

Procedures for locating all short circuits are also permitted if single short circuits are not located. One of the two conditions must be met for this purpose:

- Short circuits may not corrupt the read signals compared to the sensor signals.
- Short circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

5.2.4.1 Application 3.1 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected to both inputs of the power module for each process signal (1oo2 evaluation).

Supply the sensors from two different sensor supplies.

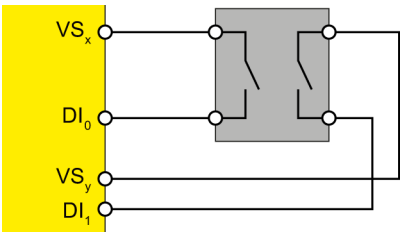


Figure 5-12 One two-channel sensor connected via two channels, internal sensor supply

You can also connect two single-channel sensors via two channels. In this case, the same process variable is acquired with two mechanically separate sensors.

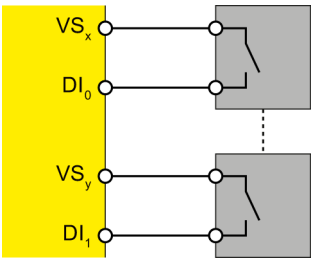


Figure 5-13 Two single-channel sensors connected via two channels, internal sensor supply

WARNING
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 11 Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	1oo2 evaluation, equivalent
Short circuit test	enable
Sensor supply	• Sensor supply n • External sensor supply

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 12 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes*
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes
Short circuit with M to VS_n or defective	yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.2.4.2 Application 3.2 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a nonequivalent sensor nonequivalent via two channels

A nonequivalent sensor is connected nonequivalent via 2 channels to both inputs of the power module for each process signal (1oo2 evaluation, nonequivalent).

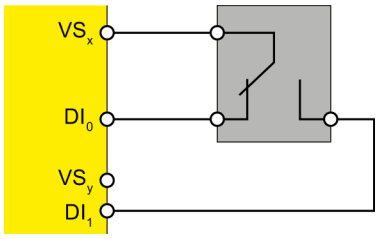


Figure 5-14 Nonequivalent sensor connected, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

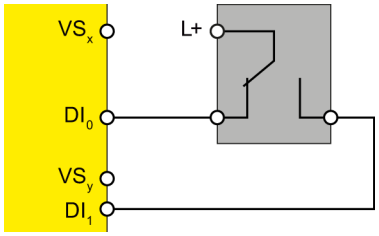


Figure 5-15 Nonequivalent sensor connected, external sensor supply

⚠ WARNING
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram – connecting two single-channel sensors nonequivalent via two channels

Two single-channel sensors are connected nonequivalent to both inputs of the power module for each process signal (1oo2 evaluation).

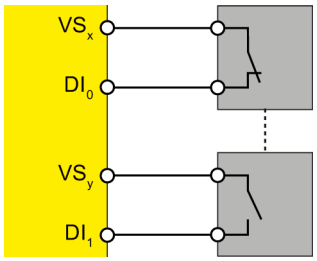


Figure 5-16 Two single-channel sensors connected nonequivalent, internal sensor supply

You can also supply the sensors by means of an external sensor supply.

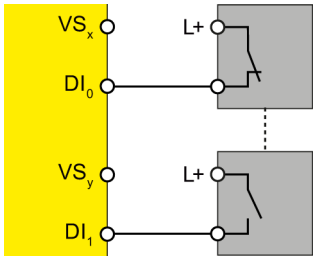


Figure 5-17 Two single-channel sensors connected nonequivalent, external sensor supply

WARNING
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 5- 13 Parameter assignment

Parameters	
Sensor evaluation	1oo2 evaluation, non equivalent
Short circuit test	• disable • enable
Sensor supply	• Sensor supply n • External sensor supply

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 5- 14 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes, if used
Short circuit with M to VS_n or defective	yes, if sensor supply is activated

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

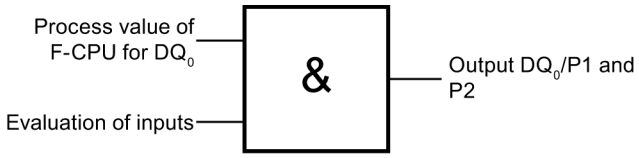
5.3 Application for internal evaluation

Function

The evaluation of the safety function takes place internally in the F-module.

You can choose between 1oo1 evaluation or nonequivalent/equivalent 1oo2 evaluation of the sensors.

- With 1oo1 evaluation, the activated inputs are logically ANDed with the process image of output DQ_0.
- With 1oo2 evaluation, the result of the inputs is logically ANDed with the process image of output DQ_0.



The acknowledgment in case of an error takes place by the safety program in the F-CPU.

Use the wiring diagrams Applications for the output DQ/P1 and P2 (Page 39) and Applications for inputs (Page 43).

You achieve SIL3/Cat.4/PLe.

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator and sensor, for example, in accordance with IEC 60947.

Note

If an error occurs at the inputs in this application, the F-module also outputs the error message "Safety-related shutdown" or "Safety event" for the output. Following elimination of the error at the inputs, a reintegration of the output is only possible after the bit pattern test (within the test time shortened to 60 s) has been performed.

Interconnection example

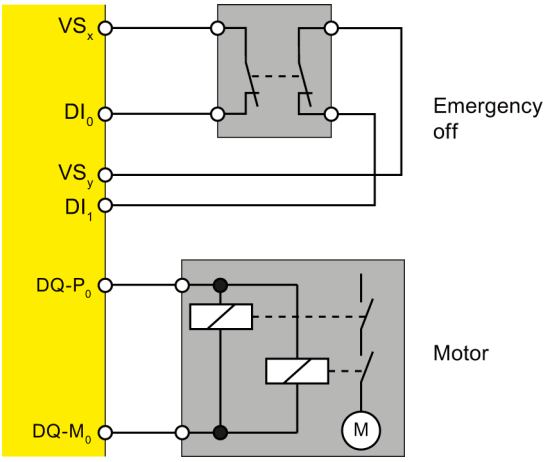


Figure 5-18 Emergency Off shutdown of a motor with equivalent 1oo2 evaluation

Parameter assignment

Assign the following parameters for the F-module:

Parameter	
Control of the output	F-CPU and onboard F-DI
Type of sensor interconnection	• 1-channel • 2-channel equivalent • 2-channel, non equivalent
Sensor supply	Sensor supply 0, Sensor supply 1, or External sensor supply

5.4 Applications for safety-related shutdown of standard modules

5.4.1 Safety-related shutdown of standard output modules, PM-switching

The F-PM-E 24VDC/8A PPM ST power module opens, together with the matching BaseUnit, a new potential group . Standard DQ modules that you use in the potential group can undergo a safety-related shutdown by the F-PM-E 24VDC/8A PPM ST power module. For this, the F-PM-E 24VDC/8A PPM ST power module performs a safety-related shutdown of voltage buses P1 and P2.

Configure the power module parameters as described in section Terminal assignment (Page 13).

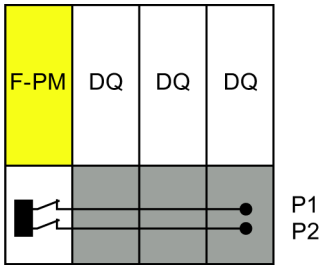


Figure 5-19 Safety-related shutdown of standard output modules

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

⚠ WARNING

Safety-related activation of standard DQ module outputs is not possible; only safety-related **shutdown** is possible. You must therefore take the following possible effects into consideration:

In the worst case scenario, you must consider all possible faults of the standard DQ modules and the program controlling them for which there is no direct fault detection. For example, the F-PM-E 24VDC/8A PPM ST and F-DQ 4×24VDC/2A PM HF do not detect external short circuits to L+ at the standard DQ module outputs. All faults of the standard DQ modules act on the process via final controlling elements. The process must be made known to the F-CPU by way of sensors and a corresponding safety program.

Because safety-critical faults in the standard DQ modules cannot be detected by self-tests within the module, the "diagnostics" must be performed indirectly via the controlled process. As long as the incorrectly controlled process does not pose a hazard, the safety-related control does not intervene It only performs a shutdown if the process exhibits unwanted or potentially dangerous behavior.

It therefore follows that the reaction times for faults within standard DQ modules are not based on the specified short fault detection times of S7 but rather depend on the controlled process and the evaluation of feedback from the process.

Safety-related process values must be

- safely
- read in by way of fail-safe inputs or fail-safe input modules (e.g., F-DI)
- the safety function must be evaluated locally in the power module F-PM-E 24VDC/8A PPM ST or processed by the fail-safe CPU to form output commands and
- output by the fail-safe output module for shutdown of the corresponding safety relay or
- output by the F-PM-E 24VDC/8A PPM ST fail-safe power module.

If the expectations at the process end are not met (due to a process malfunction or faulty standard DO modules), the standard DQ modules must be brought to a safe state by way of the higher-level safety circuit.

The process safety time is of particular importance here. During this process safety time, no hazard is posed by an incorrectly controlled process.

The safety program must react in a safety-related and logical manner to unwanted or potentially dangerous states in the process via the F-PM-E 24VDC/8A PPM ST, F-DQ 4×24VDC/2A PM HF and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use the PM-switching F-DQ 4×24VDC/2A PM HF module instead of standard DQ modules.

⚠ WARNING

Always connect the 24 V DC supply for the standard ET 200SP modules to the F-PM-E 24VDC/8A PPM ST. Otherwise, the outputs of DQ modules may exhibit safety-critical behavior.

WARNING

When supplying standard DQ modules, always use the BaseUnits of these modules to supply the actuators (actuator feedback on the DQ module).

See also Terminal assignment (Page 13).

WARNING

Note the following for the "Safety-related shutdown of standard modules" application:

If standard modules behind a F-PM-E 24VDC/8A PPM ST power module are exposed to surge conditions, immunity according to failure criterion B is achieved (according to EN 298 and IEC 61326-3-2), i.e., the standard modules may fail in the event of surge conditions.

5.4.2 Safety-related shutdown of standard output modules, PP-switching

The F-PM-E 24VDC/8A PPM ST power module opens, together with the matching BaseUnit, a new potential group . Standard DQ modules that you use in the potential group can undergo a safety-related shutdown by the F-PM-E 24VDC/8A PPM ST power module. For this, the F-PM-E 24VDC/8A PPM ST power module performs a safety-related shutdown of voltage bus P1.

Configure the power module parameters as described in section Terminal assignment (Page 13).

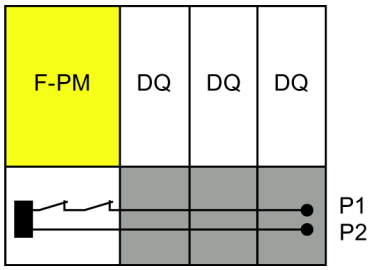


Figure 5-20 Safety-related shutdown of standard output modules

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

⚠ WARNING

Safety-related activation of standard DQ module outputs is not possible; only safety-related **shutdown** is possible. You must therefore take the following possible effects into consideration:

In the worst case scenario, you must consider all possible faults of the standard DQ modules and the program controlling them for which there is no direct fault detection. For example, the F-PM-E 24VDC/8A PPM ST and F-DQ 4×24VDC/2A PM HF do not detect external short circuits to L+ at the standard DQ module outputs. All faults of the standard DQ modules act on the process via final controlling elements. The process must be made known to the F-CPU by way of sensors and a corresponding safety program.

Because safety-critical faults in the standard DQ modules cannot be detected by self-tests within the module, the "diagnostics" must be performed indirectly via the controlled process. As long as the incorrectly controlled process does not pose a hazard, the safety-related control does not intervene It only performs a shutdown if the process exhibits unwanted or potentially dangerous behavior.

It therefore follows that the reaction times for faults within standard DQ modules are not based on the specified short fault detection times of S7 but rather depend on the controlled process and the evaluation of feedback from the process.

Safety-related process values must be

- safely
- read in by way of fail-safe inputs or fail-safe input modules (e.g., F-DI)
- the safety function must be evaluated locally in the power module F-PM-E 24VDC/8A PPM ST or processed by the fail-safe CPU to form output commands and
- output by the fail-safe output module for shutdown of the corresponding safety relay or
- output by the F-PM-E 24VDC/8A PPM ST fail-safe power module.

If the expectations at the process end are not met (due to a process malfunction or faulty standard DO modules), the standard DQ modules must be brought to a safe state by way of the higher-level safety circuit.

The process safety time is of particular importance here. During this process safety time, no hazard is posed by an incorrectly controlled process.

The safety program must react in a safety-related and logical manner to unwanted or potentially dangerous states in the process via the F-PM-E 24VDC/8A PPM ST, F-DQ 4×24VDC/2A PM HF and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use the PM-switching F-DQ 4×24VDC/2A PM HF module instead of standard DQ modules.

⚠ WARNING

Always connect the 24 V DC supply for the standard ET 200SP modules to the F-PM-E 24VDC/8A PPM ST. Otherwise, the outputs of DQ modules may exhibit safety-critical behavior.

⚠ WARNING

When supplying standard DQ modules, always use the BaseUnits of these modules to supply the actuators (actuator feedback on the DQ module).

See also Terminal assignment (Page 13).

⚠ WARNING

Note the following for the "Safety-related shutdown of standard modules" application:

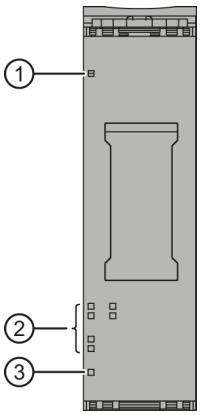
If standard modules behind a F-PM-E 24VDC/8A PPM ST power module are exposed to surge conditions, immunity according to failure criterion B is achieved (according to EN 298 and IEC 61326-3-2), i.e., the standard modules may fail in the event of surge conditions.

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display



① DIAG (green/red)
② Channel status (green), channel fault (red)
③ PWR (green)

Figure 6-1 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 69).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the inputs and outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

PWR LED

Table 6- 1 Meaning of the PWR LED

PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ available

DIAG LED

Table 6- 2 Meaning of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	Module parameters configured and module diagnostics

Channel status/channel fault LED

Table 6- 3 Meaning of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		Channel waiting for user acknowledgment

Channel status/DIAG/channel fault LED

Table 6- 4 Meaning of the channel status/DIAG/channel fault LED

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

6.2 Interrupts

Introduction

The F-PM-E 24VDC/8A PPM ST fail-safe power module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 69).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 69).

Table 6- 5 Diagnostic interrupts of the F-PM-E 24VDC/8A PPM ST

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	—	F-module	No
Parameter assignment error	16_D			
Load voltage missing	17_D			
Access to retentive storage of F-address not possible	30_D			
Different destination address (F_Dest_Add)	64_D			

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Invalid destination address (F_Dest_Add)	65_D			
Invalid source address (F_Source_Add)	66_D			
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D			
"F_SIL" parameter exceeds the application-specific SIL	68_D			
"F_CRC_Length" parameter does not match the generated CRC	69_D			
Incorrect F-parameter version or F_Block_ID	70_D			
CRC1 error	71_D			
Inconsistent iParameters (iParCRC error)	75_D			
F_Block_ID not supported	76_D			
Internal error	256_D			
Time monitoring activated	259_D			
Internal supply voltage of the module failed	260_D			
Output short-circuited to L+	261_D		Channel	Yes
Output short-circuited to ground	262_D			
Wire break	265_D			
Incorrect/inconsistent firmware present. Firmware update required	283_D			No
Discrepancy error, channel status 0/0	768_D	2, 3		
Discrepancy error, channel status 0/1	769_D			
Discrepancy error, channel status 1/0	770_D			
Discrepancy error, channel status 1/1	771_D			
Input signal could not be clearly detected	773_D	1, 2, 3		
Short circuit of internal sensor supply to L+	774_D			Yes
Overload or short circuit of internal sensor supply to ground	775_D			
No pulse detected	778_D	1		
Sensor signal chatters	784_D			
Switching frequency too high	785_D	1,2,3		No
Undertemperature	786_D		F-module	
Fault in input circuit	787_D			
PROFIsafe communication error (timeout)	792_D			
PROFIsafe communication error (CRC)	793_D			
PROFIsafe address assignment error	794_D			
Input short-circuited to L+	796_D		Channel	Yes
Output defective	797_D	—		No
Readback error	798_D			
Overload	800_D			
Supply voltage too high	802_D	1, 2, 3	F-module	
Supply voltage too low	803_D			

6.3 Diagnostic messages

Digital module error types

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 6- 6 Diagnostic messages of the F-PM-E 24VDC/8A PPM ST

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_D	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 77)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_D	Possible causes: • There is an interrupted cable between the module and actuator. • The channel is not connected (open). • There is a short circuit between channels with different signals.	• Establish a cable connection. • Disable the wire break detection for the channel in the parameter assignment. • Eliminate the short circuit.
Parameter assignment error	16_D	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Load voltage missing	17_D	Missing or insufficient supply voltage L+	• Check supply voltage L+ at BaseUnit • Check BaseUnit type
Access to retentive storage of F-address not possible	30_D	The F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Different destination address (F_Dest_Add)	64_D	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Invalid destination address (F_Dest_Add)	65_D	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Invalid source address (F_Source_Add)	66_D	The PROFIsafe driver has detected an invalid F-source address.	

Diagnostic message	Fault code	Meaning	Remedy
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D	The PROFIsafe driver has detected an invalid watchdog time.	
"F_SIL" parameter exceeds the application-specific SIL	68_D	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
"F_CRC_Length" parameter does not match the generated CRC	69_D	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Incorrect F-parameter version or F_Block_ID	70_D	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 error	71_D	The PROFIsafe driver has detected inconsistent F-parameters.	
Inconsistent iParameters (iParCRC error)	75_D	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76_D	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Internal error	256_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Internal supply voltage of the module failed	260_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the electromagnetic interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Output short-circuited to L+	261_D	Short circuit to L+ can mean: • The sensor cable is short-circuited to L+. • The output cable is short-circuited to L+.	Correct the process wiring.
Output short-circuited to ground	262_D	Short circuit to ground can mean: • The sensor cable is short-circuited to ground. • The output cable is short-circuited to ground. • The output signal is short-circuited to ground.	Correct the process wiring.
Incorrect/inconsistent firmware present. Firmware update required	283_D	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.

Diagnostic message	Fault code	Meaning	Remedy
Discrepancy error, channel status 0/0	768_D	Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring.
Discrepancy error, channel status 0/1	769_D		
Discrepancy error, channel status 1/0	770_D		
Discrepancy error, channel status 1/1	771_D		
Input signal could not be clearly detected	773_D	An error occurred in the plausibility check of the input signal between the processors. You must eliminate the error within 100 hours. If you do not eliminate the error within 100 hours, the F-module will become inoperative. Possible causes: • The input signal is faulty, e.g., as a result of impermissibly high electromagnetic interference. • A high-frequency input signal is present, e.g., due to mutual interference of sensors or the signal being above the sampling frequency of the input signal. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • The sensor/switch is bouncing.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Short circuit of internal sensor supply to L+	774_D	Possible causes: • There is a short circuit of the internal sensor supply with L+. • There is a short circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.

Diagnostic message	Fault code	Meaning	Remedy
Overload or short circuit of internal sensor supply to ground	775_D	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.
No pulse detected	778_D	A pulse with a length greater than or equal to "Minimum pulse time" has not occurred within the time configured with the "Pulse monitoring window" parameter. Possible causes: • The "Pulse monitoring window" parameter setting is too low. • The "Minimum pulse time" parameter setting is too high. • There is a wire break in the process wiring.	• Check the "Pulse monitoring window" parameter. • Check the "Minimum pulse time" parameter. • Check the process wiring.
Sensor signal chatters	784_D	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Switching frequency too high	785_D	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency. (see Technical specifications (Page 77))
Undertemperature	786_D	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 77))
Fault in input circuit	787_D	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate/reduce the electromagnetic interference. • Replace the F-module.

Diagnostic message	Fault code	Meaning	Remedy
PROFIsafe communication error (timeout)	792_D	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • Bus faults are present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
PROFIsafe communication error (CRC)	793_D	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
PROFIsafe address assignment error	794_D	An error occurred during the automatic PROFIsafe address assignment.	Check the configuration.
Input short-circuited to L+	796_D	The input signal is short-circuited to L+.	Eliminate the short circuit.
Output defective	797_D	The F-module has detected an internal error. Possible causes: • Short circuit to L+ or M • The F-module is defective.	• Check the wiring. • Replace the F-module.
Readback error	798_D	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	If the error persists, replace the F-module.
Overload	800_D	The maximum permissible output current has been exceeded. The output stage has been switched off. Possible causes: • A short circuit exists.	Check the process wiring.
Supply voltage too high	802_D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	803_D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

In the case of a voltage dip in the supply voltage L+, the DIAG LED flashes and the module is passivated.

When the voltage has recovered (level must remain above the specified value for at least 1 minute (see Technical specifications (Page 77): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Behavior in case of cross circuit/short circuit to the sensor supply

When internal sensor supply is specified and short circuit test is disabled, short circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is specified and short circuit test is enabled, short circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short circuit test and the sensor power supply. The corresponding tables for fault detection for the applications are available under Applications of the F-I/O module (Page 39).

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by the wire break check, short-circuit, chatter monitoring, pulse extension, and plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 36).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications

7

Technical specifications of F-PM-E 24VDC/8A PPM ST

	6ES7136-6PA00-0BC0
Product type designation	F-PM-E PPM 24VDC
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V12.0
STEP 7 configurable/integrated as of version	as of V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	V2.3
PROFINET as of GSD version/GSD revision	V2.31
Operating mode	
Multi-output	No
Installation type/mounting	
Rack mounting possible	No
Front installation possible	No
Rail mounting possible	Yes; standard DIN rail
Wall mounting/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
Rated value (DC)	24 V
Low limit of permissible range (DC)	20.4 V
High limit of permissible range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	75 mA; without load
Current consumption, max.	21 mA; from backplane bus
Output voltage	
Rated value (DC)	24 V

	6ES7136-6PA00-0BC0
Sensor supply	
Number of outputs	2
Output current	
Up to 60 °C, max.	0.3 A
Short circuit protection	Yes; electronic (response threshold 0.7 A to 2.1 A)
24 V sensor supply	
24 V	Yes; min. L+ (-1.5 V)
Short circuit protection	Yes
Output current, max.	600 mA; total current of all sensors
Power	
Power consumption from the backplane bus	70 mW
Power loss	
Power loss, typ.	5 W
Address space	
Address space per module	
Input	7 bytes
Output	5 bytes
Digital inputs	
Number of inputs	2
m/p-reading	Yes; p-reading
Input characteristic curve according to IEC 61131, Type 1	Yes
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
For "0" signal	-30 to +5 V
For "1" signal	+15 to +30 V
Input current	
For "1" signal, typ.	3.7 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Assignable	Yes
• For "0" to "1", min.	0.4 ms
• For "0" to "1", max.	20 ms
• For "1" to "0", min.	0.4 ms
• For "1" to "0", max.	20 ms
For counter/technological functions	
• Assignable	No
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m

	6ES7136-6PA00-0BC0
Digital outputs	
Number of outputs	1
Digital outputs, configurable	Yes
Short circuit protection	Yes
• Response threshold, typ.	> 14.8 A
Wire break detection	Yes
• Response threshold, typ.	8 mA
Overload protection	Yes
• Response threshold, typ.	8.8 A
Voltage induced on current interruption limited to	max 1.5 V
Switching capacity of outputs	
With resistive load, max.	8 A
With lamp load, max.	100 W
Load resistance range	
Low limit	3 Ω
High limit	2000 Ω
Output voltage	
Type of output voltage	DC
For "1" signal, min.	24 V; L+ (-0.5 V)
Output current	
For "1" signal, rated value	8 A
For "0" signal, residual current, max.	1.5 mA; PP-switching: Max. 1.5 mA; PM-switching: Max. 1 mA
Switching frequency	
With resistive load, max.	10 Hz; symmetrical
With inductive load, max.	0.1 Hz; acc. to IEC 947-5-1, DC13, symmetrical
With lamp load, max.	4 Hz; symmetrical
Total current of outputs	
Max. current per channel	8 A; (note derating data in the manual)
Max. current per module	8 A; (note derating data in the manual)
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m
Interrupts/diagnostics/status information	
Fail-safe values can be switched to	No
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes, see section "Interrupts/diagnostic messages" in the manual

	6ES7136-6PA00-0BC0
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	
Between channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	60 V DC / 75 V AC
Isolation	
Isolation test voltage	707 V DC (type test)
Standards, approvals, certificates	
SIL acc. to IEC 61508	SIL 3
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1	PLe
Low demand (PFD) acc. to SIL3	< 2.00E-05 1/h
High demand (PFH) acc. to SIL3	< 1.00E-09 1/h
Environmental conditions	
Operating temperature	
Min.	0 °C
Max.	60 °C
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Storage/transport temperature	
Min.	-40 °C
Max.	70 °C
Dimensions	
Width	20 mm
Height	72 mm
Depth	55 mm
Weights	
Weight, approx.	70 g

Temperature characteristic values (derating)

Mounting position	Maximum temperature	Maximum output current
Horizontal	40 °C	8 A
	50 °C	6 A
	60 °C	4 A
Vertical	50 °C	4 A

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Response times

A

A.1 Response times

Introduction

The next section shows the response times of power module F-PM-E 24VDC/8A PPM ST. The response times of the fail-safe modules are included in the calculation of the F-system response time.

Times required for the calculation

Maximum internal processing time: $T_{max.}$ = 29 ms

Maximum cycle time: T_{cycle} = 14 ms

Short circuit test time for the sensor supply configured for the channel = "Time for short circuit test" + "Startup time after short circuit test"

The input delay, short circuit test times, dark test time, switch-on time, discrepancy time, and test time are configured in STEP 7.

Definition of response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Definition of response time for internal evaluation: Cycle time + Input delay + Short circuit test time + Maximum(readback time, switch-on time, light test time)

Maximum response time in the error-free case with 1oo1 evaluation

Maximum response time = T_{max} + Input delay + Short circuit test time for the sensor supply configured for the channel

Maximum response time in the error-free case with 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Maximum (short circuit test time for the sensor supply configured for channel 0, short circuit test time for the sensor supply configured for channel n1)

Maximum response time with external short circuits

Maximum response time = Input delay + (n × T_{cycle}) + Sum(all short circuit test times + all startup times of sensors with activated short circuit test)

n = Number of sensor supplies with activated short circuit test

Maximum response time with discrepancy error and 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Discrepancy time + 2 × Maximum (short circuit test time for the sensor supply configured for channel 0, short circuit test time for the sensor supply configured for channel 1)

Maximum response time with error and change of user data

Maximum response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with detection by bit pattern test

Maximum response time = T_{cycle} + Maximum(dark test time, switch-on time) + configured test time

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Maximum response time for fail-safe digital outputs

The maximum response time for fail-safe digital outputs in the error-free case is equal to:

Maximum response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

The maximum response time for fail-safe digital outputs in the presence of an error is equal to:

Maximum response time = T_{cycle} + 2 × Maximum(dark test time, switch-on time) + interval between test pulses

A.2 Minimum distance of test pulses

The minimum interval between two test pulses depends on the activation of the light test, the configured maximum test time, and whether the output has been specified as a PM-switching or PP-switching output.

You can find the dependencies in the table below:

Assigned maximum test time	PM switching, light test not active	PM switching, light test active	PP switching, light test not active	PP switching, light test active
1000 s	62.080 s	45.147 s	82.913 s	38.137 s
100 s	5.830 s	4.238 s	7.913 s	3.521 s

Switching of loads

B

B.1 Connecting capacitive loads

If the output of power module F-PM-E 24VDC/8A PPM ST is interconnected with loads that require little current and have capacitance, this can lead to detection of a short circuit or overload. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The figure below shows typical curves for the assignable readback times representing the correlation between load resistance and switchable load capacitance at a supply voltage of 24 V DC.

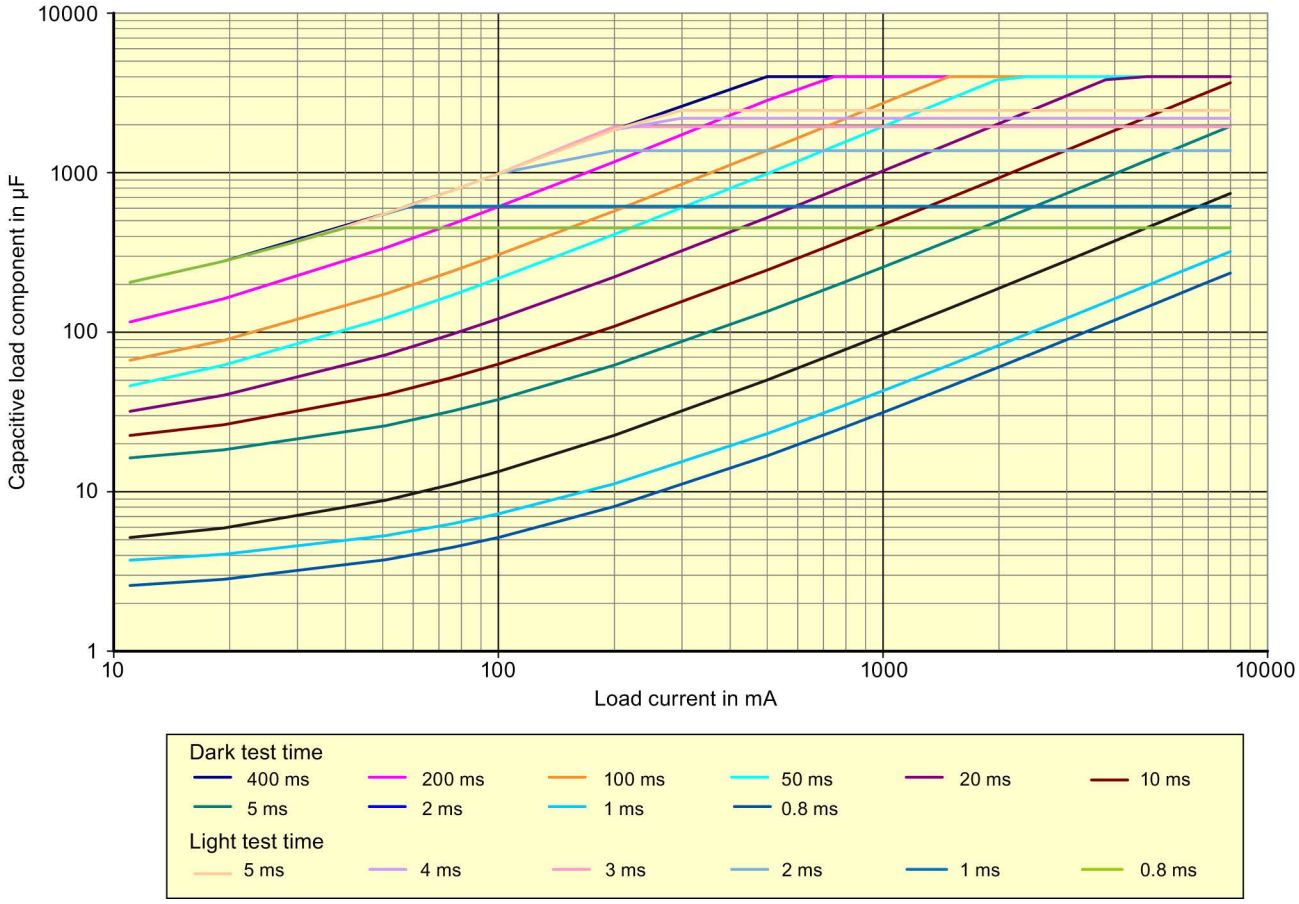


Figure B-1 Switching of capacitive loads for the F-PM-E 24VDC/8A PPM ST power module depending on the configured dark and light test times

The curves shown were plotted using a SIMATIC PS 307 10A power supply unit with a cable length of 25 m (cable cross-section of 1.5 mm^2) between the output of the F-PM-E 24VDC/8A PPM ST power module and the load.

Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

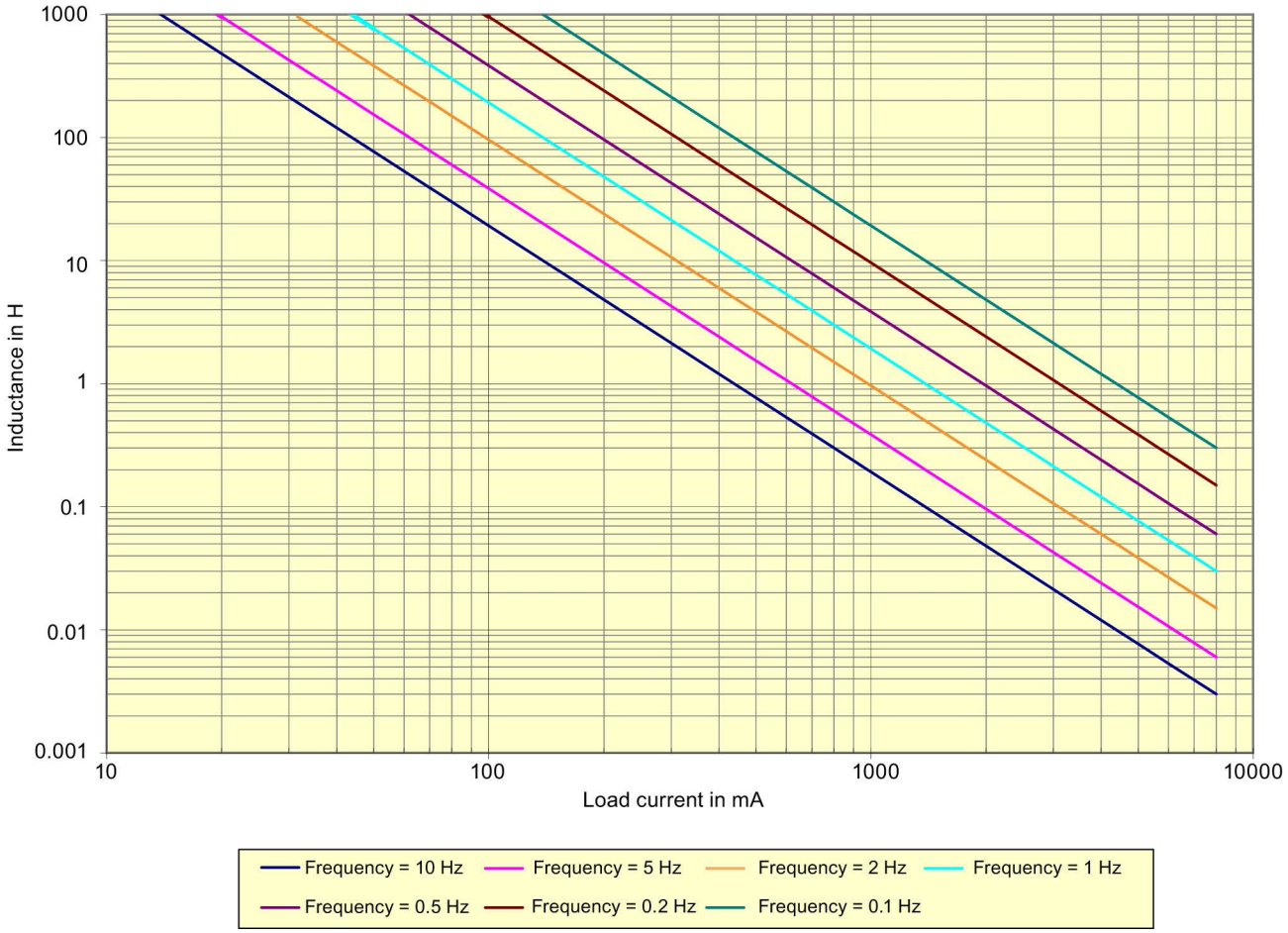


Figure B-2 Switching of inductive loads for the F-PM-E 24VDC/8A PPM ST power module depending on the load current and switching frequency

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Produktinformation zur Dokumentation der fehlersicheren Module ET 200SP

Produktinformation

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Allgemeine Ergänzungen zur Dokumentation

Inhalt

Diese Produktinformation enthält Ergänzungen und Korrekturen zur Dokumentation der F-Module ET 200SP.

Ergänzung der Kapitel 5.1.1.2 "*Anwendungsfall: Anschluss von einer Last am Digitalausgang, PP schaltend*", 5.1.1.4 "*Anwendungsfall: Anschluss von 2 Lasten parallel liegend am Digitalausgang, PP schaltend*" und 5.4.2 "*Sicherheitsgerichtete Abschaltung von Standard-Ausgabemodulen, PP schaltend*" des Gerätehandbuchs "Powermodul F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

⚠ WARNUNG
Wenn der Ausgangskanal 100 Stunden, und länger, dauerhaft „0"-Signal führen kann, muss der Helltest aktiviert werden. Beachten Sie die jeweiligen Anforderungen Ihrer Produktnormen hinsichtlich der Fehleraufdeckungszeit.

Nicht unterstützte Parameter

Die Parameter "Impulsverlängerung" und "Dunkeltest für 48 Stunden deaktivieren" werden nicht unterstützt.

Abhängigkeiten zwischen den Parametern "Diskrepanzzeit" und "Eingangsverzögerung"

Die Diskrepanzzeit muss größer als die Eingangsverzögerung parametriert werden.

Abhängigkeiten zwischen den Parametern "Hochlaufzeit des Gebers nach Kurzschlusstest" und "Zeit für Kurzschlusstest"

Die Hochlaufzeit des Gebers nach Kurzschlusstest muss mindestens 1% der Zeit für den Kurzschlusstest betragen.

Einschalten der Versorgungsspannung L+ für F-Module ET 200SP und IM

Stellen Sie sicher, dass vor dem Einschalten der Versorgungsspannung L+ eines F-Moduls sowohl das F-Modul als auch die IM gleichzeitig spannungslos waren. Eine Einschaltreihenfolge müssen Sie dabei nicht beachten.

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Zyklisches Lesen von I&M-Daten

Zyklisches Lesen von I&M-Daten kann das Timing der F-Module belasten. Vermeiden Sie deshalb schnelle Lesezyklen von unter 500 ms.

Drahtbrucherkennung F-Modul F-DQ 4x24VDC/2A PM HF

Die Ansprechschwelle der Drahtbrucherkennung beträgt < 15 mA.

Einsatz von nicht-fehlersicheren Modulen

Fehlersichere Module ET 200SP dürfen Sie in einem Dezentralen Peripheriesystem ET 200SP nur zusammen mit nicht-fehlersicheren Modulen einsetzen, die mit SELV/PELV betrieben werden. Außerdem darf das Digitalausgabemodul RQ 4x120VDC-230VAC/5A NO ST nicht mit der gleichen Spannung wie die fehlersicheren Module ET 200SP versorgt werden.

Quittierungzeit T_{DAT}

F-Modul	Quittierungszeit T_{DAT}
Digitaleingabemodul F-DI 8x24VDC HF	23 ms
Digitalausgabemodul F-DQ 4x24VDC/2A PM HF	31 ms
Powermodul F-PM-E 24VDC/8A PPM ST	30 ms

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ET 200SP

Product Information for the Documentation of ET 200SP Fail-safe Modules

Product Information

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

General amendments to the documentation

Content

This product information contains amendments and corrections to the documentation of the ET 200SP fail-safe modules.

Amendment to chapter 5.1.1.2 "*Use case: Wiring a load to the digital output, PP switching*", 5.1.1.4 "*Use case: Wiring of two parallel loads to the digital output, PP switching*" and 5.4.2 "*Safety-related shutdown of standard output modules, PP switching*" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

⚠ WARNING
The light test must be activated if the output channel can permanently carry the "0" signal for 100 hours or more. Consult the respective requirements of your product standards regarding error detection time.

Unsupported parameters

The "Pulse stretching" and "Disable dark test for 48 hours" parameters are not supported.

Dependencies between the "Discrepancy time" and "Input delay" parameters

The configured discrepancy time must be greater than the configured input delay.

Dependencies between the "Startup time of the sensors after short circuit test" and "Time for short circuit test" parameters

The startup time of the sensor after a short circuit test must amount to at least 1% of the time for the short circuit test.

Switching on the supply voltage L+ for the ET 200SP F-modules and IM

Make sure that the F-module as well as the IM were de-energized at the same time before you switch on the supply voltage L+ for an F-module. You do not have to observe a switch-on sequence.

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Cyclic reading of I&M data

Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Open-circuit detection for F-DQ 4x24VDC/2A PM HF fail-safe module

The response threshold of the open-circuit detection is < 15 mA.

Using non-fail-safe modules

In an ET 200SP distributed I/O system, you can only use ET 200SP fail-safe modules together with non-fail-safe modules that are operated with SELV/PELV. In addition, the digital output module RQ 4x120VDC-230VAC/5A NO ST cannot be supplied with the same voltage as the ET 200SP fail-safe modules.

T_{DAT} acknowledgment time

F-Module	T_{DAT} acknowledgment time
Digital input module F-DI 8x24VDC HF	23 ms
Digital output module F-DQ 4x24VDC/2A PM HF	31 ms
Power module F-PM-E 24VDC/8A PPM ST	30 ms

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Information produit sur la documentation des modules de sécurité ET 200SP

Information produit

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Addenda généraux à la documentation

Contenu

Cette information produit contient des addenda et des correctifs à la documentation des modules de sécurité ET 200SP.

Addendum au chapitre 5.1.1.2 "*Cas d'application : Connexion d'une charge à la sortie TOR, commutation PP*", 5.1.1.4 "*Cas d'application : Connexion de 2 charges parallèles à la sortie TOR, commutation PP*" et 5.4.2 "*Désactivation de sécurité de modules de sorties standard, commutation PP*" du manuel "Module de puissance F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

⚠ ATTENTION
Si la voie de sortie peut fournir un signal "0" en continu pendant 100 heures et plus, le test avec activation doit être activé. Tenez compte des exigences spécifiques aux normes de votre produit en ce qui concerne le temps de détection des erreurs.

Paramètres non pris en charge

Les paramètres "Impulsion prolongée" et "Désactivation du test avec désactivation pour 48 heures" ne sont pas pris en charge.

Dépendances entre les paramètres "Temps de discordance" et "Retard à l'entrée"

Le temps de discordance doit être supérieur au retard à l'entrée.

Dépendances entre les paramètres "Temps de démarrage du capteur après le test de court-circuit" et "Temps de test de court-circuit"

Le temps de démarrage du capteur après le test de court-circuit doit être égal au moins égal à 1% au temps de test de court-circuit.

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Mise en route de la tension d'alimentation L+ des modules F ET 200SP et IM

Assurez-vous que le module F et l'IM sont tous deux hors tension avant de mettre en route la tension d'alimentation L+ d'un module F. Pour ce faire, il n'est pas nécessaire de suivre un ordre d'activation.

Lecture cyclique des données I&M

La lecture cyclique des données I&M peut surcharger la synchronisation des modules F. Il convient donc d'éviter les cycles rapides de lecture inférieurs à 500 ms.

Détection de rupture de fil du module de sécurité F-DQ 4x24 V CC/2A PM HF

Le seuil de déclenchement de la détection de rupture de fil est < 15 mA.

Utilisation de modules non de sécurité

Les modules de sécurité ET 200SP ne doivent être utilisés dans un système de périphérie décentralisée ET 200SP qu'avec des modules non de sécurité fonctionnant avec une TBTS/TBTP. En outre, le module de sorties TOR RQ 4x120VDC-230VAC/5A NO ST ne doit pas être alimenté avec la même tension que les modules de sécurité ET 200SP.

Temps d'acquittement T_{DAT}

Module F	Temps d'acquittement T_{DAT}
Module d'entrées TOR F-DI 8x24 V CC HF	23 ms
Module de sorties TOR F-DQ 4x24 V CC/2A PM HF	31 ms
Module d'alimentation F-PM-E 24 V CC/8A PPM ST	30 ms

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ET 200SP distributed I/O system

Product Information

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Warning notice system

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⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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Preface

Scope of the product information

This product information amends the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293) to include ET 200SP fail-safe modules.

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Product overview

1

1.1 What are fail-safe automation systems and fail-safe modules?

Fail-safe automation systems

Fail-safe automation systems (F-systems) are used in systems with higher-level safety requirements. F-systems serve to control processes and ensure that they are in a safe state immediately after shutdown. In other words, F-systems control processes in which an immediate shutdown does not endanger persons or the environment.

Fail-safe modules

The key difference between fail-safe modules (F-modules) and standard ET 200SP modules is that they have an internal two-channel design. The two integrated processors monitor each other, automatically test the input and output circuits, and switch the F-I/O module to a safe state in the event of a fault.

The F-CPU communicates with the fail-safe modules via the fail-safe PROFIsafe bus profile.

Fail-safe power modules, together with the respective BaseUnit, serve the load voltage supply of the potential group and the safety-oriented tripping of the load voltage for standard output modules.

Fail-safe digital input modules detect the signal states of safety-oriented sensors and send the relevant safety message frames to the F-CPU.

Fail-safe digital output modules are suitable for safety-related shutdown procedures with short circuit and cross-circuit protection up to the actuator.

Possible uses of ET 200SP with fail-safe modules

The use of ET 200SP with fail-safe modules allows conventional configurations in safety engineering to be replaced with PROFNET IO components. This includes the replacement of switching devices for emergency STOP, protective door monitors, two-hand operation, etc.

ET 200SP fail-safe modules are supported with the STEP 7 Safety Advanced optional package V12 including HSP 54 or higher.

ET 200SP fail-safe modules are supported with IM155-6PN ST as of firmware V1.1.

Achievable safety classes

Fail-safe modules are equipped with integrated safety functions for safety mode.

The following safety classes can be achieved through appropriate parameter assignment of the safety functions in STEP 7 Professional V12 SP1 or higher with STEP 7 Safety Advanced optional package V12 or higher, through a specific combination of fail-safe and standard modules, and through a specific arrangement and wiring of sensors and actuators:

Safety class in safety mode		
According to IEC 61508	According to ISO 13849-1:2006	
SIL2	Category 3	(PL) Performance Level d
SIL3	Category 3	(PL) Performance Level e
SIL3	Category 4	(PL) Performance Level e

Use in SIMATIC Safety F-systems

ET 200SP fail-safe modules can be used with the STEP 7 Safety Advanced optional package, V12 or higher under PROFINET IO, together with an F-CPU.

SIMATIC Safety F-system with ET 200SP

The following figure shows a sample configuration for a SIMATIC Safety F-system with, among other things, an ET 200SP on a PROFINET IO. The PROFINET IO lines can be set up with copper cable, with fiber-optic cable or WLAN.

You will find further information on the Internet at Application planning (Page 13).

Tasks of the fail-safe IO controller (F-CPU) include the exchange of safety-related and non-safety-related data with fail-safe and standard ET 200SP modules.

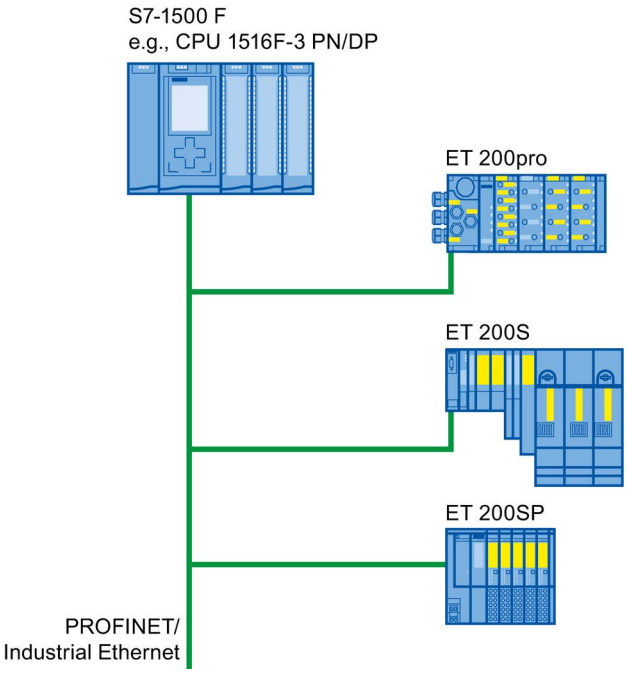


Figure 1-1 Fail-safe SIMATIC Safety automation system (sample configuration)

Use in safety mode only

Fail-safe modules can only be used in fail-safe mode. They cannot be used in non-fail-safe mode In this context, fail-safe mode/non-fail-safe mode refers to the operating mode of the F-I/O module, which either does or doesn't support safety-related communication via safety message frames.

Fail-safe modules and non-fail-safe modules can be combined within an ET 200SP.

1.2 Fault reactions with fail-safe modules

Safe state (safety concept)

The basic principle behind the safety concept is the existence of a safe state for all process variables.

Note

For digital F-modules, this safe state is the value "0". This applies to both sensors and actuators.

Fault reactions and startup of the F-system

The safety function requires that fail-safe values (safe state) be applied to the fail-safe module instead of process values (**passivation of the fail-safe module**) in the following situations:

- When the F-system is started up
- If errors are detected during safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error)
- If F-I/O faults or channel faults are detected (e.g., wire break, discrepancy error)

Detected faults are written to the diagnostic buffer of the F-CPU and communicated to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. When the system is powered down and then restarted, any faults still existing are detected again during startup. However, you have the option of saving faults in your safety program.

⚠ WARNING

For channels that you set to "deactivated" in *STEP 7*, no diagnostic response or error handling is triggered when a channel fault occurs, not even when such a channel is affected indirectly by a channel group fault ("Channel activated/deactivated" parameter).

Remedying faults in the F-system

To remedy faults in your F-system, follow the procedure described in IEC 61508-1:2010 section 7.15.2.4 and IEC 61508-2:2010 section 7.6.2.1 e.

The following steps must be performed:

1. Diagnostic and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Fail-safe value output for F-modules

In the case of F-modules with inputs, the F-system provides fail-safe values (0) for the safety program instead of the process data pending at the fail-safe inputs in case of passivation.

In the case of F-modules with outputs, the F-system transfers fail-safe values (0) to the fail-safe outputs instead of the output values provided by the safety program in case of passivation. The output channels are de-energized. This also applies when the F-CPU goes into STOP mode. The parameter assignment of fail-safe values is not possible.

Depending on which F-system you are using and the type of fault that occurred (F-I/O fault, channel fault or communication error), fail-safe values are used either for the relevant channel only or for all channels of the relevant fail-safe module.

Reintegration of a fail-safe module

The system changes from fail-safe to process values (reintegration of an F-module) either automatically or only after user acknowledgment in the safety program. If channel faults occur, it may be necessary to remove and reinsert the F-module. A detailed listing of faults requiring removal and insertion of the F-module can be found in the section Diagnostic messages of the respective F-module.

After reintegration, the following occurs:

- In the case of an F-module with inputs, the process data pending at the fail-safe inputs are provided to the safety program
- In the case of an F-module with outputs, the output values provided in the safety program are again transferred to the fail-safe outputs

Additional information on passivation and reintegration

For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety, Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Reaction of the F-module with inputs to communication errors

F-modules with inputs respond differently to communication errors compared to other errors.

If a communication error is detected, the current process values remain set at the inputs of the F-module. There is no passivation of the channels. The current process values are passivated in the F-CPU.

Application planning

2

2.1 Forming potential groups with fail-safe modules

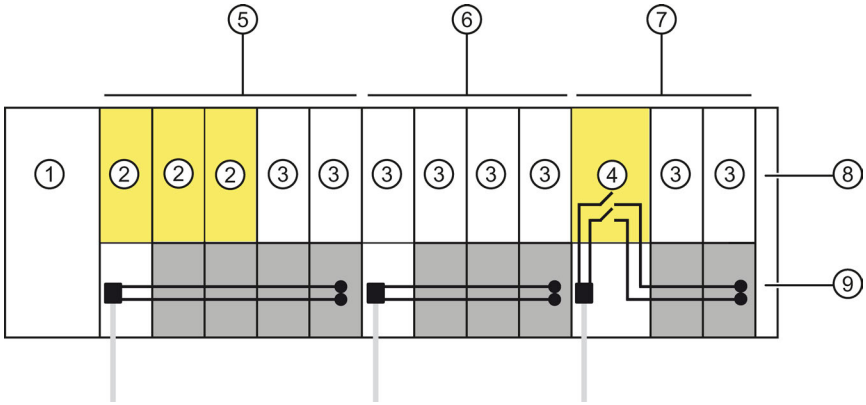
Introduction

ET 200SP distributed I/O systems can be configured using fail-safe and non-fail-safe modules. This chapter provides an example of a mixed configuration comprising fail-safe and non-fails-safe modules.

Assembly example for ET 200SP with fail-safe and non-fail-safe modules

Generally speaking, it is not necessary to operate fail-safe and non-fail-safe modules in separate potential groups. You can divide the modules into fail-safe and non-fail-safe potential groups and mount them.

The following diagram shows an assembly example with fail-safe and non-fail-safe modules within a single ET 200SP.



① Interface module IM 155-6 PN HF
② F-module
③ Non-fail-safe module
④ Power module F-PM-E 24VDC/8A PPM ST
⑤ Mixed fail-safe and non-fail-safe potential group with BaseUnits BU15..D and BU15..B.
You achieve SIL3/Cat.4/PLe for the fail-safe modules.
⑥ Non-fail-safe potential group with BaseUnits BU15..D and BU15..B.
⑦ Fail-safe potential group with BaseUnits BU20..D and BU15..B.
Through disconnection of the power bus, and thus of the non-fail-safe modules, up to SIL2/Cat.3/PLd is possible.
⑧ Server module
⑨ P1/P2 power buses

Figure 2-1 ET 200SP assembly example with fail-safe modules

Installation

3

3.1 Basics

The following applies to ET 200SP fail-safe modules:

⚠ WARNING
Protection from conductive contaminants In consideration of the environmental conditions, the devices must be protected from conductive contaminants. One way to accomplish this is by installing the devices in a control cabinet with an appropriate degree of protection.

Connecting

4

4.1 Additional rules and provisions for operation of the ET 200SP with fail-safe modules

4.1.1 Safe functional extra-low voltage (SELV) for fail-safe modules

⚠ WARNING

The fail-safe modules must be operated with safe functional extra low voltage (SELV, PELV).

You can find more information on safe functional extra-low voltage in the data sheets, for example, of the applicable power supplies.

The fail-safe modules work with a rated voltage of 24 V DC. The tolerance range is 20.4 V DC to 28.8 V DC.

Within the overvoltage range from 32 V DC to 36 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages greater than 36 V DC, the F-modules are permanently de-energized.

Use a power supply unit that does not exceed U_m = 36 V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g., use of an overvoltage protector.

All system components that can supply electrical energy in any form whatsoever must fulfill this condition.

Each additional circuit (24 V DC) used in the system must have a safe functional extra low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.

Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safe functional extra-low voltage as well. The process signal of a 24 V DC digital module may not exceed a fault voltage U_m in the event of a fault.

⚠ WARNING

Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.

An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which would cause the
fault voltage U_m to be exceeded.

Power supply requirements for compliance with NAMUR recommendations

Note

To ensure adherence to the NAMUR recommendation NE 21, IEC 61131-2 and EN 298, only use power packs/power supply units (230 V AC → 24 V DC) with a mains buffering time of at least **20 ms**. The latest up-to-date information on PS components is available on the Internet (http://mall.automation.siemens.com).

It goes without saying that these requirements also apply to power packs/power supply units not constructed using ET 200SP / S7-300/-400/-1500 technology.

4.1.2 Requirements of sensors and actuators for fail-safe modules

General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:

⚠ WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Also bear in mind that sensors and actuators generally do not have proof-test intervals of 20 years as defined in IEC 61508:2010 without considerable loss of safety.

The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. A listing of values achieved by F-modules in the technical specifications of the F-modules is available under "Fail-safe performance characteristics".

To achieve the respective safety class, suitably qualified sensors and actuators are necessary.

Additional sensor requirements

General rule: To achieve SIL3/Cat.3/PLe, a single-channel sensor is all you need. However, to achieve SIL3/Cat.3/PLe with a single-channel sensor, the sensor itself must be SIL3/Cat.3/PLe-capable; otherwise the sensor must be connected by two channels to achieve this safety level.

To achieve SIL3/Cat.4/PLe, sensors must be connected by two channels.

⚠ WARNING

In the case of fail-safe input modules, a "0" value is output to the F-CPU after detection of faults. You therefore need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.

Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the respective actuator when it is in the "0" state (EMERGENCY-STOP button pressed).

Duration requirements for sensor signals

⚠ WARNING

Observe the following requirements for sensor signals:

- In order to ensure the correct detection of the sensor signals via fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
- In order for pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

Reliable detection by F-modules with inputs

The minimum duration of sensor signals for F-modules with inputs depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in section "Response times" of the respective F-module.

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period) with parameters.

High-speed actuators may briefly drop out or be activated during this test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

⚠ WARNING

If the actuators switch voltages greater than 24 V DC (e.g., 230 V DC), the outputs of a fail-safe output module and the parts carrying a higher voltage must be electrically isolated (according to IEC 60664-1).

This is generally the case for relays and contactors. Particular attention must be paid to this issue for semiconductor switching devices.

Technical specifications of sensors and actuators

Refer to the manuals of the fail-safe modules for technical specifications to assist you in selecting sensors and actuators.

4.1.3 Capacitive crosstalk of digital input/output signals

When fail-safe digital output and input signals are in a single cable, F-DQ modules and F-PM-E modules may experience readback errors.

Cause: Capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply of the inputs, the steep switching edge of the output drivers caused by the coupling capacitance of the line may result in crosstalk to other non-activated output or input channels. This may then lead to a response of the readback circuit in these channels. The module detects a cross circuit/short circuit and performs a safety-related shutdown.

Remedy:

- Separate cables for F-DI modules, F-DQ modules, and F-PM-E modules or non-fail-safe DQ modules
- Separate cables for F-DQ channel and F-DI channels for the F-PM-E module
- Coupling relay or diodes in the outputs
- Disable the sensor supply test if safety class requirements allow it

Cause: magnetic crosstalk

Note that an inductive load connected to the F-DQ channels can induce capacitive coupling of a strong magnetic field.

Remedy:

- Spatially disconnect the inductive loads or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

Configuring

5

5.1 Assigning the F-destination address for fail-safe modules

5.1.1 Assigning the F-destination address

The F-destination address is saved permanently on the coding element of the ET 200SP fail-safe modules.

Note

During assignment of the F-destination address, the F-modules must be supplied with supply voltage L+.

Note

Note the following in conjunction with configuration control:

Before you can use configuration control together with F-modules, you must assign the F-destination address to the F-modules at the designated slots. For this, each F-module must be inserted in the slot configured for it. The actual configuration can then differ from the specified configuration.

For additional information on assigning the F-destination address, refer to the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) programming and operating manual.

Maintenance 6

6.1 Firmware update

Introduction

It may be necessary to update the firmware during operation (e.g. function expansions).

Update the firmware of the interface module and I/O modules using firmware files.

Options for the firmware update

Online via PROFINET IO/PROFIBUS DP (with STEP 7)

Requirements

The ET 200SP is accessible online via PROFINET IO/PROFIBUS DP.

Additional requirement for fail-safe modules

⚠ WARNING

Check of the firmware version for F-validity

When using a new firmware version, you must check whether the employed firmware version is approved for use in the respective module.

The approved firmware version is specified in the appendices of the Certificate for SIMATIC Safety.

Procedure

Connect the programming device or PC to the PROFINET IO or PROFIBUS DP interface of the ET 200SP.

Note

Firmware update of analog I/O modules

For analog I/O modules, L+ supply voltage must be present on the module at the start of and during the firmware update.

You can find additional information on the procedure in the online help for STEP 7.

See also

Certificate (http://support.automation.siemens.com/WW/view/en/49368678/134200)

Technical specifications

7

7.1 Electromagnetic compatibility of fail-safe modules

Protecting ET 200SP with fail-safe modules against overvoltages

If your equipment requires protection from overvoltage, we recommend that you use an external protective circuit (surge filter) between the load voltage power supply and the load voltage input of the BaseUnits to ensure surge immunity for the ET 200SP with fail-safe modules.

Note

Lightning protection measures always require a case-by-case examination of the entire system. An almost complete protection from overvoltages, however, can only be achieved if the entire building surroundings have been designed for overvoltage protection. In particular, this involves structural measures in the building design phase.

For detailed information regarding overvoltage protection, we recommend that you contact your Siemens representative or a company specializing in lightning protection.

The following figure shows an example configuration with fail-safe modules. Voltage is supplied by 1 power supply unit. Note, however, that the total current of the modules fed by the power supply unit must not exceed the permissible limits. You can also use multiple power supply units.

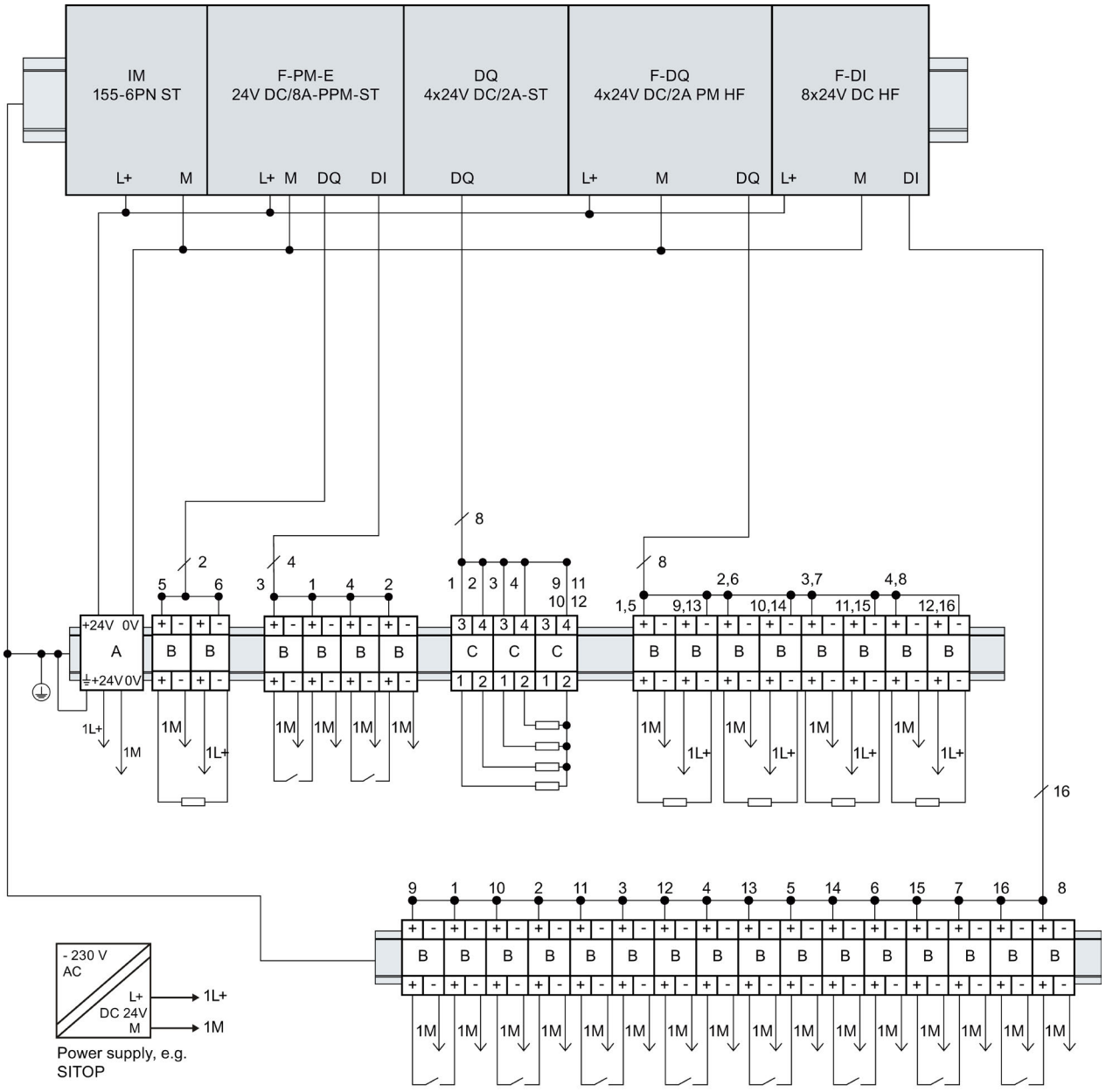


Figure 7-1 External protective circuit (surge filter) for ET 200SP with fail-safe modules

Name	Order number of Dehn Co.
A = BVT AD 24	918 402
B = DCO RK D 5 24	919 986
C = DEHNconnect DCO RK E 60	919 990

7.2 Standards and approvals

CE mark

The ET 200SP F distributed I/O system meets the requirements and safety objectives of the following EC directives and satisfies the harmonized European Standards (EN) for programmable logic controllers published in the official journals of the European Community:

- 2006/42/EC "Directive on Machinery" (Machinery Directive)
- 2006/95/EC "Electrical Equipment Designed for Use within Certain Voltage Limits" (Low-Voltage Directive)
- 2004/108/EC "Electromagnetic Compatibility" (EMC Directive)
- 94/9/EC "Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres" (Explosion Protection Directive)

The EC declarations of conformity are kept available for the relevant authorities at:

Siemens Aktiengesellschaft
Industry Sector
I IA AS FA DH AMB
PO Box 1963
D-92209 Amberg, Germany

These are also available for download on the Customer Support web page, keyword "Declaration of Conformity".

Accessories/spare parts

8

8.1 Lightning protection and overvoltage protection for fail-safe modules

Overvoltage suppressors for fail-safe electronic modules

Note

This section lists only those overvoltage suppressors that may be used for the protection of fail-safe modules.

Be sure to observe the detailed information on lightning protection and overvoltage protection of the ET 200SP distributed I/O device in ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Components for overvoltage protection of fail-safe modules (lightning protection zone transition 0_B to 1)

The table below lists overvoltage arresters you can use for fail-safe modules:

Table 8- 1 Components for the overvoltage protection (only for unshielded lines)

Fail-safe modules	Connecting of the lines to interface 0_B to 1 with:	Article number
Supply voltage 1L+, L+ (24 V DC)	BLITZDUCTOR BVT AD 24	918 402
Inputs/outputs of the F-modules (24 V DC)	DEHNconnect RK DCO RK D 5 24	919 986
Direct ordering of the components from: DEHN + SÖHNE GmbH + CO. KG. Hans-Dehn-Str. 1 D-92318 Neumarkt, Germany Phone +49 (0)9181-906-730		

Glossary

1oo1 evaluation

Type of → sensor evaluation – in the case of the 1oo1 evaluation, there → is one sensor with a 1-channel connection to the F module.

1oo2 evaluation

Type of → sensor evaluation – in the case of 1oo2 evaluation , two input channels are assigned one two-channel sensor or two one-channel sensors. The input signals are compared internally for equivalence or nonequivalence.

Acknowledgment time

During the acknowledgment time, the → F-I/O acknowledge the sign of life specified by the → F-CPU. The acknowledgment time is included in the calculation of the → monitoring time and → response time of the overall fail-safe system.

Actuator

Actuators can be power relays or contactors for switching on loads, or they can be loads themselves (e.g., directly controlled solenoid valves).

Availability

Availability is the probability that a system is functional at a specific point in time. Availability can be increased by redundancy, e.g., by using multiple -> sensors at thesame measuring point.

Channel fault

Channel-specific fault, such as a wire break or short circuit.

In channel-specific passivation, the affected channel is either automatically reintegrated or the fail-safe module must be removed and reinserted after the fault has been eliminated.

Channel group

The channels of a module are grouped together in a channel group. Certain parameters in STEP 7 can only be assigned to channel groups, rather than to individual channels.

Channel number

Channel numbers are used to uniquely identify the inputs and outputs of a module and to assign channel-specific diagnostic messages.

Channel-specific passivation

With this type of passivation, only the affected channel is passivated in the event of a → channel fault. In the event of a → module fault, all channels of the → fail-safe module are passivated.

CRC

Cyclic Redundancy Check

CRC signature

The validity of the process values in the safety message frame, the accuracy of the assigned address references, and the safety-related parameters are validated by means of the CRC signature in the safety message frame.

Dark period

Dark periods occur during shutdown tests and complete bit pattern tests. The fail-safe output module switches test-related zero signals to the active output. This output is then briefly disabled (= dark period). An adequate carrier → actuator will not respond to this and will remain activated.

Derating

See temperature characteristics

Discrepancy analysis

The discrepancy analysis for equivalence/non-equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same levels). A check is performed to determine whether the difference (for nonequivalence testing: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

The discrepancy analysis compares the two input signals of the 1oo2 sensor evaluation in the fail-safe input module.

Discrepancy time

Configurable time for the → discrepancy analysis. If the discrepancy time is set too high, the fault detection time and → fault reaction time are extended unnecessarily. If the discrepancy time is set too low, availability is decreased unnecessarily since a discrepancy error is detected when, in reality, no error exists.

Fail-safe modules

ET 200SP modules with integrated safety functions that can be used for safety-related operation (safety mode).

Fail-safe systems

Fail-safe systems (F-systems) remain in a safe state or immediately assume another safe state as soon as particular failures occur.

Fault response time

The maximum fault response time of an F-system defines the interval between the occurrence of any fault and a safe reaction at all affected fail-safe outputs.

For → F-systems overall: The maximum fault response time defines the interval between the occurrence of any fault at any → F-I/O and the safe reaction at the corresponding fail-safe output.

For digital inputs: The maximum fault response time defines the interval between the occurrence of the fault and the safe reaction at the backplane bus.

For digital outputs: The maximum fault response time defines the interval between the occurrence of the fault and the safe reaction at the digital output.

Fault tolerance time

The fault tolerance time of a process is the time a process can be left unattended without risk to life and limb of the operating personnel, or damage to the environment.

Any type of F-system control is tolerated within this fault tolerance time, i.e. the → F-system can control its processes incorrectly or even not at all. The fault tolerance time depends on the type of process and must be determined on a case-by-case basis.

F-CPU

An F-CPU is a central processing unit with fail-safe capability that is permitted for use in SIMATIC Safety. A standard user program can also be run on the F-CPU.

F-I/O

Collective name for fail-safe inputs and outputs available in SIMATIC S7 for integration into the SIMATIC Safety F-system. Available F-I/O modules:

- Fail-safe I/O module for ET 200eco
- Fail-safe signal modules S7-300 (F-SMs)
- Fail-safe modules for ET 200S
- Fail-safe modules for ET 200SP
- Fail-safe DP standard slaves
- Fail-safe PA field devices
- Fail-safe IO devices

F-monitoring time

→ PROFIsafe monitoring time

F-Systems

→ fail-safe systems

Module fault

Module faults can be external faults (e.g. missing load voltage) or internal faults (e.g. processor failure). Internal faults always require module replacement.

Monitoring time

→ PROFIsafe monitoring time

M-switch

Each fail-safe digital output of ET 200SP F-modules consists of a P-switch DO-P_x (current sourcing) and an M-switch DO-M_x (current sinking). The load is connected between the P-switch and M-switch. The two switches are always activated so that voltage is applied to the load.

Nonequivalent sensor

A nonequivalent → sensor is a two-way switch that is connected to two inputs of an → F-I/O (via 2 channels) in → fail-safe systems (for → 1oo2 evaluation of sensor signals).

Passivation

If an → F-I/O module detects a fault it switches either the affected channel or all channels to a → safe state, i.e. the channels of this F-I/O module are passivated. The F-I/O module signals the detected faults to the → F-CPU.

When passivating channels at F-I/O with inputs, the → F-System provides fail-safe values for the → safety program instead of the process values pending at the fail-safe inputs.

When passivating channels at F-I/O with outputs, the F-system returns fail-safe values (0) to the fail-safe outputs instead of the output values provided by the safety program.

Performance Level

Performance Level (PL) according to ISO 13849-1:2006 or EN ISO 13849-1:2008

PROFIsafe

Safety-oriented PROFINET I/O bus profile for communication between the → safety program and the → F-I/O module in a → fail-safe system.

PROFIsafe address

Every → fail-safe module has a PROFIsafe address. You have to configure the PROFIsafe address.

PROFIsafe monitoring time

Monitoring time for safety-related communication between the F-CPU and F-I/O

Proof-test interval

Period after which a component must be forced to fail-safe state, that is, it is either replaced with an unused component, or is proven faultless.

P-switch

→ M-switch

Redundancy, availability-enhancing

Multiple instances of components with the objective of maintaining component functionality in the event of hardware faults.

Redundancy, safety-enhancing

Multiple availability of components with the aim of exposing hardware faults based on comparison; such as → 1oo2 evaluation in → fail-safe modules.

Reintegration

After the elimination of a fault, it is necessary to ensure the reintegration (depassivation) of the → F-I/O. Reintegration (switchover from fail-safe values to process values) occurs either automatically or only after a user acknowledgment in the safety program.

In the case of a fail-safe input module, the process values pending at the fail-safe inputs are made available to thesafety program again after reintegration. In the case of a fail-safe output module, the → fail-safe system transfers the output values in the safety program to the fail-safe outputs again.

Safe state

The basic principle of the safety concept in F-systems is the existence of a safe state for all process variables. For the digital F-I/O, for example, the safe state is the value "0".

Safety class

Safety level (Safety Integrity Level) SIL according to IEC 61508:2010. The higher the Safety Integrity Level, the more rigid the measures for prevention of systematic faults and for management of systematic faults and hardware failures.

The fail-safe modules support operation in safety mode up to safety class SIL3.

Safety function

A mechanism integrated in the → F-CPU and → F-I/O that enables their use in → the fail-safe system SIMATIC Safety.

According to IEC 61508:2010 A safety function is implemented by a safety system in order to maintain or force a system safe state in the event of a specific fault.

Safety message frame

In safety mode, data are transferred between the → F-CPU and → F-I/O in a safety message frame.

Safety mode

Operating mode of → F-I/O that enables → safety-related communication via → safety message frames.

→ ET 200SP fail-safe modules can only used in safety mode.

Safety program

Safety-related user program

Safety-related communication

Communication used to exchange fail-safe data.

Sensor evaluation

There are two types of sensor evaluation:

→ 1oo1 evaluation – sensor signal is read once

→ 1oo2 evaluation – sensor signal is read in twice by the same F-module and compared internally

Sensors

Sensors are used for accurate detection of digital and analog signals as well as routes, positions, velocities, rotational speeds, masses, etc.

SIL

Safety Integrated Level → safety class

Standard mode

Operating mode of F-I/O in which standard communication is possible by means of → safety message frames, but not → safety-related communication.

Fail-safe ET 200SP modules can only be operated in safety mode.

Value status

The value status is the binary additional information of a digital signal. The value status is entered in the process image of the input and provides information on the validity of the signal.

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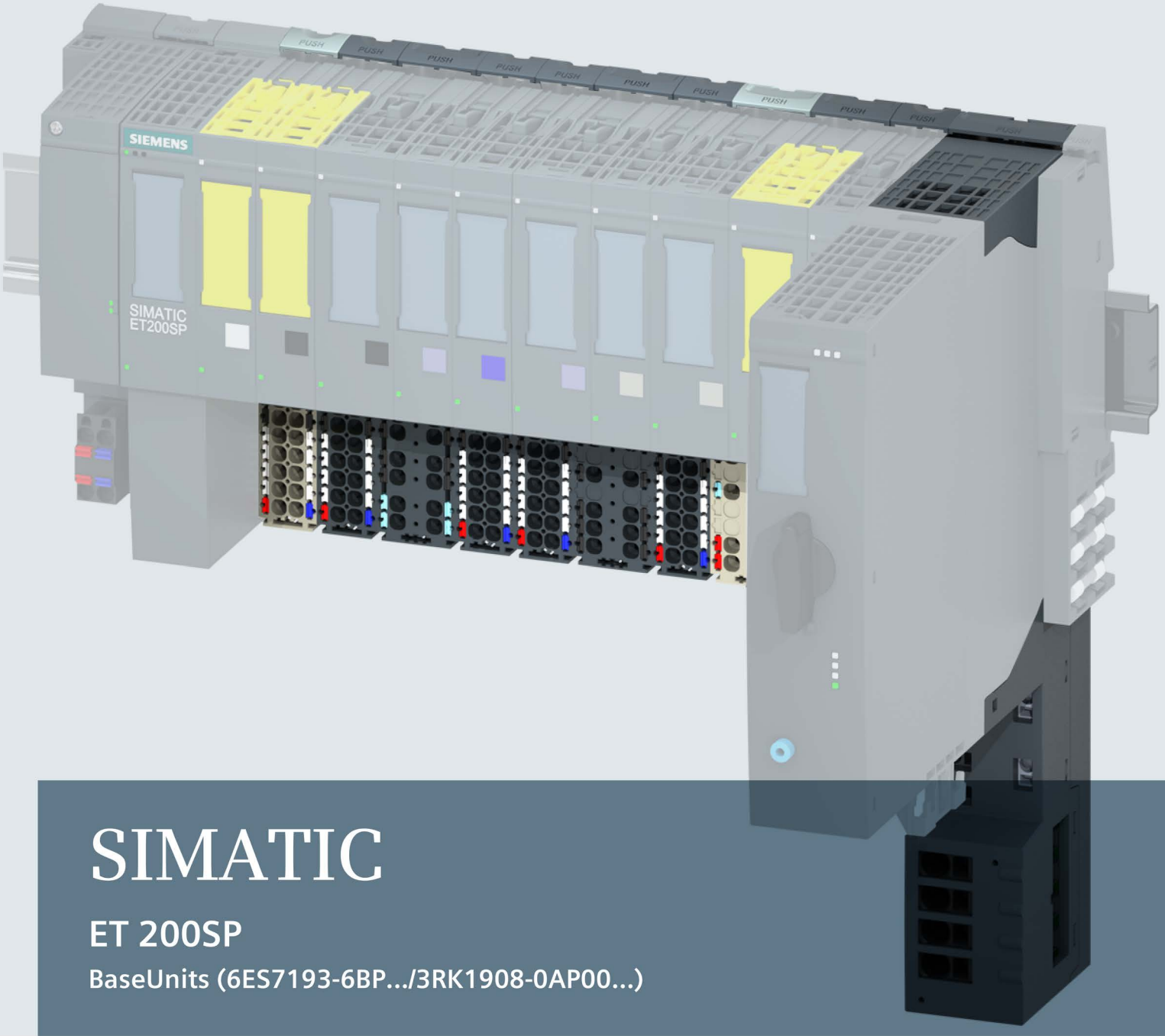

SIMATIC

ET 200SP

BaseUnits (6ES7193-6BP.../3RK1908-0AP00...)

Manual

Edition 12/2016

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ET 200SP BaseUnits (6ES7193-6BP.../3RK1908-0AP00…)

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions affecting the system in general are described there.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Changes compared to the previous version

In contrast to the previous version, the chapters "BaseUnits for motor starters" and "Dimension drawings for motor starters" have been added to this manual.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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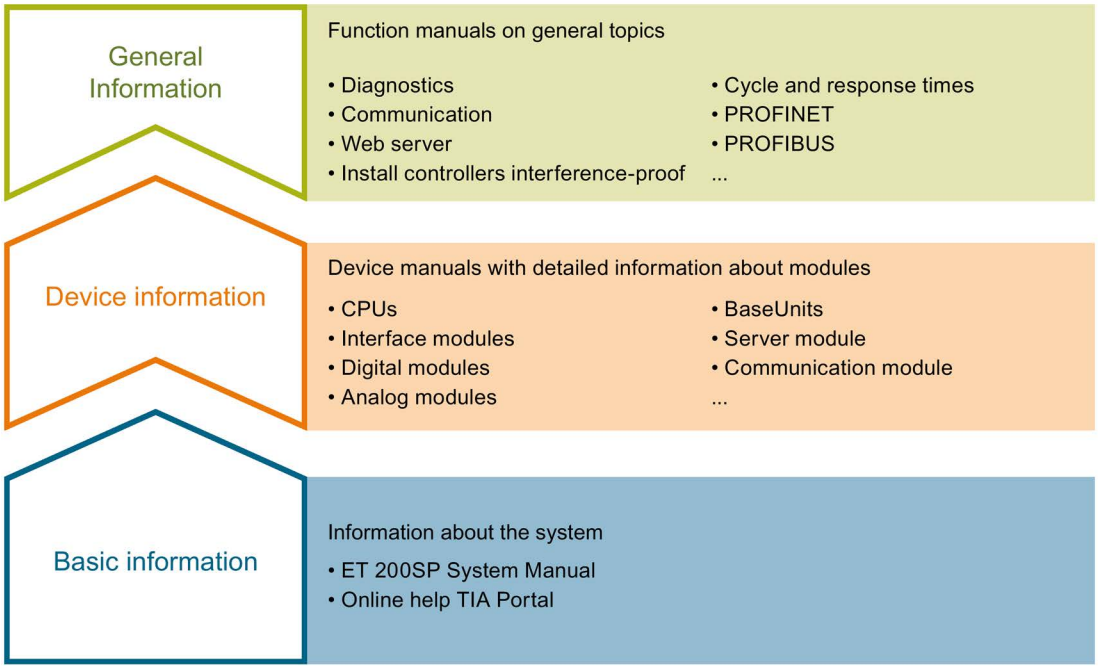
Guide to the documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (http://support.industry.siemens.com/cs/ww/en/ps/ae).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

General properties of the BaseUnits

In the ET 200SP distributed I/O system, there are a number of different BaseUnits. The BaseUnit determines, among other things, the process connection, the suitable I/O modules/motor starters, and the infeed of the supply voltage. All properties can be identified by the short designation of the BaseUnit which is explained below.

Table 2- 1 Properties of the BaseUnits

Short description BU15-P16+A10+2D/T (example)			BaseUnit properties
Module width	BU	15	BaseUnit with width of 15 mm
		20	BaseUnit with width of 20 mm
		30	BaseUnit with width of 30 mm
Process connection	P	4	• Connection method: Push-in terminal • Number of terminals to the I/O module: 4
		8	• Connection method: Push-in terminal • Number of terminals to the I/O module: 8
		16	• Connection method: Push-in terminal • Number of terminals to the I/O module: 16
Connection to the AUX busbar	A	0	No connection to the AUX busbar
		10	n = number of AUX terminals, e.g. 10
Self-assembling voltage buses	2		2 push-in terminals for supplying or tapping the supply voltage via the self-assembling voltage buses P1, P2 (see D, B)
	12		• 2 push-in terminals for supplying or tapping the supply voltage via the self-assembling voltage buses P1, P2 (see D, B) • 2x5 push-in additional terminals (1B to 5B, 1C to 5C) for connecting further potential up to a maximum supply current of 24 V DC / 10 A
	0		No terminals with access to the self-assembling voltage buses P1, P2
		B	• Looping through the potential group • Tapping of the supply voltage for external components or looping through with a maximum total current of 10 A per potential group
		D	• Opening a new potential group • Feeding in of supply voltage up to a maximum supply current of 10 A
Additional functions	T		Integrated temperature sensor to compensate the reference junction temperature for thermocouples

Properties of the BaseUnits for motor starters

The following table lists the properties of the individual BaseUnits for motor starters:

BaseUnit	Properties
BU30-MS1	• Push-in terminals for opening a new potential group (24 V DC). • Feeding in of supply voltage up to a maximum supply current of 7 A DC. • Opening a new supply voltage potential group (500 V AC) • Feeding in of supply voltage up to a maximum supply current of 32 A AC.
BU30-MS2	• Looping through the potential group (24 V DC) • Push-in terminals for opening a new supply voltage potential group (500 V AC) • Feeding in of supply voltage up to a maximum supply current of 32 A AC.
BU30-MS3	• Push-in terminals for opening a new potential group (24 V DC). • Feeding in of supply voltage up to a max. supply current of 7 A DC • Looping through the supply voltage potential group (500 V AC)
BU30-MS4	• Looping through the supply voltage potential group (500 V AC) • Looping through the potential group (24 V DC)
BU30-MS5	• Looping through the potential group (24 V DC) • Push-in terminals for opening a new supply voltage potential group (500 V AC) • Feeding in of supply voltage up to a maximum supply current of 32 A AC. • One fail-safe digital input
BU30-MS6	• Looping through the potential group (24 V DC) • Looping through the supply voltage potential group (500 V AC) • Push-In terminals • One fail-safe digital input

Selecting, installing and connecting BaseUnits

See the System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)

WARNING

Personal injury or damage to equipment is possible.

Connecting a rated supply voltage to the BaseUnit higher than the one given in the technical specifications may lead to dangerous situations in your plant or cause defects in ET 200SP components.

Therefore, only connect the rated supply voltage given in the technical specifications to the BaseUnit.

The connected rated supply voltage must correspond to the rated supply voltage of the I/O modules in the potential group.

When mains voltage is connected to the BaseUnit, you must ensure that all other supply voltages on this BaseUnit use the same phase as the mains.

The Totally Integrated Automation Selection Tool (TIA Selection Tool) (http://www.siemens.com/tia-selection-tool) supports you in selecting, configuring and ordering the ET 200SP modules. This tool can be downloaded free of charge from the Internet (http://support.automation.siemens.com/WW/view/en/58649293).

WARNING

Hazardous Voltage (when using ET 200SP motor starters)
Can Cause Death, Serious Injury, or Property Damage.

Proper use of hardware products

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Machinery Directive 2006/42/EC.

WARNING

Hazardous Voltage (when using ET 200SP motor starters)
Can Cause Death, Serious Injury, or Property Damage.

Please take note of our latest information.

Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we publish a special newsletter containing information on product developments and features that are (or could be) relevant to operation of safety-related systems. By subscribing to the appropriate newsletter, you will ensure that you are always up-to-date and able to make changes to your system, when necessary:

Siemens Newsletter (http://www.industry.siemens.com/newsletter)

Sign on to the following newsletter under "Products & Solutions":

- Control Components and System Engineering News
- Safety Integrated Newsletter

BaseUnits for I/O modules

3

3.1 BU15-P16+A10+2D (BU type A0)

3.1.1 Product overview

Article number

6ES7193-6BP20-0DA0

View

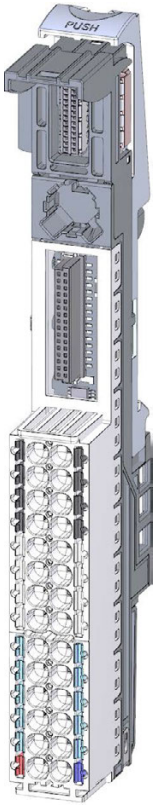


Figure 3-1 BaseUnit BU15-P16+A10+2D

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the last two digits of the article number.
  - Supply voltage (L+ terminal, ground): Max. 24 VDC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- Access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 10 AUX terminals for connecting a protective conductor or potential. The AUX busbar is not connected to the I/O module.
- Connection method using push-in terminals

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated from the sum of 1 and 2 may not exceed 10 A.

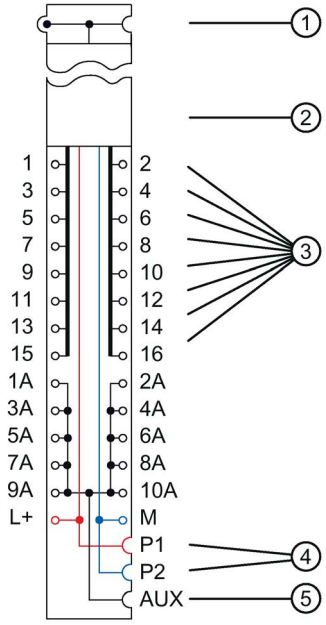
3.1.2 Connecting up

Pin assignment

Table 3- 1 Pin assignment for BaseUnit BU15-P16+A10+2D

Pin assignment for BaseUnit BU15-P16+A10+2D	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 9A, 10A, AUX	Protective-conductor terminal or potential bus freely usable up to 24 V DC with max. 10 A
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Interrupted voltage buses with connection to the terminals for infeed
⑤ Disconnected AUX busbar connected to the terminals

Figure 3-2 Block diagram BU15-P16+A10+2D

3.1.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A10+2D

	6ES7193-6BP20-0DA0
Product type designation	BU15-P16+A10+2D
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
between the potential groups	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	141 mm
Weights	
Weight, approx.	50 g

3.2 BU15-P16+A0+2D (BU type A0)

3.2.1 Product overview

Article number

6ES7193-6BP00-0DA0

View

Figure 3-3 BaseUnit BU15-P16+A0+2D

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the last two digits of the article number.
  - Supply voltage (L+ terminal, ground): Max. 24 VDC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Connection method using push-in terminals

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated from the sum of 1 and 2 may not exceed 10 A.

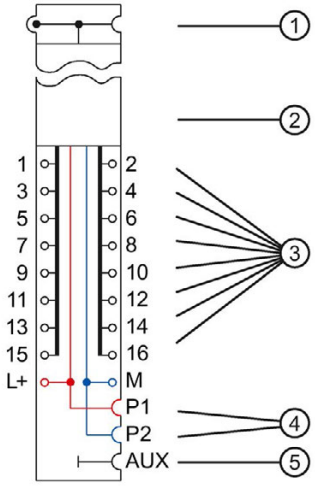
3.2.2 Connection

Pin assignment

Table 3- 2 Pin assignment for BaseUnit BU15-P16+A0+2D

Pin assignment for BaseUnit BU15-P16+A0+2D	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Interrupted voltage buses with connection to the terminals for infeed
⑤ Disconnected AUX busbar not connected to the terminals

Figure 3-4 Block diagram BU15-P16+A0+2D

3.2.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A0+2D

	6ES7193-6BP00-0DA0
Product type designation	BU15-P16+A0+2D
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
between the potential groups	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	117 mm
Weights	
Weight, approx.	40 g

3.3 BU15-P16+A10+2B (BU type A0)

3.3.1 Product overview

Article number

6ES7193-6BP20-0BA0

View

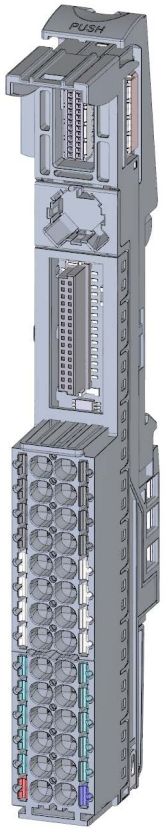


Figure 3-5 BaseUnit BU15-P16+A10+2B

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 10 AUX terminals for connecting a protective conductor or potential. The AUX busbar is not connected to the I/O module.
- Connection method using push-in terminals

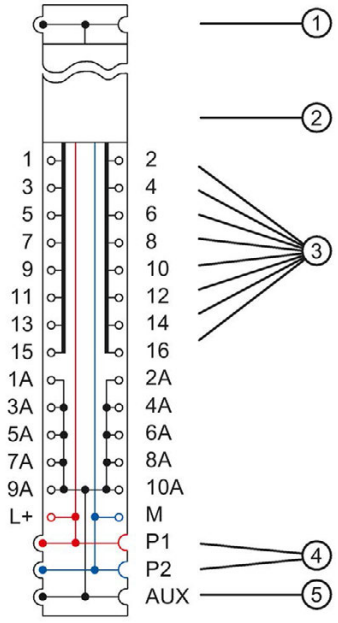
3.3.2 Connection

Pin assignment

Table 3- 3 Pin assignment for BaseUnit BU15-P16+A10+2B

Pin assignment for BaseUnit BU15-P16+A10+2B	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 9A, 10A, AUX	Protective conductor connection or voltage bus freely usable up to 24 V DC with max. 10 A
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Connected voltage buses with connection to the terminals
⑤ Connected AUX busbar connected to the terminals

Figure 3-6 Block diagram BU15-P16+A10+2B

3.3.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A10+2B

	6ES7193-6BP20-0BA0
Product type designation	BU15-P16+A10+2B
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	141 mm
Weights	
Weight, approx.	50 g

3.4 BU15-P16+A0+2B (BU type A0)

3.4.1 Product overview

Article number

6ES7193-6BP00-0BA0

View

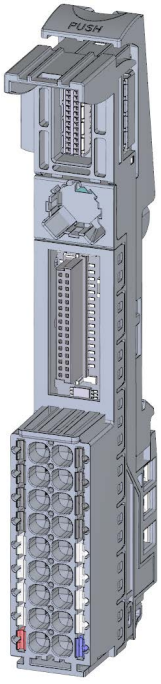


Figure 3-7 BaseUnit BU15-P16+A0+2B

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Connection method using push-in terminals

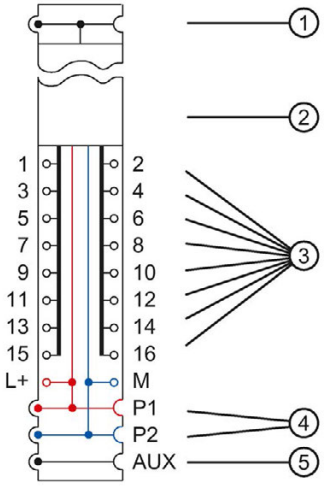
3.4.2 Connection

Pin assignment

Table 3- 4 Pin assignment for BaseUnit BU15-P16+A0+2B

Pin assignment for BaseUnit BU15-P16+A0+2B	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Connected voltage buses with connection to the terminals
⑤ Connected AUX busbar not connected to the terminals

Figure 3-8 Block diagram BU15-P16+A0+2B

3.4.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A0+2B

	6ES7193-6BP00-0BA0
Product type designation	BU15-P16+A0+2B
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	117 mm
Weights	
Weight, approx.	40 g

3.5 BU15-P16+A0+12D/T (BU type A1)

3.5.1 Product overview

Order number

6ES7193-6BP40-0DA1

View

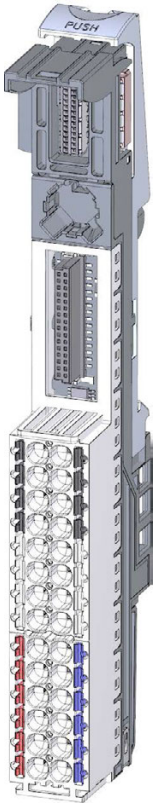


Figure 3-9 BaseUnit BU15-P16+A0+12D/T

Properties

- BaseUnit for all I/O modules of BaseUnit type "A1". Can be recognized by the last two digits of the order number.

  Note

  Using another I/O module can trigger an internal, non-exchangeable fuse and you must exchange the terminal box.

  - Supply voltage (L+ terminal, ground): Max. 24 VDC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 2x5 additional terminals for supplying a supply voltage up to 24 V DC/ 10 A. The additional terminals are not connected to the I/O module.
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection method using push-in terminals

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated from the sum of 1 and 2 may not exceed 10 A.

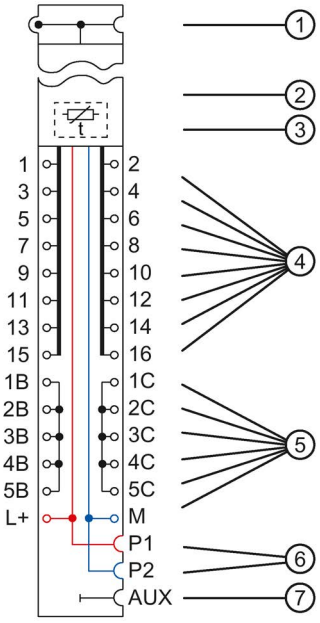
3.5.2 Connection

Pin assignment

Table 3- 5 Pin assignment for BaseUnit BU15-P16+A0+12D/T

Pin assignment for BaseUnit BU15-P16+A0+12D/T	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
1B, 2B, 3B, 4B, 5B / 1C, 2C, 3C, 4C, 5C	2 x 5 add-on terminals for the infeed of a supply voltage up to 24 V DC with max. 10 A
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Internal reference junction for temperature compensation
④ Terminals with connection to the I/O module
⑤ Additional terminals for feeding an additional supply voltage
⑥ Interrupted voltage buses with connection to the terminals for infeed
⑦ Disconnected AUX busbar not connected to the terminals

Figure 3-10 Block diagram BU15-P16+A0+12D/T

3.5.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A0+12D/T

	6ES7193-6BP40-0DA1
Product type designation	BU15-P16+A0+12D/T
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Analog inputs	
Thermocouple (TC)	
Temperature compensation	
• Internal temperature compensation	Yes
Electrical isolation	
between backplane bus and supply voltage	Yes
between the potential groups	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	141 mm
Weights	
Weight, approx.	50 g

3.6 BU15-P16+A0+2D/T (BU type A1)

3.6.1 Product overview

Article number

6ES7193-6BP00-0DA1

View

Figure 3-11 BaseUnit BU15-P16+A0+2D/T

Properties

- BaseUnit for all I/O modules of BaseUnit type "A1". Can be recognized by the last two digits of the article number.

  Note

  Using another I/O module can trigger an internal, non-exchangeable fuse and you must exchange the terminal box.

  - Supply voltage (L+ terminal, ground): Max. 24 VDC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection method using push-in terminals

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated from the sum of 1 and 2 may not exceed 10 A.

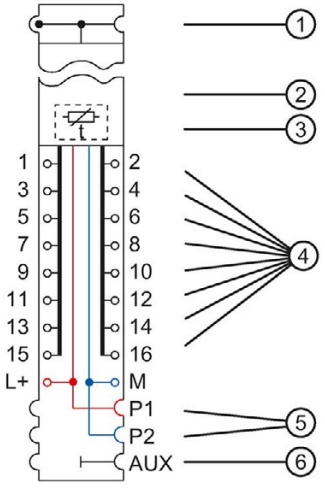
3.6.2 Connection

Pin assignment

Table 3- 6 Pin assignment for BaseUnit BU15-P16+A0+2D/T

Pin assignment for BaseUnit BU15-P16+A0+2D/T	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Internal reference junction for temperature compensation
④ Terminals with connection to the I/O module
⑤ Interrupted voltage buses with connection to the terminals for infeed
⑥ Disconnected AUX busbar not connected to the terminals

Figure 3-12 Block diagram BU15-P16+A0+2D/T

3.6.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A0+2D/T

	6ES7193-6BP00-0DA1
Product type designation	BU15-P16+A0+2D/T
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Analog inputs	
Thermocouple (TC)	
Temperature compensation	
• Internal temperature compensation	Yes
Electrical isolation	
between backplane bus and supply voltage	Yes
between the potential groups	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	117 mm
Weights	
Weight, approx.	40 g

3.7 BU15-P16+A0+12B/T (BU type A1)

3.7.1 Product overview

Article number

6ES7193-6BP40-0BA1

View

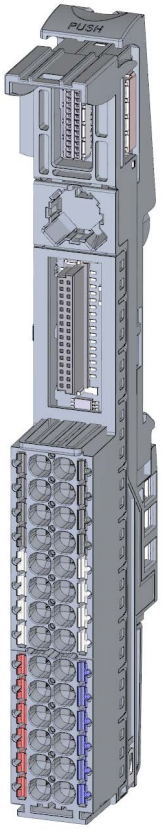


Figure 3-13 BaseUnit BU15-P16+A0+12B/T

Properties

- BaseUnit suitable for all I/O modules of BaseUnit type "A1". Can be recognized by the last two digits of the article number.

  Note

  Using another I/O module can trigger an internal, non-exchangeable fuse and you must exchange the terminal box.

  – Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 2x5 additional terminals for feeding a supply voltage up to 24 VDC/ 10 A. The additional terminals are not connected to the I/O module.
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection method using push-in terminals

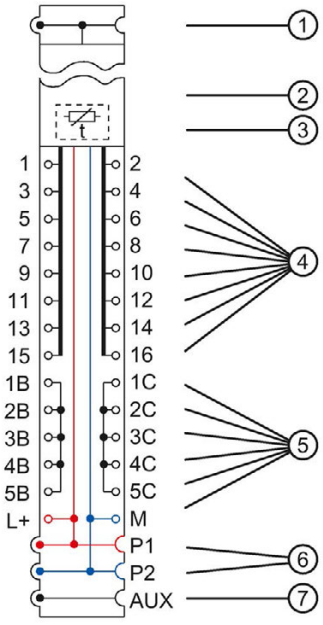
3.7.2 Connection

Pin assignment

Table 3- 7 Pin assignment for BaseUnit BU15-P16+A0+12B/T

Pin assignment for BaseUnit BU15-P16+A0+12B/T	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
1B, 2B, 3B, 4B, 5B / 1C, 2C, 3C, 4C, 5C	2 x 5 add-on terminals for the infeed of a supply voltage up to 24 V DC with max. 10 A
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Internal reference junction for temperature compensation
④ Terminals with connection to the I/O module
⑤ Additional terminals for feeding an additional supply voltage
⑥ Connected voltage buses with connection to the terminals
⑦ Connected AUX busbar not connected to the terminals

Figure 3-14 Block diagram BU15-P16+A0+12B/T

3.7.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A0+12B/T

	6ES7193-6BP40-0BA1
Product type designation	BU15-P16+A0+12B/T
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Analog inputs	
Thermocouple (TC)	
Temperature compensation	
• Internal temperature compensation	Yes
Electrical isolation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	141 mm
Weights	
Weight, approx.	50 g

3.8 BU15-P16+A0+2B/T (BU type A1)

3.8.1 Product overview

Article number

6ES7193-6BP00-0BA1

View

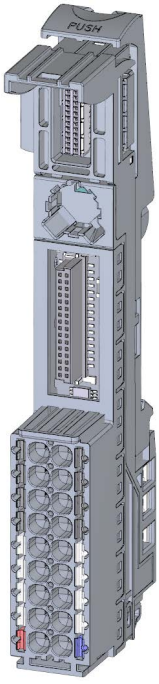


Figure 3-15 BaseUnit BU15-P16+A0+2B/T

Properties

- BaseUnit suitable for all I/O modules of BaseUnit type "A1". Can be recognized by the last two digits of the article number.

  Note

  Using another I/O module can trigger an internal, non-exchangeable fuse and you must exchange the terminal box.

  – Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection method using push-in terminals

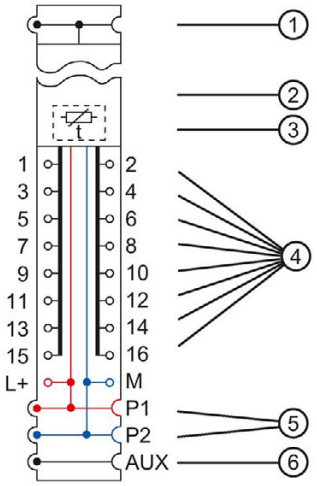
3.8.2 Connection

Pin assignment

Table 3- 8 Pin assignment for BaseUnit BU15-P16+A0+2B/T

Pin assignment for BaseUnit BU15-P16+A0+2B/T	
Terminal	**Descriptions**
1 to 16	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram



① Backplane bus
② I/O module
③ Internal reference junction for temperature compensation
④ Terminals with connection to the I/O module
⑤ Connected voltage buses with connection to the terminals
⑥ Connected AUX busbar not connected to the terminals

Figure 3-16 Block diagram BU15-P16+A0+2B/T

3.8.3 Technical specifications

Technical specifications of the BaseUnit BU15-P16+A0+2B/T

	6ES7193-6BP00-0BA1
Product type designation	BU15-P16+A0+2B/T
Supply voltage	
Rated value (DC)	24 V
External fuse for power supply lines	Yes: 24 VDC / 10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Analog inputs	
Thermocouple (TC)	
Temperature compensation	
• Internal temperature compensation	Yes
Electrical isolation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Height	117 mm
Weights	
Weight, approx.	40 g

3.9 BU20-P12+A4+0B (BU type B0)

3.9.1 Product overview

Article number

6ES7193-6BP20-0BB0

View

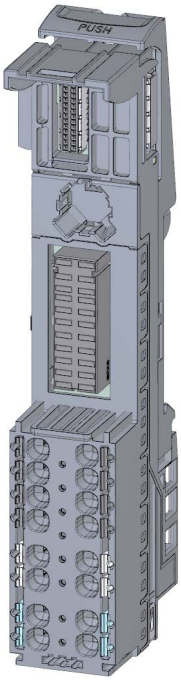


Figure 3-17 BaseUnit BU20-P12+A4+0B

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "B0/B1". Can be recognized by the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 12): Max. 5 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals
- 12 terminals to the process (assignment with the I/O module)
- Connection method using push-in terminals

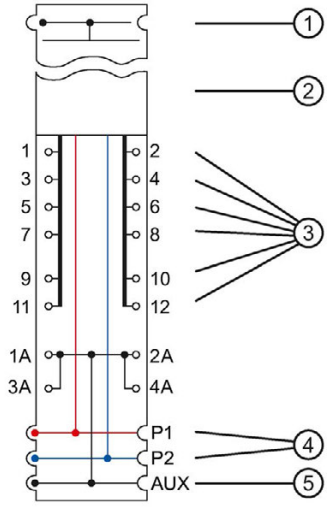
3.9.2 Connecting

Pin assignment

Table 3- 9 Pin assignment for BaseUnit BU20-P12+A4+0B

Pin assignment for BaseUnit BU20-P12+A4+0B	
Terminal	**Descriptions**
1 to 12	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
1A, 2A, 3A, 4A, AUX	Protective conductor connection or voltage bus (freely usable up to 230 V AC/ DC with max 10 A). If you connect a voltage, it must belong to the same potential group as the rated supply voltage.

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Connected voltage buses without connection to the terminals
⑤ Connected AUX busbar connected to the terminals

Figure 3-18 Block diagram BU20-P12+A4+0B

3.9.3 Technical specifications

Technical specifications of the BaseUnit BU20-P12+A4+0B

	6ES7193-6BP20-0BB0
Product type designation	BU20-P12+A4+0B
Supply voltage	
Rated value (DC)	24 V
Rated value (AC)	230 V; 110 V
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	3250 VDC
Dimensions	
Width	20 mm
Height	117 mm
Weights	
Weight, approx.	48 g

3.10 BU20-P12+A0+4B (BU type B1)

3.10.1 Product overview

Article number

6ES7193-6BP20-0BB1

View

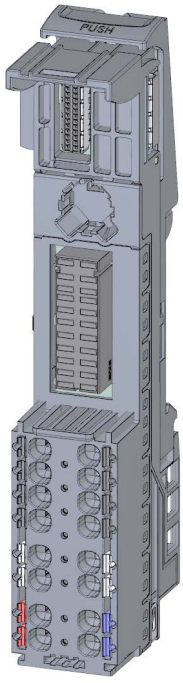


Figure 3-19 BaseUnit BU20-P12+A0+4B

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "B1". Can be recognized by the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 12): Max. 5 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the power and AUX busbars via terminals
- 12 terminals to the process (assignment with the I/O module)
- Connection method using push-in terminals

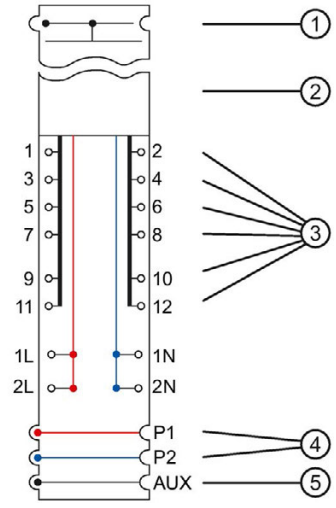
3.10.2 Connecting up

Pin assignment

Table 3- 10 Pin assignment for BaseUnit BU20-P12+A0+4B

Pin assignment for BaseUnit BU20-P12+A0+4B	
Terminal	**Descriptions**
1 to 12	Assignment is determined by the I/O module. See manual I/O Module
(AUX)	No access to the AUX busbar via terminals
1L, 2L, (P1) / 1N, 2N, (P2)	1L, 2L: Rated supply voltage up to 230 V AC with max. 10 A 1N, 2N: Neutral/ground

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Connected voltage buses without connection to the terminals
⑤ Connected AUX busbar not connected to the terminals

Figure 3-20 Block diagram BU20-P12+A0+4B

3.10.3 Technical specifications

Technical specifications of the BaseUnit BU20-P12+A0+4B

	6ES7193-6BP20-0BB1
Product type designation	BU20-P12+A0+4B
Supply voltage	
Rated value (DC)	24 V
Rated value (AC)	230 V; 110 V
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
between Powerbus and supply voltage	Yes
Isolation	
Isolation tested with	3250 VDC
Dimensions	
Width	20 mm
Height	117 mm
Weights	
Weight, approx.	48 g

3.11 BU20-P6+A2+4D (BU type C0)

3.11.1 Product overview

Article number

6ES7193-6BP20-0DC0

View

Figure 3-21 BaseUnit BU20-P6+A2+4D

Properties

- BaseUnit suitable for all I/O modules of BaseUnit type "C0/C1". Can be recognized by the last two digits of the article number.
  - Supply voltage (terminal 1L, 2L / 1N, 2N): Max. 230 V AC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 4): Max. 5 A
  - Current carrying capacity per process terminal (terminal 5 and 6): Max. 10 A
- The BaseUnit opens up a new potential group by means of the inserted I/O module. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- Access to the AUX busbar via terminals
- 6 terminals to the process (assignment with the I/O module)
- Two AUX terminals for connecting a PE terminal or potential. The AUX busbar is not connected to the I/O module.
- Connection method using push-in terminals

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated from the sum of 1 and 2 may not exceed 10 A.

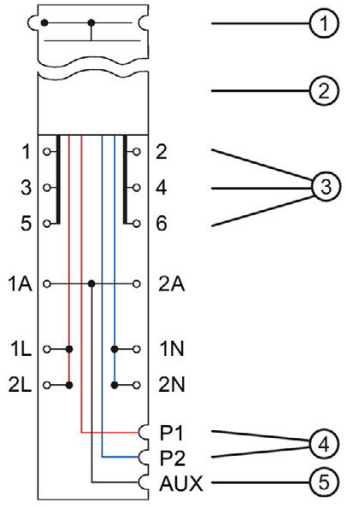
3.11.2 Connecting

Pin assignment

Table 3- 11 Pin assignment for BaseUnit BU20-P6+A2+4D

Pin assignment for BaseUnit BU20-P12+A2+4D	
Terminal	**Descriptions**
1 to 6	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
1A, 2A, AUX	Protective conductor connection or voltage bus freely usable up to 230 V AC/ DC with max 10 A. If you connect a voltage, it must belong to the same potential group as the rated supply voltage.
1L, 2L, (P1) / 1N, 2N, (P2)	1L, 2L: Rated supply voltage up to 230 V AC with max. 10 A 1N, 2N: Neutral/ground

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Interrupted voltage buses with connection to the terminals for infeed (via the plugged-in I/O module)
⑤ Disconnected AUX busbar connected to the terminals

Figure 3-22 Block diagram BU20-P6+A2+4D

3.11.3 Technical specifications

Technical specifications of the BaseUnit BU20-P6+A2+4D

	6ES7193-6BP20-0DC0
Product type designation	BU20-P6+A2+4D
Supply voltage	
Rated value (DC)	24 V; 30 V
Rated value (AC)	230 V; 110 V
External fuse for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
Isolation	
Isolation tested with	3250 VDC
Dimensions	
Width	20 mm
Height	117 mm
Weights	
Weight, approx.	47 g

3.12 BU20-P6+A2+4B (BU type C1)

3.12.1 Product overview

Article number

6ES7193-6BP20-0BC1

View

Figure 3-23 BaseUnit BU20-P6+A2+4B

Properties

- BaseUnit suitable for all I/O modules of BaseUnit type "C0/C1". Can be recognized by the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 4): Max. 5 A
  - Current carrying capacity per process terminal (terminal 5 and 6): Max. 10 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX bus are connected to the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals
- 6 terminals to the process (assignment with the I/O module)
- Two AUX terminals for connecting a PE terminal or potential. The AUX busbar is not connected to the I/O module.
- Connection method using push-in terminals

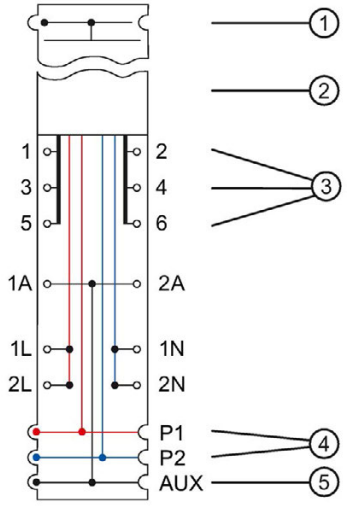
3.12.2 Connecting

Pin assignment

Table 3- 12 Pin assignment for BaseUnit BU20-P6+A2+4B

Pin assignment for BaseUnit BU20-P12+A2+4B	
Terminal	**Descriptions**
1 to 6	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300).
1A, 2A, AUX	Protective conductor connection or voltage bus freely usable up to 230 V AC/ DC with max 10 A. If you connect a voltage, it must belong to the same potential group as the rated supply voltage.
1L, 2L, (P1) / 1N, 2N, (P2)	1L, 2L: Rated supply voltage up to 230 V AC with max. 10 A 1N, 2N: Neutral/ground

Block diagram



① Backplane bus
② Power module
③ Terminals with connection to the I/O module
④ Connected voltage buses with connection to the terminals for infeed (via the plugged-in I/O module)
⑤ Connected AUX busbar connected to the terminals

Figure 3-24 Block diagram BU20-P6+A2+4B

3.12.3 Technical specifications

Technical specifications of the BaseUnit BU20-P6+A2+4B

	6ES7193-6BP20-0BC1
Product type designation	BU20-P6+A2+4B
Supply voltage	
Rated value (DC)	24 V; 30 V
Rated value (AC)	230 V; 110 V
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
Isolation	
Isolation tested with	3250 VDC
Dimensions	
Width	20 mm
Height	117 mm
Weights	
Weight, approx.	47 g

3.13 BU20-P12+A0+0B (BU type D0)

3.13.1 Product overview

Article number

6ES7193-6BP00-0BD0

View

Figure 3-25 BaseUnit BU20-P12+A0+0B

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "D0". Can be recognized by the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 12): Max. 5 A
- The BaseUnit conducts the potential group further. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the power and AUX busbars via terminals
- 12 terminals to the process (assignment with the I/O module)
- Connection method using push-in terminals

Note

The shield connection (shield support and shield terminal) is not intended for BaseUnit BU20-P12+A0+0B and must not be installed.

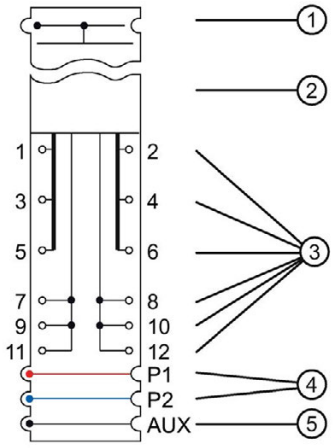
3.13.2 Connecting

Pin assignment

Table 3- 13 Pin assignment for BaseUnit BU20-P12+A0+0B

Pin assignment for BaseUnit BU20-P12+A0+0B	
Terminal	**Descriptions**
1 to 12	Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300)

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Connected voltage buses without connection to the terminals
⑤ Connected AUX busbar not connected to the terminals

Figure 3-26 Block diagram BU20-P12+A0+0B

3.13.3 Technical specifications

Technical specifications of the BaseUnit BU20-P12+A0+0B

	6ES7193-6BP00-0BD0
Product type designation	BU20-P12+A0+0B
Supply voltage	
Rated value (AC)	400 V; 230 VAC (L1/ N)
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	5 A
Electrical isolation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	3250 VDC
Dimensions	
Width	20 mm
Height	117 mm
Weights	
Weight, approx.	47 g

3.14 BU20-P8+A4+0B (BU type F0)

3.14.1 Product overview

Note when you use the AUX terminals as a PE busbar:

NOTICE
If AUX is used as PE, AUX must be identified as green-yellow (e.g., gn/ye color-coded labels). These identifications must be removed if the terminals are no longer used as PE.

Article number

6ES7193-6BP20-0BF0

View

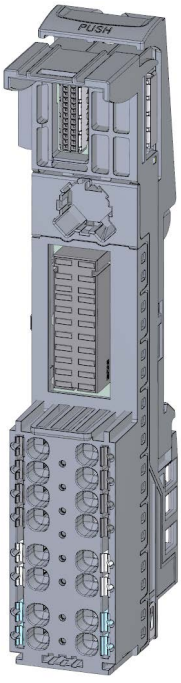


Figure 3-27 BaseUnit BU20-P8+A4+0B

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "F0". Can be recognized by the last two digits of the order number.
  - Current carrying capacity per process terminal (terminals 1 to 4 and 9 to 12): Max. 5 A
- The BaseUnit loops the potential group through with the self-assembling voltage buses P1, P2 and the AUX bus of the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals 1A to 4A
- 8 terminals to the process (occupied by the I/O module)
- Connection method using push-in terminals

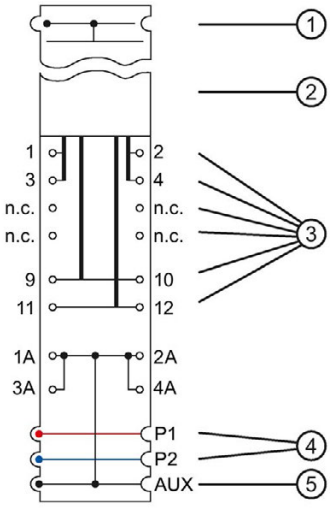
3.14.2 Connecting up

Pin assignment

Terminals of a potential group	Fail-safe module Overvoltage category 3	Non-fail-safe module Overvoltage category 2
1 to 4	Up to 230 VAC/VDC (AC only one phase) Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300)	
9 to 12	Safe extra low voltage SELV/PELV Assignment is determined by the I/O module. See manual I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300)	
P1, P2, AUX (1A to 4A)	SELV/PELV (max. 10 A)	SELV/PELV or Up to 230 VAC/VDC (AC only one phase) (max. 10 A)

The AUX terminals may only be used with an identical voltage or PE associated with the supply voltage.

Block diagram



① Backplane bus
② I/O module
③ Terminals with connection to the I/O module
④ Connected voltage buses without connection to the terminals
⑤ Connected AUX busbar connected to the terminals

Figure 3-28 Block diagram BU20-P8+A4+0B

3.14.3 Technical specifications

Technical specifications of the BaseUnit BU20-P8+A4+0B

	6ES7193-6BP20-0BF0
Product type designation	BU20-P8+A4+0B
Supply voltage	
Rated value (DC)	See manual
Rated value (AC)	See manual
Current carrying capacity	
Current carrying capacity up to 60 °C, max.	10 A
Electrical isolation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
between Powerbus and supply voltage	Yes
Insulation	
Insulation tested with	3250 VDC 1 min (type test); 2545 VDC 2 s (routine test)
Dimensions	
Width	20 mm
Height	117 mm
Weights	
Weight, approx.	48 g

BaseUnits for motor starters

4

4.1 Introduction

Properties of the infeed bus

- The infeed bus is set up by connecting the BaseUnits, and wiring takes place automatically
- The infeed bus distributes the energy to the SIMATIC ET 200SP motor starter within one load group
- The max. current carrying capacity is up to 32 A (3-phase)
  - With infeed (for one load group) and motor connection
  - Infeed bus: 3-pole + PE
  - The voltage range for power infeed is 48 … 500 V AC

You must observe the deratings depending on the configuration.

Properties of the self-assembling voltage bus (power bus)

- Maximum current: 7 A
- Rated voltage: 24 V DC

You must observe the deratings depending on the configuration.

AUX1 bus

The AUX1 bus is not supported in the BaseUnits of the SIMATIC ET 200SP motor starters.

You can find assembly rules of the BaseUnits for the SIMATIC ET 200SP motor starter in the System Manual SIMATIC ET 200SP motor starters.

4.2 BU30-MS1 - BaseUnit with 24 V DC and 500 V AC infeed

4.2.1 Product overview

Article number

3RK1908-0AP00-0AP0

View

Figure 4-1 BaseUnit with 24 V DC and 500 V AC infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit opens a new potential group (24 V DC). The power buses P1 and P2 are interrupted to the left-hand neighboring module (BaseUnit, interface module/CPU).
- The BaseUnit opens a new potential group (500 V DC). The infeed bus L1 (L), L2 (N), L3, PE is interrupted to the left-hand BaseUnit of the ET 200SP motor starter.
- Connection method using push-in terminals
- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is included in the scope of delivery.
- The fail-safe input F-DI of the fail-safe motor starter is connected to the power bus.

Maximum configuration per voltage group (24 V DC)

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total overall current calculated according to 1. and 2. must not exceed 7 A.

Maximum configuration of the infeed bus (500 V AC)

The number of motor starters that can be used per infeed group depends on the following factors:

1. Total current requirement of all motor starters operated on this infeed group.
2. Ambient temperature and installation type in which the motor starters are operated. You can find further information in the derating table in the Manual SIMATIC ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109479973).

4.2.2 Connection

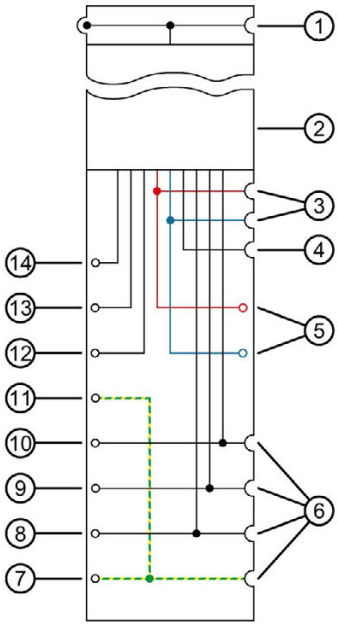
Pin assignment

Table 4- 1 Pin assignment for BaseUnit with 24 V DC and 500 V AC infeed

Pin assignment for BaseUnit with 24 V DC and 500 V AC infeed	
Terminal	**Descriptions**
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. See Manual ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109479973).
T1, T2, T3, PE	Motor feeder
24 V DC, M	24 V DC: Supply voltage 24 V DC with max. 7 A M: Ground

Block diagram

The figure below shows the block diagram of the BaseUnit with 24 V DC and 500 V AC infeed.



① Backplane bus
② Motor starter module
③ Interrupted power buses 24 V DC, M
④ Interrupted AUX bus
⑤ Terminals for 24 V DC and ground M
⑥ Interrupted busbars for the infeed system L1(L), L2(N), L3, PE
⑦ Infeed terminal for protective ground PE
⑧ Infeed terminal L3
⑨ Infeed terminal L2(N)
⑩ Infeed terminal L1(L)
⑪ Terminal for protective ground PE
⑫ Terminal T3
⑬ Terminal T2
⑭ Terminal T1

Figure 4-2 Block diagram BaseUnit with 24 V DC and 500 V AC infeed

4.2.3 Technical specifications

Technical specifications of the BaseUnit with 24 V DC and 500 V AC infeed

	3RK1908-0AP00-0AP0
Product type designation	BU30-MS1
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating)
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 ... 500 V AC
Max. current-carrying capacity	32 A (observe derating)
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weights	
Weight, approx.	164 g

4.3 BU30-MS2 - BaseUnit with 500 V AC infeed

4.3.1 Product overview

Article number

3RK1908-0AP00-0CP0

View

Figure 4-3 BaseUnit with 500 V AC infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit handles the potential group (P1, P2) of the left-hand neighboring module.
- The BaseUnit opens a new 500 V AC infeed group. The potential group (24 V DC) is looped through.
- Connection method using push-in terminals
- The touch protection cover for the infeed bus is included in the scope of delivery.
- The fail-safe input F-DI of the fail-safe motor starter is connected to the power bus.

Maximum configuration of the infeed bus (500 V AC)

The number of motor starters that can be used per infeed group depends on the following factors:

1. Total current requirement of all motor starters operated on this infeed group.
2. Ambient temperature and installation type in which the motor starters are operated. You can find further information in the derating table in the Manual SIMATIC ET 200SP motor starters.

4.3.2 Connection

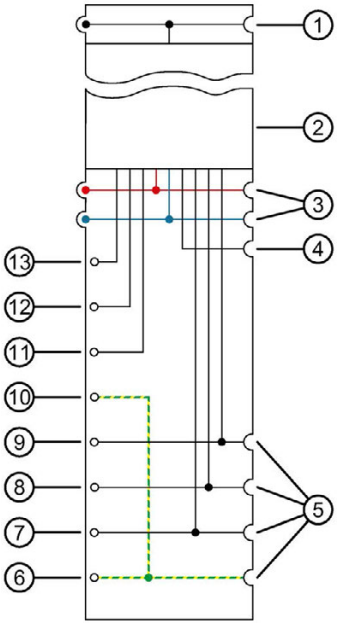
Pin assignment

Table 4- 2 Pin assignment for BaseUnit with 500 V AC infeed

Pin assignment for BaseUnit with 500 V AC infeed	
Terminal	**Descriptions**
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. See Manual ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109479973).
T1, T2, T3, PE	Motor feeder

Block diagram

The figure below shows the block diagram of the BaseUnit with 500 V AC infeed.



① Backplane bus
② Motor starter module
③ Connected power buses 24 V DC, M
④ Interrupted AUX bus
⑤ Interrupted busbars for the infeed system L1(L), L2(N), L3, PE
⑥ Infeed terminal for protective ground PE
⑦ Infeed terminal L3
⑧ Infeed terminal L2(N)
⑨ Infeed terminal L1(L)
⑩ Terminal for protective ground PE
⑪ Terminal T3
⑫ Terminal T2
⑬ Terminal T1

Figure 4-4 Block diagram BaseUnit with 500 V AC infeed

4.3.3 Technical specifications

Technical specifications of the BaseUnit with 500 V AC infeed

	3RK1908-0AP00-0CP0
Product type designation	BU30-MS2
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating)
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 ... 500 V AC
Max. current-carrying capacity	32 A (observe derating)
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	160 g

4.4 BU30-MS3 - BaseUnit with 24 V DC infeed

4.4.1 Product overview

Article number

3RK1908-0AP00-0BP0

View

Figure 4-5 BaseUnit with 24 V DC infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit opens a new potential group (24 V DC). The power buses P1 and P2 are interrupted to the left-hand neighboring module (BaseUnit, interface module/CPU).
- This BaseUnit handles the infeed bus (500 V AC) of the left-hand BaseUnit and loops this through.
- Connection method using push-in terminals
- The touch protection cover for the infeed bus is not included in the scope of delivery.
- The fail-safe input F-DI of the fail-safe motor starter is connected to the power bus.

Maximum configuration per voltage group (24 V DC)

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total overall current calculated according to 1. and 2. must not exceed 7 A.

4.4.2 Connection

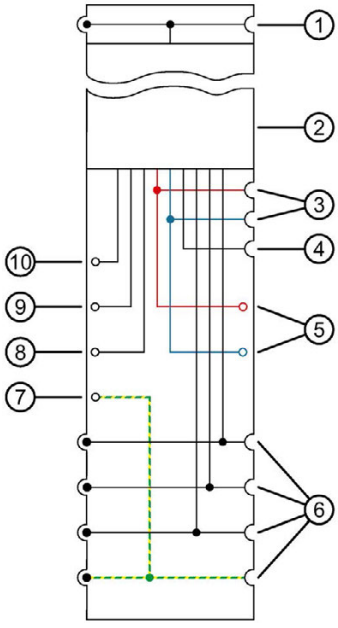
Pin assignment

Table 4- 3 Pin assignment for BaseUnit with 24 V DC infeed

Pin assignment for BaseUnit with 24 V DC infeed	
Terminal	**Descriptions**
T1, T2, T3, PE	Motor feeder
24 V DC, M	24 V DC: Rated supply voltage 24 V DC with max. 7 A M: Ground

Block diagram

The figure below shows the three-phase connection with 24 V infeed and mains infeed.



① Backplane bus
② Motor starter module
③ Interrupted power buses 24 V DC, M
④ Interrupted AUX bus
⑤ Terminal for 24 V DC and ground M
⑥ Connected busbars for the infeed system L1(L), L2(N), L3, PE
⑦ Terminal for protective ground PE
⑧ Terminal T3
⑨ Terminal T2
⑩ Terminal T1

Figure 4-6 Block diagram BaseUnit with 24 V DC infeed

4.4.3 Technical specifications

Technical specifications of the BaseUnit with 24 V DC infeed

	3RK1908-0AP00-0BP0
Product type designation	BU30-MS3
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating)
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 ... 500 V AC
Max. current-carrying capacity	32 A (observe derating)
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	152 g

4.5 BU30-MS4 - BaseUnit without infeed

4.5.1 Product overview

Article number

3RK1908-0AP00-0DP0

View

Figure 4-7 BaseUnit without infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- No new potential groups are opened with this BaseUnit.
- The potential group (24 V DC) is looped through.
- The infeed group (500 V AC) is looped through.
- Connection method using push-in terminals
- The touch protection cover for the infeed bus is not included in the scope of delivery.
- The fail-safe input F-DI of the fail-safe motor starter is connected to the power bus.

4.5.2 Connection

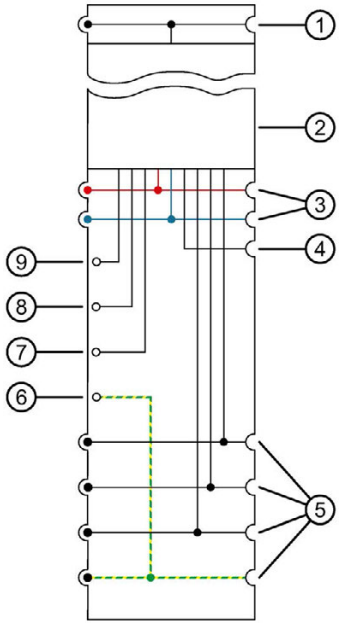
Pin assignment

Table 4- 4 Pin assignment for BaseUnit without infeed

Pin assignment for BaseUnit without infeed	
Terminal	**Descriptions**
T1, T2, T3, PE	Motor feeder

Block diagram

The figure below shows the block diagram of the BaseUnit without infeed.



① Backplane bus
② Motor starter module
③ Connected power buses 24 V DC, M
④ Interrupted AUX bus
⑤ Connected busbars for the infeed system L1(L), L2(N), L3, PE
⑥ Terminal for protective ground PE
⑦ Terminal T3
⑧ Terminal T2
⑨ Terminal T1

Figure 4-8 Block diagram BaseUnit without infeed

4.5.3 Technical specifications

Technical specifications of BaseUnit without infeed

	3RK1908-0AP00-0DP0
Product type designation	BU30-MS4
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating)
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 ... 500 V AC
Max. current-carrying capacity	32 A (observe derating)
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	150 g

4.6 BU30-MS5 BaseUnit with 500 V AC infeed and F-DI

4.6.1 Product overview

Article number

3RK1908-0AP00-0EP0

View

Figure 4-9 BaseUnit with 500 V AC and F-DI

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit handles the potential group (P1, P2) of the left-hand neighboring module.
- The BaseUnit opens a new 500 V AC infeed group. The potential group (24 V DC) is looped through.
- The BaseUnit has one F-DI input terminal for fail-safe control signals of the motor starter. This signal is not forwarded to neighboring motor starters.
- Connection method using push-in terminals
- The touch protection cover for the infeed bus is included in the scope of delivery.

Maximum configuration of the infeed bus

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total overall current calculated according to 1. and 2. must not exceed 7 A.

Properties of the F-DI input

The fail-safe digital input "F-DI" has the following properties:

- Use of interconnection type 1oo1 possible
- Sink input
- Input delay 10 ms
- Status indication of input F-DI at motor starter module (green LED)

4.6.2 Connection

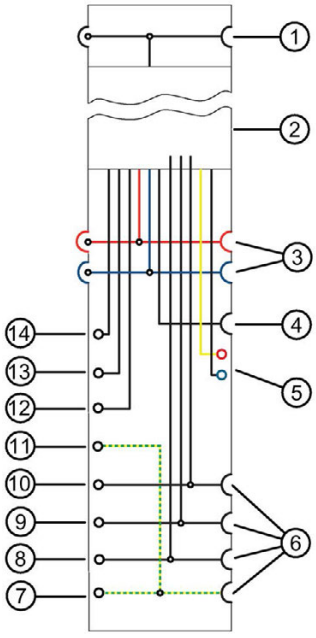
Pin assignment

Table 4- 5 Pin assignment for BaseUnit with 500 V AC infeed and F-DI

Pin assignment for BaseUnit with 500 V AC infeed and F-DI	
Terminal	**Descriptions**
T1, T2, T3, PE	Motor feeder
F-DI, M	F-DI: Connection of fail-safe signal M: Reference potential of fail-safe signal
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. See Manual ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109479973).

Block diagram

The figure below shows the two-phase connection with 500 V AC infeed and F-DI:



① Backplane bus
② Motor starter module
③ Connected power buses 24 V DC, M
④ Interrupted AUX bus
⑤ Safety input F-DI (P24/M)
⑥ Interrupted busbars for the infeed system L1(L), L2(N), L3, PE
⑦ Infeed terminal for protective ground PE
⑧ Infeed terminal L3
⑨ Infeed terminal L2(N)
⑩ Infeed terminal L1(L)
⑪ Terminal for protective ground PE
⑫ Terminal T3
⑬ Terminal T2
⑭ Terminal T1

Figure 4-10 BaseUnit block diagram with 500 V AC infeed and fail-safe input

4.6.3 Technical specifications

Technical specifications of the BaseUnit with 500 V AC infeed and F-DI

	3RK1908-0AP00-0EP0
Product type designation	BU30-MS5
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating)
Galvanic isolation between fail-safe digital input and supply voltage	Yes
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 ... 500 V AC
Max. current-carrying capacity	32 A (observe derating)
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	152 g

4.7 BU30-MS6 BaseUnit without infeed and with F-DI

4.7.1 Product overview

Article number

3RK1908-0AP00-0FP0

View

Figure 4-11 BaseUnit without 500 V AC infeed, with F-DI

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit handles the potential group (P1, P2) of the left-hand neighboring module.
- This BaseUnit handles the potential group/infeed bus (500 V AC) of the left-hand BaseUnit and loops this through.
- The BaseUnit has one F-DI input terminal for fail-safe control signals of the motor starter. This signal is not forwarded to neighboring motor starters.
- Connection method using push-in terminals
- The touch protection cover for the infeed bus is not included in the scope of delivery.

Properties of the F-DI input

The fail-safe digital input "F-DI" has the following properties:

- Use of interconnection type 1oo1 possible
- Sink input
- Input delay 10 ms
- Status indication of input F-DI at motor starter module (green LED)

4.7.2 Connection

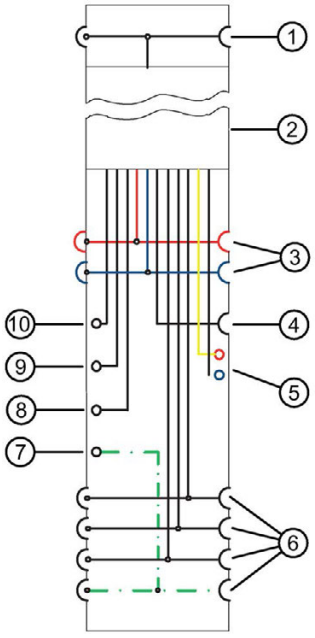
Pin assignment

Table 4- 6 Pin assignment for BaseUnit with 24 V DC infeed

Pin assignment for BaseUnit with 24 V DC infeed	
Terminal	**Descriptions**
T1, T2, T3, PE	Motor feeder
F-DI, M	F-DI: Connection of fail-safe signal M: Reference potential of fail-safe signal

Block diagram

The following figure shows the block diagram for the BaseUnit without infeed, but with fail-safe input:



① Backplane bus
② Motor starter module
③ Connected power buses 24 V DC, M
④ Interrupted AUX bus
⑤ Safety input F-DI (P24/M)
⑥ Connected busbars infeed system L1, L2, L3, PE
⑦ Terminal for protective ground PE
⑧ Terminal T3
⑨ Terminal T2
⑩ Terminal T1

Figure 4-12 Block diagram BaseUnit without infeed, with fail-safe input

4.7.3 Technical specifications

Technical specifications of BaseUnit without infeed, with F-DI

	3RK1908-0AP00-0FP0
Product type designation	BU30-MS6
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating)
Rated insulation voltage in accordance with IEC 60947-1	500 V
Galvanic isolation between fail-safe digital input and supply voltage	Yes
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 ... 500 V AC
Max. current-carrying capacity	32 A (observe derating)
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	152 g

Dimension drawings of I/O modules

A

Dimension drawing BU15-P16+A10+2D, BU15-P16+A10+2B, BU15-P16+A0+12D/T, BU15-P16+A0+12B/T

The figure below shows the dimension drawing of the BU15-P16+A10+2D with plugged-in I/O module as an example.

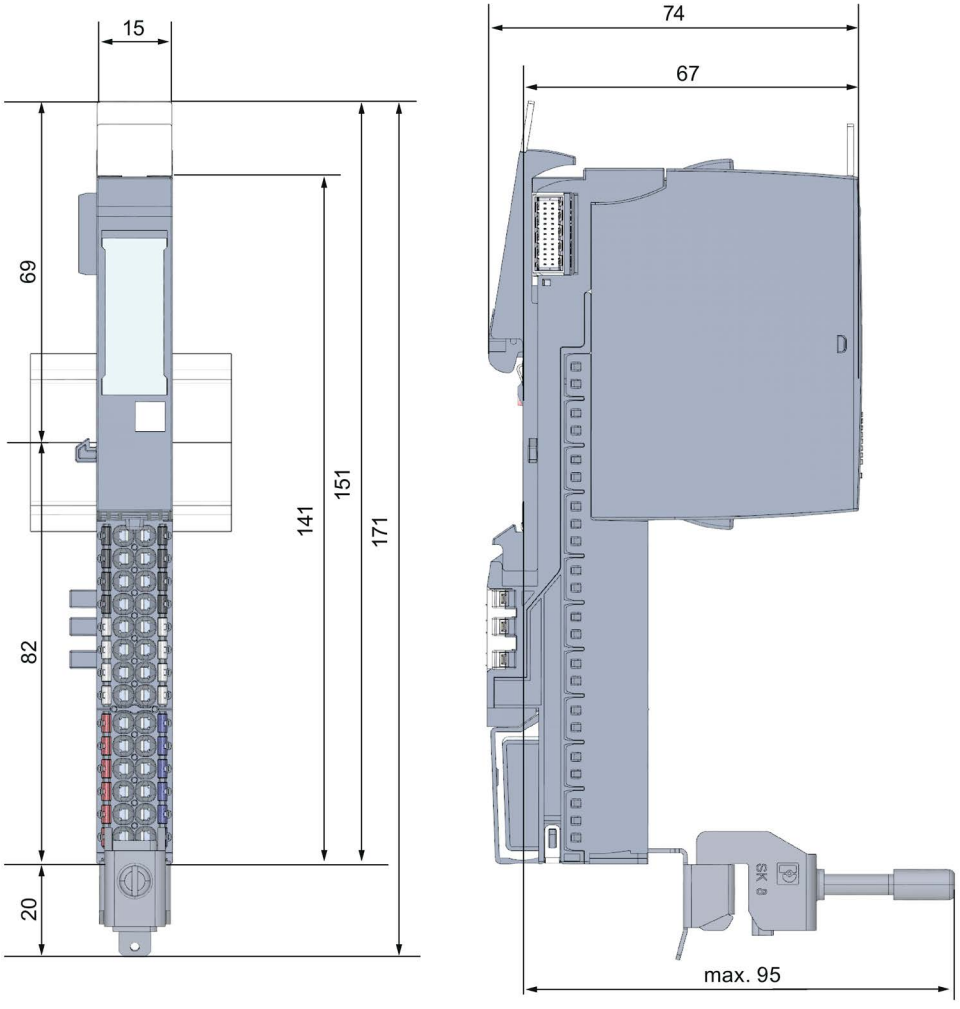


Figure A-1 Dimension drawing BU15-P16+A10+2D

Dimension drawing BU15-P16+A0+2D, BU15-P16+A0+2B, BU15-P16+A0+2D/T, BU15-P16+A0+2B/T

The figure below shows the dimension drawing of the BU15-P16+A0+2D with plugged-in I/O module as an example.

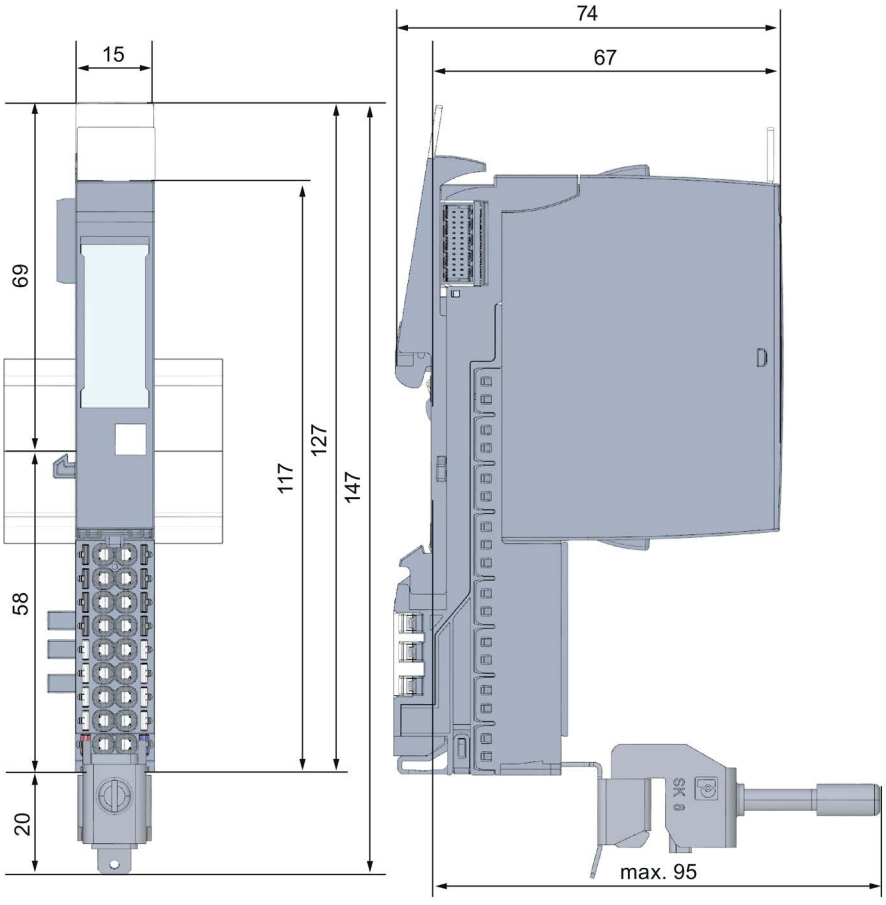


Figure A-2 Dimension drawing BU15-P16+A0+2D

Dimension drawing BU20-P6+A2+4D, BU20-P6+A2+4B, BU20-P12+A4+0B, BU20-P12+A0+0B, BU20-P12+A0+4B, BU20-P8+A4+0B

The figure below shows the dimension drawing of the BU20-P12+A4+0B with plugged-in I/O module as an example.

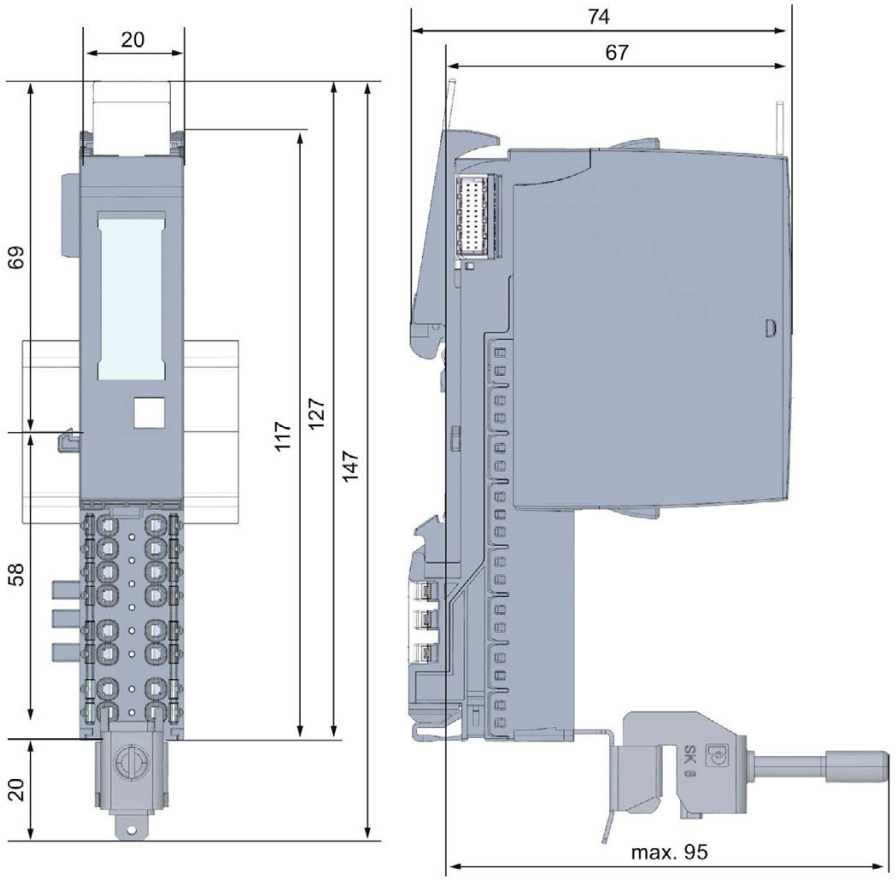


Figure A-3 Dimension drawing BU20-P12+A4+0B

Dimension drawing test probe for measurement tap

The figure below shows the dimension drawing of a suitable test probe for measurement tap at the BaseUnit.

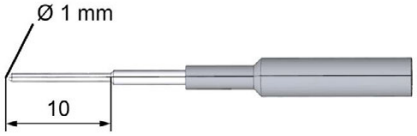


Figure A-4 Dimension drawing test probe

Dimension drawings of motor starters

B

Dimension drawing BU30-MS1, BU30-MS2, BU30-MS3, BU30-MS4, BU30-MS5, BU30-MS6

The figure below shows the dimension drawing of the BU30-MS-1 with plugged-in motor starter module as an example.

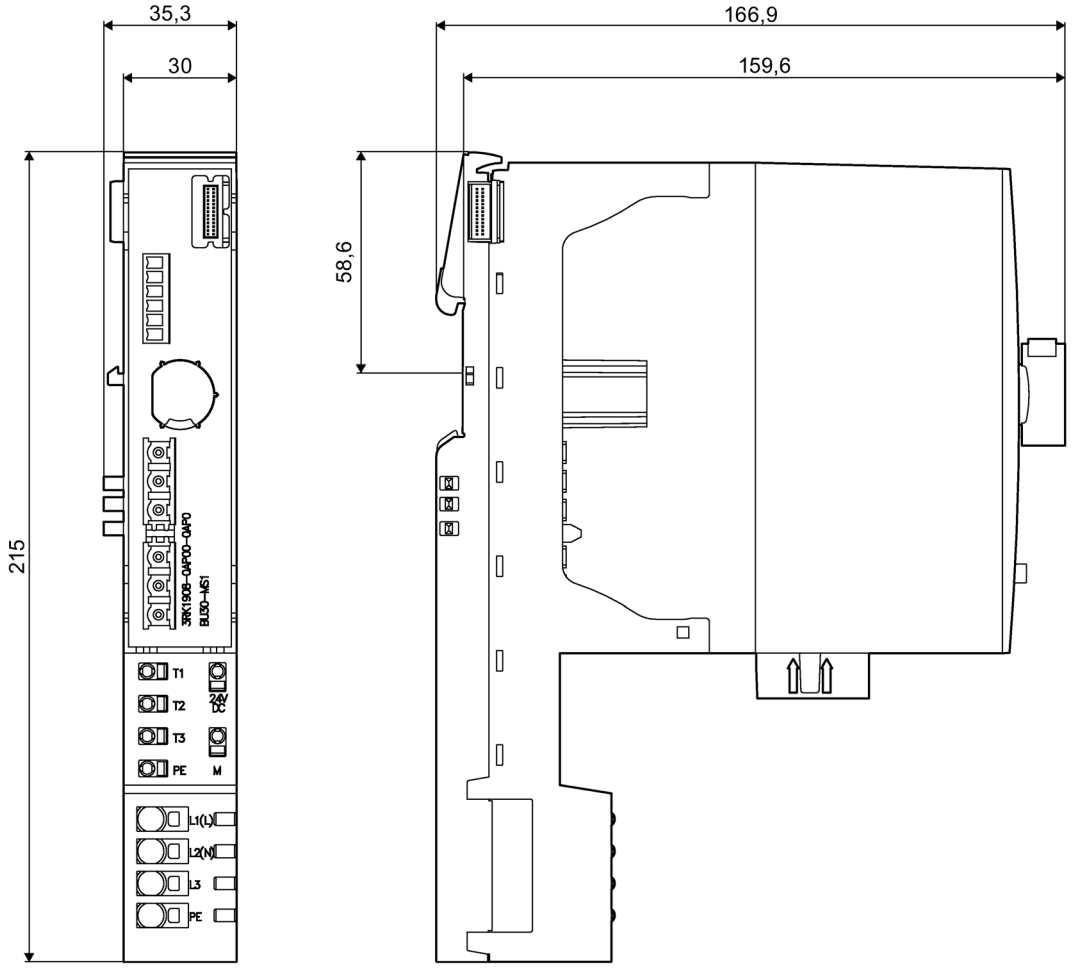


Figure B-1 Dimension drawing BU30-MS1

SIEMENS

SIMATIC

S7-1500, ET 200SP, ET 200pro

Cycle and response times

Function manual

Edition 09/2016

siemens.com

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S7-1500, ET 200SP, ET 200pro Cycle and response times

Function Manual

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09/2016

A5E03461504-AC

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

The controller offers various options for program execution with different run priorities. Cyclic-driven and time-driven program execution have the largest share. The response times of a controller are therefore significantly determined by the processing cycles.

There is also the possibility of event-driven program execution. The event-driven program execution is normally limited to a few selected events.

This manual provides information on the following topics:

- Types of program execution
- Run priorities
- Cycle and response times, and the influences to which they are subject
- Configuration options for the optimization of your user program

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the SIMATIC industrial automation system
- Knowledge of the use of Windows-based computers
- Knowledge of working with STEP 7

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation mainly describes the CPU components of the cycle and response times of the S7-1500 automation system, the CPUs of the ET 200SP distributed I/O system, and the CPU 1516pro-2 PN of the ET 200pro distributed I/O system. You can find links to more information on the ET 200MP, ET 200SP and ET 200pro distributed I/O systems at the corresponding points in this manual.

What's new compared to the previous version of the function manual (02/2014 edition)?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Scope of the function manual expanded to include the CPUs of the ET 200SP distributed I/O system and CPU 1516pro-2 PN of the ET 200pro distributed I/O system	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in CPUs in other designs (ET 200SP) and in the CPU 1516pro-2 PN (degree of protection IP 65, IP 66 and IP 67).	Starting from section Program execution (Page 12)

See also

SIMATIC Portal (http://www.siemens.com/simatic-tech-doku-portal)

Catalog (http://mall.automation.siemens.com)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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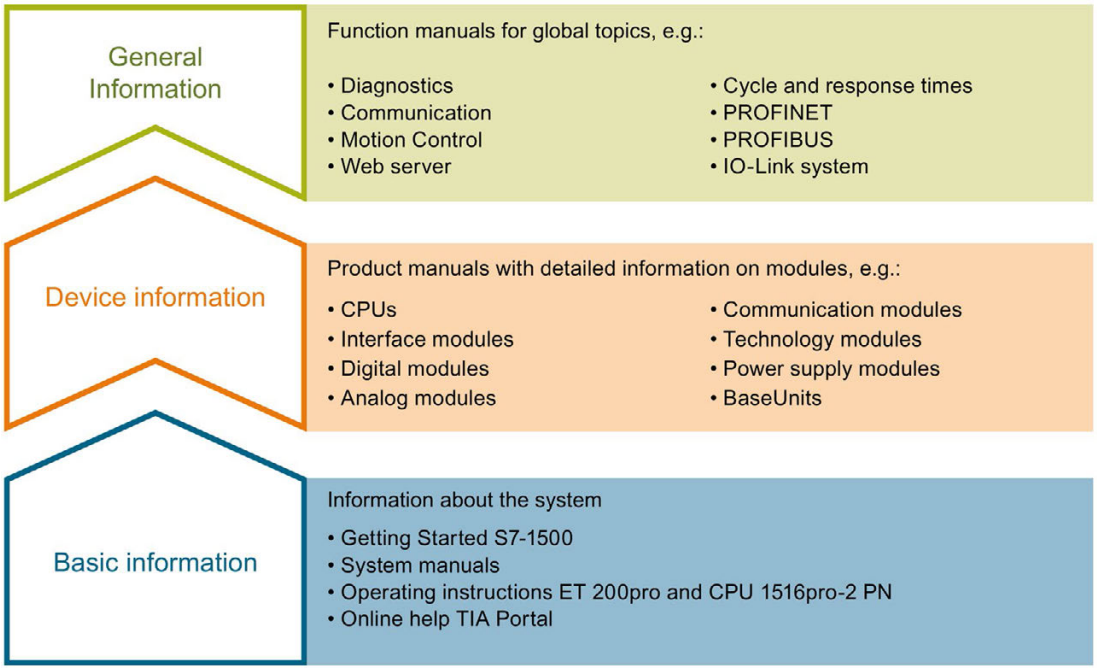
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

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You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

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In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

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- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Program execution 2

2.1 Principle of operation

Introduction

You often program your user program with a cyclic OB, usually in OB 1. With complex applications, problems are often encountered in complying with the response times required by the application. You can often meet the response time requirements by splitting the user program up into several parts with different response time requirements. The CPU offers a number of different OB types for this purpose, the properties (priority, frequency, etc.) of which can be adapted to meet your requirements.

Program organization

You can choose from the following types of program execution for running your user program:

Program execution in the cyclic program of the CPU:

The CPU executes the user program cyclically. When the execution has reached the end of a cycle, the program execution starts again in the next cycle. In the simplest case, you execute the entire user program in the cyclic program of the CPU. All tasks in the user program are then processed with equal rank. This also results in the same response times for all tasks.

In addition to program execution in the cyclic program, there is time-driven and event-driven program execution.

Time-driven execution:

In a complex user program, there are frequently portions with different response time requirements. You can optimize the response times by taking advantage of these differences in the requirements. To do so, you can move the program parts with higher response time requirements to higher-priority OBs with shorter cycles, for example cyclic interrupt OBs.

The execution of these parts can thus occur with different frequencies and priorities.

Event-driven execution:

Depending on the I/O modules used, you can configure hardware interrupts for specific process events (such as an edge change of a digital input) that result in the call of the assigned hardware interrupt OB. The hardware interrupts have a higher priority and interrupt the cyclic program of the CPU. You can achieve very short response time in the CPU with hardware interrupts by directly triggering program execution.

Keep in mind that the time characteristics of your application becomes less predictable with intense use of hardware interrupts. The reason for this is that the time at which the triggering events occur can result in drastically different response times.

Tip: Use hardware interrupts only for a few selected events.

Special consideration for hardware interrupts: If you have assigned an OB to an event (hardware interrupt), the OB then has the priority of the event.

Using process image partitions

If a program is distributed over various OBs, for example, due to differing response time requirements, it is advisable and often necessary to assign the update of the used I/O data directly to these OBs. You can use process image partitions for this purpose.

You group the input and output data in a process image partition according to their use in the program and assign the data to the OB.

A process image partition of the inputs (PIPI) permits the associated input data for an OB program to be updated immediately before the OB program starts.

A process image partition of the outputs (PIPQ) permits the output data associated with an OB program to become effective on the outputs immediately after the OB program runs.

You have 32 (0 … 31) process image partitions at your disposal. The I/O is assigned to the process image partition 0 by default (setting: "Automatic update"). Process image partition 0 is permanently assigned to cyclic execution.

You have to configure the "system-side update of process image partitions". You can find additional information on configuration of process image partitions in the online help for STEP 7 under the keyword "Assign process image/process image partition".

Interruptibility of program execution

Each organization block is processed according to the priority it has been assigned. You can adapt the priority according to the response time requirements for most organization blocks.

All cycle OBs always have the lowest priority of 1. The highest priority is 26.

Communication tasks always have priority 15. If necessary, you can change the priority of your blocks and select a higher priority than the communication.

Organization blocks or system activities with higher priority interrupt those with lower priority, and thus extend the runtime of the interrupted organization blocks or system activities. If two pending tasks have the same priority, these tasks are processed in the order in which the tasks occurred.

Note

Higher priority OBs

Communication functionality is strongly influenced by too many or runtime-intensive OBs with a priority > 15.

When using OBs with a priority > 15, you should consider the runtime load that they cause in order to keep communication functionality at a reasonable level.

Reference

You can find additional information on the subject of "priorities" in the section Events and OBs of the system manual S7-1500 Automation system (http://support.automation.siemens.com/WW/view/en/59191792), the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and the operating instructions for CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416).

You can find additional information on organization blocks and their priorities for Motion Control in the function manual S7-1500T Motion Control V3.0 in the TIA Portal V14 (https://support.industry.siemens.com/cs/ww/en/view/109481326).

2.2 CPU overload behavior

Principle of CPU overload behavior

An occurring event triggers the execution of the associated OB. Depending on the OB priority and the current processor load, a time delay may occur before the OB is executed when there is an overload. The same event can therefore occur once or several times before the user program processes the OB belonging to the preceding event. The CPU handles such a situation as follows: The operating system queues the events in the queue associated with their priority in the order of their occurrence.

To control temporary overload situations, you can limit the number of queued events that originate from the same source. The next event is discarded as soon as the maximum number of pending triggers of a specific cyclic interrupt OB, for example, is reached.

An overload occurs when events which originate from the same source occur faster than they can be processed by the CPU.

Configuration of the overload response

In the properties of an organization block in which an overload can occur, you can select the response to an overload occurrence under "Attributes" and "Event queuing".

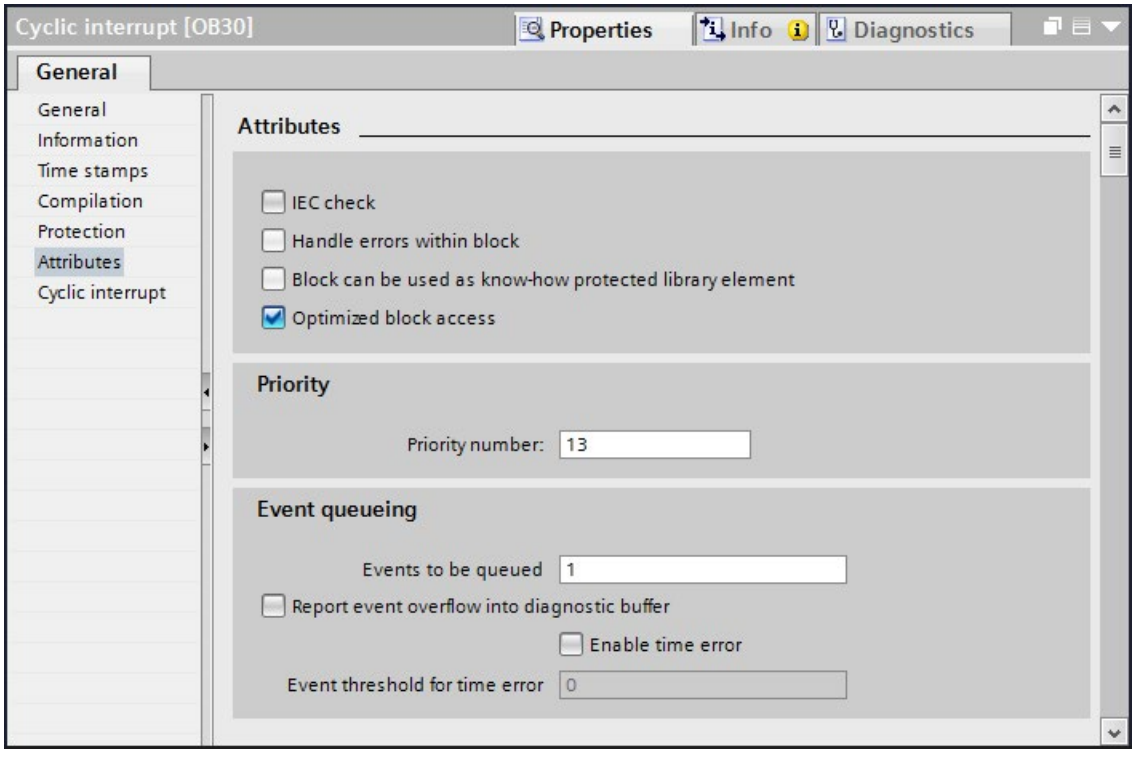


Figure 2-1 Configuration of the overload response in the block properties

Below, the term "similar events" refers to events from a single source, such as triggers for a specific cyclic interrupt OB.

The OB parameter "Events to be queued" is used to specify how many similar events the operating system places in the associated queue and therefore post-processes. If this parameter has the value 1, for example, exactly one event is stored temporarily.

Note

Post-processing of cyclic events is often not desirable, as this can lead to an overload with OBs of the same or lower priority. Therefore, it is generally advantageous to discard similar events and to react to the overload situation during the next scheduled OB execution. If the value of the "Events to be queued" parameter is low, this ensures that an overload situation is mitigated rather than aggravated.

If the maximum number of triggers is reached in the queue for a cyclic interrupt OB (Cyclic interrupt), for example, each additional trigger is only counted and subsequently discarded. During the next scheduled execution of the OB, the CPU provides the number of discarded triggers in the "Event_Count" input parameter (in the start information). You can then react appropriately to the overload situation. The CPU then sets the counter for lost events to zero.

If the CPU first discards a trigger for a cyclic interrupt OB, for example, its further behavior depends on the OB parameter "Report event overflow into diagnostic buffer": If the check box is selected, the CPU enters the event DW#16#0002:3507 once in the diagnostics buffer for the overload situation at this event source. The CPU suppresses additional diagnostics buffer entries of the event DW#16#0002:3507 until all events from this source have been post-processed.

The cyclic interrupt OB parameter "Enable time error" is used to specify whether the time error OB should be called when a specific overload level is reached for similar events. You can find the OB parameter "Enable time error" in the properties of the OB in the "Attributes" category.

When you enable the time error OB (check box selected), use the OB parameter "Event threshold for time error" to specify the number of similar events in the queue as of which the time error OB is called. If this parameter has the value 1, for example, the CPU enters the event DW#16#0002:3502 once in the diagnostics buffer and requests the time error OB when the second event occurs. The CPU suppresses additional diagnostics buffer entries of the event DW#16#0002:3502 until all events from this source have been post-processed.

Note

The "Enable time error" parameter is not enabled in the default setting. If a time error occurs due to a cyclic interrupt OB, for example, the CPU does not change to STOP mode.

In the event of an overload, you therefore have the option of programming a reaction well before the limit is reached for similar events and thus before events are discarded.

The following value range applies to the "Event threshold for time error" parameter:
1 ≤ "Event threshold for time error" ≤ "Events to be queued".

Cyclic program execution

3

3.1 Cycle

Definition of cycle

A cycle includes the following sections:

- Automatic update of the process image partition 0 of the inputs (PIPI 0)
- Execution of the cyclic program
- Update of process image partition 0 of the outputs (PIPQ 0)

The process image partition 0 is automatically updated in the cycle. You assign the I/O addresses to these process image partitions (PIPI 0 / PIPQ 0) when you configure the I/O modules via the "Automatic update" setting (default).

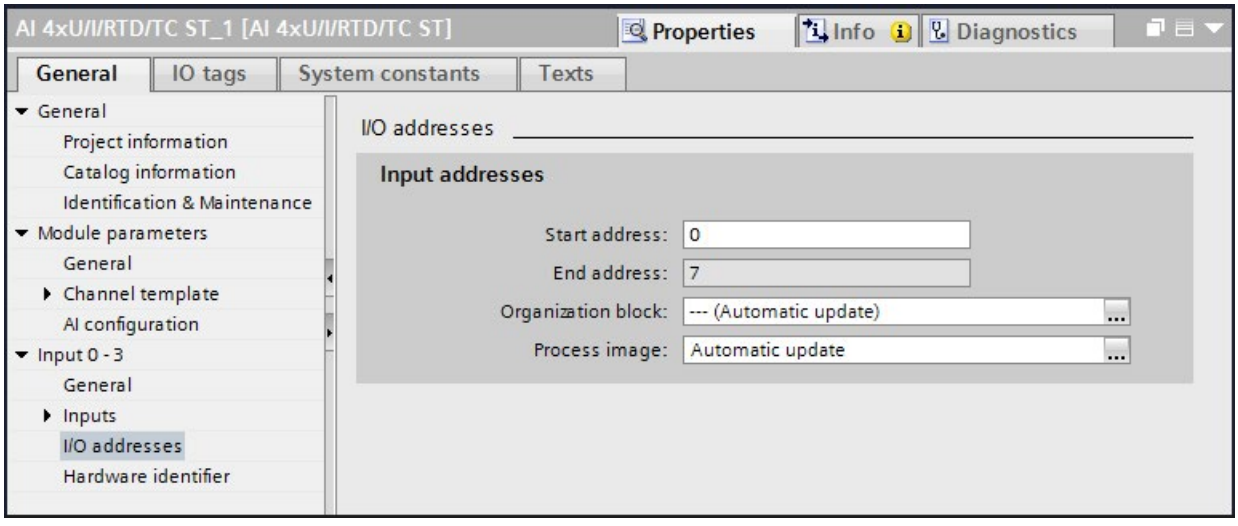
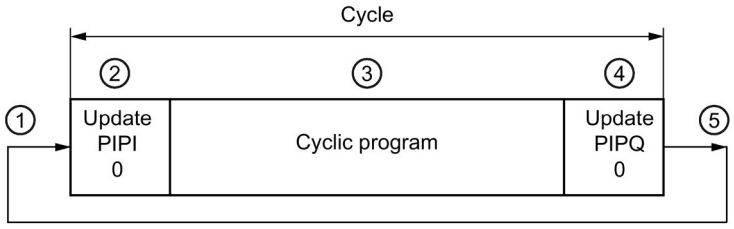


Figure 3-1 Assigning I/O addresses to process image partitions

The figure below illustrates the phases that are passed through during a cycle.



① The operating system starts measurement of the cycle time.
② The CPU reads the status of the inputs at the input module and writes the input data to the process image input.
③ The CPU processes the user program and executes the instructions specified in the program.
④ The CPU writes the states from the process image output to the output modules.
⑤ The operating system evaluates the determined cycle time and starts the measurement again.

Figure 3-2 Cycle

3.2 Cycle time

Definition of cycle time

The cycle time is the time the CPU needs to execute the cyclic program and to update the process image input and output as well as for all program parts and system activities that interrupt this cycle.

3.2.1 Different cycle times

Introduction

The cycle time (T_{cyc}) is not the same length in each cycle because the execution times may vary. Causes of this include:

- Different program runtimes

  (e.g. program loops, conditional commands, conditional block calls, or different program paths)

- Lengthening due to interruptions

  (e.g. time-driven interrupt execution, execution of hardware interrupts or communication)

Causes of different cycle times

The cycle time T_{cyc2} is longer than T_{cyc1}, because the cyclic program is interrupted by a cyclic interrupt OB in this example (e.g. OB 30) The cyclic interrupt OB in turn is interrupted by Motion Control functions and communication.

The figure below shows the different cycle times T_{cyc1} and T_{cyc2}.

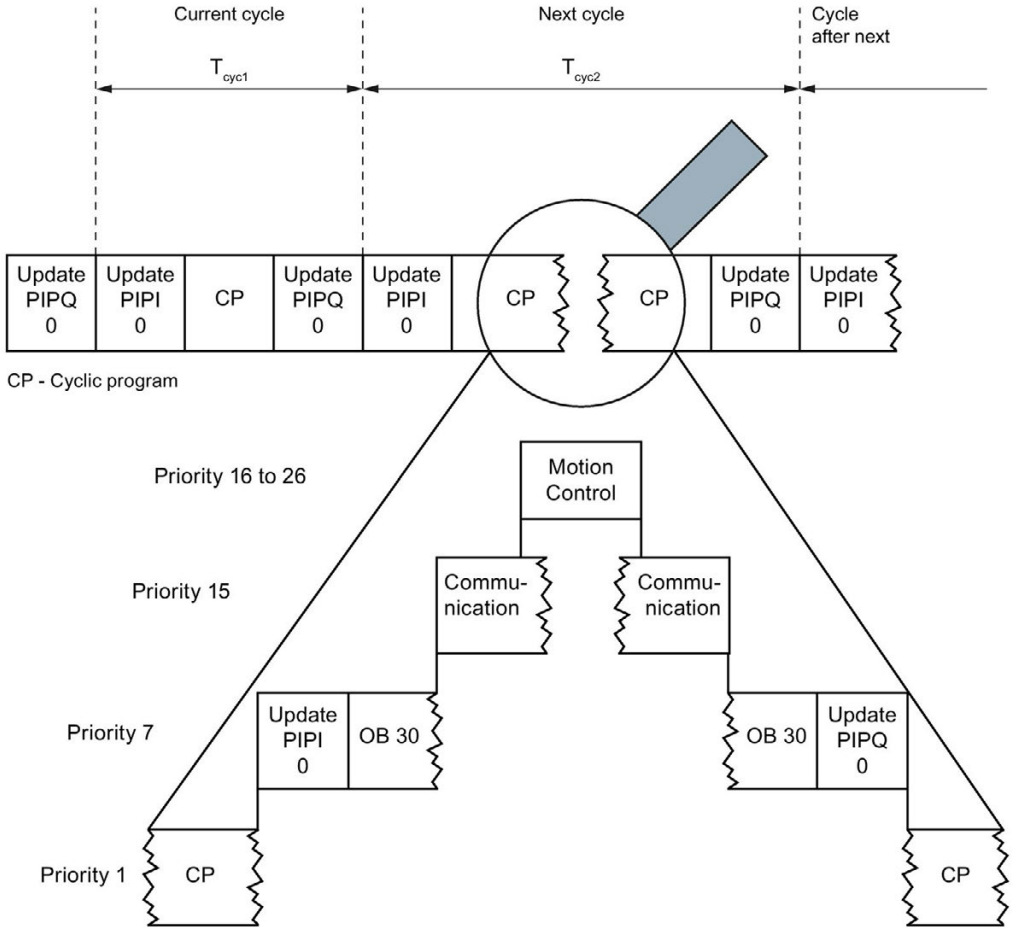


Figure 3-3 Possible causes of differing cycle times

Minimum cycle time

In STEP 7, you can set a minimum cycle time for a CPU. The default for the minimum cycle time is one millisecond. It may be advisable to increase this setting in the following cases:

- To reduce the cycle time's fluctuation range.
- To make remaining computing time available for communication tasks that the CPU can process until the expiry of the minimum cycle time, for example, when
  - The CPU is mainly used for communication purposes
  - The processing power of the communication is not enough because many organization blocks are set with a priority > 15 (e.g. for Motion Control functions)

Maximum cycle time

The cycle time is monitored by the CPU. By default, the maximum cycle time is 150 ms. You can set this value from 1 ms to 6000 ms when assigning parameters to the CPU. When the cycle time is longer than the maximum cycle time, the time error OB (OB 80) is called.

You have the option of restarting the maximum cycle time using the "RE_TRIGR" instruction, and thus extending it.

With the user program in OB 80 you specify how the CPU responds to the time error. The CPU goes to STOP under the following conditions.

- If you have not loaded an OB 80.
- If the cycle is still not completed after an additional maximum cycle time

Keep in mind that the cycle time is extended by interruptions as shown in the previous figure.

Cycle time statistics

You can read the cycle time statistics either directly from STEP 7 (Online tools task card) or with the "RT_INFO" instruction.

You can use the "RT_INFO" instruction to generate statistics in STEP 7 on the runtime of specific organization blocks, communication or the user program. For example, this includes

- The minimum and maximum cycle time
- The portions of runtime used for communication and the user program

---

Note

Showing the cycle time statistics on the display and Web server

With the S7-1500 CPUs, you also have the option of calling the cycle time statistics via the display of the CPU. As of firmware version 2.0 of the CPUs, the cycle time statistics are also displayed in the Web server.

To view the cycle time statistics directly in STEP 7, follow these steps:

1. Establish an online connection to the CPU with STEP 7.
2. Select the Online tools task card on the very right.

Result: The diagram of the cycle time statistics is displayed in the cycle time section.

The following figure shows an extract from STEP 7 with the cycle time statistics. In this example, the cycle time fluctuates between 7 ms and 12 ms. The current cycle time is 10 ms. The maximum cycle time that can be set in this example is 40 ms.

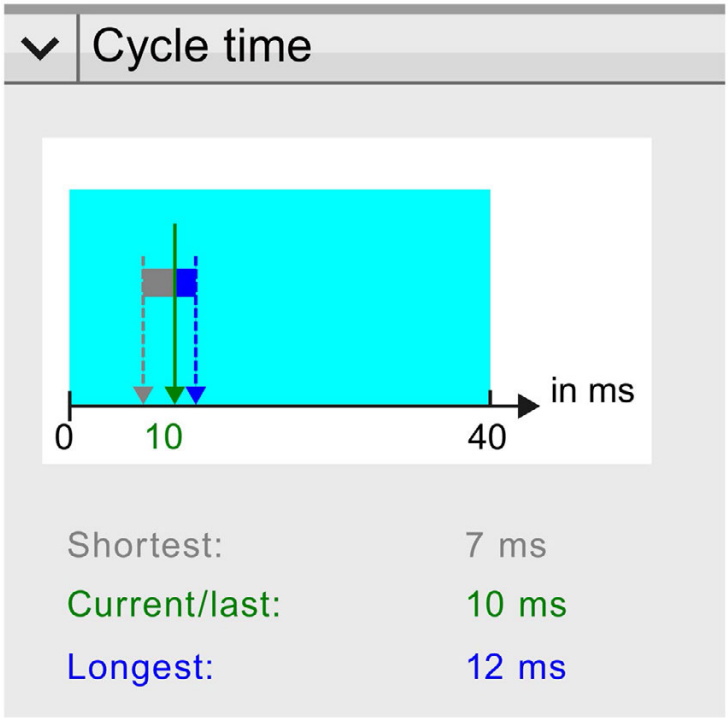


Figure 3-4 Cycle time statistics

You can find additional information on the runtime characteristics of the CPU with the "RT_INFO" instruction in the user program. You can read the utilization of the CPU by the user program and communication in percentage, and you can also read the runtime statistics of individual OBs.

Reference

You can find additional information on the "RT_INFO" instruction in the STEP 7 online help.

3.2.2 Influences on the cycle time

3.2.2.1 Update time for process image partitions

Estimating update time for process image partitions

The update time of the process image partitions depends on the volume of assigned central and distributed I/O module data.

You can estimate the update time using the following formula:

Base load for process image update
\+ Number of words in the process image x copy time for central I/O
\+ Number of words in the process image via DP x copy time for PROFIBUS I/O
\+ Number of words in the process image via PROFINET x copy time for PROFINET I/O

= Update time of the process image partition

Update times of the process image partitions

The following table contains the times for estimating the typical update times of the process image partitions.

Table 3- 1 Data for estimating the typical update time of the process image partition

Components	Update time of the CPU			
	S7-1500			
	1511(F)-1 PN 1511T-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN	1515(F)-2 PN 1515T-2 PN 1516(F)-3 PN/DP	1517(F)-3 PN/DP 1517T(F)-3 PN/DP	1518(F)-4 PN/DP 1518(F)-4 PN/DP ODK
Base load for process image partition update	35 µs	30 µs	7 µs	5 µs
Copy time for central I/O	9 µs/word	8 µs/word	5 µs/word	4 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word	0.5 µs/word	0.4 µs/word	0.3 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word	0.5 µs/word	0.4 µs/word	0.3 µs/word

Components	Update time of the CPU		
	ET 200SP		
	1510SP(F)-1 PN	1512SP(F)-1 PN	1515SP(F)-PC
Base load for process image partition update	60 µs	60 µs	30 µs
Copy time for central I/O	0.5 µs/word	0.5 µs/word	0.5 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word	0.5 µs/word	0.5 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word	0.5 µs/word	0.5 µs/word

Components	Update time of the CPU
	ET 200pro
	1516pro(F)-2 PN
Base load for process image partition update	30 µs
Copy time for central I/O	120 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word

Note

Update time of the backplane bus for ET 200SP CPUs

For the update time of the ET 200SP CPUs, observe also the information in table "Update time of the ET 200SP CPUs" in the section Response time for cyclic and time-driven program execution (Page 33).

3.2.2.2 User program execution time

Introduction

Organization blocks or system activities with higher priority interrupt those with lower priority, and thus extend the runtime of the lower-priority organization blocks or system activities.

Program execution time without interruptions

The user program has a certain runtime without interruptions. The length of the runtime depends on the number of operations that are executed in the user program.

The following table contains the typical durations of operations.

Table 3- 2 Duration of an operation

	S7-1500						
CPU	**1511(F)-1 PN** **1511T-1 PN** **1511C-1 PN**	**1512C-1 PN**	**1513(F)-1 PN**	**1515(F)-2 PN** **1515T-2 PN**	**1516(F)-3 PN/DP**	**1517(F)-3 PN/DP** **1517T(F)-3 PN/DP**	**1518(F)-4 PN/DP** **1518(F)-4 PN/DP ODK**
Bit operations, typ.	60 ns	48 ns	40 ns	30 ns	10 ns	2 ns	1 ns
Word operations, typ.	72 ns	58 ns	48 ns	36 ns	12 ns	3 ns	2 ns
Fixed-point arithmetic, typ.	96 ns	77 ns	64 ns	48 ns	16 ns	3 ns	2 ns
Floating-point arithmetic, typ.	384 ns	307 ns	256 ns	192 ns	64 ns	12 ns	6 ns

	ET 200SP		
CPU	**1510SP(F)-1 PN**	**1512SP(F)-1 PN**	**1515SP(F)-PC**
Bit operations, typ.	72 ns	48 ns	30 ns
Word operations, typ.	86 ns	58 ns	36 ns
Fixed-point arithmetic, typ.	115 ns	77 ns	48 ns
Floating-point arithmetic, typ.	461 ns	307 ns	192 ns

	ET 200pro
CPU	**1516pro(F)-2 PN**
Bit operations, typ.	10 ns
Word operations, typ.	12 ns
Fixed-point arithmetic, typ.	16 ns
Floating-point arithmetic, typ.	64 ns

Note
Instruction "RUNTIME"

You can measure the runtimes of program sequences with the instruction "RUNTIME".

Extension due to nesting of higher-priority OBs and/or interrupts

The interruption of a user program at the end of an instruction by a higher-priority OB causes a certain basic time expenditure. Take account of this basic time expenditure in addition to the update time of the assigned process image partitions and the execution time of the contained user program. The following tables contain the typical times for the various interrupts and error events.

Table 3- 3 Basic time expenditure for an interrupt

	S7-1500			
CPU	**1511(F)-1 PN** **1511T-1 PN** **1511C-1 PN** **1512C-1 PN** **1513(F)-1 PN**	**1515(F)-2 PN** **1515T-2 PN** **1516(F)-3 PN/DP**	**1517(F)-3 PN/DP** **1517T(F)-3 PN/DP**	**1518(F)-4 PN/DP** **1518(F)-4 PN/DP ODK**
Hardware interrupt	90 µs	80 µs	20 µs	12 µs
Time-of-day interrupt	90 µs	80 µs	20 µs	12 µs
Time-delay interrupt	90 µs	80 µs	20 µs	12 µs
Cyclic interrupt	90 µs	80 µs	20 µs	12 µs

	ET 200SP		
CPU	**1510SP(F)-1 PN**	**1512SP(F)-1 PN**	**1515SP(F)-PC**
Hardware interrupt	90 µs	90 µs	80 µs
Time-of-day interrupt	90 µs	90 µs	80 µs
Time-delay interrupt	90 µs	90 µs	80 µs
Cyclic interrupt	90 µs	90 µs	80 µs

	ET 200pro
CPU	**1516pro(F)-2 PN**
Hardware interrupt	80 µs
Time-of-day interrupt	80 µs
Time-delay interrupt	80 µs
Cyclic interrupt	80 µs

Table 3- 4 Basic time expenditure for an error OB

	S7-1500			
CPU	**1511(F)-1 PN** **1511T-1 PN** **1511C-1 PN** **1512C-1 PN** **1513(F)-1 PN**	**1515(F)-2 PN** **1515T-2 PN** **1516(F)-3 PN/DP**	**1517(F)-3 PN/DP** **1517T(F)-3 PN/DP**	**1518(F)-4 PN/DP** **1518(F)-4 PN/DP ODK**
Programming error	90 µs	80 µs	20 µs	12 µs
I/O access error	90 µs	80 µs	20 µs	12 µs
Time error	90 µs	80 µs	20 µs	12 µs
Diagnostic interrupt	90 µs	80 µs	20 µs	12 µs
Module failure/recovery	90 µs	80 µs	20 µs	12 µs
Station failure/recovery	90 µs	80 µs	20 µs	12 µs

	ET 200SP		
CPU	**1510SP(F)-1 PN**	**1512SP(F)-1 PN**	**1515SP(F)-PC**
Programming error	90 µs	90 µs	80 µs
I/O access error	90 µs	90 µs	80 µs
Time error	90 µs	90 µs	80 µs
Diagnostic interrupt	90 µs	90 µs	80 µs
Module failure/recovery	90 µs	90 µs	80 µs
Station failure/recovery	90 µs	90 µs	80 µs

	ET 200pro
CPU	**1516pro(F)-2 PN**
Programming error	80 µs
I/O access error	80 µs
Time error	80 µs
Diagnostic interrupt	80 µs
Module failure/recovery	80 µs
Station failure/recovery	80 µs

Reference

You can find additional information on the topic of error handling in the Events and OBs section of the

- System manual S7-1500 Automation system (http://support.automation.siemens.com/WW/view/en/59191792)
- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- Operating instructions CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)

You can find additional information on the topic of the complete cycle time of a program in an FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/87668055).

3.2.2.3 Extension of cycle time due to communication load

Impact of communication on the cycle time

In the sequence model of the CPU, communication tasks are processed with priority 15. All program parts with priority > 15 (e.g. for Motion Control functions) are unaffected by communication.

Configured communication load

The CPU operating system provides the maximum specified percentage of total CPU processing power for communication tasks. The communication load is preset in STEP 7 at 50%, for example, for the CPUs of the S7 series. If the processing power is not needed for communication, then the processing power is available to the operating system and the user program.

Communication is allocated the requisite computing time in 1 ms increments, with priority 15. At 50% communication load, 500 µs of each 1 millisecond are used for communication.

The following formula may be used to estimate the extension of the cycle time by communication.

$$\text{Actual cycle time} = \text{Cycle time without communication} \times \frac{100}{100 - \text{"configured communication load in \%"}}$$

Figure 3-5 Formula: Impact of communication load

With a complete use of the communication load of 50% (default), the following value results:

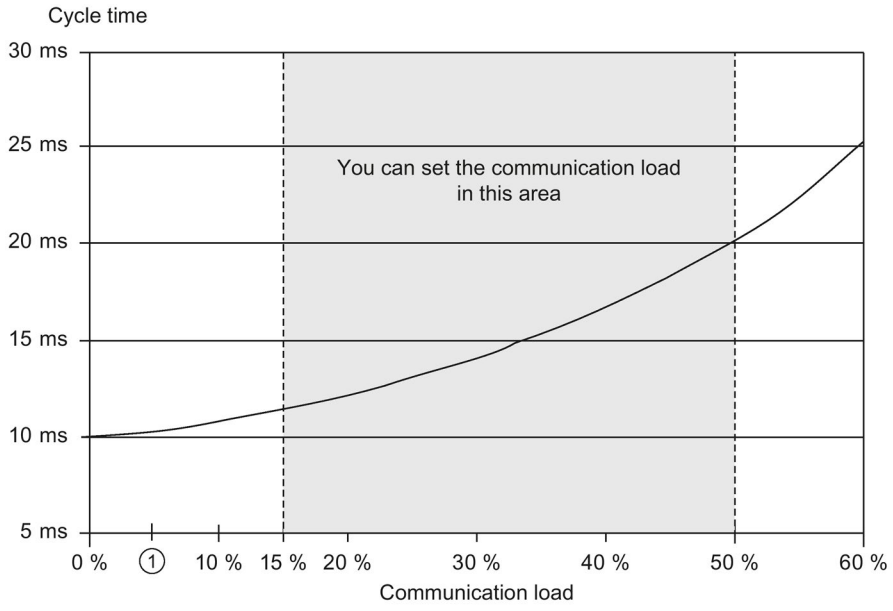
$$\text{Actual cycle time} = \text{Cycle time without communication} \times 2$$

Figure 3-6 Extension of cycle time due to communication load

The actual cycle time is up to twice as long as the cycle time without communication when you use the default communication load.

Dependency of maximum cycle time on the configured communication load

The diagram shows the nonlinear relationship between maximum cycle time and configured communication load with a pure cycle time of 10 ms, which means without interruptions.



① CPUs 1517(F)-3 PN/DP, CPU 1517T(F)-3 PN/DP, CPU 1518(F)-4 PN/DP, CPU 1518(F)-4 PN/DP ODK: The (minimum) communication load that can be set is 5%.

Figure 3-7 Maximum cycle time depending on the configured communication load

The shown influence of the communication load on the execution time applies to all OBs with a priority ≤ 15.

Reducing the cycle time with a lower communication load

You can reduce the setting for the communication load in the hardware configuration. If you set a communication load of 20% instead of the default 50%, for example, the cycle time extension due to the communication is reduced from a factor of 2 to 1.25.

Effect on the actual cycle time

Communication is only one cause of extension of the cycle time. All events that extend the cycle time (e.g. hardware interrupts) mean that more asynchronous events can occur within a cycle which additionally extend the cyclic program. This extension depends on the number of events that occur in the cyclic program and the time required to process these events.

Note

Checking parameter changes

- Check the effects of a value change on the "Cycle load due to communication" parameter during system operation. You can use the "RT_INFO" instruction to determine the portions of runtime used for communication and the user program.
- Take the communication load into consideration when setting the maximum cycle time to prevent time errors (for example, exceeding the cycle time within a cycle) from occurring.

Tips

Whenever possible, use the default setting for the configured communication load.

If you reduce the value of the communication load, keep in mind that communication tasks are interrupted by higher-priority OBs. This means it will also take longer to process the communication.

See also

Different cycle times (Page 18)

3.2.2.4 Special consideration when PROFINET IO communication is configured on the 2nd PROFINET interface (X2)

Introduction

If you configure the PROFINET IO communication on the 2nd PROFINET interface (X2) (operated as IO controller or IO device) of the CPUs 1515(F)-2 PN, 1515T-2 PN, 1516(F)-3 PN/DP and 1516(F)pro-2 PN (as of firmware version 2.0), additional system load occurs.

This additional system load has priority 26 and extends the runtime of the program. The execution of synchronous cycle interrupts or hardware interrupts, for example, can be delayed as a result.

The additional system load depends on:

- The communication load on the 2nd PROFINET interface (X2)
- The number of IO devices that the CPU on the 2nd PROFINET interface (X2) updated within a millisecond

You determine the additional system load with the RT_INFO (read RUNTIME statistics) instruction at the Mode parameter with mode 10 or mode 20.

Reducing additional system load

Reduce the communication load on the 2nd PROFINET interface, e.g. with:

- Fewer HMI devices or slower update cycles of the HMI devices
- Less or slower communication with other CPUs

Increase the update times in STEP 7 for all IO devices that are assigned to the 2nd PROFINET interface (X2):

1. Select the "I/O communication" in the "Network view" of STEP 7.
2. Set the "Update mode" parameter to "Adjustable".
3. Select a higher value for the "Update time [ms]" parameter in the drop-down list.
4. Repeat this setting for the other IO devices.

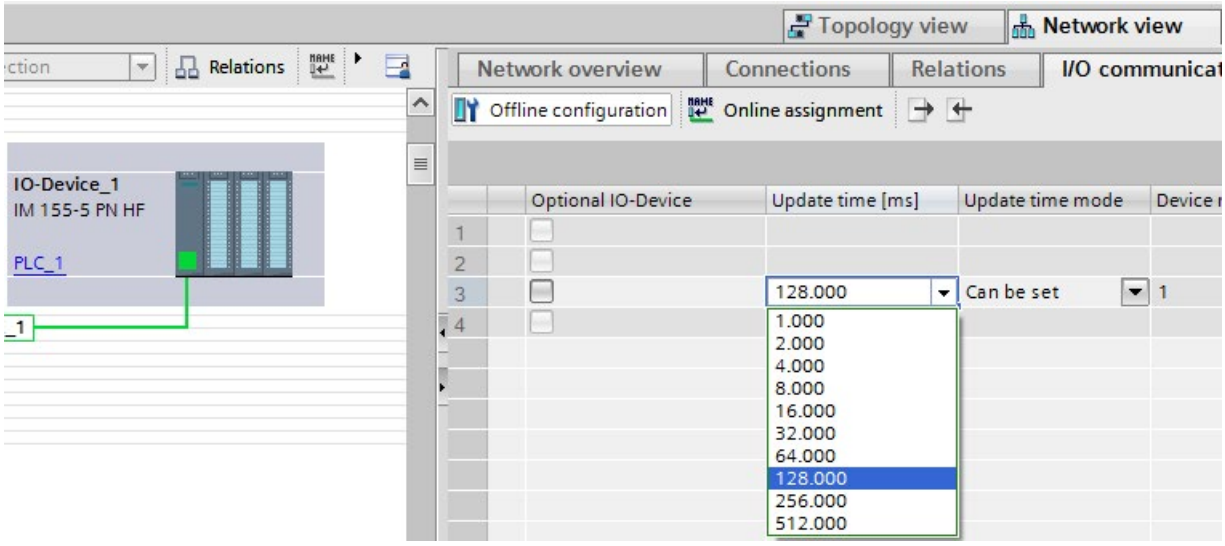


Figure 3-8 Increasing update times

3.3 Time-driven program execution in cyclic interrupts

With a cyclic interrupt, you can have a particular program processed in a defined cycle. A priority from 2 to 24 can be set for the cyclic interrupt. This makes the priority of cyclic interrupts higher than the priority of the cyclic program. A cyclic interrupt increases the execution time of the cyclic program.

Tip: By shifting program sections to cyclic interrupts, you can reduce the response times or better adapt them to your requirements.

In STEP 7, the organization blocks OB 30 to OB 38 are provided for the execution of cyclic interrupts. You can create additional cyclic interrupts starting with organization block OB 123. The number of available organization blocks depends on the CPU used.

Definition

A cyclic interrupt is an interrupt initiated according to a defined cycle that causes a cyclic interrupt OB to be processed.

Cycle of a cyclic interrupt

The cycle of a cyclic interrupt is defined as the time from the call of a cyclic interrupt OB to the next call of a cyclic interrupt OB.

The following figure shows an example of the cycle of a cyclic interrupt.

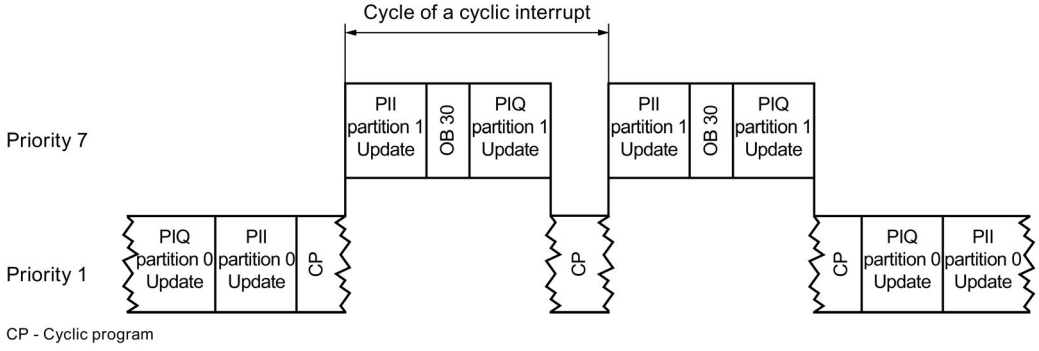


Figure 3-9 Call interval of a cyclic interrupt

Accuracy of a cyclic interrupt

If a cyclic interrupt is not delayed by a higher-priority OB or communication activities, the accuracy with which it is started is nevertheless subject to system-dependent fluctuations.

The following table shows the accuracy (typical times) with which a cyclic interrupt is triggered:

Table 3- 5 Accuracy of cyclic interrupts

	S7-1500			
CPU	**1511(F)-1 PN** **1511T-1 PN** **1511C-1 PN** **1512C-1 PN** **1513(F)-1 PN**	**1515(F)-2 PN** **1515T-2 PN** **1516(F)-3 PN/DP**	**1517(F)-3 PN/DP** **1517T(F)-3 PN/DP**	**1518(F)-4 PN/DP** **1518(F)-4 PN/DP ODK**
Cyclic interrupt	±90 µs	±80 µs	±30 µs	±25 µs

	ET 200SP		
CPU	**1510SP(F)-1 PN**	**1512SP(F)-1 PN**	**1515SP(F)-PC**
Cyclic interrupt	±90 µs	±90 µs	±80 µs

	ET 200pro
CPU	**1516pro(F)-2 PN**
Cyclic interrupt	±80 µs

3.4 Response time for cyclic and time-driven program execution

Introduction

In this section you will learn about the concept of "response time", and how to calculate the response time.

Definition

The response time in the case of cyclic or time-controlled program execution is the time between the detection of an input signal and the change of a connected output signal.

Fluctuation in the response time of the CPU

The actual response time of the CPU fluctuates between one and two cycles for cyclic program execution and between one and two cyclic interrupt cycles for time-controlled program execution.

You should always assume the longest response time when configuring your system.

The following figure shows the shortest and longest response times of the CPU to an event.

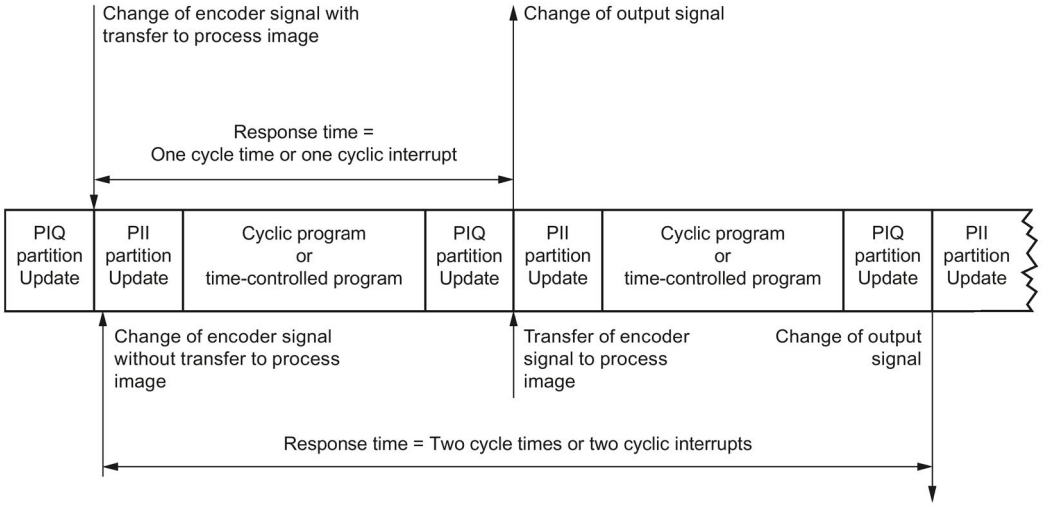


Figure 3-10 Shortest and longest response times of the CPU

Factors

To determine the process response time, you must take account of the following factors in addition to the CPU response time described above:

- Delay of the inputs and outputs on the input/output module
- Switching times of the sensors and actuators used
- Update times for PROFINET IO or DP cycle times on PROFIBUS DP, update time of the backplane bus for ET 200SP CPUs

Delay at the inputs and outputs of the modules

The delay and cycle times can be found in the technical specifications for the input/output modules.

Update times for PROFINET IO and DP cycle times on PROFIBUS DP

When distributed I/O is used, the maximum response time is additionally extended by the bus transmission times of PROFIBUS or PROFINET. These bus transmission times occur during both the reading and output of the process image partitions. The bus transmission times correspond to the bus update cycle of the distributed device.

PROFINET IO

If you use STEP 7 to configure your PROFINET IO system, STEP 7 calculates the update time. To display the update time, follow these steps:

- Select the PROFINET interface of the I/O module.
- In the General tab, select "Advanced options > Real time settings > IO cycle".

The update time is displayed in the "Update time" field and can be set for each IO device.

PROFIBUS DP

If you use STEP 7 to configure your PROFIBUS DP master system, STEP 7 calculates the DP cycle time. To display the DP cycle time, follow these steps:

- Select the PROFIBUS subnet in the network view.
- In the General tab of the Inspector window, navigate to the Bus parameters.

The DP cycle time is displayed in the "Parameters" field at "Typical Ttr".

The following figure illustrates the additional bus runtimes using distributed I/O.

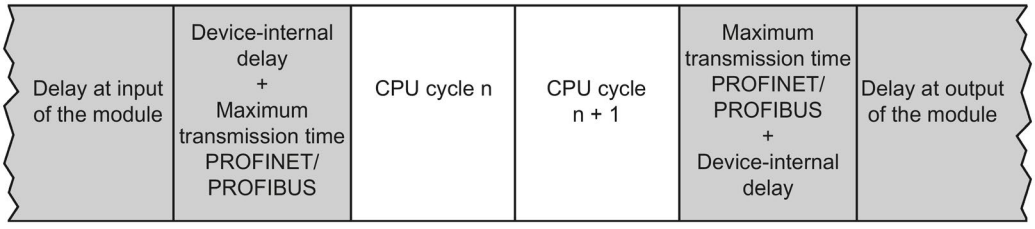


Figure 3-11 Additional bus runtimes with distributed I/O

You can achieve a further optimization of the response times using isochronous mode.

Update time of the backplane bus for ET 200SP CPUs

The following table shows the central (typical) update times of the backplane bus in the ET 200SP CPUs.

Table 3- 6 Update time of the ET 200SP CPUs

Components	Update time of the CPU		
	ET 200SP		
	1510SP(F)-1 PN	1512SP(F)-1 PN	1515SP(F)-PC
Update time for central I/O	250 µs to 1 ms, depending on number and type of central I/O modules[1]		

[1] The duration of the update time depends on the number of the I/O modules and their type (ST, HF, HS). The update time is set at 1 ms for a max. central I/O configuration with standard I/O modules. By using HF I/O modules, for example, and by reducing the number of modules, the update time can be reduced down to 250 µs.

Reference

The following links provide additional information:

- Application example for determining the response time for PROFINET (http://support.automation.siemens.com/WW/view/en/21869080)
- Transmission times and isochronous mode in function manual PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856); see also the section "Tips on assembly"
- Transmission times and isochronous mode in function manual PROFIBUS with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/59193579); see also the section "Network settings"
- Delays at the input or output of the modules can be found in the manual for the respective device.
- Information on device-internal delays can be found in the manuals for the ET 200MP and ET 200SP distributed I/O systems.

3.5 Summary of response time with cyclic and time-controlled program execution

Estimation of the shortest and longest response time

The following formulas may be used to estimate the shortest and longest response time:

Estimation of the shortest response time

The shortest response time is the sum of:

1 x delay of the input/output module for inputs
+ 1 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for ET 200SP CPUs)
+ 1 x transfer time of the process image input
+ 1 x execution of the user program
+ 1 x transfer time of the process image output
+ 1 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for ET 200SP CPUs)
+ 1 x delay of the input/output module for outputs

= Shortest response time

* Time is dependent on the configuration and the extent of the network.

The shortest response time is equivalent to the sum of the cycle time plus the input and output delay times.

Estimation of the longest response time

The longest response time is the sum of:

1 x delay of the input/output module for inputs
+ 2 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for ET 200SP CPUs)
+ 2 x transfer time of the process image input
+ 2 x execution of the user program
+ 2 x transfer time of the process image output
+ 2 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for ET 200SP CPUs)
+ 1 x delay of the input/output module for outputs

= Longest response time

* Time is dependent on the configuration and the extent of the network.

The longest response time is equivalent to the sum of twice the cycle time plus the delay times of the inputs and outputs. The longest reaction time includes twice the update time for PROFINET IO or twice the DP cycle time on PROFIBUS DP.

Event-driven program execution

4

4.1 Response time of the CPUs when program execution is event-controlled

Introduction

In order to detect events in the process immediately in the user program and to react to them with an appropriate program, you use hardware interrupts. In STEP 7, organization blocks OB 40 to OB 47 are provided for processing a hardware interrupt. You can create additional hardware interrupts starting with organization block OB 123. The number of available organization blocks depends on the CPU used.

Definition

A hardware interrupt is an interrupt that occurs during the running program execution, due to an interrupt-triggering process event. The operating system calls the assigned interrupt OB; as a result, the execution of the program cycle or of lower priority program parts is interrupted.

Interrupt response times of the CPUs for hardware interrupts

The interrupt response times of the CPUs start with the occurrence of a hardware interrupt event in the CPU and end with the start of the assigned hardware interrupt OB.

This time is subject to system-inherent fluctuations, and this is expressed using a minimum and maximum interrupt response time.

The following table contains the length of the typical response times of the CPUs for hardware interrupts.

Table 4- 1 Response times of the CPUs for hardware interrupts

		S7-1500			
CPU		1511(F)-1 PN 1511T-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN	1515(F)-2 PN 1515T-2 PN 1516(F)-3 PN/DP	1517(F)-3 PN/DP 1517T(F)-3 PN/DP	1518(F)-4 PN/DP 1518(F)-4 PN/DP ODK
Interrupt response times	Min.	100 µs	90 µs	30 µs	20 µs
	Max.	400 µs	360 µs	120 µs	90 µs

		ET 200SP		
CPU		**1510SP(F)-1 PN**	**1512SP(F)-1 PN**	**1515SP(F)-PC**
Interrupt response times	Min.	100 µs	100 µs	90 µs
	Max.	400 µs	400 µs	360 µs

		ET 200pro
CPU		**1516pro(F)-2 PN**
Interrupt response times	Min.	90 µs
	Max.	360 µs

Note that the times are extended if higher-priority interrupts are queued up for execution, and if the hardware interrupt OB is assigned to a process image partition. You can find these times in the 'Extension due to nesting of higher-priority OBs and/or interrupts' table in the section User program execution time (Page 23)

If you need fast interrupt response times, do not assign a process image partition to the hardware interrupt OB and use direct access in the hardware interrupt OB.

You can find additional information on determining response times for PROFINET in the application example with the entry ID 21869080 on the Service&Support (http://support.automation.siemens.com/WW/view/en/21869080) Internet page.

Influence of input modules on the interrupt response times of hardware interrupts

Digital input modules:

Interrupt response time of hardware interrupts = internal interrupt processing time + input delay (see section Technical specifications in the manual)

Analog input modules:

Interrupt response time of hardware interrupts = internal interrupt processing time + conversion time (see section Technical specifications in the manual)

Impact of communication on interrupts

Communication tasks are always processed by the CPU with priority 15. If you do not want the interrupt execution to be delayed or interrupted by communication, configure the interrupt execution with priority > 15. The default setting for interrupt execution is priority 16.

Special consideration when PROFINET IO communication is configured on the 2nd PROFINET interface (X2)

You can find information in the section Special consideration when PROFINET IO communication is configured on the 2nd PROFINET interface (X2) (Page 29).

4.2 Process response time when program execution is event-driven

When program execution is event-driven, the process response time is determined by the following:

- Delay times of the input and output modules used
- Update times for PROFIBUS/PROFINET for distributed modules; update time of the backplane bus for ET 200SP CPUs
- Interrupt response time of CPU
- Runtimes of the interrupt OB including update of the process image partition

The following figure shows the individual execution steps for event-driven program execution.

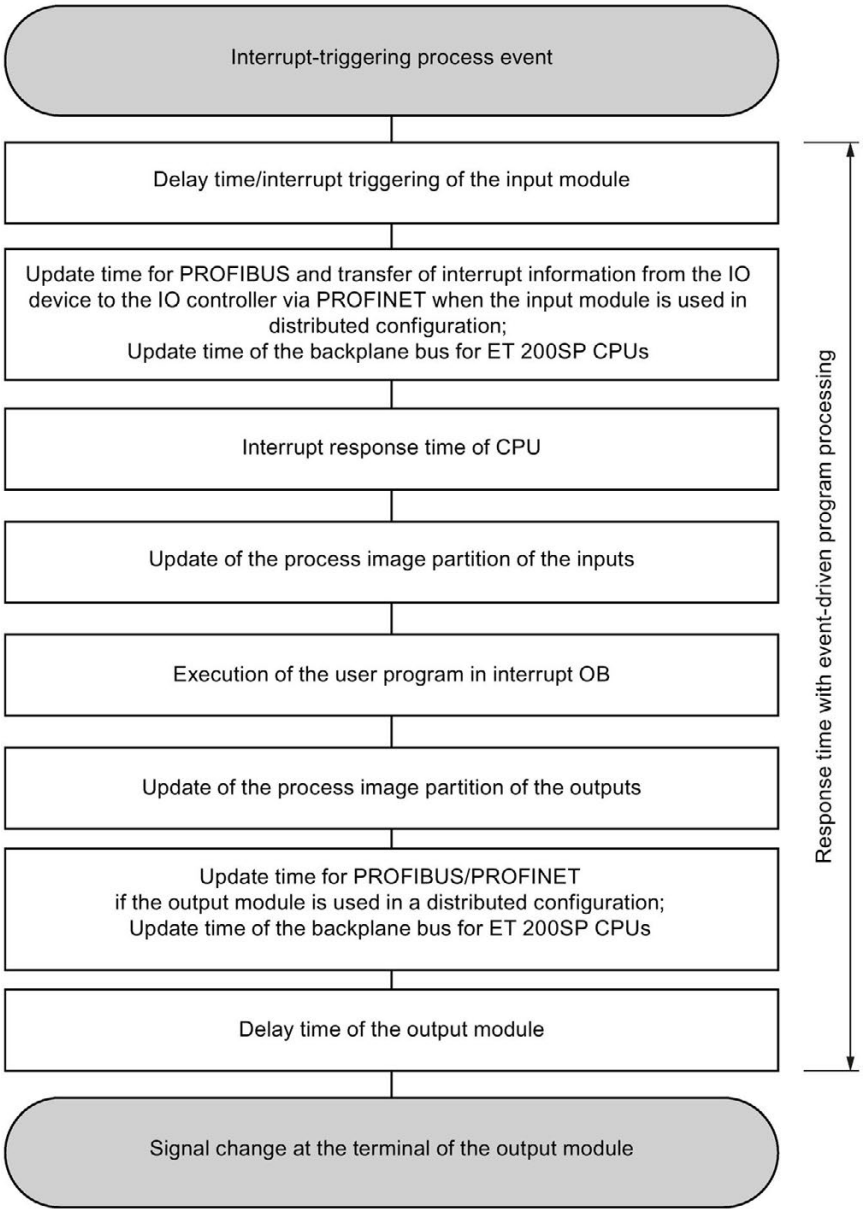


Figure 4-1 Schematic representation of event-driven program execution

Glossary

Automation system

An automation system in the context of SIMATIC S7 is a programmable logic controller.

Cyclic interrupt

A cyclic interrupt is generated periodically by the CPU in a configurable time pattern. At this point in time the corresponding organization block is processed.

Diagnostic interrupt

Diagnostics-capable modules signal detected system errors to the CPU using diagnostic interrupts.

Hardware interrupt

A hardware interrupt is started by interrupt-triggering modules when a specific event occurs in the process. The hardware interrupt is reported to the CPU. The assigned organization block is then processed according to the interrupt priority.

Interrupt

The CPU's operating system distinguishes between various priority classes that control the execution of the user program. These priority classes include interrupts, such as hardware interrupts. When an interrupt occurs, the operating system automatically calls an assigned organization block, in which the user programs the desired response.

Process image

The process image is part of the CPU system memory. At the start of the cyclic program, the signal states of the input modules are transmitted to the process image input. At the end of the cyclic program, the process image output is transmitted as signal state to the output modules.

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S7-1500, ET 200SP, ET 200pro

Structure and Use of the CPU Memory

Function manual

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S7-1500, ET 200SP, ET 200pro Structure and Use of the CPU Memory

Function Manual

Preface

Documentation guide 1

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation describes the various memory areas of the S7-1500 CPUs, ET 200SP CPUs and the ET 200pro CPU 1516pro-2 PN, and shows how you can optimally use these memory areas.

Additionally this manual shows how you can free work memory by using recipes and data logs.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the SIMATIC industrial automation system
- Knowledge about the use of computers
- Knowledge of working with the TIA Portal and STEP 7

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation is valid for all CPUs of the product families S7-1500 and ET 200SP and for the ET 200pro CPU 1516pro-2 PN.

What's new compared to the previous version of the function manual (01/2013 edition)

What's new?		What are the customer benefits?	Where can I find information?
New contents	Analyzing memory requirements and memory usage	You have various options for analyzing the memory requirements and the memory usage of the CPU: • with STEP 7 • with the display of the CPU • with the Web server of the CPU	Section Memory requirements and memory usage (Page 16)
	Memory behavior in load memory when loading software changes	When loading software changes to the SIMATIC memory card, the files in question are only deleted after creation of the new files. For this reason, the CPU requires adequate free memory space on the SIMATIC memory card. You have various options for creating memory space; these will be explained.	Section Memory behavior in load memory when loading software changes (Page 26)
	Service life of SIMATIC memory cards	Using calculation examples of the service life of a SIMATIC memory card, you can estimate which SIMATIC memory card is required for your automation task.	Section Service life of the SIMATIC memory card (Page 51)
Changed contents	Scope of the function manual expanded to include the CPUs of the distributed I/O system ET 200SP and the CPU 1516pro-2 PN	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in CPUs in other designs (ET 200SP) and in the CPU 1516pro-2 PN (degree of protection IP65, IP66 and IP67).	Manual CPU 1510SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/90157130) Manual CPU 1512SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/90157013) Operating instructions CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)

See also

SIMATIC Portal (http://www.siemens.com/simatic-tech-doku-portal)

Catalog (www.siemens.com/industrymall)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

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- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet.

See also

Industry Mall (https://mall.industry.siemens.com)

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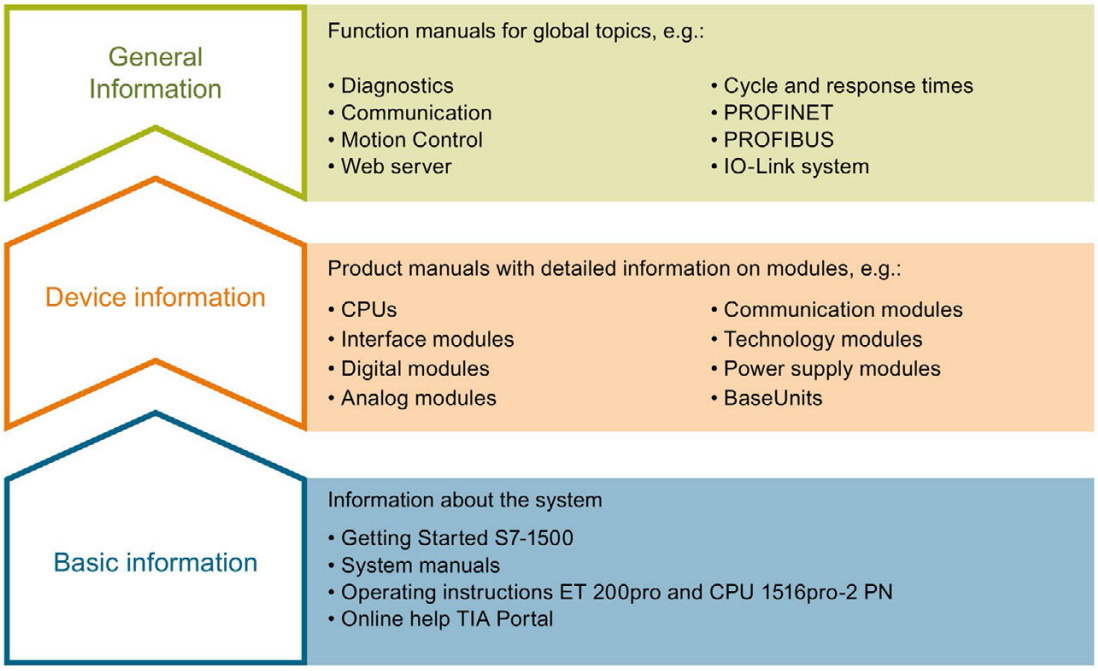
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

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You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Memory areas and retentive memory

2

Memory areas

The automation data is located in the automation system in different memory areas.

The offline data of the project created in STEP 7 is located on the hard disk of the programming device. The online data of the project is located in the load memory on the SIMATIC memory card. In addition, the work memory, retentive memory and other memory areas are located on the CPU.

The following figure shows an overview of the memory areas of the S7-1500 and ET 200SP CPUs and the ET 200pro CPU 1516pro-2 PN.

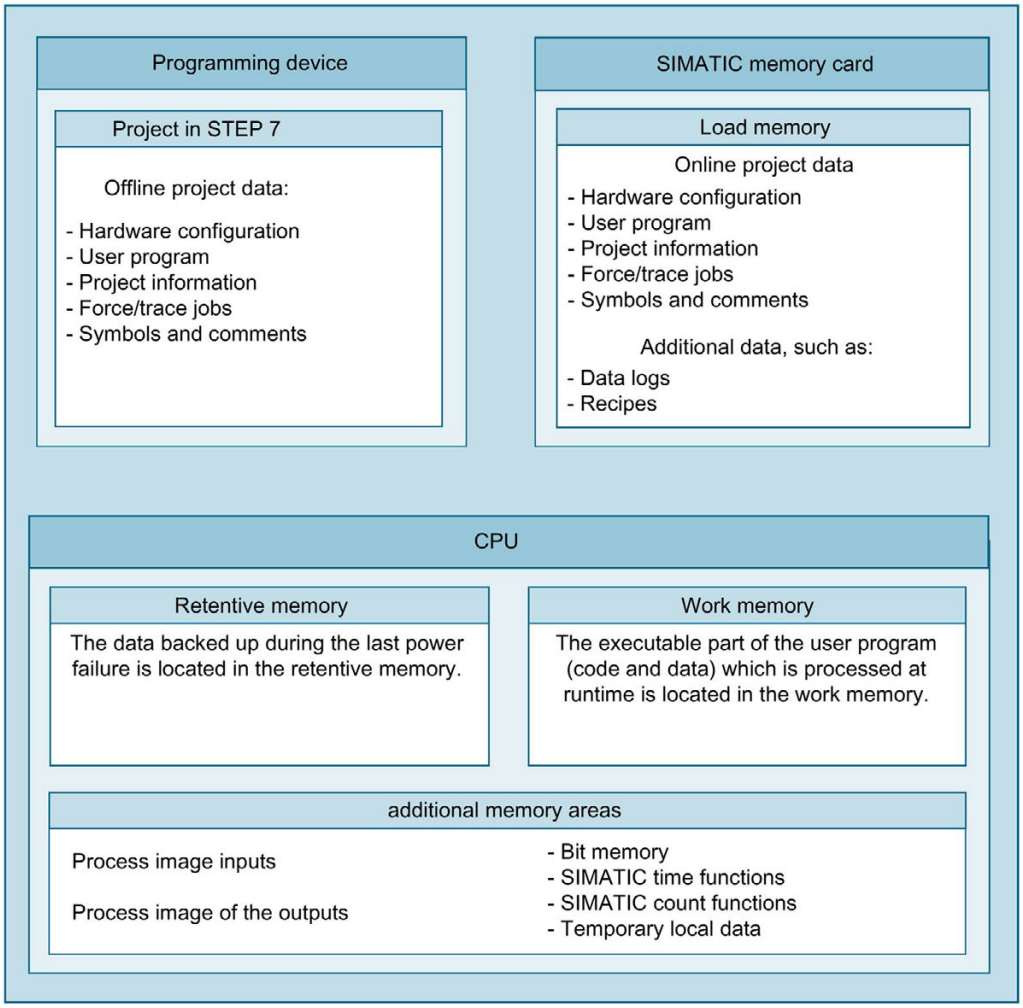


Figure 2-1 Memory areas

Load memory

Load memory is non-volatile memory for code blocks, data blocks, technology objects and the hardware configuration. The load memory is located on the SIMATIC memory card. STEP 7 transfers the project data from the programming device to the load memory.

If you have copied additional data (e.g. HMI backups or other files) via the CPU Web server or Explorer to the SIMATIC memory card, this data is also located in the load memory of the SIMATIC memory card.

Note

An inserted SIMATIC memory card is required to operate the CPU.

Work memory

The work memory is volatile memory that contains the code and data blocks. The work memory is integrated into the CPU and cannot be extended. The work memory is only used in operation of the CPU.

In the CPUs, the work memory is divided into two areas:

- Code work memory: The code work memory contains runtime-relevant parts of the program code.
- Data work memory: The data work memory contains the runtime-relevant parts of the data blocks and technology objects. At the operating mode transitions POWER ON to startup and STOP to startup, tags from global data blocks, instance data blocks and technology objects are initialized with their start values; retentive tags retain their actual values as saved in the retentive memory.

Retentive memory

The retentive memory is non-volatile memory for saving a limited amount of data in the event of power failure.

The following actions delete the content of the retentive memory:

- Memory reset
- Reset to factory settings

You can find additional information on memory reset and resetting to factory settings in the S7-1500 Automation system, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual, the ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and the ET 200pro CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416) operating instructions.

Additional memory areas

Besides the memory areas that have been described for the user program and data, the CPU has additional memory areas available.

The additional memory areas include the following:

- Process images
- Temporary local data

The CPU-specific sizes can be found in the technical specifications for the respective CPU.

2.1 Memory requirements and memory usage

In STEP 7, you can retrieve information about the memory areas of the CPU on the display of the CPU (only applies to the S7-1500 CPUs) and via the Web server.

Memory requirements of the program in the offline project

The display of the memory usage in the program information of STEP 7 is intended to determine whether the project is becoming too big for a particular CPU or a particular memory card already during the creation or modification of a project. You can find this information under "Program information" in the project tree, for example. In the "Resources" tab you can find information about the total size of the memory areas of the respective CPU project (in the figure below in the line "Total"), and about the memory requirements of the program elements (blocks, data types, objects for motion control and PLC tags) and their percentages in the respective memory area of the offline project (in the figure below in the line "Used:"). In the overview table you can also find information about the assigned inputs and outputs.

For a CPU, you can select the total size of the load memory in a drop-down list. Select the size of the load memory in accordance with the size of the SIMATIC memory card you are using. The percentage shown in the Load memory column depends on the selected size of the load memory. As soon as the memory size exceeds the size of the load memory of the memory card you are using, the sizes indicated turn red. The drop-down list therefore only serves as a visual aid.

The following figure shows an overview of the usage of the different memory areas of the "Resources tab:

	Objects	Load memory	Code work-memory	Data work-memory	Retain memory
1		19 %	1 %	8 %	23 %
2					
3	Total:	0 kB	1048576 bytes	5242880 bytes	484000 bytes
4	Used:	0 kB	15293 bytes	411034 bytes	110592 bytes
5	Details	2 MB			
6	OB	4 MB	469 bytes		
7	FC	12 MB	410 bytes		
8	FB	24 MB	14414 bytes		
9	DB	256 MB		411034 bytes	110592 bytes
10	Data types	2 GB 6681 bytes	-		
11	PLC tags	32 GB			0 bytes

Figure 2-2 Display of the usage of the different memory areas

Note

Display of memory usage under "Program information"

The display of the memory usage in the program information is an offline display in STEP 7 and only shows the memory requirements of the program in the project. The program on the memory card of the CPU may vary, however, e.g.:

- if it is more recent
- if it contains blocks created via other projects
- if it contains blocks generated on the CPU

See the FAQ "How do you estimate the memory requirements of your user program in the load memory of an S7-1500 CPU and an ET 200SP CPU (Open Controller)?" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/97553417).

Data on the SIMATIC memory card

In addition to the program and the associated program elements (blocks, data types, objects for motion control and PLC tags), the following data is stored:

- Hardware configuration
- Project information
- Force/trace jobs
- Symbols and comments

The following further data may also be found on the memory card:

- Recipes, data logs and HMI backups
- Non-SIMATIC files which were copied to the memory card via the Web server of the CPU or offline via the Explorer (e.g. PDF files etc.)

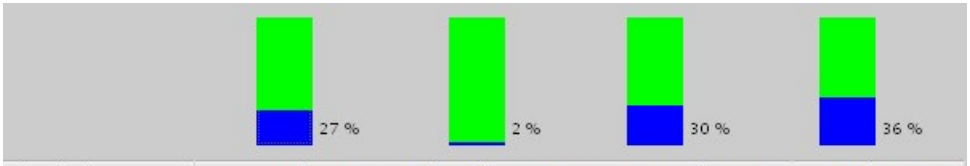
Display of the memory usage of the CPU

In online mode, the online function "Memory" provides you with the following up-to-date memory information:

- Size of the total free and already allocated load memory on the SIMATIC memory card.
- Size of the total free and already allocated work memory, separated by code and data.
- Size of the total free and already allocated retentive memory.

The online function "Memory" can be found in Online & Diagnostics under "Diagnostics > Memory". You can access the functions under Online & Diagnostics in various ways:

- In the project tree under every configured CPU.
- In the project tree under Online access > Accessible devices, to display the usage of CPUs which were not configured in the project.
- In all views of the device configuration (topology view, network view, device view) by selecting a CPU with the right mouse button.



Sizes in bytes	Load memory	Code work-memory	Data work-memory	Retain memory
Free:	6291456	1048576	5242880	524288
In use:	2316997	17355	2299642	301234
Total:	8608453	1065931	7542522	825522

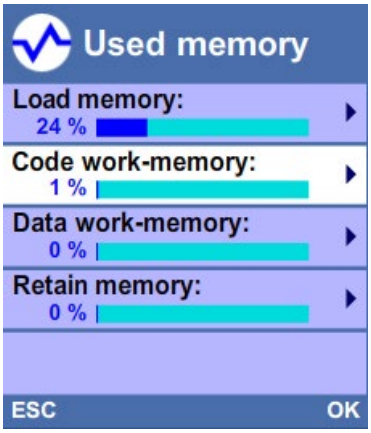
Figure 2-3 "Memory" online function

Display of the memory usage in the display of the CPU

To obtain information about the available memory via the display, proceed as follows:

- Select the "Diagnostics" menu on the display with the help of the arrow keys.
- Select the "Memory" command from the "Diagnostics" menu.

Under the "Memory" command you can find information about the usage of the various memory areas (see following figure). Please note that the memory allocation is queried at the time of the call and is not continuously updated.



To find out details about the respective memory areas (e.g. code work memory), select the required memory area with the help of the arrow keys (see following figure).

In the detail view, e.g. of the code work memory, the display provides you with the following information:

- Memory space which is still available in the code work memory.
- Memory space which is already allocated in the code work memory.
- Total available memory space in the code work memory.

Display of the memory usage in the Web server

On the Web server, you can find information about the current usage of the individual memory areas on the Web page "Diagnostics" in the "Memory" tab.

Detailed information about the use of the Web server can be found in the S7-1500 Web server (https://support.industry.siemens.com/cs/ww/en/view/59193560) function manual.

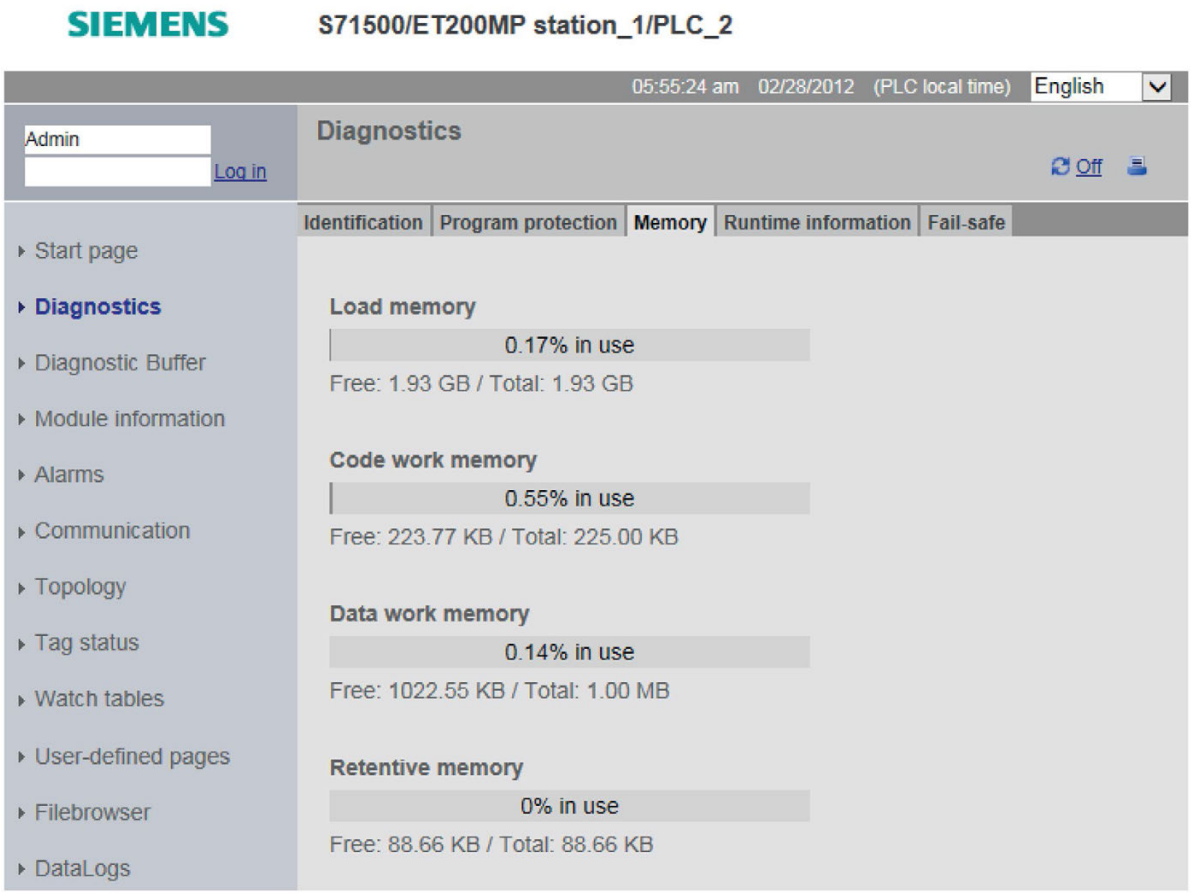


Figure 2-4 Display of the memory usage in the Web server

2.2 Retentive memory areas

Introduction

The CPUs have memory available for storing retentive data at POWER-OFF. Details about the size of the retentive memory can be found in the technical specifications for the respective CPU.

In STEP 7, you can find the configured CPU's retentive memory utilization offline at "Program information > Resources" or online at Online & Diagnostics under "Diagnostics > Memory".

If you define data as retentive, its content is retained beyond program startup after STOP or a power failure.

You can define the following data and objects as retentive:

- Tags of global data blocks
- Tags of instance data blocks of a function block
- Bit memories, timers and counters

Tags of technology objects are always retentive, for example, adjustment values of absolute encoders. The volume of retentive data of technology objects therefore is also included in the volume of retentive data which you can define as retentive in your project.

Tags of a global data block

In a global data block, you can define either individual tags from a block or all of its tags collectively as retentive, depending on the setting for the "Optimized block access" attribute:

- "Optimized block access" activated: In the declaration table of the data block, you can define individual tags as retentive.

	Name	Data type	Start value	Retain	Visible in HMI	Comment
1	Static			☐	☐	
2	var1	Bool	false	☑	☑	
3	var2	Bool	false	☐	☑	
4	var3	Bool	false	☑	☑	
5	var4	Bool	false	☐	☑	
6	var5	Bool	false	☑	☑	

Figure 2-5 Retentivity setting "Optimized block access" activated

- "Optimized block access" not activated: In the declaration table of the data block, you can only define the retentivity of all tags collectively.

	Name	Data type	Offset	Start value	Retain	Visible in HMI	Comment
1	Static				☐	☐	
2	var6	Bool	...	false	☑	☑	
3	var7	Bool	...	false	☑	☑	
4	var8	Bool	...	false	☑	☑	
5	var9	Bool	...	false	☑	☑	
6	var10	Bool	...	false	☑	☑	

Figure 2-6 Retentivity setting "Optimized block access" not activated

You can find additional information on optimized and non-optimized data blocks in the Programming guideline for S7-1200/S7-1500 (https://support.industry.siemens.com/cs/de/de/view/90885040/en).

Tags of an instance data block of a function block

In STEP 7, you can define the tags from the instance data block of a function block as retentive. Depending on the setting for the "Optimized block access" attribute, you can define retentivity either for individual tags from a block or for all of its tags collectively:

- "Optimized block access" activated: In the interface of the function block, you can define individual tags as retentive.
- "Optimized block access" not activated: In the instance data block, you can only define the retentivity of all tags collectively.

Creation of a data block in the user program

The instruction "CREATE_DB" is used to create a new data block in the load and/or work memory. For data blocks which you create in the load memory, depending on the selection for the ATTRIB parameter, the generated data block either has the property "retentive" or the property "non-retentive". Setting the retentivity for individual tags is not possible here. The "Optimized block access" attribute is disabled.

You can find additional information on the "CREATE_DB" instruction in the STEP 7 online help under "PLC programming > Instructions > Extended instructions > Data block functions > CREATE_DB Create data block".

Tags of technology objects

Tags of technology objects are retentive, for example adjustment values of absolute encoders. STEP 7 automatically manages the retentivity of the tags of technology objects so that you do not have to configure any retentivity.

The retentive tags of technology objects are unaffected by a memory reset. They can only be deleted by resetting to factory settings.

Bit memories, timers and counters

In STEP 7, you can define the number of retentive bit memories, times and counters in the PLC tag table using the "Retentive memory" button.

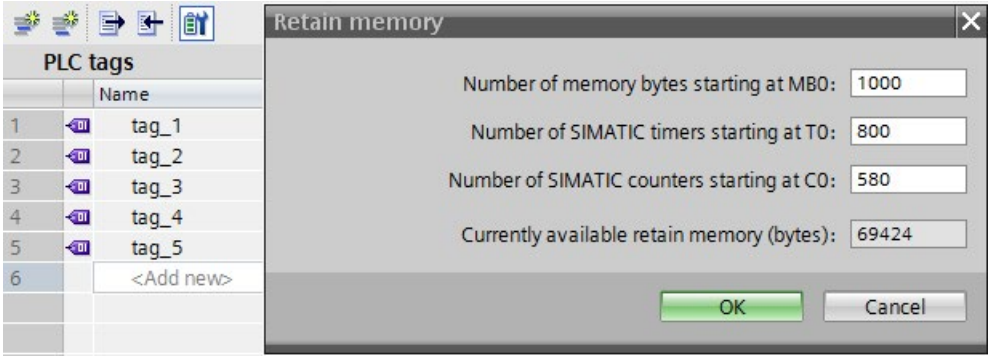


Figure 2-7 Definition of the number of retentive bit memories, timers and counters (beginning at 0, continuing without gaps) using the "Retentive memory" button

Reference

You can find additional information on configuring retentivity in the STEP 7 online help.

2.3 Summary of retentive behavior

Retentive behavior of the memory objects

This section gives an overview of the retentive behavior of memory objects for the CPUs. In addition to the retentive memory areas described, there are other objects with retentive characteristics, for example, the diagnostics buffer. These objects do not occupy any storage space in the retentive memory.

The following table shows the retentive behavior of the memory objects at the operating mode transitions STOP to startup and POWER ON to startup, as well as the memory-influencing functions "Memory reset" and "Reset to factory settings".

Table 2- 1 Retentive behavior of the memory objects

Memory object	Operating mode transitions		Memory reset	Reset to factory settings
	STOP → STARTUP	POWER ON → STARTUP		
Actual values of the data blocks, instance data blocks	Can be set in the Properties of the DB in STEP 7.[1].		-	-
Bit memories, timers and counters - configured as retentive	x	x	-	-
Bit memories, timers and counters - configured as non-retentive	-	-	-	-
Retentive tags of technology objects (e.g. adjustment values of absolute encoders)	x	x	x	-
Diagnostics buffer entries (retentive area)	x	x	x	-
Diagnostics buffer entries (non-retentive area)	x	-	-	-
Operating hours counter	x	x	x	-
Clock time	x	x	x	-
x = content is retained – = object is initialized				

1) For DBs with optimized access the retentive behavior is configurable for specific tags.

Diagnostics buffer

With the CPUs, a portion of the diagnostics buffer is retentive. The number of retentive diagnostics buffer entries depends on the type of CPU. The latest entries in the diagnostics buffer are retained after power failure, and are not affected by a memory reset. The retentive portion of the diagnostics buffer can only be deleted by resetting to factory settings. The entries in the diagnostics buffer do not occupy any storage space in the retentive memory.

Operating hours counter

The operating hours counters of the CPUs are retentive and are not affected by a memory reset. By resetting to factory settings, the operating hours counters are set to zero.

Clock time

The clock time of the CPUs is retentive and is not affected by a memory reset. By resetting to factory settings, the clock time is reset.

Reference

You can find additional information on memory reset and resetting to factory settings in the S7-1500 Automation system, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual, the ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and the ET 200pro CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416) operating instructions.

2.4 Memory behavior when loading software changes

Introduction

In the STOP and RUN modes of the CPU, you can load changes to the software without this affecting the actual values of tags already loaded.

In STEP 7, you load changes to the software (in the project tree and with selected PLC station) under "Download to device > Software (only changes)".

Impact of software changes on PLC tags

You can load the following software changes without affecting the actual values of PLC tags that have already been loaded:

- Name change
- Comment change
- Addition of new tags
- Deletion of tags
- Change of retentivity settings for Retentive memory areas (Page 21)

The actual values are affected by loading the following software changes:

- Data type change
- Address change

Memory reserve of global DBs and instance DBs

Each function block or data block with the "Optimized block access" attribute activated contains, by default, a memory reserve which you can use for subsequent interface changes. The memory reserve is initially not used. When you have compiled and loaded the block, and then observe that you want to reload interface changes, activate the memory reserve. All tags that you subsequently declare will be placed in the memory reserve. During the next load, the new tags are then initialized to their start values. Tags which have already been loaded are not reinitialized.

The setting for memory reserve can be found in STEP 7 in the data block properties in the category "Download without reinitialization".

Impacts of software changes on data blocks without memory reserve

If you are not using memory reserve, you can load the following software changes without this reinitializing the actual values of DB tags that have already been loaded:

- Change of initial value
- Comment change

Impacts of software changes on data blocks with memory reserve

If you are using memory reserve for data blocks ("Optimized block access" attribute and "Download without reinitialization" button activated), you can load the following software changes without this reinitializing the actual values of DB tags which have already been loaded:

- Change of initial value
- Comment change
- Addition of new tags

If the button "Enable download without reinitialization for retentive tags" is deactivated, then all actual values of the data block are reinitialized on the next loading of the following software changes:

- Name change
- Data type change
- Retentivity change
- Deletion of tags
- Changes to the memory reserve settings

Reference

You can find additional information on setting and activating the memory reserve, and on loading block changes, in the online help for STEP 7 under "PLC programming > Compile and download blocks > Download blocks for S7-1200/1500 > Download block extensions without reinitialization".

2.5 Memory behavior in load memory when loading software changes

Memory requirements in RUN mode

For the consistent and atomic handling of the entire load procedure, the CPU requires adequate free memory space on the SIMATIC memory card. The files affected by loading the software changes to the CPU are only deleted after the new files have been created. This SIMATIC memory card therefore requires memory space corresponding approximately to the space required for all program objects to be loaded on the memory card.

If this amount of memory is not available on your SIMATIC memory card, the following message is displayed in STEP 7 during the load procedure in the CPU: "There is insufficient memory on the memory card for this amount of data."

In order to still enable the loading of changes to the CPU in such a case, we recommend one or more of the following options:

- Load in RUN mode
  - Delete any files no longer required (e.g. CSV files, panel backups, etc.) on the memory card using the Web server.
  - If possible, load extensive changes in RUN mode in several steps, or load after every modification step.
- Load in STOP mode
  - If loading in several steps is not possible, load extensive changes in STOP mode. Please note that when loading in STOP mode, the actual values of non-retentive data are not initialized.
- Use a larger memory card
  - In order to perform extensive load processes in RUN mode of the CPU, use a larger memory card. A description of how to change the memory card can be found in the section "Changing the memory card without losing retained data".

Impact of minor program changes on the load procedure

There are dependencies between the objects of a program, e.g. of code blocks to called code blocks, of code blocks to data blocks and of data blocks to data types (PLC data types, FB types). This means that the load procedure for a minor change may be very time-consuming if the change affects a large number of dependent objects.

Example:

A STEP 7 program contains an organization block (OB), 20 functions (FC) and a data block (DB). The OB calls the 20 FCs and all FCs access the DB. If you change the program code in one of the FCs, the following load procedure only contains the changed FC. If you change the data type of a tag in the DB, however, the following load procedure then changes all the FCs and the DB.

The following figure shows the objects in the load procedure in a preview.

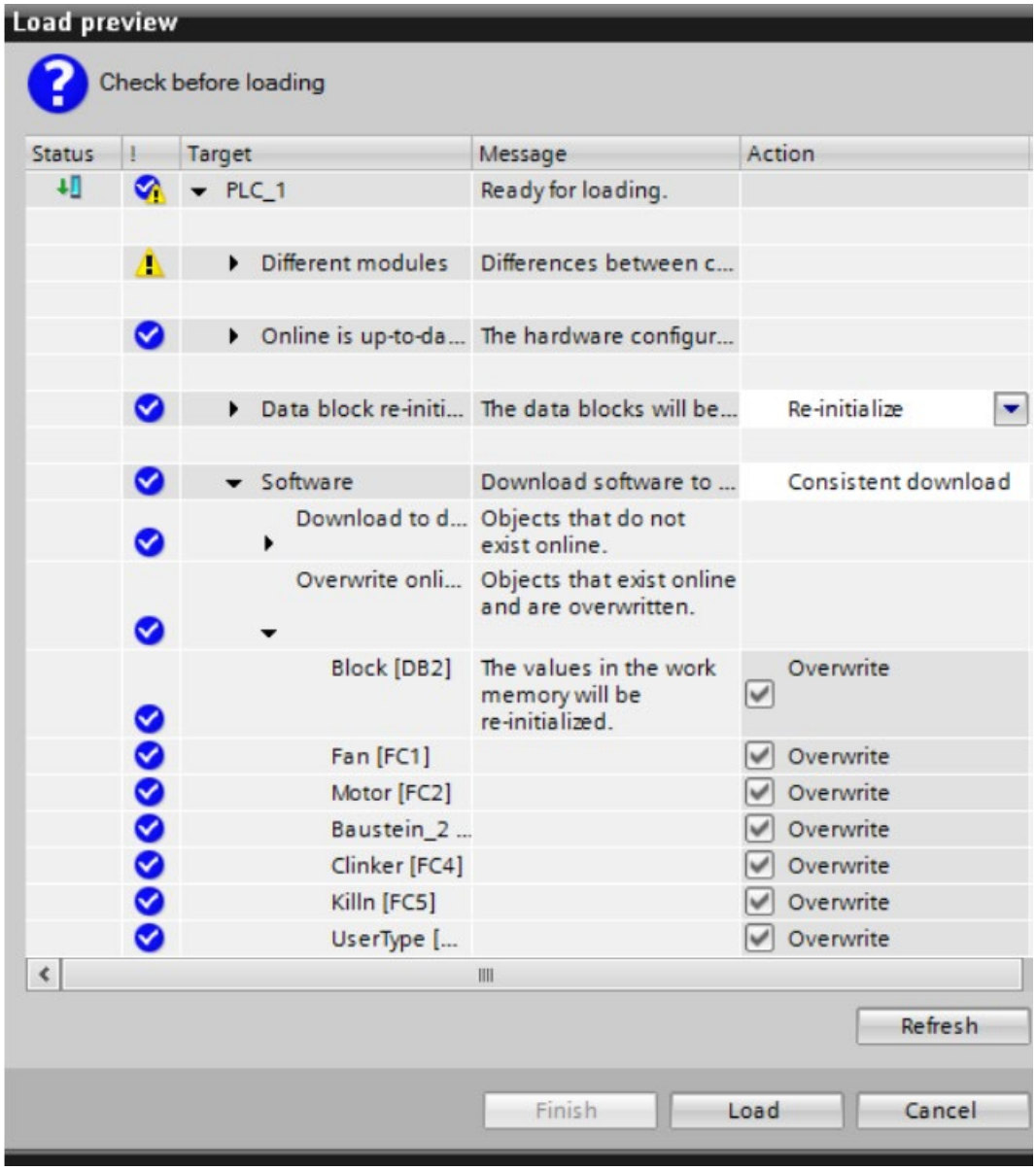


Figure 2-8 Preview for loading

To find the interdependencies of the individual objects, double-click in the project tree on "Program information" and in the dialog "Program information" change to the "Dependency structure" tab.

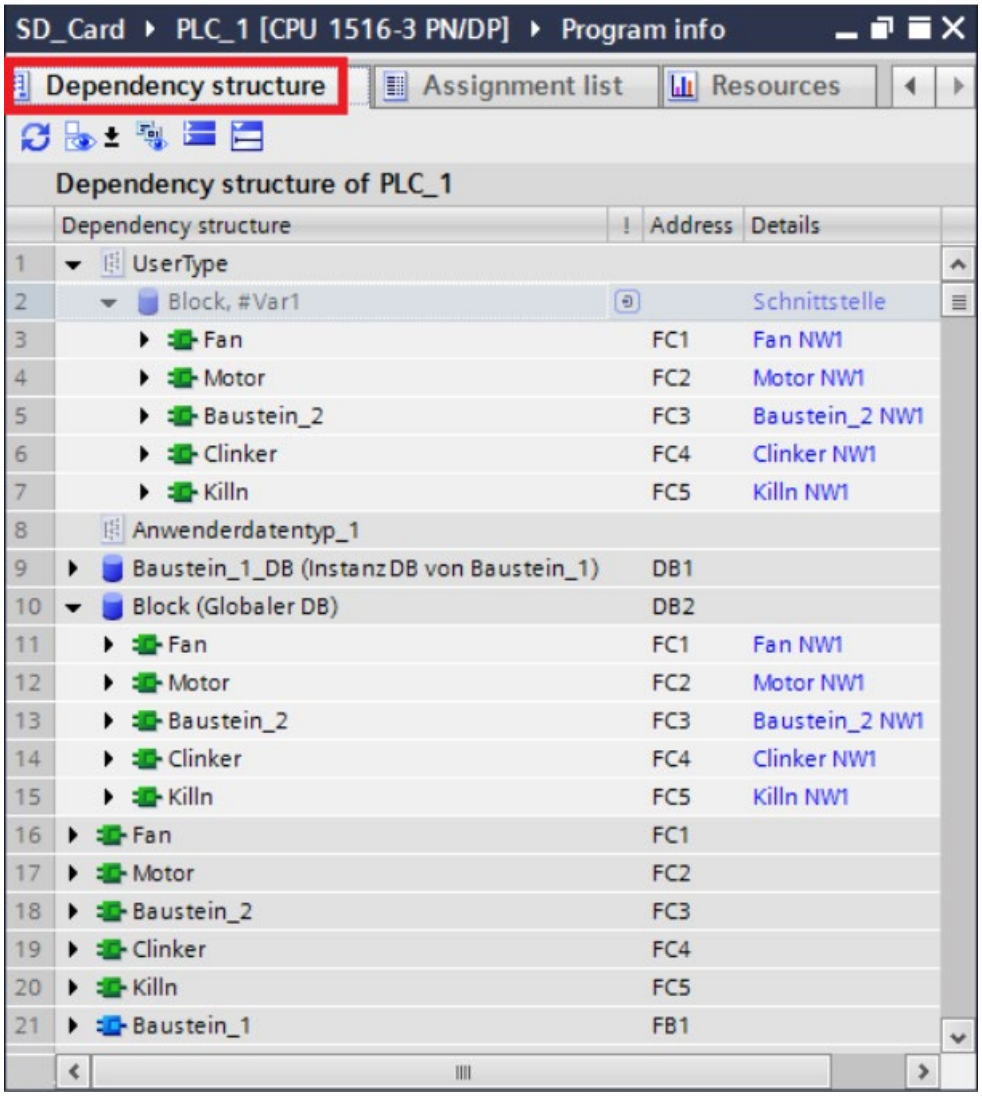


Figure 2-9 Dependency structure

Memory requirements for saving trace recordings

The "Save measurements on device (memory card)" function allows you to save trace recordings on your SIMATIC memory card.

Response when number reached

The parameter "Deactivate recording" repeats the measurements until the configured "Number of measurements" has been reached.

The parameter "Overwrite oldest recording" replaces the oldest measurement with the latest measurement when the configured "Number of measurements" has been reached. Keep in mind, however, that writing data to the SIMATIC memory card continuously will shorten its service life.

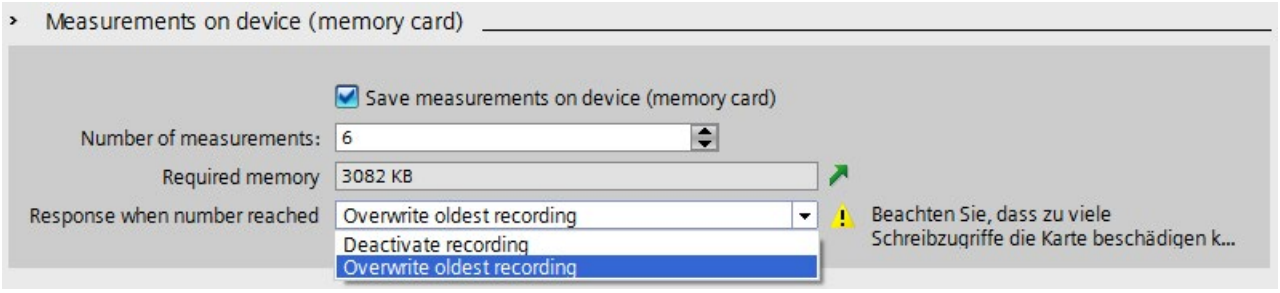


Figure 2-10 Dialog of settings for saving measurements on the memory card in STEP 7

Number of measurements

The CPU supports a maximum of 999 measurements. While the CPU writes the trace recordings to the load memory of the memory card, it pauses monitoring of the trigger conditions for the trace job. Once the CPU has finished saving the trace recordings, it resumes checking the trigger conditions.

NOTICE
Memory required on the SIMATIC memory card Keep in mind that the "Save measurements on device (memory card)" function requires free memory of more than 1024 KB on your SIMATIC memory card. This required memory is independent of the card size of the SIMATIC memory card you are using. If this space is no longer available, the CPU stops storing measurements on the memory card and writes a corresponding entry to the diagnostic buffer. Make sure that sufficient memory is available on the SIMATIC memory card before you execute the "Save measurements on device (memory card)" function. Delete any trace recordings no longer required from the SIMATIC memory card.

You can find additional information on trace recordings in the Using the trace and logic analyzer function (http://support.automation.siemens.com/WW/view/en/64897128) function manual, in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual and in the STEP 7 online help.

Memory requirements in STOP mode

Even when downloading in STOP mode a certain amount of reserve memory is required, because your memory card needs sufficient free memory for consistent downloading of individual data blocks. The files affected by loading the data blocks are only deleted after the new files have been created. Therefore, for the modifications you must have available at least the memory requirement of the largest data block.

Contrary to downloading in RUN mode, when downloading in STOP mode, modified code blocks in the CPU are deleted first prior to downloading of the modified code block. For this reason, when downloading code blocks in STOP mode, no additional memory is required on the memory card.

If insufficient reserve memory is available in your SIMATIC memory card when loading in STOP mode, the following message is displayed in STEP 7 during the load procedure: "There is insufficient memory on the memory card for this amount of data."

In order to still enable the loading of changes to the CPU in such a case, we recommend one or more of the following options:

- Delete any files no longer required (e.g. CSV files, panel backups, etc.) from the memory card using the Web server.
- Use a larger memory card. A description of how to change the memory card can be found in the section "Changing the memory card without losing retained data".

Note

Please note that retained data and possibly also project data is lost with the following three options. Therefore only use the following options described if the two options described previously did not lead to the desired result.

- In STEP 7, load your program with the menu command "Online > Download and reset PLC program" into the CPU.
- Remove the memory card from the slot of the CPU and delete the content of the memory card you no longer need with your programming device.
- Delete the entire contents, e.g. by formatting the memory card. A description of how to format the memory card can be found in the section "Formatting a SIMATIC memory card".

Also refer to the FAQ "When downloading to the S7-1500 CPU, why is the message "There is insufficient memory on the memory card for this amount of data" displayed although there is still enough memory available?" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/107108015).

Changing the memory card without losing retained data

You can change or use a larger SIMATIC memory card without losing the retained data. When you switch off the CPU, the retained data is backed up in the retentive memory of the CPU. While the CPU is switched off, you can remove the memory card and copy the contents to a larger memory card. After switching on the CPU, data backed up in the CPU when switched off is restored.

Formatting a SIMATIC memory card

To create storage space on your SIMATIC memory card, you can format the SIMATIC memory card. During formatting, the entire content of the memory card with the exception of the IP address is deleted.

The SIMATIC memory card may only be formatted in the CPU. With a SIMATIC memory card inserted, follow these steps:

Formatting with STEP 7:

- Establish an online connection.
- Double-click "Online & diagnostics" in the project tree.
- In the dialog window select "Functions > Format memory card" and then select the "Format" button.

Formatting via the display of the CPU

- In the display of the CPU, select the menu "Settings" > "Card functions" > "Format card" and confirm with OK.

NOTICE
Format the SIMATIC memory card Do **not** format the memory card with Windows tools. Formatting with Windows makes the memory card unusable for use in a CPU of the S7-1500 product family. If you have inadvertently formatted the card with Windows tools, you can restore the functioning of the card by reformatting the card in the CPU in SIMATIC format.

Memory usage and application examples 3

3.1 Memory usage for recipes

Introduction

A recipe represents a collection of parameter records with the same structure. These recipe data records are located in a non-runtime-relevant data block in the load memory, and do not occupy any storage space in the work memory. You have the option of reading individual recipe data records into a data block in the work memory and accessing the data in the user program. You can write a recipe data record that has been changed in the user program back to the recipe data block.

Recipes contain, for example, the related data of a specific batch in production. You can export recipe data records of a recipe DB as csv file. A Web browser can read data using the Web server in the CPU, even when the CPU is in STOP mode. You can also access the data directly on the SIMATIC memory card with a card reader on the programming device.

Processing sequence

- **Saving a recipe in load memory**

  STEP 7 stores the individual data records of a recipe in a non-runtime-relevant DB and loads it to the CPU. To configure a non-runtime-relevant DB, you must activate the "Only store in load memory" block attribute. The recipes then only use storage space in the load memory, and not in the work memory.

- **Working with recipe data in the user program**

  You can use the "READ_DBL" instruction to copy a data record belonging to the current recipe from the DB in the load memory to a runtime-relevant DB in the work memory. As a result, the work memory only has to accommodate the data for the currently required recipe data record. The user program can now access the data of the current data record.

- **Saving back changed recipe data records**

  You can use the "WRIT_DBL" instruction to write new or changed data records of a recipe from the user program back to the load memory. The data written to the load memory is portable and not affected by a memory reset. To back up changed data records (recipes), you have to upload the data blocks and back them up on the PG/PC. You can find information on uploading data blocks in the online help for STEP 7 under "PLC programming > Compile and download blocks > Download blocks for S7-1200/1500 > Download blocks from a memory card".

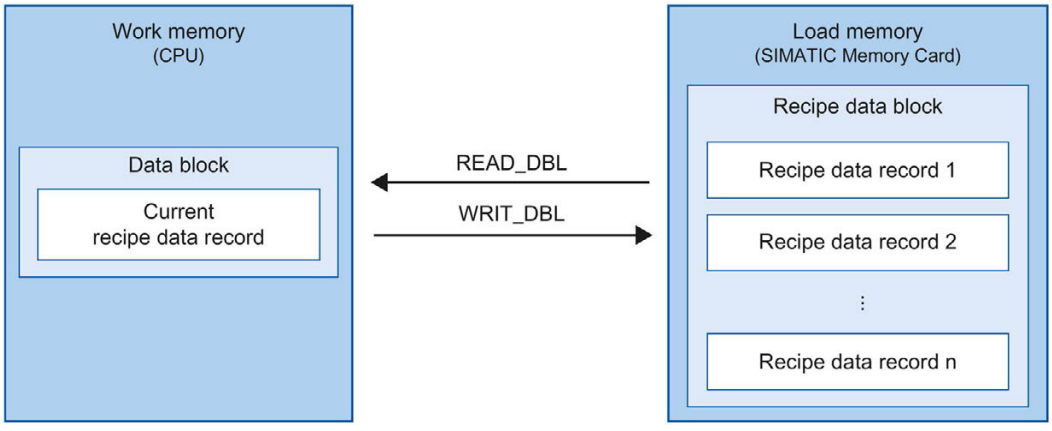


Figure 3-1 Processing sequence with "READ_DBL" and "WRIT_DBL"

Also see the FAQ "In STEP 7 (TIA Portal) how do you configure data blocks with the "Only store in load memory" attribute?" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/53034113).

Note

Instructions that access the SIMATIC memory card have a lower performance than instructions that access the work memory. The associated blocks (e.g. READ_DBL and WRIT_DBL) are therefore asynchronous. Their execution extends if necessary over several cycles.

NOTICE

Service life of the SIMATIC memory card

Only a limited number of delete and write operations are possible on the SIMATIC memory card. After expiration of the service life, there is a risk that the card can no longer be used. Therefore, use a SIMATIC memory card with sufficient memory for your particular purposes.

Additional information on the service life of the SIMATIC memory card can be found in the section Service life of the SIMATIC memory card (Page 51).

Import and export of recipe data

You have the option of exporting a recipe DB's recipe data records as a CSV file, and of importing them from a CSV file into a DB. The csv file is located in the "\recipes" directory on the SIMATIC memory card. You can open and process this file further with a spreadsheet program, e.g. Microsoft Excel.

You can easily manage the csv files on the SIMATIC memory card using the CPU's Web server (e.g. rename, save to hard disk, delete, etc.). In order to prevent unwanted tampering, configure the access privileges for the Web server in STEP 7. Additional information on the Web server can be found in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual, in the File browser section.

- **Export of recipe data**

  The "RecipeExport" instruction exports all of a recipe DB's recipe data records from the load memory to a csv file on the SIMATIC memory card. The csv file has the same name as the DB's recipe. The csv file is stored in the "\recipes" directory on the SIMATIC memory card.

  The "RecipeExport" instruction only exports valid and unencrypted recipe data records.

- **Import of recipe data**

  The "RecipeImport" instruction imports all recipe data records from the csv file into the recipe DB in the load memory. The name of the csv file must match the name of the recipe DB.

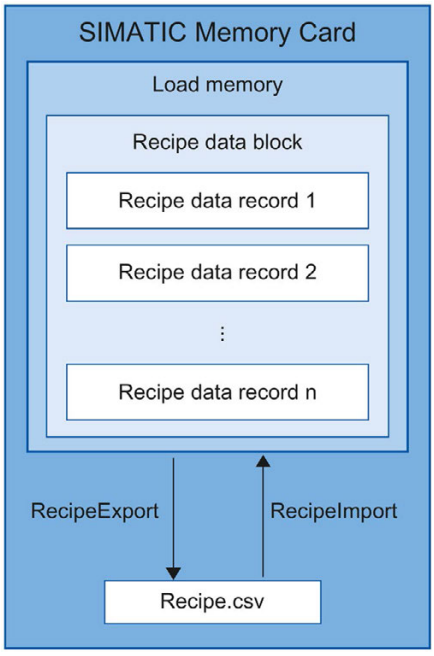


Figure 3-2 Import and export of recipe data

Note

Asynchronous instructions

Please note that the "RecipeExport" and "RecipeImport" instructions are asynchronous instructions.

In contrast to synchronous instructions, this means the execution of an asynchronous instruction can extend over multiple calls before execution is completed. The CPU processes asynchronous instructions in parallel with the cyclic user program.

A CPU can process several asynchronous instruction jobs in parallel. The CPU can process a maximum of 10 jobs of the instructions listed in parallel.

For more information on asynchronous instructions, refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

Reference

You can find additional information on the instructions for recipes in the online help for STEP 7 under "PLC programming > Instructions > Instructions (S7-1200, S7-1500) > Extended instructions > Recipes and data logging > Recipe functions".

Also see the FAQ "Using Recipe Functions for persistent Data with SIMATIC S7-1200 and S7-1500" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109479727).

3.2 Memory usage for data logging

3.2.1 Overview of data logging

With data logging, you save selected process values from the user program in a file, the data log. The data logs are saved on the SIMATIC memory card in csv format and stored in the "\datalogs" directory. A Web browser can read data using the Web server in the CPU, even when the CPU is in STOP mode. You can also access the data directly on the SIMATIC memory card with a card reader on the programming device.

NOTICE
Service life of the SIMATIC memory card Only a limited number of delete and write operations are possible on the SIMATIC memory card. Cyclic write operations via the user program to the SIMATIC memory card reduce the service life of the SIMATIC memory card. After expiration of the service life, there is a risk that the card can no longer be used. Therefore, use a SIMATIC memory card with sufficient memory for your particular purposes. Information on the service life of the SIMATIC memory card can be found in the section Service life of the SIMATIC memory card (Page 51).

The "data logging" instructions may be used in your program to create, open, write, and close data logs. You decide which tags are logged by creating a data block that defines a single data log data record. Your data block is used as temporary storage for a new data log data record. New current values for the tags must be transferred into the data block during runtime by means of user program instructions. If all tag values have been updated, you can execute the "DataLogWrite" instruction, in order to transfer data from the data block into the data log.

You manage your data logs using the integrated Web server. On the standard "File browser" web page, you can download or delete data logs. After you have transferred a data log to your PC, you can analyze the data using popular spreadsheet programs, e.g. Microsoft Excel.

The following figure shows the basic sequence for creating a data log:

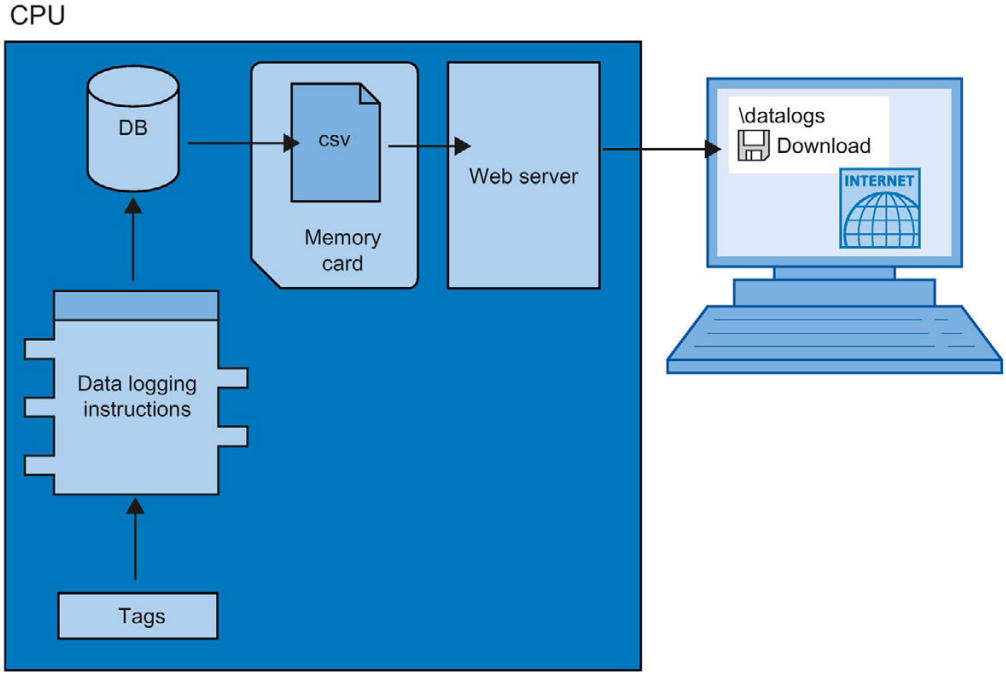


Figure 3-3 Basic sequence during the creation of a data log

3.2.2 Data structure of the data logs

Introduction

You use the "DataLogCreate" instruction to create a data log in STEP 7. The NAME parameter assigns the data log a name. The DATA and HEADER parameters specify the data type of all data elements in a data log data record, and the header line of the data log. The RECORDS parameter indicates the maximum number of records in the data log.

NAME parameter for the "DataLogCreate" instruction

You use the NAME parameter to assign a name for the data log. This is the name under which the data log is saved in the "\datalogs" directory of the SIMATIC memory card.

DATA parameter for the "DataLogCreate" instruction

The DATA block parameter specifies the structure of the data log's records. The columns and data types of a data record in the data log are determined by the elements of the structure declaration or array declaration of this data buffer. Each element of a structure or array corresponds to a column in a row in the data log.

HEADER parameter for the "DataLogCreate" instruction

Using the HEADER block parameter, you can assign a heading in the header row to each column in the data log.

RECORDS parameter for the "DataLogCreate" instruction

The RECORDS parameter specifies the maximum number of records that can be stored in a data log. If the specified maximum number of records in a data log is reached, the next write operation overwrites the oldest data record.

3.2.3 Instructions for data logging

Overview

The following table gives an overview of the instructions for data logging. You will find the data logging instructions in "STEP 7" in the "Instructions" task card, under "Extended instructions > Recipe and data logging > Data Logging".

Table 3- 1 Overview of the data logging instructions

Name of the instruction	Description
"DataLogCreate": Create data log	With the "DataLogCreate" instruction you create a data log. The data log is saved on the SIMATIC memory card in the "\datalogs" directory. You can use the data logging instructions to save process data. The amount of data that can be stored in a data log depends on the available storage space on the SIMATIC memory card.
"DataLogOpen": Open data log	With the "DataLogOpen" instruction, you open an existing data log on the SIMATIC memory card. A data log must be open before you can write new data records to it. The data log is automatically opened when the "DataLogCreate" and "DataLogNewFile" instructions are executed. A maximum of 10 data logs can be open at any one time. The data log to be opened can be selected using the ID or name of the data log. The maximum file size of data logs is 2 GB. A maximum number of 1000 data log files is possible with firmware version V2.0.
DataLogWrite": Write data log	With the "DataLogWrite" instruction you write a data record into an existing data log. Use the ID parameter to select the data log to which the data record is to be written. To write a new data record, the data log must be open.
DataLogClose": Close data log	With the "DataLogClose" instruction, you close an open data log. You select the data log using the ID parameter. At switch to STOP operating state, all open data logs are closed.
DataLogNewFile": Data log in new file	With the "DataLogNewFile" instruction you create a new data log with the same properties as an already existing data log. By creating a new data log, you prevent cyclic overwriting of existing data records. When the instruction is called it creates a new data log on the SIMATIC memory card using the name defined in the NAME parameter. You use the ID parameter to specify the ID of the old data log whose properties you want to apply to the new data log. The ID of the new data log is then output at the ID parameter.
DataLogClear": Clear data log	The "DataLogClear" instruction deletes all data records in an existing data log. The header of the data log is not deleted (see the description of the parameter Data structure of the data logs (Page 39)).
DataLogDelete": Delete data log	The "DataLogDelete" instruction is used to delete a data log from the SIMATIC memory card. Select the data log to be deleted using the NAME and ID parameters.

Note

Asynchronous instructions

Please note that the instructions listed in the table are asynchronous instructions.

In contrast to synchronous instructions, this means the execution of an asynchronous instruction can extend over multiple calls before execution is completed. The CPU processes asynchronous instructions in parallel with the cyclic user program.

A CPU can process several asynchronous instruction jobs in parallel. The CPU can process a maximum of 10 jobs of the instructions listed in the table in parallel.

For more information on asynchronous instructions, refer to the S7-1500, ET 200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792).

3.2.4 Example program for data logging

This example program shows the storing of 3 process values for counter state, temperature, and pressure in a data log.

The example shows the basic functioning of the instructions for data logs. The complete program logic is not shown.

Note

General use of data logs

- Data logs are automatically opened after execution of the "DataLogCreate" and "DataLogNewFile" instructions.
- Data logs are automatically closed at a change of CPU from RUN to STOP, or during a restart of the CPU.
- A data log must be open in order to be able to write data to the data log with the "DataLogWrite" instruction.
- A maximum of 10 data logs can be open at any one time, even when more than 10 data logs exist.

Tags of the data block

The following figure shows the tags of the "My_Datalog_Vars" data block. These tags are used by the "Data logging" instructions "DataLogCreate" and "DataLogNewFile". The "MyDataLogName" and "MyNEWDataLogName" tags are called in the NAME block parameter, and give the data logs a name. The "MyData" structure is called in the DATA block parameter and specifies the structure of the csv file. The three MyData tags temporarily store new values. The tag values at these DB addresses are transferred to a data log using the "DataLogWrite" instruction. The "MyDataLogHeaders" tag is called in the HEADER block parameter and specifies a header for the data log.

My_Datalog_Vars

	Name	Data type	Start value
1	Static		
2	MyNEWDataLogName	String	'MyNEWDataLog'
3	MyDataLogName	String	'MyDataLog'
4	MyDataLogID	DWord	0
5	MyDataLogHeaders	String	'Count,Temperature,Pressure'
6	MyData	Struct	
7	MyCount	Int	0
8	MyTemperature	Real	0.0
9	MyPressure	Real	0.0

Figure 3-4 Declaration table with the data block's tags

Network 1

A rising edge at REQ starts the creation of the data log.

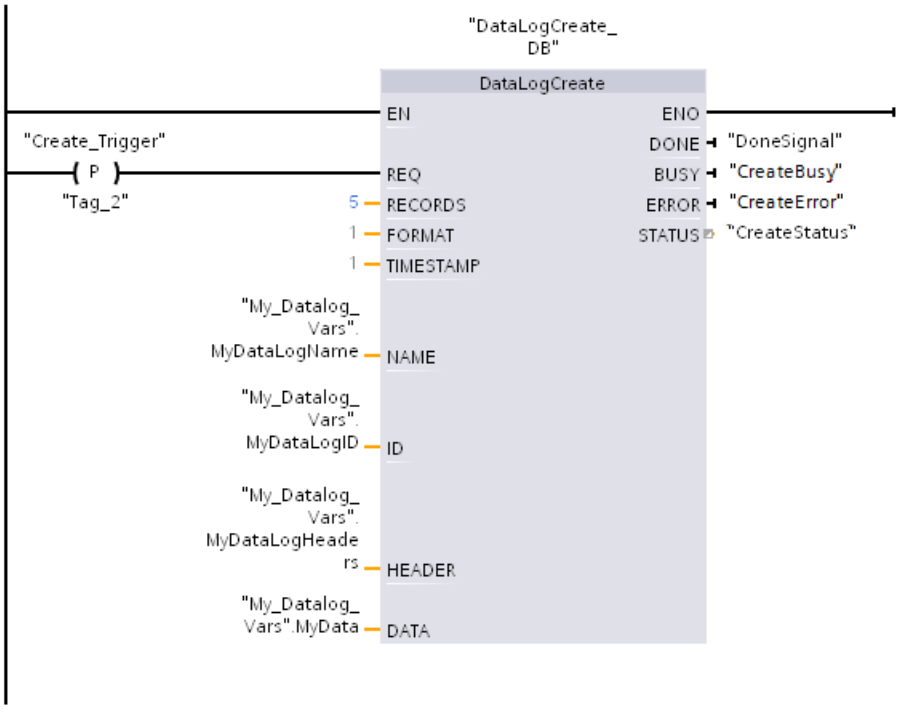


Figure 3-5 Network 1

Network 2

Detect the output DONE of "DataLogCreate", because after the execution of "DataLogCreate" it is only set to 1 for one cycle.

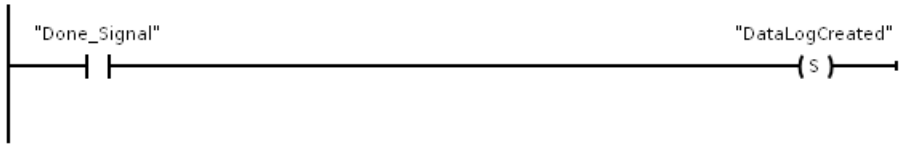


Figure 3-6 Network 2

Network 3

A rising edge triggers the point in time at which new process values are stored in the MyData structure.

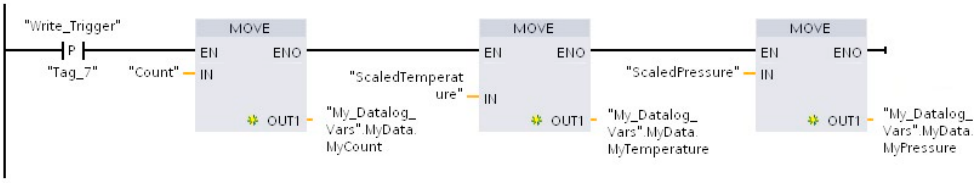


Figure 3-7 Network 3

Network 4

The state of the input EN is based on the point in time at which the execution of "DataLogCreate" was completed. One execution of "DataLogCreate" extends over multiple cycles, and must be completed before a write operation is executed. The rising edge at input REQ is the event that triggers an activated write operation.

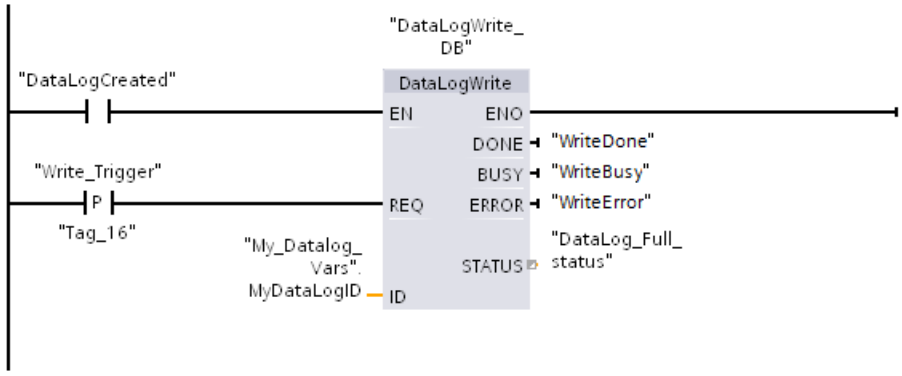


Figure 3-8 Network 4

Network 5

Close the data log after the last data record has been written. After execution of the "DataLogWrite" instruction, which writes the last data record, the STATUS output is set to "1".

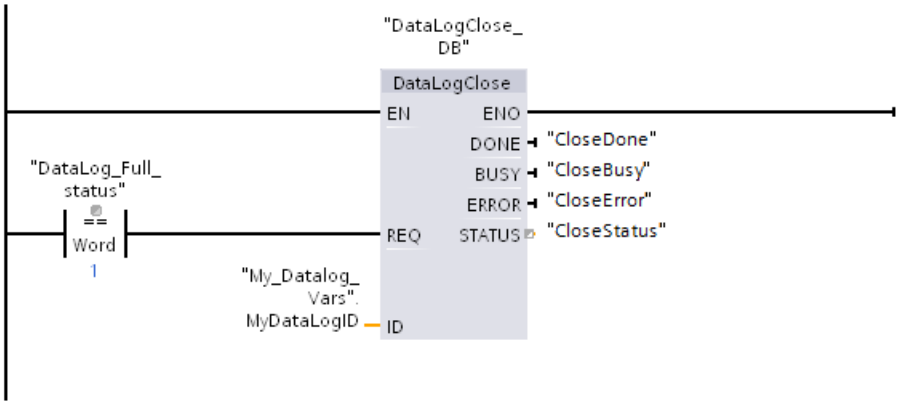


Figure 3-9 Network 5

Network 6

A rising edge at the input REQ of the instruction "DataLogOpen" simulates that the user presses a button on an HMI device, which opens a data log. If you open a data log in which all records are occupied by process data, then the next execution of the "DataLogWrite" instruction overwrites the oldest data record. You can however also preserve the old data log, and create a new data log instead. This is shown in network 7.

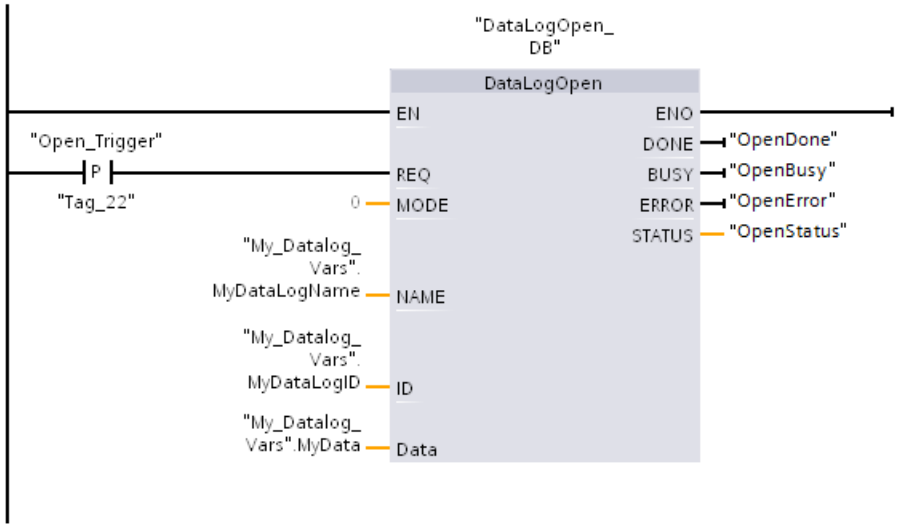


Figure 3-10 Network 6

Network 7

The ID parameter is an IN/OUT type. First you indicate the ID value of the existing data log whose structure you want to copy. After the "DataLogNewFile" instruction has been executed, a new and unique ID value for the new data log is written back into the address of the ID reference. The required detection DONE bit = TRUE is not shown. An example for the logic of the DONE bit can be found in networks 1, 2 and 4.

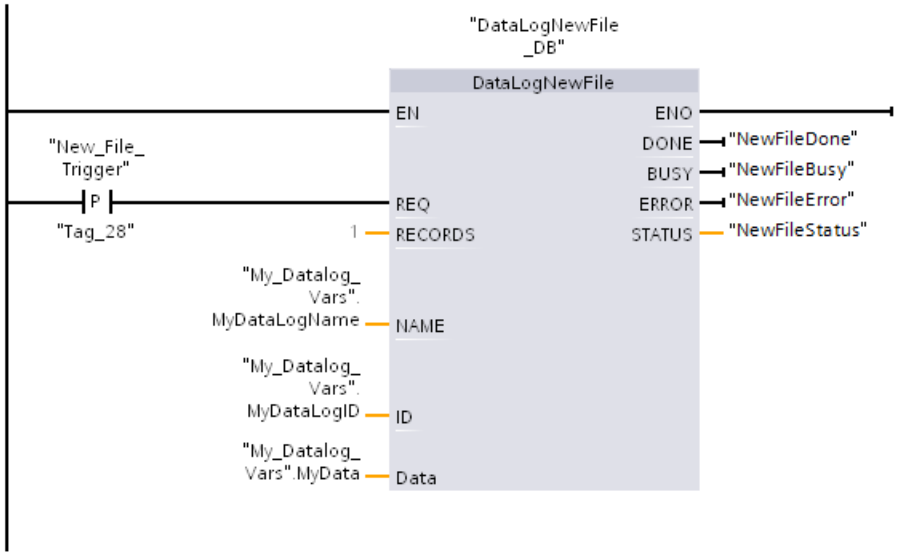


Figure 3-11 Network 7

The data logs created in the example program can be found on the CPU Web server's standard "File browser" Web page in the "\datalogs" folder.

The following figure shows the standard Web page of the Web server using the example of the CPU 1516-3 PN/DP.

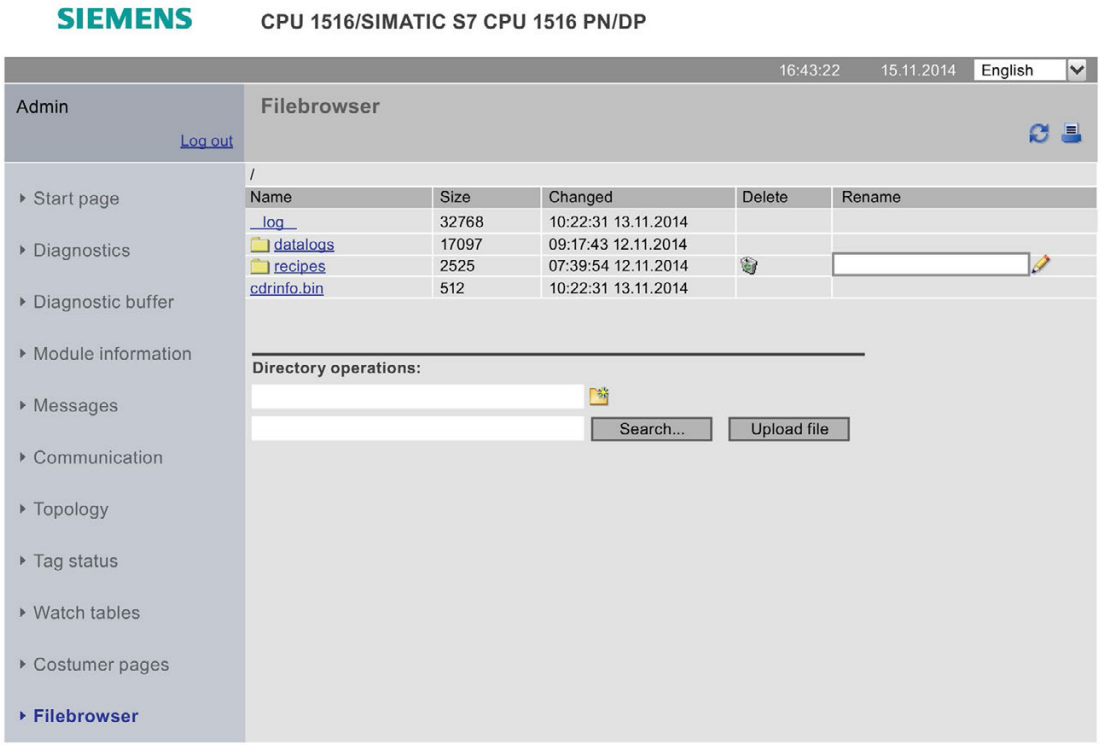


Figure 3-12 Standard "File browser" web page of the Web server

In the file browser, you can download the data logs created in the example program. It is not possible to delete or rename the data logs in the Web server. To delete a data log you either use the DataLogDelete instruction or you format the SIMATIC memory card.

On the DataLogs web page, you can have all the data logs that you created displayed. You can call and empty the relevant data log file by clicking the icon .

Note

Manipulation of the data logs using a card reader

Do not delete or change the data logs using a card reader on the PG/PC. You can copy the data logs on the SIMATIC memory card, however, using a card reader on the PG/PC.

The recommended medium for viewing, downloading (copying) and deleting data logs is the file browser of the Web server, however. Direct file access via the Windows Explorer carries a risk of the inadvertent deletion of or modification of data logs or system files. This may result, however, in files being damaged or the SIMATIC memory card becoming unusable.

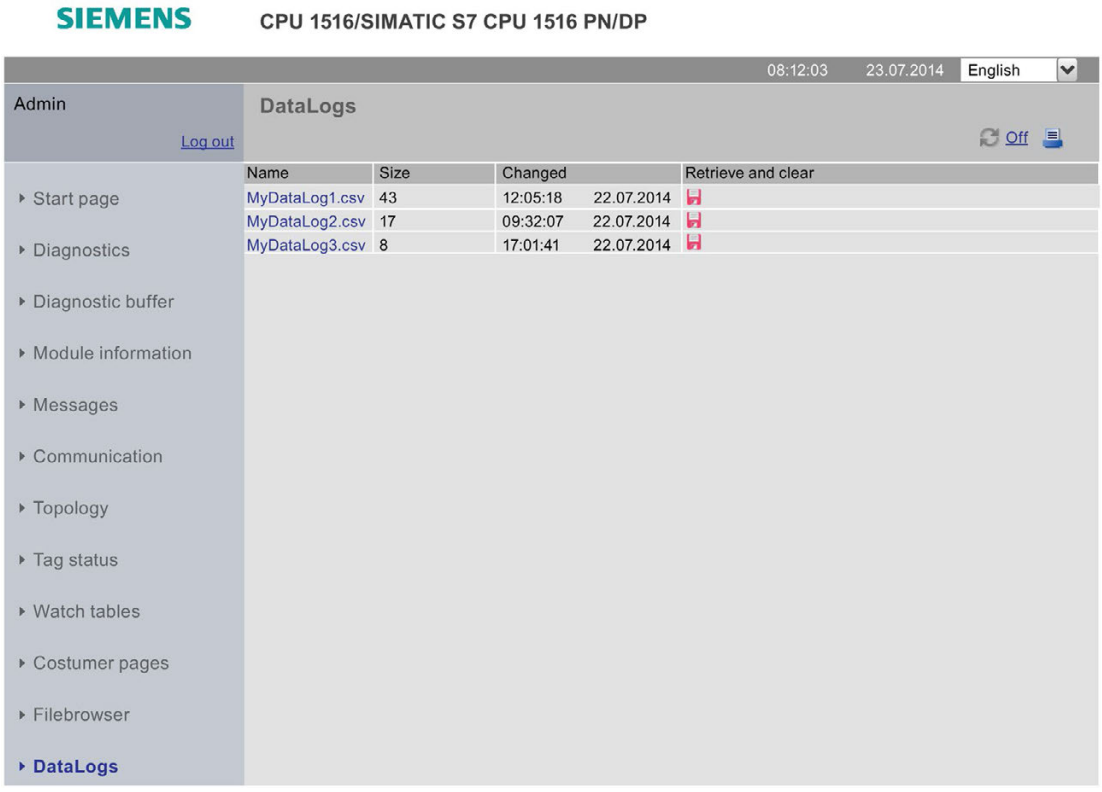
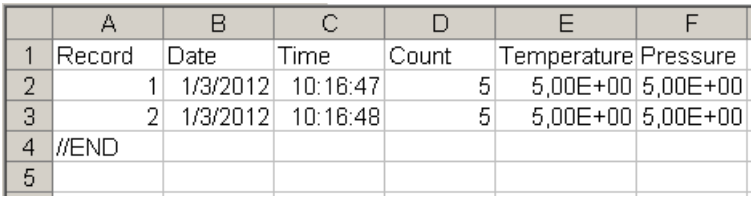
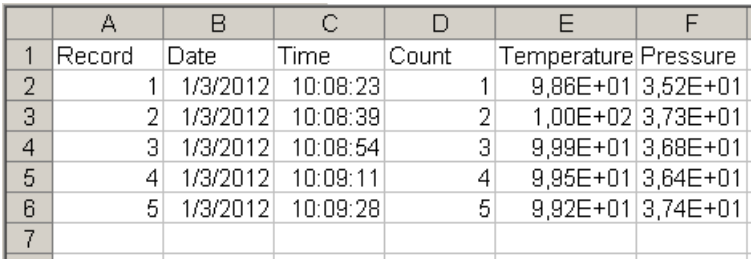
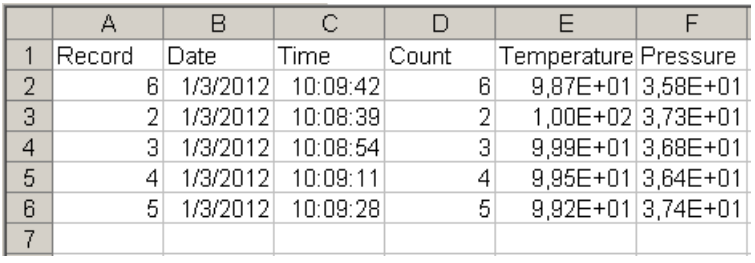


Figure 3-13 Example - Data logs in the folder "\datalogs" of the file browser

Table 3- 2 Downloaded examples of data logs displayed in Microsoft Excel

Two data records written in a data log which contains a maximum of five data records.	
Five data records written in a data log which contains a maximum of five data records.	
After another data record has been written, the 6th write operation overwrites the oldest data record (record 1) with data record 6. Another write operation overwrites data record 2 with data record 7, etc.	

3.2.5 Calculation of the data log size

The maximum memory size is allocated when you create the data log. In addition to the size required for all data records, you must take into consideration the memory required for a data log header (if used), a time stamp header (if used), a data record index header and the minimum block size for memory allocation.

The formula below represents a method to help you determine the estimated size of your data log. Make sure that you observe the rule for the maximum size.

Data bytes of the data log = ((data bytes in a data record + time stamp bytes + 12 bytes) * number of data records)

Header

Header bytes of the data log = header character bytes + 2 bytes

Header character bytes

- No data header and no time stamp = 7 bytes
- No data header and time stamp (with time stamp header) = 21 bytes
- Data header and no time stamp = Number of character bytes in all column headers including separating commas
- Data header and time stamp (with time stamp header) = Number of character bytes in all column headers including separating commas + 21 bytes

Data

Data bytes of the data log = ((data bytes in a data record + time stamp bytes + 12 bytes) * number of data records)

Data bytes in a data record

The DATA parameter of the "DataLogCreate" instruction points to a structure that assigns the number of data fields and the data type of each data field for a data log data record.

Multiply the number of the respective data type with the number of bytes required for this data type. Repeat the procedure for each data type in a data record and add all data bytes for the sum of all data elements in a data record.

Size of the individual data types

The data in data logs is saved as character bytes in csv format (comma separated values). The table below shows the number of bytes that are required to save each data type.

Data type	Bytes
Any	10
Bool	1
Byte	4
Char	1
Date	10
DInt	12
DTL	31
DWord	11
Int	7
LDT	31
LReal	25
Real	16
Sint	5
String	**Example 1:** MyString String[10] The maximum character string size is specified with 10 characters. • Text character + automatic filling with spaces = 10 bytes • Quotation marks at the start and end + comma character = 3 bytes 10 + 3 = 13 bytes total **Example 2:** Mystring2 String If no size is specified in square brackets, 254 bytes are assigned by default. • Text character + automatic filling with spaces = 254 bytes • Quotation marks at the start and end + comma character = 3 bytes 254 + 3 = 257 bytes total
Time	14
Tod	12
UDInt	12
UInt	7
USInt	5
WChar	1
Word	6

Number of data records in a data log

The RECORDS parameter of the "DataLogCreate" instruction specifies the maximum number of data records that can be stored in a data log.

Time stamp bytes in a data record

- No time stamp = 0 bytes
- Time stamp = 22 bytes

Example for size of a CSV file

The figure "Open CSV file" shows a CSV file opened in a spreadsheet program with five written data records in one data log.

The figure "Size of the header and the data records" shows the size of the header used in the CSV file and the size of the individual data records on the SIMATIC memory card.

The figure "Column size" shows the size of the respective columns depending on the data type used.

Open CSV file

	A	B	C	D	E	F
1						
2	Record	Date	UTC Time	Count	Temperature	Pressure
3	1	9/30/2010	20:26:56	1	9.86E+01	3.52E+01
4	2	9/30/2010	20:28:43	2	1.00E+02	3.73E+01
5	3	9/30/2010	20:29:03	3	9.99E+01	3.68E+01
6	4	9/30/2010	20:29:21	4	9.95E+01	3.64E+01
7	5	9/30/2010	20:30:19	5	9.92E+01	3.74E+01
8						

Size of the header and the data records

G
49 (42 characters + 5 commas + 2 line ending)
79 (72 + 5 commas + 2 line ending)
79 (72 + 5 commas + 2 line ending)
79 (72 + 5 commas + 2 line ending)
79 (72 + 5 commas + 2 line ending)
77 (72 + 5 commas)
Total = 442

Column size

9	Size of each column:					
10	index	Date	Time	int	real	real
11	11	10	12	7	16	16

As the example shows, each data record also consists of a separating comma (1 byte each) which must be taken into account when calculating the total size of the column.

Keep in mind that the calculation for the size of the header, the data records and the columns is not part of the opened CSV file. The size information was added manually to illustrate the elements that make up the size of a data log. You can display the total size of a data log you have created as CSV file in the Web server on the "DataLogs" website.

3.3 Service life of the SIMATIC memory card

Calculation of the theoretical service life of a SIMATIC memory serves as a decision aid for selecting which card you need for your automation task. The following examples only return a guide value, however. A precise calculation of the service life is not possible due to the fact that the description cannot cover all the theoretically possible scenarios.

Influences on the service life

You can influence the service life of SIMATIC memory cards by the following factors:

- Size of card
- Number and type of write operations

  The number of physical write operations to the memory blocks of the card results from the number and type of write operations from the application.

Structure of a SIMATIC memory card

The internal flash memory of the SIMATIC memory card is organized in memory blocks. A memory block is a memory area of a fixed size. A write operation always addresses entire memory blocks on the SIMATIC memory card. When a memory block has been written once it must be deleted before it can be written again. The number of delete/write operations per memory block is limited. The service life of the SIMATIC memory card is measured by the maximum number of supported delete or write operations per memory block.

In contrast to delete or write operations, read operations have a negligible impact on the service life. The influence of the read operations is reduced with progressive memory technology, so that the influence by read operations is not included in this calculation. A very high number of read operations can, however, influence the service life to a small extent.

Max. number of write/delete operations

In order to be able to carry out as many write operations as possible on the SIMATIC memory card, the internal controller of the memory card ensures that the available memory blocks are evenly used. Internal algorithms distribute the write accesses to the same logical memory area over changing physical memory areas in order to use the memory blocks evenly.

The following table shows the number of maximum possible write/delete operations based on the SIMATIC memory card. The number of maximum write/delete operations of the respective SIMATIC memory card is also available online in the technical specifications of the respective SIMATIC memory card.

Memory size of the SIMATIC memory card *	Article number	Max. number of write/delete operations per memory block
4 MB	6ES7954-8LCxx-0AA0	500 000
12 MB	6ES7954-8LExx-0AA0	500 000
24 MB	6ES7954-8LFxx-0AA0	500 000
256 MB	6ES7954-8LL02-0AA0	200 000
2 GB	6ES7954-8LP01-0AA0	100 000
2 GB	6ES7954-8LP02-0AA0	60 000
32 GB	6ES7954-8LT02-0AA0	50 000

* The memory size figures named in the table are theoretical values. The actual existing memory size in practice is below the theoretical value. The reason for this is that the internal controller of the card and the file system reserve part of the existing memory for internal memory management.

Note

Write or delete operations

Write or delete operations, particularly cyclic write/delete operations via the user program, to the SIMATIC memory card reduces its life.

Cyclic execution of the following instructions reduces the service life of the memory card depending on the number of write operations and data:

- "CREATE_DB" (with ATTRIB "Create DB in load memory")
- "DataLogWrite"
- "RecipeExport"
- "RecipeImport" (if target DB in load memory)
- "SET_TIMEZONE"

Please also note that, in addition to the cyclic write/delete operations, writing or deleting very large amounts of data also has a negative impact on the service life of the SIMATIC memory card.

Guaranteed data retention time

If you do not use your SIMATIC memory card for a longer period of time, there is the risk that data contained on the memory card may no longer be readable after a certain amount of time.

With proper storage, the guaranteed data retention time of a SIMATIC memory card is 10 years on delivery. With a number of ≤ 10% of the maximum write/delete operations, the data stored on the card has a retention time of 10 years.

Please note that increasing numbers of write/delete operations to the card reduces its data retention time. If 90% of the maximum write/delete operations is reached, the guaranteed data retention time is reduced to 1 year. If 100% of the maximum write/delete operations is reached, the retention time of the saved data can no longer be guaranteed.

Determining the current consumption status of a SIMATIC memory card in STEP 7

When you activate the "Aging of the SIMATIC memory card" option, you enter a threshold value as a percentage in the text box below. As soon as the service life of the SIMATIC memory card has reached the threshold value (e.g. 80%), the CPU outputs a diagnostics alarm.

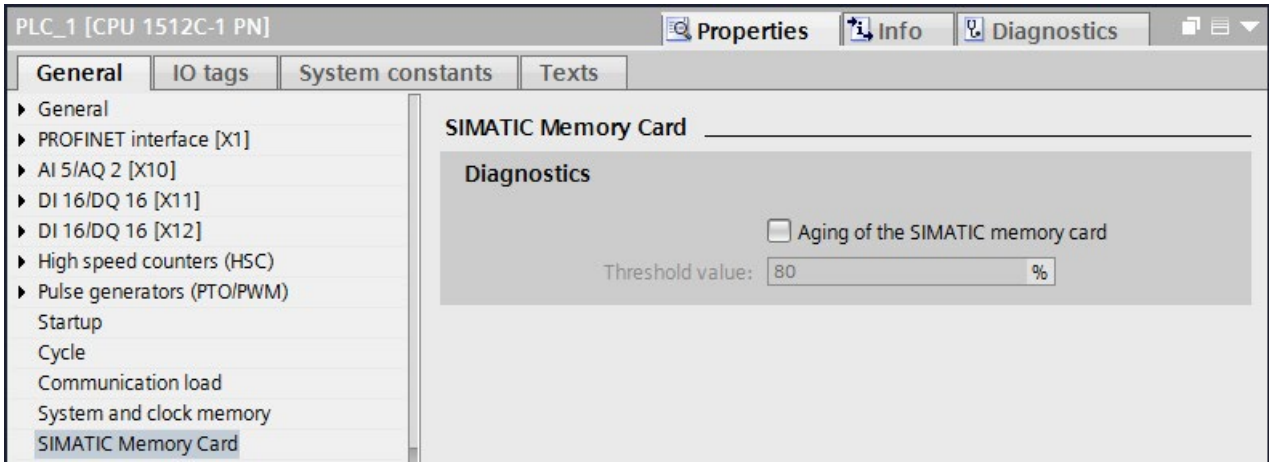


Figure 3-14 Enabled option "Aging of the SIMATIC memory card"

Calculation of the theoretical service life of a SIMATIC memory card

We will use the following example as a basis for calculation:

The user uses a new **256** MB memory card. In accordance with the table, this memory card type supports **200000** write operations. After parameter changes, the user would like to write **200** data blocks of **5** KB each to the SIMATIC memory card with a frequency of **50** times per day using the "RecipeExport" instruction.

Step 1: Calculating the write operations

First use the following formula to calculate the service life of the SIMATIC memory card:

$$\text{Write operations} = \frac{\text{Size of the memory card} \ * \ \text{Maximum number of write operations}}{\text{Number of written bytes}}$$

We first use the sizes from the example in the formula "Write operations" as a basis for calculating the service life:

- Size of the memory card: **256** MB = **268435456** byte
- Maximum number of write operations: **200000**
- Number of written bytes: **1024000** byte (**200** x **5** KB)

If we use the sizes from the example in the formula, we obtain the following result:

$$\text{Write operations} = \frac{268\,435\,456 \text{ byte} \ * \ 200\,000}{1\,024\,000 \text{ byte}} = 52\,428\,800 \text{ write operations}$$

Step 2: Calculating the service life

Use the following formula to calculate the service life in years:

$$\text{Service life} = \frac{\frac{\text{Write operations}}{\text{Write operations per day}}}{365 \text{ days}} : \text{Net-gross factor} = \text{years}$$

Note

Net-gross factor

With every write operation, internal data (metadata) is also written to the SIMATIC memory card. Due to this additional data, include the net-gross factor **10** when calculating the service life.

If we use the sizes from the example in the formula, we obtain the following result:

$$\text{Service life} = \frac{\frac{52\,428\,800}{50}}{365 \text{ days}} : 10 = 287 \text{ years}$$

Calculation with more frequent write accesses and a higher number of bytes written

If the frequency of write accesses and the number of bytes written per day increases, the service life of the SIMATIC memory card is reduced.

Using empirical values, the following table shows how the service life of a SIMATIC memory card with a size of 256 MB is reduced.

Write accesses per day	Number of bytes written per instruction	Service life of the SIMATIC memory card in years
50	1024000	287
100	1024000	143
400	1024000	36
400	2048000	18
400	4096000	9

The following table shows how the same values impact the service life of a SIMATIC memory card with a size of 2 GB (6ES7954-8LP01-0AA0).

Write accesses per day	Number of bytes written per instruction	Service life of the SIMATIC memory card in years
50	1024000	1149
100	1024000	575
400	1024000	144
400	2048000	72
400	4096000	36

The result shows that a high number of write accesses together with a high number of written bytes significantly shortens the service life of the SIMATIC memory card.

Reference

An alternative method for calculating the service life of a SIMATIC memory card is available in an FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482591).

Glossary

Bit memory

Bit memory is a memory area of the CPU that can be addressed from any code block (FC, FB, OB). You have read/write access to this memory area. The bit memory area can be used to store temporary results, for example.

Counters

In STEP 7, counting tasks are performed using counters. You can modify the contents of the "counter cells" using STEP 7 instructions (for example, count up/down).

Data block

Data blocks store information for the program. They can be defined either in such a way that all code blocks can access them (global data block) or that they are assigned to a specific FB or SFB (instance data block).

Data log

Data logs are csv files for the storage of tag values. The data logs are saved on the SIMATIC memory card in the "\datalogs" directory. Data records of tag values are written to a data log by means of instructions in the user program.

Global data block (DB)

Every function block, every function, and every organization block can read the data from a global data block, or write its own data to a global data block. This data is retained in the data block, even when the data block is exited.

Instance data block (IDB)

A data block is assigned to each call of a function block in the STEP 7 user program. The instance data block stores the values of input, output and in/out parameters, as well as local block data.

Local data

This memory area accepts the temporary local data of a block for the duration of processing.

Memory reset

During memory reset the CPU is set to the configured initial state.

Optimized block access

Data blocks with optimized access have no fixed structure. In the declaration, the data elements only receive a symbolic name, and no fixed address within the block. The elements are automatically arranged in the block's available memory area in such a way that its capacity is optimally exploited.

In these data blocks, you can only address tags symbolically. For example, you would access the "FillState" tag in the "Data" DB as follows:

"Data".FillState

Optimized access offers the following advantages:

- The data is structured and saved in a manner that is optimal for the CPU used. This allows you to increase CPU performance.
- Access errors, e.g. from the HMI, are not possible.
- You can selectively define individual tags as retentive.

Process images (I/O)

The CPU transfers the values from the input and output modules in this memory area. At the start of the cyclic program, the signal states of the input modules are transmitted to the process image input. At the end of the cyclic program, the process image output is transmitted as signal state to the output modules.

Reset to factory setting

Resetting to factory settings restores the CPU settings to the delivery state.

Restart

Restart occurs at the transitions from STOP to STARTUP, and POWER ON to STARTUP. Before the cyclic program processing, the CPU first processes the startup OB or OBs.

Restart has the following effects on the memory areas of the CPU:

- The process images are deleted.
- The retentive tags of data blocks retain the values saved in retentive memory.
- All retentive bit memories, timers, and counters retain the values saved in retentive memory.
- All non-retentive user data is initialized:
  - Data blocks receive their start value
  - Bit memories, timers, and counters with "0"

SIMATIC memory card

Memory for the user program for programmable modules and communication processors. You can also use the SIMATIC memory card for changing user software and user data.

Standard access

Data blocks with standard access have a fixed structure. In the declaration, the data elements contain both a symbolic name and a fixed address within the block. The address is displayed in the "Offset" column.

In these data blocks, you can address tags both symbolically and absolutely:

"Data".FillState

DB1.DBW2

Timers

In STEP 7, programmed time processes are performed using timers. The content of timer cells is automatically updated by the operating system, asynchronously to the user program. STEP 7 instructions are used to define the precise function of the timer cell (for example, on-delay time) and to trigger its execution (for example, start).

User program

The user program contains all instructions, declarations and data for signal processing required to control a plant or a process. The user program is assigned to a programmable module (for example, CPU, CM) and can be structured in smaller units.

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SIEMENS

SIMATIC

S7-1500, ET 200SP, ET 200pro

Web server

Function manual

Edition 09/2016

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S7-1500, ET 200SP, ET 200pro Web server

Function Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation supports you in the operation of the Web server.

The Web server offers, among other things, web page access to diagnostic data and to process data of the CPU.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge in the field of automation technology
- Knowledge of the industrial automation system SIMATIC
- Experience of working with Windows-based computers
- Knowledge about how to use STEP 7 (TIA Portal)

Scope of the documentation

This documentation is valid for CPUs as of firmware version V2.0 and contains illustrations of the Web server user interface. The images used are identical for all CPUs of the S7-1500 automation system and distributed I/O system ET 200SP and the CPU 1516pro-2 PN of distributed I/O system ET 200pro.

The displayed illustrations can differ from the interface of the Web server in some details, e.g. depending on the browser used.

What's new compared to the previous version of the function manual (12/2014 edition)

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Handling of certificate modified	You protect the Web server against tapping or distortion of the communication through access via the secure transmission protocol "HTTPS" including a special Web server certificate.	Section Configuring the Web server (Page 19)
	Four additional languages for the Web server interface	You can set the Web server interface to the following languages: • Korean • Russian • Turkish • Portuguese (Brazil)	Section Start page with general CPU information (Page 32)
	Assignment of different project languages extended	You can assign up to three different project languages for comments, alarm texts and diagnostic information to the user interface languages of the Web server.	Section Language settings (Page 29)
	"Start page" web page extended	The display of the TIA project name immediately indicates whether the desired project is selected.	Section Start page with general CPU information (Page 32)
	"Diagnostics" web page extended by one tab: • "Program protection" • "Runtime information" • "Fail-safe" (with an F-CPU)	Here you can find information about: • Know-how protection or copy protection of the PLC program • Program/communication load and cycle time • F-collective signatures, cycle times and runtimes of the F-runtime group(s)	Section Diagnostics (Page 36)
	"Alarms" web page extended	You can acknowledge alarms of the CPU via the Web server.	Section Alarms (Page 49)
	"Tag status" and "Watch tables" web pages extended	You can change the value of tags and write them to the CPU, also using the absolute address.	Section Tag status (Page 64) Section Watch tables (Page 66)
	New web page "Online backup"	You can back up and restore the CPU configuration to/from the SIMATIC memory card via the Web server.	Section Online backup (Page 99)
	New "Motion Control diagnostics" web page	You can monitor statuses, errors, technology alarms and the current values of configured technology objects (TOs) with the Web server without STEP 7.	Section Motion Control diagnostics (Page 103)
	New web page "Online backup"	You can read, view and save trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance without STEP 7.	Section Trace (Page 110)

What's new?		What are the customer benefits?	Where can I find the information?
Changed contents	Scope of the function manual expanded to include CPUs of the distributed I/O system ET 200SP and the CPU 1516pro-2 PN	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in CPUs in other designs (ET 200SP) and in the CPU 1516pro-2 PN (degree of protection IP65, IP66 and IP67).	Manual CPU 1510SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/90157130) Manual CPU 1512SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/90157013) Operating instructions CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)
	Web page "Watch tables": Note added on the maximum configuration limits.		Section Watch tables (Page 66)
	Web page "User pages": Note added on the maximum size of the HTML pages.		Section User pages (Page 68)

Conventions

In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

See also

SIMATIC Portal (http://www.siemens.com/simatic-tech-doku-portal)

Catalog (http://mall.automation.siemens.com)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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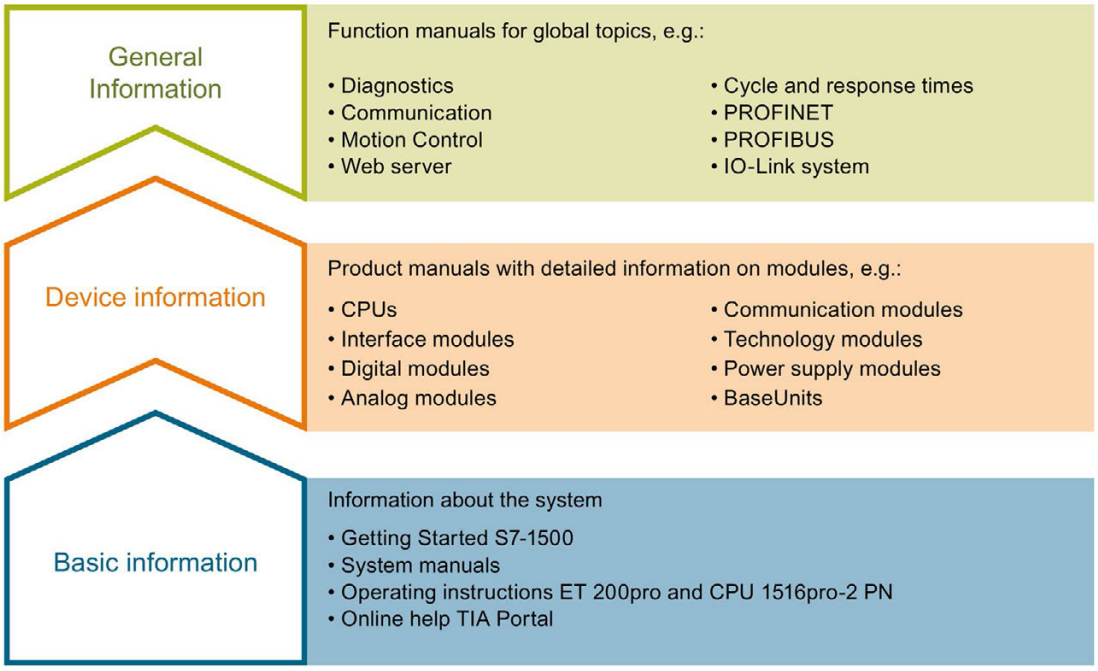
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

General information 2

2.1 Properties of the Web server

Benefits of the Web server

The Web server lets you monitor and administer the CPU through authorized users by means of a network. Evaluations, diagnostics, and modifications are thus possible over long distances. Monitoring and evaluation is possible without STEP 7; all you need is a web browser. Make sure that you take appropriate measures (e.g., limiting network access, using firewalls) to protect the CPU from being compromised.

Activating the Web server

The Web server is deactivated in the delivery state of the CPU. This means that you must load a project in which the Web server is activated to enable access using the Web browser.

Security functions

The Web server provides the following security functions:

- Access via the secure transmission protocol "HTTPS" using the CA-signed Web server certificate
- User authorizations you can configure by means of user list
- Activation for specific interfaces

Web browser

You need a web browser to access the HTML pages of the CPU.

The following web browsers have been tested for communication with the CPU. Other web browsers may also work, especially newer versions. However, if problems occur with web browsers not mentioned here that cannot be rectified, use one of the following tested web browsers:

- Internet Explorer (Version 11)
- Microsoft Edge (Windows 10)
- Mozilla Firefox (Version 42 to 47)
- Google Chrome (version 46, 47)
- Mobile Safari and Chrome for iOS (iOS 9)
- Android Browser and Android Chrome (Jelly Bean 4.3, KitKat 4.4, Lollipop 5.0 … 5.1.x, Marshmallow 6.0 operating system)

Note

If you are using Internet Explorer, disable "Compatibility view" in the settings ("Options" menu).

Note

For access to display devices with low screen resolution, we recommend the use of basic websites, see section Basic websites (Page 121).

Note

Older versions of the web browsers mentioned which previously supported access to the HTML pages of the CPU continue to do so. However, these older versions do not support the new functions and HTML pages described in this edition.

Note

Two reserved communication connections are available to the Web server for communication with the CPU.

Depending on the web browser used, different numbers of connections to the CPU are established. If more connections are available, more communication connections will be established.

If no more connections are available, display or functional problems may occur, because the Web server will reject all other communication connections apart from the two that are reserved.
For this reason, the web pages may not load fully.

Note

If you access the Web server of the CPU using a communication processor (CP), ensure that the cache (temporary Internet files) is enabled in your browser. Choose the "Automatically" option in the cache settings of your browser.

If the cache is disabled or if a setting other than "Automatically" is made in the cache settings of your browser, this may result in slow access times and incomplete display.

Reading out data

With the Web server, you can read out the following data from the CPU and, in some cases, modify and write back the data to the CPU:

- Start page with general CPU information (Page 32)
- Information on Diagnostics (Page 36)
  - Identification
  - Program protection
  - Memory
  - Runtime information
  - Fail-safe (with an F CPU)
- Contents of the diagnostics buffer (Page 40)
- Module information (Page 41)
- Firmware update (Page 47)
- Alarms (Page 49)
- Information on Communication (Page 50)
  - Important interface parameters
  - Port statistics
  - Display of the communication resources
  - Display of the communication connections
- PROFINET Topology (Page 55)
  - Graphical view (set and actual topology)
  - Table view (actual topology)
  - Status overview
- Tag status (Page 64)
- Watch tables (Page 66)
- User pages (Page 68)
- Filebrowser (Page 97)
- DataLogs (Page 98)
- Online backup and restoration of the configuration (Page 99)
- Diagnostic information for technology objects (Page 103)
- Evaluation of trace recordings (Page 110)
- Reading out service data (Page 120)
- Basic websites (Page 121)

On the following pages, you will find more detailed descriptions of the HTML pages.

Web access to the CPU via PG/PC, HMI devices and mobile terminal devices

Proceed as follows to access the Web server:

1. Use STEP 7 to download a project in which the Web server is enabled to the CPU.
2. Connect the display device (PG/PC, HMI, mobile terminal device) with the CPU or a communication module using a PROFINET interface.
   If you are working with WLAN, activate the WLAN on the display device and establish a connection to the access point (e.g. SCALANCE W788-1RR or SCALANCE W784-1), which is in turn connected to the CPU.
3. Open the web browser on the display device.
4. Enter the IP address of the interface of the CPU which is connected to the client in the "Address" field of the web browser in the following format: http://a.b.c.d or https://a.b.c.d (sample input: http://192.168.3.141).
   The CPU intro page opens. From the intro page you can navigate to additional information.

Additional information on access using the secure transmission protocol "HTTPS" is available in the section Configuring the Web server (Page 19) under "Permit access only with HTTPS".

Additional information

Using a smartphone, you can access the Web server of the CPU either via WLAN or access to the CPU via the SIMATIC S7 app (using Web server functionality). You can find additional information in the FAQ entry ID 103473392 on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/103473392) Internet page.

Note: The Web server must also be activated for access to the CPU via the SIMATIC S7 app.

The SIMATIC S7 app offers you additional functions. You can find a detailed application example with further documentation and example projects on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/84133612) Internet page.

2.2 Configuring the Web server

To use the full range of functions offered by the Web server, you need to make the settings in STEP 7 listed below:

Procedure

You have opened the properties dialog of the CPU in the STEP 7 project view.

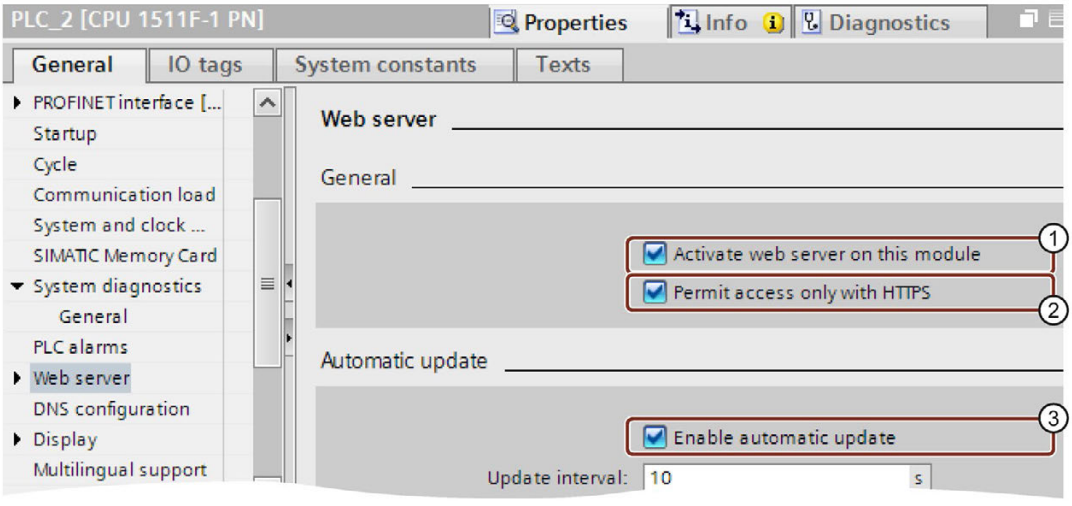


Figure 2-1 Web server settings in STEP 7

① Activate Web server

In the default setting of a configured CPU, the Web server is disabled. Proceed as follows to enable the Web server:

1. Open the "Devices & Networks" view with a double-click in the STEP 7 project tree.
2. Select the required CPU in the device view, network view or topology view.
3. Navigate to the "Web server" area in the Inspector window properties, "General" tab.
4. Select the "Activate web server on this module" check box.
   The following note is output:

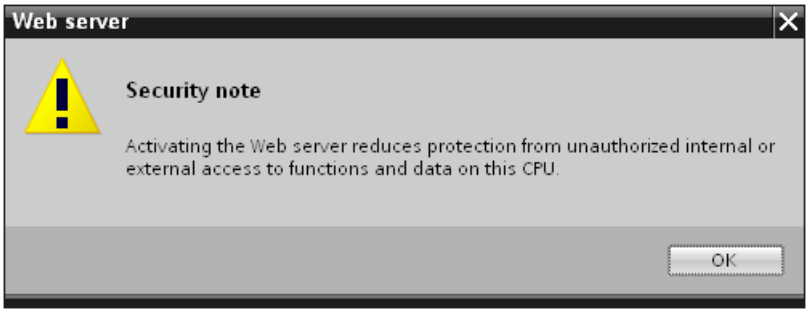


Figure 2-2 Security note upon activation of the Web server in STEP 7

Note

When projects from deliveries are applied in which the Web server was already activated and configured on the module, this security note is not shown.

Creating and assigning a Web server certificate

The activation of the Web server using the secure transmission protocol "HTTPS" requires a valid Web server certificate.

With SIMATIC S7-1500 CPUs as of firmware V2.0, you have to create the certificate for the Web server of the CPU with STEP 7 yourself and assign it to the Web server in the CPU properties. When the hardware configuration is downloaded to the CPU, this certificate is also automatically downloaded. STEP 7 itself has a Certification Authority (CA) certificate, with which the device certificate (end-entity certificate) of the Web server is signed.

Note

If you update the firmware of a SIMATIC S7-1500 CPU or ET 200SP with firmware version < V2.0 to firmware version ≥ V2.0, a valid server certificate is automatically generated and used. The same applies to the replacement parts scenario in which a newer CPU replaces a CPU with firmware version < V2.0.

You can create different Web server certificates:

- If you use the certificate manager in the global security settings, the certificate authority of the project (CA certificate) signs the device certificate of the Web server. During loading, the CA certificate of the project is automatically loaded as well.
- If you do not use the certificate manager in the global security settings, STEP 7 generates the device certificate as a self-signed certificate.

NOTICE
Utilizing the full functionality of the Web server A valid CA-signed Web server certificate in the CPU is a requirement for: • User management with password-protected users • The use of safety-related functions (online backup and restore of the CPU configuration, saving and downloading diagnostic information in csv files) To use the full functionality of the Web server, we therefore recommend that you use the Certificate Manager to create a CA-signed server certificate in the global security settings and assign it to the CPU.

Creating a self-signed server certificate

To create a self-signed Web server certificate, follow these steps:

1. in the Inspector window Properties of the CPU, "General" tab, navigate to the "Web server > Security" area.
2. Click the "Add" button in the drop-down list to select a certificate.
   The "Create a new certificate" dialog opens.
3. Select the "Self-signed" check box in the subsequent dialog.

4. Enter the parameters for the new certificate or confirm the default settings.
   - Select "Web server" in the "Usage" box.
   - Enter the IP address(es) of the interface(s) or the domain name of the configured CPU in the "Subject Alternative Name" field.
5. Click "OK" to confirm.
6. Compile and load the configuration into the CPU.
   The device certificate of the Web server is a component of the configuration.

Creating and assigning a CA-signed Web server certificate

To create a CA-signed Web server certificate, follow these steps:

1. In the Inspector window Properties of the CPU, "General" tab, navigate to the "Protection & Security > Certificate Manager" area and select the "Use global security settings for certificate manager" option.
   The "Global security settings" appear in the project tree.

   Note

   To edit the Certificate Manager in the global security settings, you require the "Configure security" configuration permission.

2. Log on as a user in the project tree in the "Global security settings > User logon" area.
   The "Administrator" role is the default for the first logon for a new project.
3. in the Inspector window Properties of the CPU, "General" tab, navigate to the "Web server > Security" area.
4. Click the "Add" button in the drop-down list to select a certificate.
   The "Create a new certificate" dialog opens.
5. In the following dialog, select the "Signed by certificate authority" check box and select the certificate authority from the drop-down list.
6. Enter the parameters for the new certificate or confirm the default settings.
   - Select "Web server" in the "Usage" box.
   - Enter the IP address(es) of the interface(s) or the domain name of the configured CPU in the "Subject Alternative Name" field.
7. Click "OK" to confirm.
8. Compile and load the configuration in the CPU.
   The device certificate of the Web server and the CA certificate are components of the configuration.

NOTICE
Addressing the Web server of the CPU via domain names If you enter the IP address(es) of the interface(s) of the configured CPU in the "Subject Alternative Name" field, the generated certificate may not be accepted by all Internet browsers. You also need to create and load a new server certificate (end-entity certificate) every time you change the IP address of an Ethernet interface of the CPU, since the identity of the CPU changes along with the IP address. You can avoid this problem by addressing the Web server of the CPU using domain names instead of IP address(es), e.g. "myconveyer-cpu.room13.myfactory.com". For this purpose, you have to manage the domain names of your CPU via a DNS server.

Additional information

Detailed information on local self-signed certificates and global CA certificates, on the "Public Key Infrastructure" (PKI) and on certificate management can be found in the Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925) and in the online help for STEP 7, keyword "Secure communication".

② Permit access only with HTTPS

Note: The activation of the Web server using the secure transmission protocol "HTTPS" requires a valid Web server certificate in the CPU. See "Creating and assigning a Web server certificate" in the section above.

The web pages are transmitted by default via non-secure connection and are not protected from attacks by third parties. If you always want to transmit web pages to the browser in secure form, enable the "Permit access only with HTTPS" option in the CPU properties. Note that the URL of the CPU starts with "https://" in this case.

For error-free HTTPS access to the CPU, the following conditions must be met:

- The current date/time must be set in the CPU.

  Note

  When using secure communication (e.g. HTTPS), make sure that the corresponding modules have the current time of day and the current date. Otherwise, the modules evaluate the used certificates as invalid and the secure connection will not be established.

- The IP address of the CPU must be set.

- A valid server certificate offered by the CPU is installed in the Web browser.

NOTICE
Safety-related functions only possible with CA-signed Web server certificate Online backup and restore of the CPU configuration, see section Online backup (Page 99), as well as saving and downloading diagnostic information to csv files are only possible with a CA-signed Web server certificate. A valid CA-signed Web server certificate in the CPU is also required for user administration with password-protected users. To use the full functionality of the Web server, we therefore recommend that you use the Certificate Manager to create a CA-signed server certificate in the global security settings and assign it to the CPU.

If no CA-signed Web server certificate is installed, a warning is output recommending that you do not use the page. To view the page, you may need to "Add an exception", depending on the Web browser used.

A valid CA certificate is available for download from the "Intro" web page under "Download certificate".

You can find instructions for installing the certificate in the help system of your Web browser and in the FAQ with the entry ID 103528224 at the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/103528224) website.

Note

To protect against manipulation from the outside, download the certificate only in an environment that is guaranteed not to be compromised. Installation of the CA certificate has to be carried out once for each display device you wish to use.

Access protection

The certificate establishes an encrypted connection that prevents tapping or distortion of the communication but does not provide access protection. This means you have to protect your CPU from unauthorized access with the corresponding configuration in the user management.

You can find additional information on access protection in the online help for STEP 7, keyword: "Protection".

③ Automatic update

Automatic updating is activated in the default setting of a configured CPU.

The following web pages are updated automatically:

- Start page
- Diagnostics (memory, runtime information, fail-safe)
- Diagnostics buffer
- Module information
- Alarms
- Communication
- Topology
- Tag status
- Watch tables
- Filebrowser
- DataLogs
- Motion Control diagnostics
- Trace

Note

The preset activation interval is 10 seconds.
Larger amounts of data or several HTTP-/HTTPS connections increase the update time.

Setting the language for the Web

In total, you can assign up to three different project languages to the user interface languages of the Web server.

In STEP 7, activate the project languages you wish to use and then assign one of the activated project languages to each interface language of the Web server.

You can find additional information about the language settings and a description of how to assign a project language to the interface languages in the section Language settings (Page 29).

Amending user management

Note: A valid CA-signed Web server certificate in the CPU along with a secure HTTPS connection are required for user administration with password-protected users. See "Creating and assigning a Web server certificate" and "Permit access only with HTTPS" in this section.

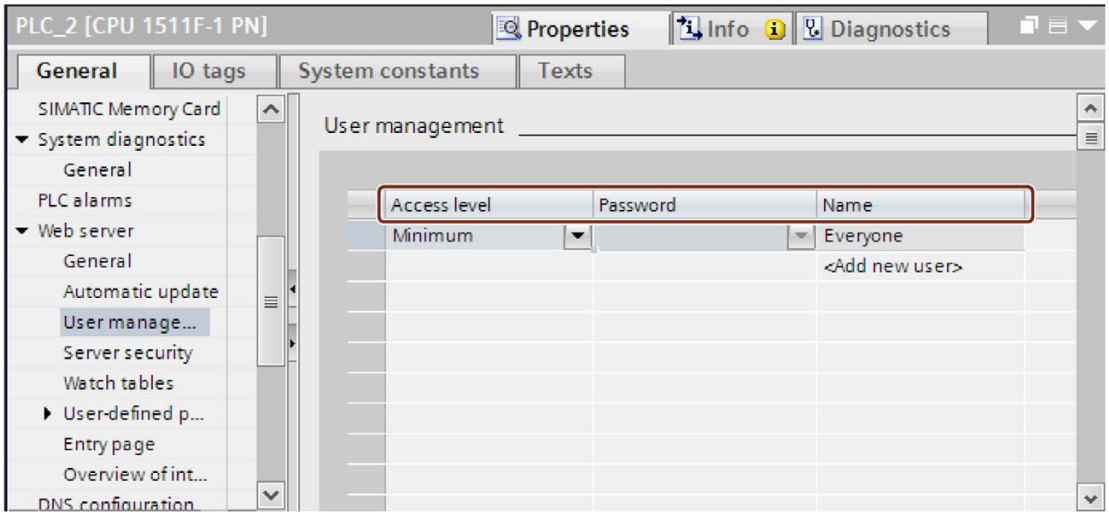


Figure 2-3 User management in STEP 7

In STEP 7, you can manage the user list in the "Web server > User management" area.

The user list provides the following options:

- Create users
- Specify access permissions
- Assign passwords

Users only have access to the options that are permanently linked to the access rights.

You can assign different user rights depending on the used CPU and firmware.

The available user rights can be available for selection as follows in STEP 7:

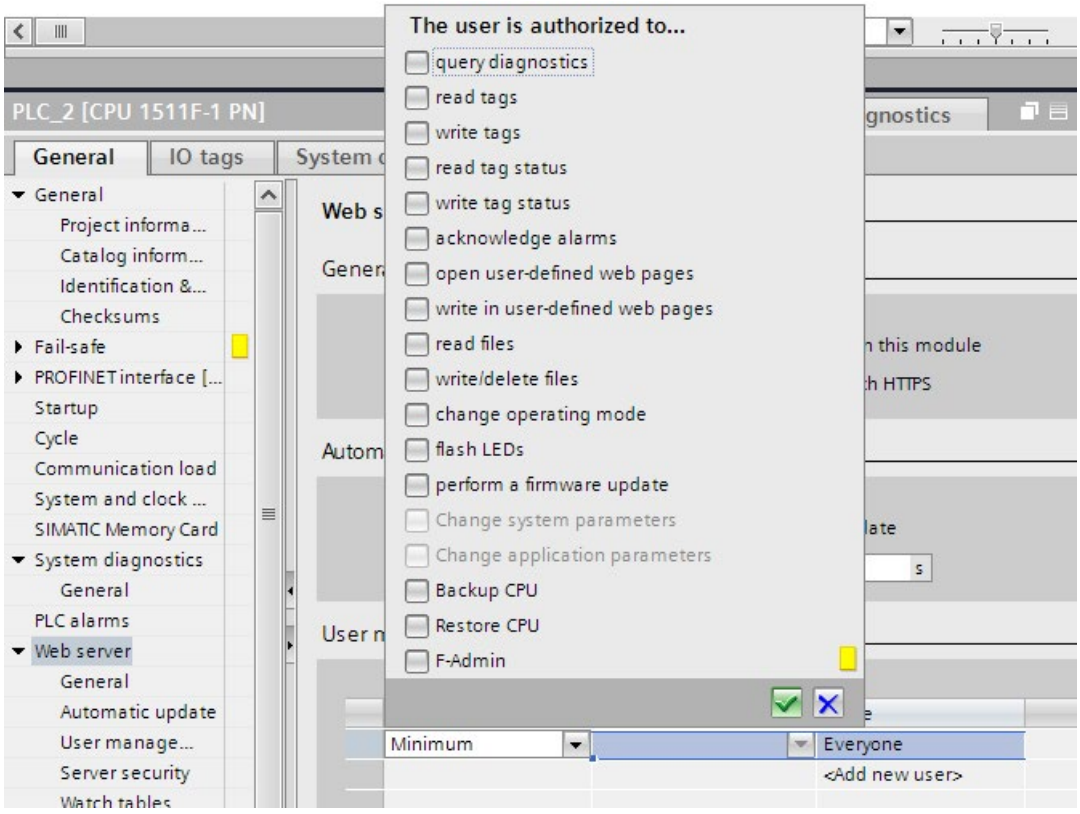


Figure 2-4 Assignment of user rights in STEP 7

If you are not logged in, you automatically access the Web server as the user "Everybody".

It does not matter in this case whether you have configured additional users.

User "Everybody"

A user with the name "Everybody" is preset in the user list; this user has minimum access rights. These are read-only access to the intro page and start page. The user "Everybody" is defined without a password. However, you can assign all access authorizations available in STEP 7 to this user.

You can create a maximum of 20 users and a user "Everybody".

Because the user "Everybody" is defined in STEP 7 without assignment of a password, be careful of the access authorizations that you assign to this user.
Certain authorizations, such as the possibility of changing the operating mode, could represent a security risk.
For the assignment of security-relevant authorizations, we recommend that you create a user with password protection in STEP 7.

WARNING

With an F-CPU, do **not** assign the access authorization "F-Admin" to the user "Everybody".

Make sure that you observe the warnings relating to this in the section "Restoring a backup of the safety program to an S7-300/1500 F-CPU" in the manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

Passwords should always be more than 8 characters in length and contain uppercase and lowercase characters as well as special characters and numbers (?!+%$1234...). Computer keyboard character strings and words from the dictionary are unsuitable. Change the password regularly.

Note

When assigning rights, note that read or write access to the watch tables and tag status is retained even if you have disabled the "Accessible from HMI/OPC UA" attribute in the PLC tag table when configuring the data block in STEP 7.

User pages

In the "User pages" area you can download your own web pages to the CPU and make your own web applications available via the web browser.

You can find additional information in section User pages (Page 68).

Activation of the Web server for specific interfaces

In the area "Overview of interfaces", you have the option to enable or disable access to the Web server.

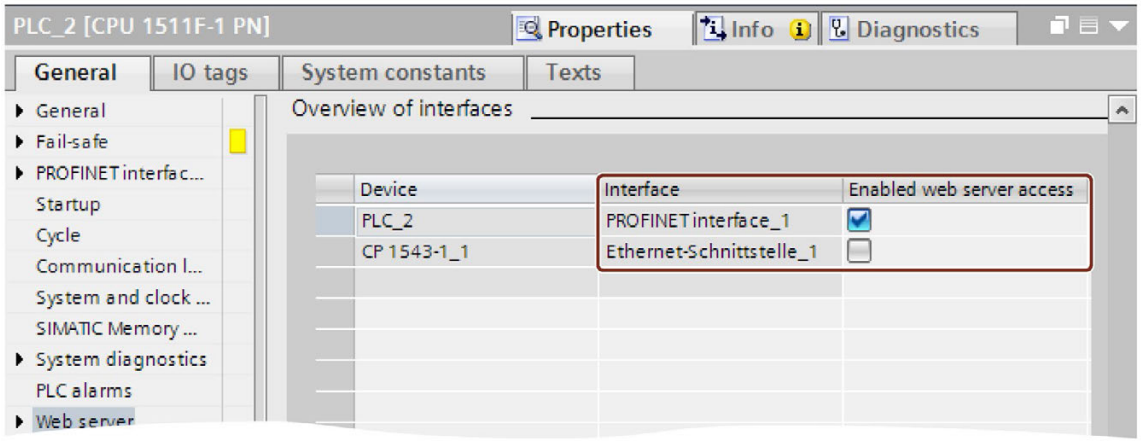


Figure 2-5 Activation of access to the Web server via the interfaces

2.3 Language settings

Introduction

The Web server provides the user interface in the following languages:

- German (Germany)
- English (U.S.)
- French (France)
- Italian (Italy)
- Spanish (traditional sort)
- Japanese
- Chinese (Simplified)
- Korean
- Russian
- Turkish
- Portuguese (Brazil)

Requirements for the availability of the East Asian languages

The following requirements must be met for the East Asian languages:

- The corresponding support package for East Asian languages is installed on the display device (e.g., PC).
  For this purpose, activate the "Install files for East Asian languages" option in the "Regional and Language Options > Languages" tab of the Windows Control Panel.
- STEP 7 for East Asian languages is installed on the programming device used to configure the CPU.

Note

East Asian languages are not supported for SIMATIC HMI devices with Windows CE operating system.

Requirements for multilingual output of text

To ensure that the Web server displays alarms, comments and diagnostic information correctly in the various project languages, you have to assign a project language of the Web server to each required interface language in STEP 7.

Note

The project languages of the STEP 7 project you want to assign must be activated and the corresponding texts (translations) must be available in the project. The project languages selection is available in the project tree under "Languages & Resources".

Setting the language for the Web

Once you have activated the Web server on your module, assign a project language of the STEP 7 project from the drop-down list to each interface language.

1. Navigate to the "Multilingual support" area in the Inspector window Properties of the CPU, "General" tab.
2. Assign a project language from the drop-down list to each interface language of the Web server.

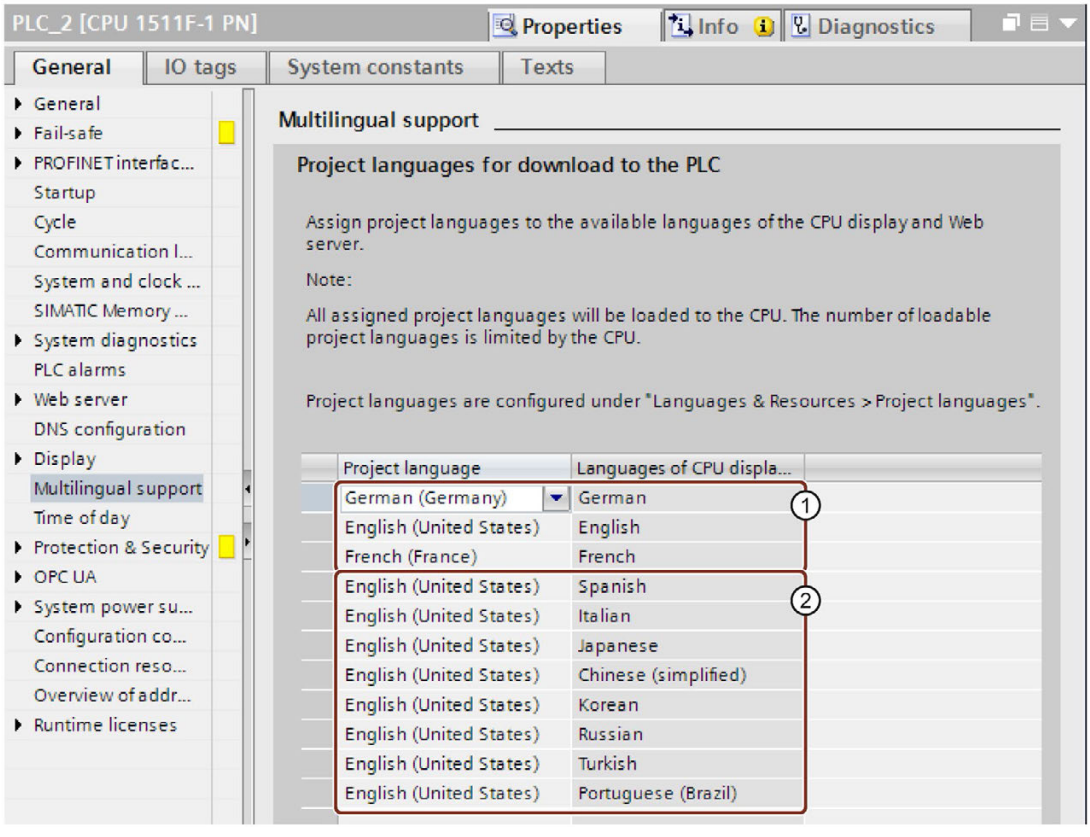


Figure 2-6 Language settings for the Web server in STEP 7

You can also assign interface languages the same project language, for example:

- ① Project language German for user interface language German, English (US) for English, French for French.
- ② Project language English (US) for all other available interface languages of the Web server.

In total, you can assign up to three different project languages of the STEP 7 project to the user interface languages of the Web server.

Reference

You can find additional information on how to set the project language in STEP 7 in the online help for STEP 7, keyword: "Selecting project languages".

See also

Configuring the Web server (Page 19)

2.4 Updating and saving information

Updating the screen content

Automatic updating is activated in the default setting. The preset update time is 10 s.

You update the web pages manually with the <F5> function key.

Disabling automatic updating for an individual web page

Click Off to temporarily deactivate automatic updating for a web page.
Note that the deactivation affects only the currently visited web page. Automatic updating is activated again when you change to a different web page.

You reactivate automatic updating by clicking On.

Note

If the load on the CPU is very high during operation, for example, due to a large number of PROFINET interrupts or extensive communication jobs, the updating of web pages may be significantly delayed for the duration of this high CPU load.

Printing web pages

The Web server offers you a print preview on most web pages. Click the symbol to open it.

Created printouts always contain the current information in the CPU. This means that it is possible that the information in the print preview is more up-to-date than the information in the standard view.

Web pages

3

3.1 Start page with general CPU information

Connecting to the Web server

Establish a connection to the Web server by entering the IP address of the interface of the configured CPU which is connected to the client in the address bar of the web browser, for example, http://192.168.3.141 or https://192.168.3.141. The connection is set up and the "Intro" page opens.

The examples in the next section provide information about the different web pages.

Intro

The figure below shows the first page (Intro) called by the Web server.

Figure 3-1 Intro page of the Web server of the CPU 1516-3 PN/DP

Click the NEXT link to go to the Web server pages.

Note

Select the "Skip Intro" check box in order to skip the intro. The Web server will then take you directly to its start page in future. This setting is saved in the user profile of the current PC user.

You can undo the setting "Skip Intro" by clicking the "Intro" link in the left-hand navigation bar of a web page.

Setting the user interface language

You can change the language for the Web server interface, e.g., from English to German, in the upper right corner. This option is available to you on all web pages of the Web server.

Start page

The start page before login offers information as shown in the figure below. The CPU image with LEDs returns the actual CPU status at the time of the data request.

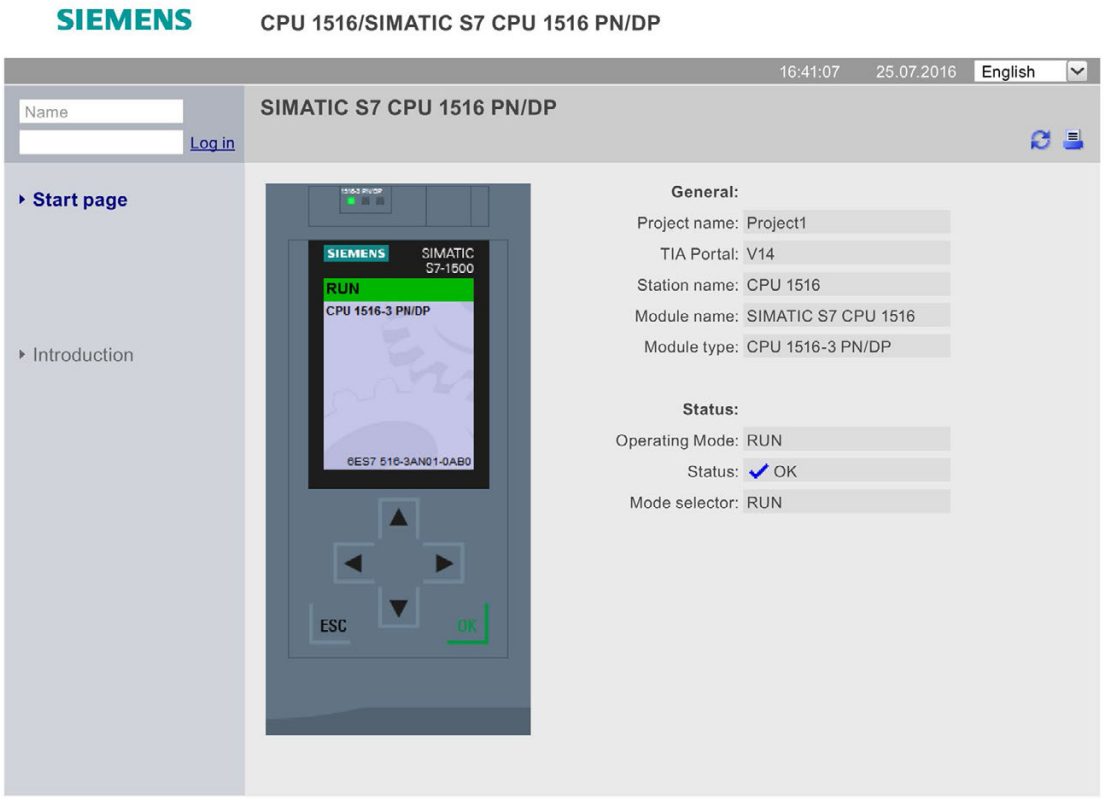


Figure 3-2 Start page before login

Log in

To use the full functionality of the web pages, you must be logged in. Log in with a user name and password specified in the Web configuration in STEP 7. You now have corresponding permissions to access the web pages released for this user. If you have not configured a user, read-only access is granted to intro and start pages by default.

Note

After carrying out your required actions, log out explicitly from the Web server by clicking "Logout" in order to minimize the risk of unauthorized external access.

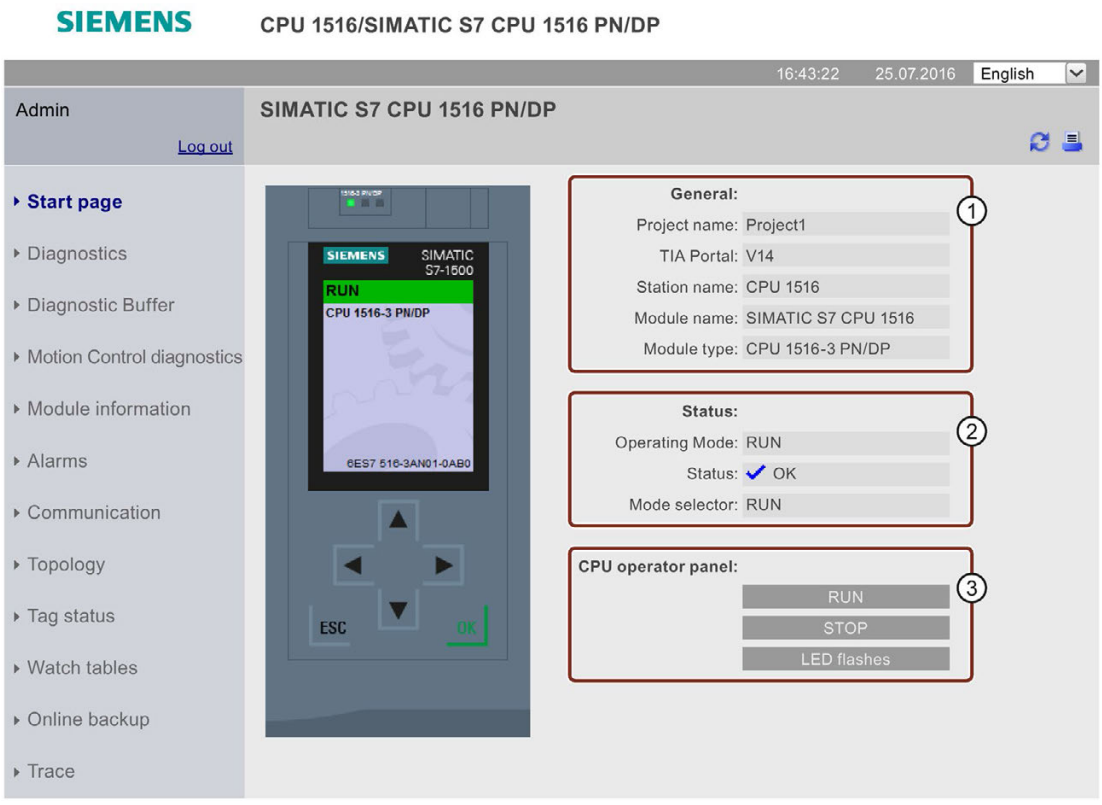


Figure 3-3 Start page after login

① "General"

"General" contains information on the CPU with the Web server to which you are currently connected, as well as the version of the TIA Portal with which the CPU was configured.

② "Status"

"Status" contains information about the CPU at the moment of the query.

③ "CPU operator panel"

If you have the necessary access permissions, you can change the operating mode of the CPU ("RUN"/"STOP" buttons) or have the LEDs flash ("Flash LED" button) in the "CPU operator panel" area.

Additional information for F-CPUs

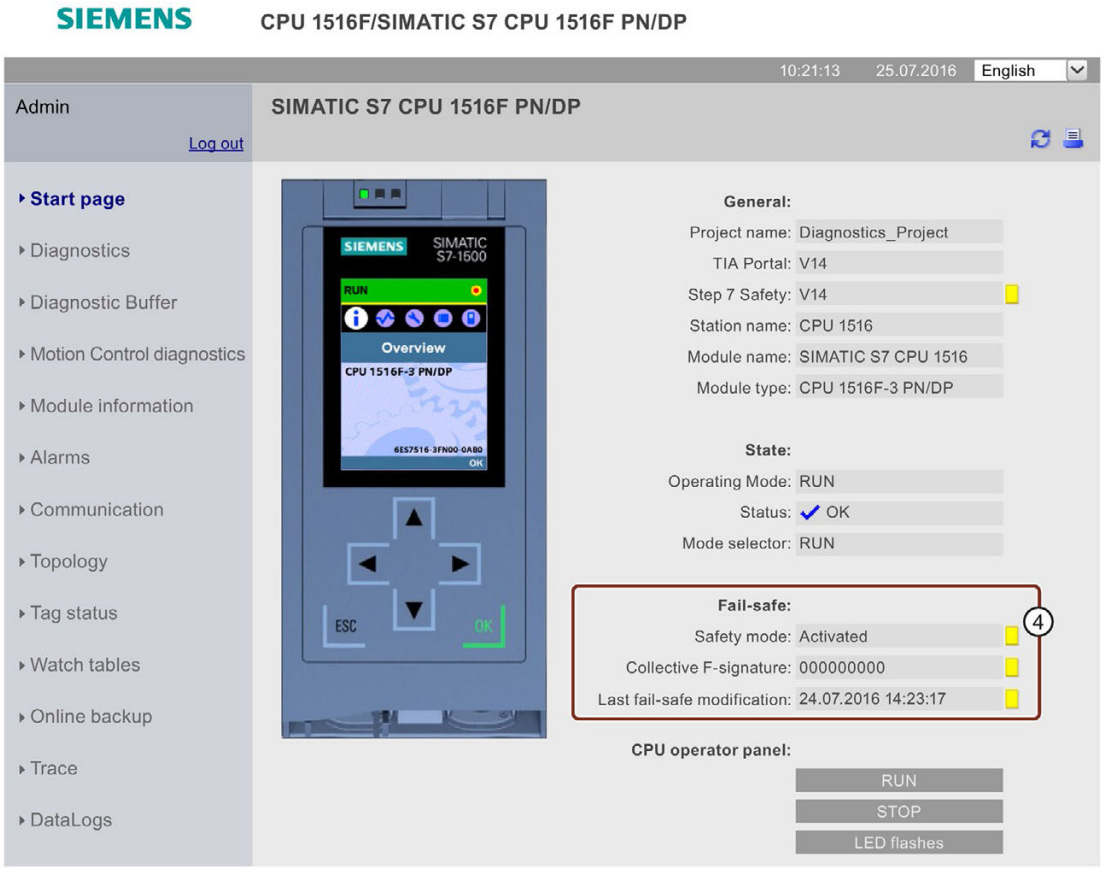


Figure 3-4 Start page after login to an F-CPU

④ "Fail-safe"

"Fail-safe" contains additional information on the F-CPU.

Reference

You can find additional information in the section Configuring the Web server (Page 19).

3.2 Diagnostics

Overview

The "Diagnostics" web page provides more information about the tabs:

- Identification
- Program protection
- Memory
- Runtime information
- Fail-safe (with an F CPU)

"Identification" tab

The CPU characteristics are available in the "Identification" tab.

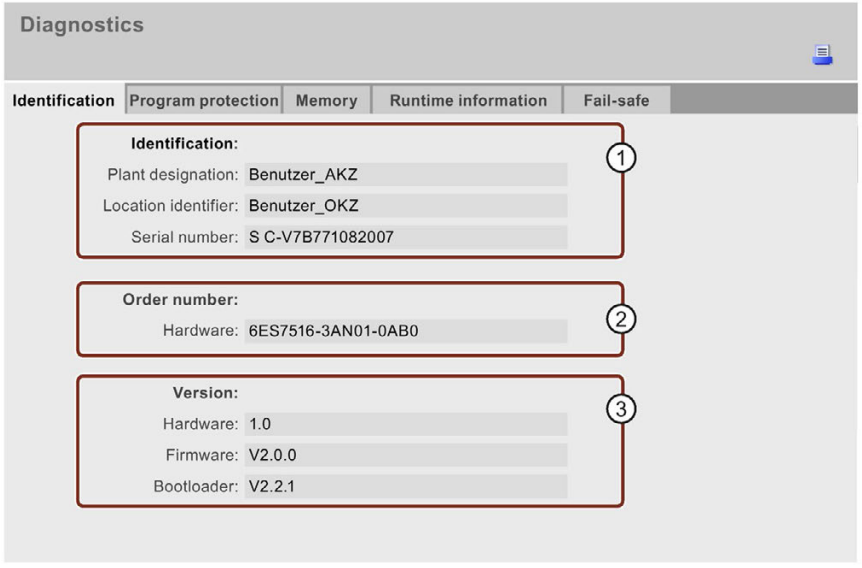


Figure 3-5 Identification tab

① "Identification"

The "Identification" info box contains the plant and location designation and the serial number. Plant and location designations can be configured in STEP 7 in the properties dialog box of the CPU, in the "General" tab.

② "Order number"

The "Order number" info box contains the order number for the hardware.

③ "Version"

You can find the hardware, firmware and bootloader versions in the "Version" info box.

"Program protection" tab

The "Program protection" tab provides information on whether the PLC program contains know-how protection or copy protection.

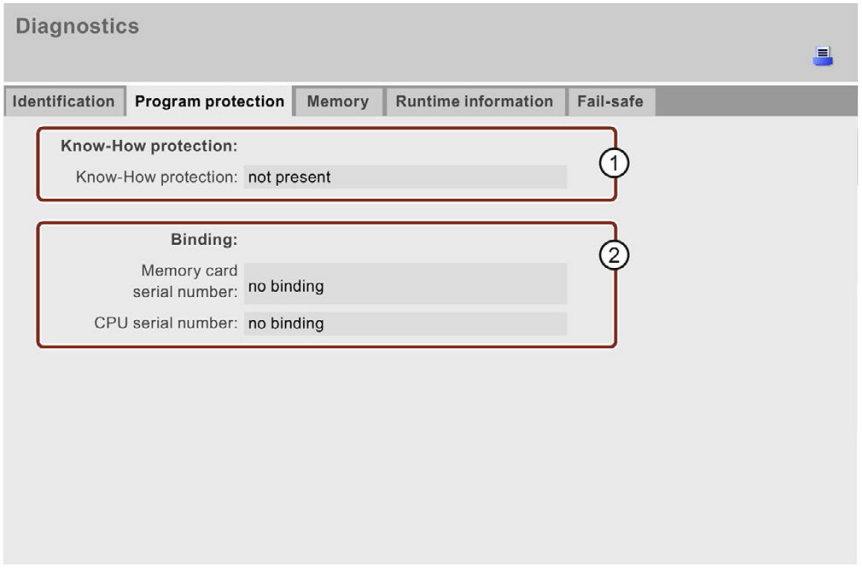


Figure 3-6 "Program protection" tab

① "Know-how protection"

Information on whether the PLC program contains at least one block with know-how protection or not can be found in the info field "Know-how protection".

② "Binding"

In the info field "Binding" you can find information on whether copy protection has been activated by binding at least one program block of the PLC program to the serial number of the CPU or memory card.

- "Binding"
- "No binding"
- "No matching binding": At least one block is bound to a different serial number (load process is rejected)

"Memory" tab

The "Memory" tab contains current values on the memory currently in use.

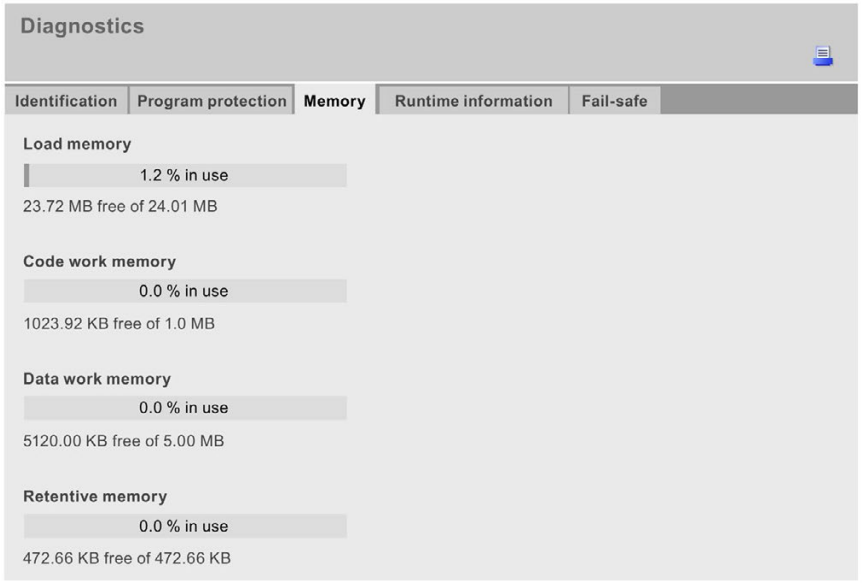


Figure 3-7 "Memory" tab

"Runtime information" tab

Current information on program/communication load and cycle time can be found in the "Runtime information" tab. This enables you to see whether there may be runtime problems during execution of your user program.

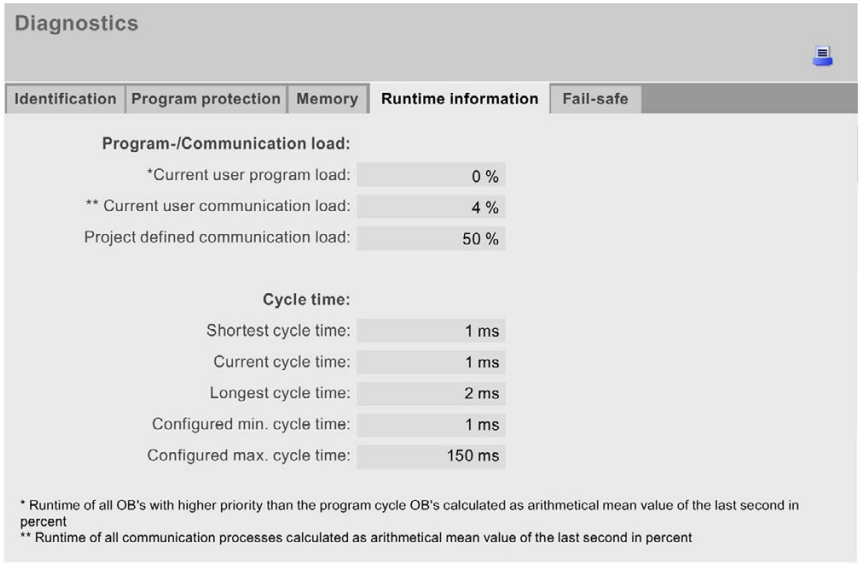


Figure 3-8 "Runtime information" tab

"Fail-safe" tab (with an F-CPU)

The safety program of an F-CPU consists of one or two F-runtime groups. You can find their F-collective signatures, cycle times (F-monitoring time) and runtimes in the "Fail-safe" tab.

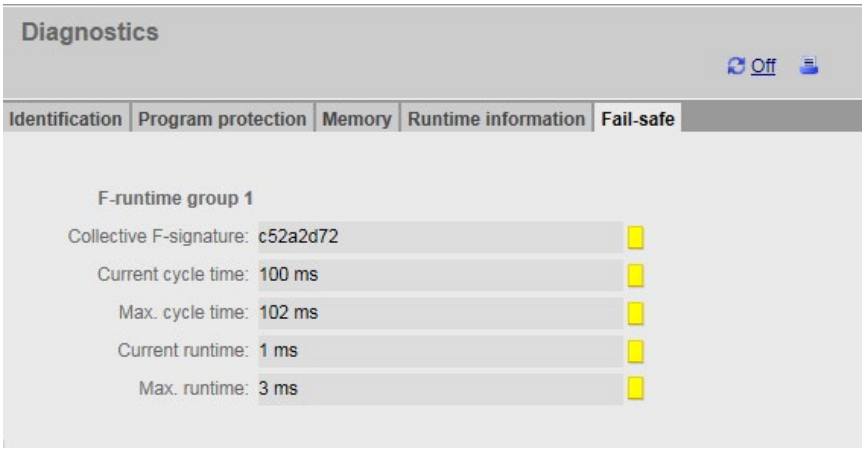


Figure 3-9 "Fail-safe" tab

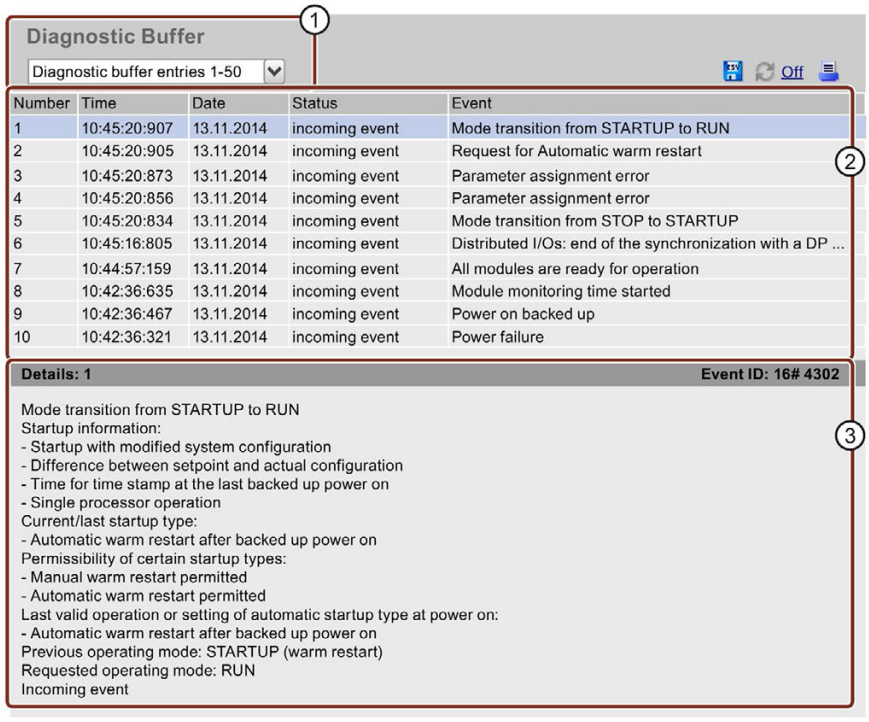
3.3 Diagnostics buffer

Requirements

The Web server is activated, languages are set, the text libraries are loaded and the project has been compiled and downloaded with STEP 7.

Diagnostics buffer

The browser displays the content of the diagnostics buffer on the "Diagnostics buffer" web page.



Number	Time	Date	Status	Event
1	10:45:20:907	13.11.2014	incoming event	Mode transition from STARTUP to RUN
2	10:45:20:905	13.11.2014	incoming event	Request for Automatic warm restart
3	10:45:20:873	13.11.2014	incoming event	Parameter assignment error
4	10:45:20:856	13.11.2014	incoming event	Parameter assignment error
5	10:45:20:834	13.11.2014	incoming event	Mode transition from STOP to STARTUP
6	10:45:16:805	13.11.2014	incoming event	Distributed I/Os: end of the synchronization with a DP ...
7	10:44:57:159	13.11.2014	incoming event	All modules are ready for operation
8	10:42:36:635	13.11.2014	incoming event	Module monitoring time started
9	10:42:36:467	13.11.2014	incoming event	Power on backed up
10	10:42:36:321	13.11.2014	incoming event	Power failure

Figure 3-10 Diagnostics buffer

① "Diagnostics buffer entries 1-50"

The diagnostics buffer can accommodate different numbers of alarms depending on the CPU used.
For information on the maximum number of diagnostics buffer entries, refer to the technical specifications of the CPU used.

Select an interval for the entries from the drop-down list. Each interval comprises 50 entries.

② "Event"

The "Event" info box contains the diagnostics interrupts with date and time.

Note that the diagnostics events are displayed in the project language of the STEP 7 project that is assigned to the current user interface language of the Web server. You can find out how to assign project languages to interface languages in section Language settings (Page 29).

③ "Details"

This field outputs detailed information about a selected event. Select the corresponding event from the ② "Event" info field.

Saving diagnostics buffer entries

You can save diagnostics buffer entries to a csv file for further processing in a spreadsheet program or database program.
Save the data by clicking the icon.

A dialog opens in which you can specify the file name and target directory.

3.4 Module information

Module information

The status of a device is indicated by means of symbols and comments on the "Module information" web page.

Figure 3-11 Module information

Meaning of the symbols in the "Status" column

Table 3- 1 Meaning of symbols

Symbol	Symbol color	Meaning
	Green	Component is OK
	Gray	Deactivated PROFIBUS slaves or PROFINET devices.
	Gray	State cannot be determined • "State cannot be determined" is displayed during system diagnostics for all configured I/O modules and I/O systems after restart of the CPU. • However, this state can also be displayed temporarily during operation if a diagnostics interrupt burst occurs for all modules. • It is not possible to determine the status of modules on a subsystem that is connected to a CP.
	Red	Component "not reachable" "Not reachable" is displayed when a module has been removed or a module has been configured but does not exist.
	Black	No input or output data available. Input or output channels of the (sub)module are disabled.
	Green	Maintenance required (Maintenance Required)
	Yellow	Maintenance demanded (Maintenance Demanded)
	Red	Error - component faulty or not available due to an incorrect type
	Red	A module in a lower module level does not have the status "Component OK"

Navigation to further module levels

The status of individual components/modules/submodules is displayed when you navigate to the further module levels:

- To the next higher module level using the links in the display of the module levels
- To the next lower module level using the links in the "Name" column

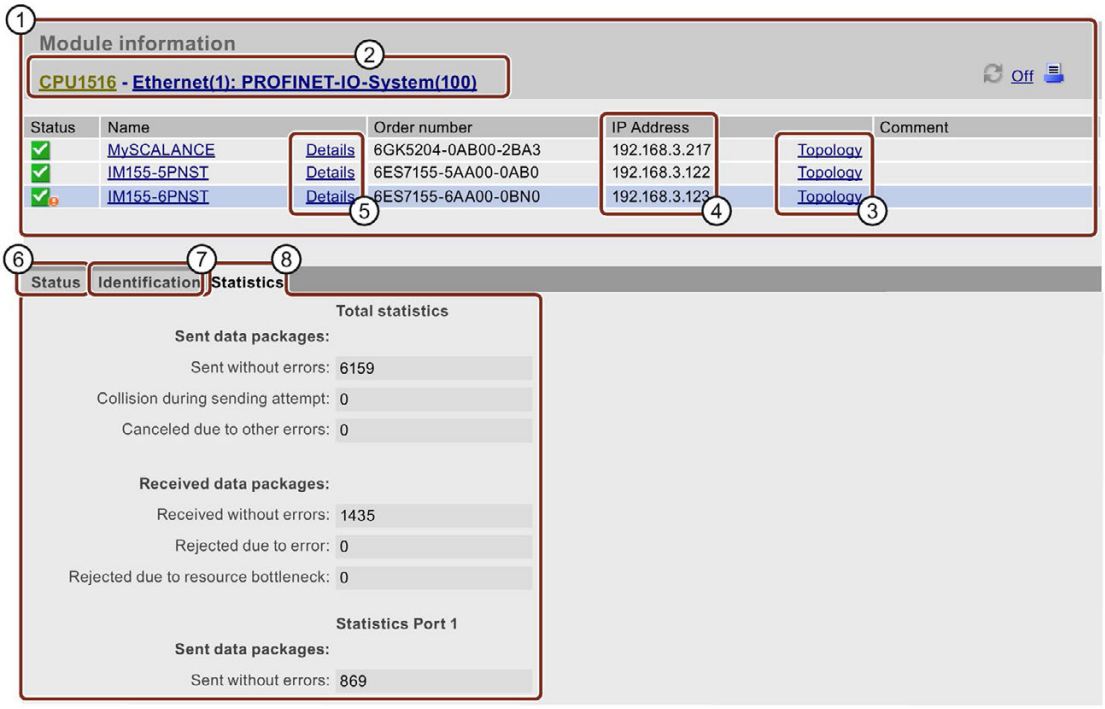


Figure 3-12 Navigation to further module levels

① "Module information"

Depending on the selected level, the table contains information about the rack, the DP master system, the PROFINET IO master system, about the devices, the individual modules, as well as the modules or submodules of the device.

② "Display of the module levels"

The links are used to access the "Module information" of the higher module levels.

③ "Topology"

The two web pages, "Topology" and "Module information", are linked. A click on "Topology" of the selected module automatically takes you to this module in the graphic view of the set topology on the "Topology" web page. The module is displayed in the visible area of the "Topology" web page. The device header of the selected module flashes for a few seconds.

④ "IP address"

If a link is available, you can use it to access the Web server of the configured device you selected.

⑤ "Details"

Additional information about the selected module is provided in the "Status" and "Identification" tabs via the "Details" link.

⑥ "Status" tab

The tab contains information about the status of the selected module when a fault or alarm exists.

⑦ "Identification" tab

The tab contains data on the identification of the selected module.

Note

This tab displays only the data configured offline of the module.

⑧ "Statistics" tab

The tab is only displayed for PROFINET IO devices and includes the following information on communication statistics of the selected IO device:

- "Total statistics - Sent data packages"

  You can assess the data transmission on the transmit line based on the key data in this info box.

- "Total statistics - Received data packages"

  You can assess the data transmission on the receive line based on the key data in this info box.

- "Statistics port x - Sent data packages"

  You can assess the data transmission on the transmit line for each port based on the key data in this info box.

- "Statistics port x - Received data packages"

  You can assess the data transmission on the receive line for each port based on the key data in this info box.

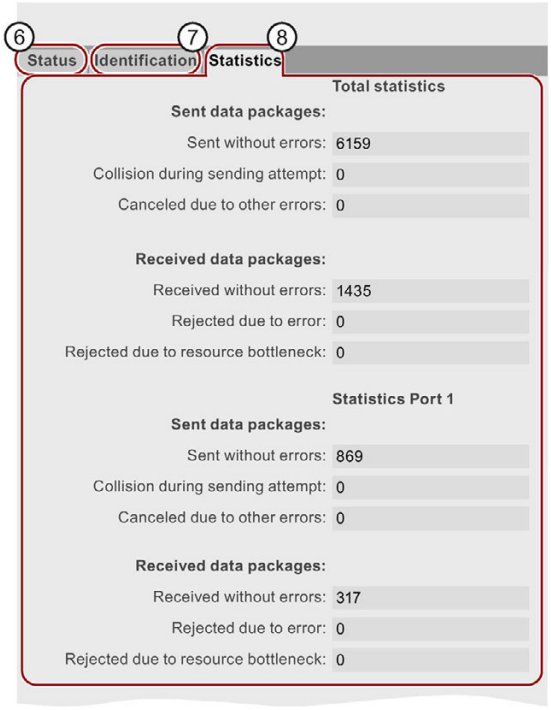


Figure 3-13 "Statistics" tab

Reference

You can find additional information in the "Statistics" tab in the section Communication (Page 50).

Example: Module information - module

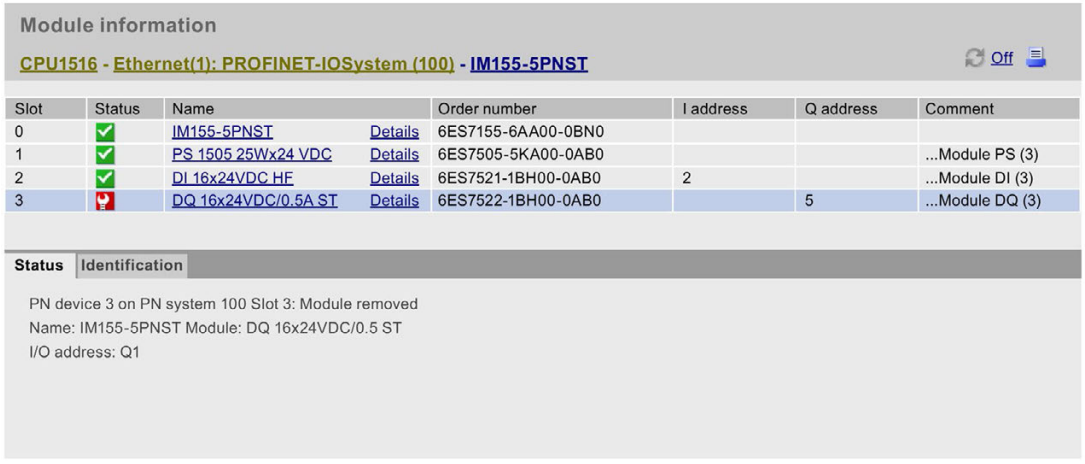


Figure 3-14 Example: Module information - module

Note

If you are using the function Configuration control (option handling) in the central configuration of your plant, the information text in the headings area of the web page informs you that the status of the I/O modules may be displayed inconsistently. No corresponding text is displayed for the distributed I/O.

Example: Module information - submodule

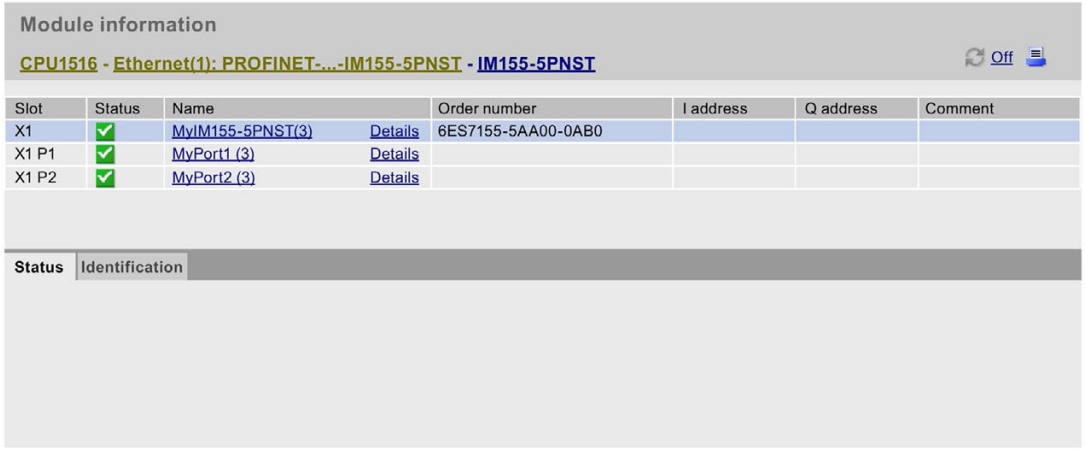


Figure 3-15 Example: Module information - submodule

Reference

You can find additional information on the "Module information" in the online help for STEP 7, keyword: "Module information".

3.5 Firmware update

Introduction

You update the firmware as a user with the corresponding access rights on the "Module information" web page at the module level. You will find information on user management in section Configuring the Web server (Page 19) under "Amending user management".
You use an update file to update the firmware of the CPU, the display of the CPU, or the individual central or distributed modules. Note that all modules you want to update must be compatible with the TIA Portal as of V12.0.

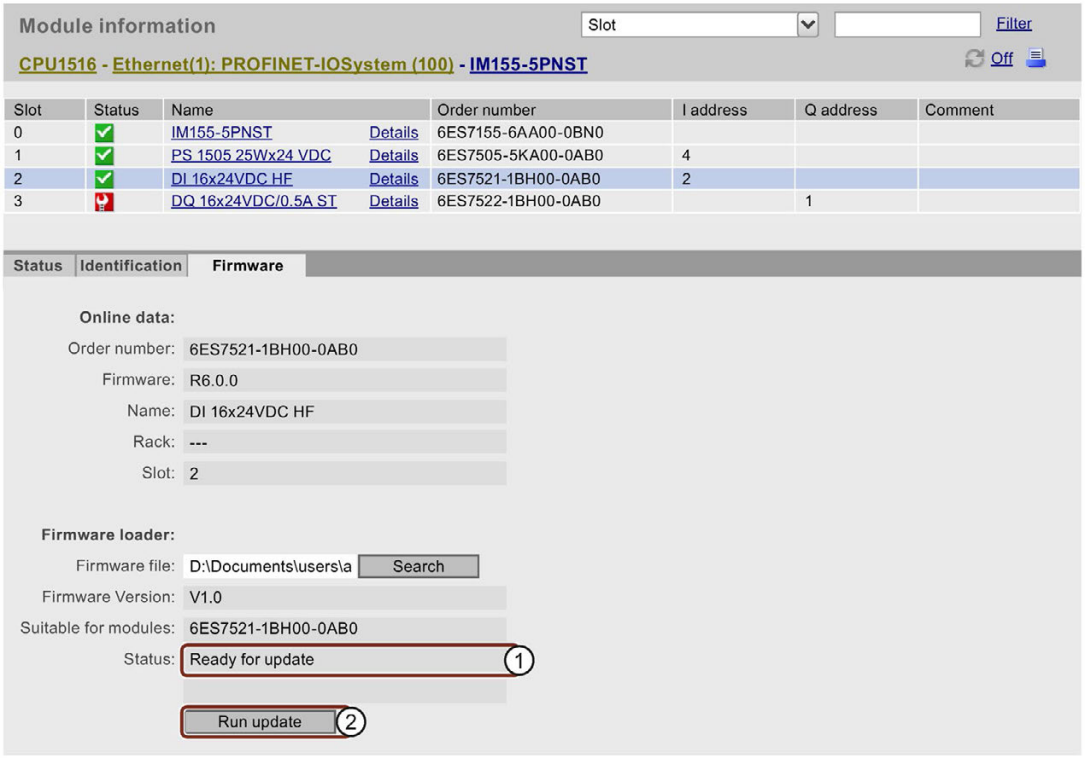
Note

A firmware update is not possible if access is via a mobile terminal device with the "iOS" operating system.

Procedure

The following steps are required to perform a firmware update:

- Click on "Browse" in the Firmware Loader area.
- Select the file you would like to use for the firmware update. You can find the available firmware updates on the Service&Support page on the Internet (http://support.automation.siemens.com).



① Status of the selected firmware file

② Button to execute the update

Figure 3-16 Module information, "Firmware" tab, "Ready for update" status

The Firmware Loader checks the file name of the selected firmware file and outputs the alarm "Firmware is not suitable" or "Ready for update" in the "Status" line.

- If the status is "Ready for update", click "Run update". If the CPU is in RUN mode during the update, the following alarm is output:

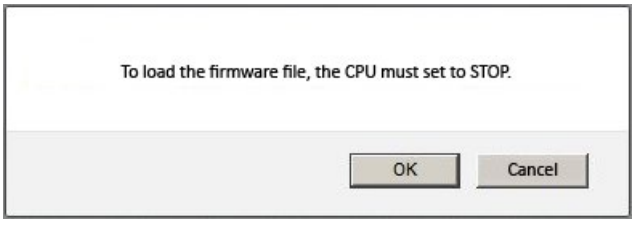


Figure 3-17 Alarm after clicking "Run update"

Acknowledge the alarm output by clicking "OK". The CPU is set to STOP mode and the firmware update is executed.
If you click "Cancel", the CPU remains in the current mode and the firmware update is canceled.

- A alarm informs you about the order number and version ID of the updated firmware once the update is complete.
The CPU is automatically placed in RUN mode when the mode selector of the CPU is in RUN and when you acknowledge the alarm with "OK". This may take a few minutes; there is no progress indicator.
If you click "Cancel", the CPU remains in STOP mode and you can run additional updates.

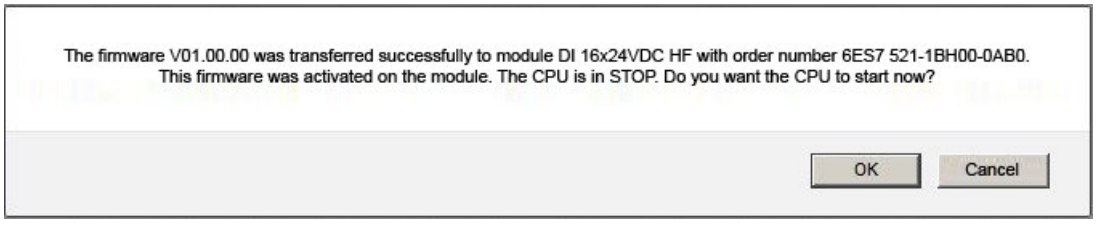


Figure 3-18 Alarm: Firmware successfully transferred

3.6 Alarms

Requirements

The alarm texts were configured in the user-specific languages. For information about configuring alarm texts, refer to STEP 7 and to the Service&Support pages (http://www.siemens.com/automation/service&support).

Alarms

To receive compact information on fault analysis, we recommend that you always first read out the content of the alarm buffer. This is the most effective method to get an overview of the pending faults.

The browser displays the content of the alarm buffer on the "Alarms" web page.

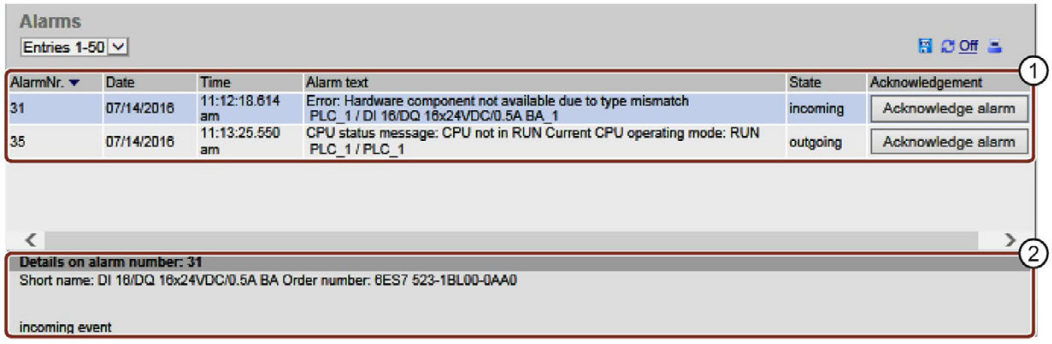


Figure 3-19 Alarms

① "Alarms"

CPU alarms are displayed in descending chronological order with **date** and **time** in info box ①.

The **alarm text** parameter is an entry which contains the alarm texts configured for the corresponding fault definitions.

Note that the alarm texts are displayed in the project language of the STEP 7 project that is assigned to the current user interface language of the Web server. You can find out how to assign project languages to interface languages in section Language settings (Page 29).

Sorting

You also have the option to display the individual parameters of the currently displayed web page (max. 50 entries) sorted in ascending or descending order. For this purpose, click on one of the parameters in the column header:

- Alarm number
- Date
- Time (of the CPU)
- Alarm text
- Status
- Acknowledgment

The alarms are returned in chronological order when you click the "Date" entry. Incoming and outgoing events are output at the **Status** parameter.

If you have the appropriate user rights (see section Configuring the Web server (Page 19)), for alarms which can be acknowledged, a button is available to you in the "Acknowledgment" column with which you can acknowledge the alarm.

② "Details on alarm number"

You can view detailed alarm information in this info box. Select the corresponding alarm from the info field ②.

Saving alarms

You can save alarms to a csv file for further processing in a spreadsheet program or database program.
Save the data by clicking the icon.

A dialog opens in which you can specify the file name and target directory.

3.7 Communication

Overview

The "Communication" web page provides detailed information about the following tabs:

- Parameters
- Statistics
- Resources
- Connections

① "Parameter" tab

A summary of the information on the PROFINET and Ethernet interfaces of the selected CPU is available in the "Parameter" tab.

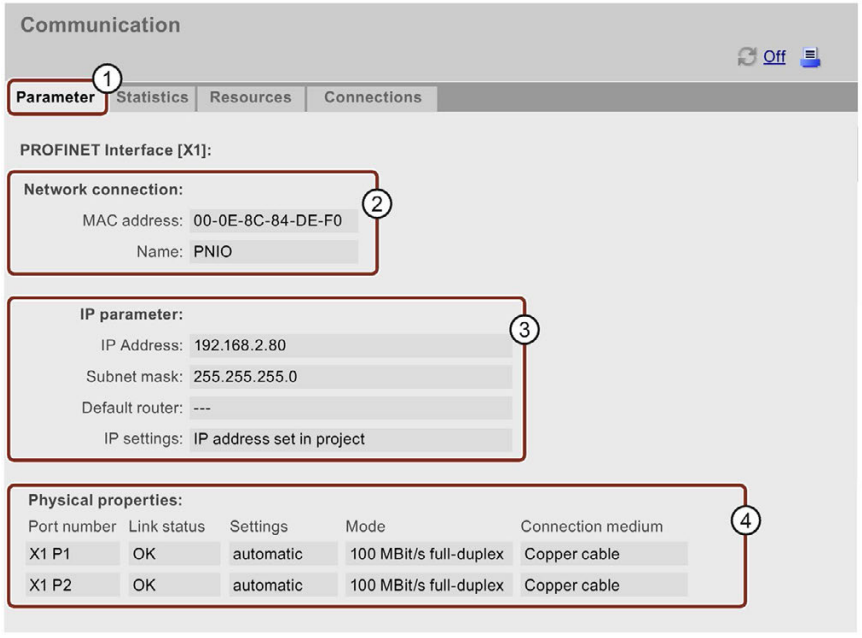


Figure 3-20 Parameters of the integrated PROFINET and Ethernet interfaces

② "Network connection"

The item "Network connection" includes information for identification of the integrated PROFINET and Ethernet interfaces of the corresponding CPU. The MAC address is located on the CPU above the respective PROFINET or Ethernet interface.

③ "IP parameter"

This parameter includes information on the configured IP address and number of the subnet in which the corresponding CPU is located.

④ "Physical properties"

The following information on the interface hardware is available in the "Physical properties" field:

- Port number
- Link status
- Settings
- Mode
- Connection medium

① "Statistics" tab

Information on the data transmission can be found on the "Statistics" tab.

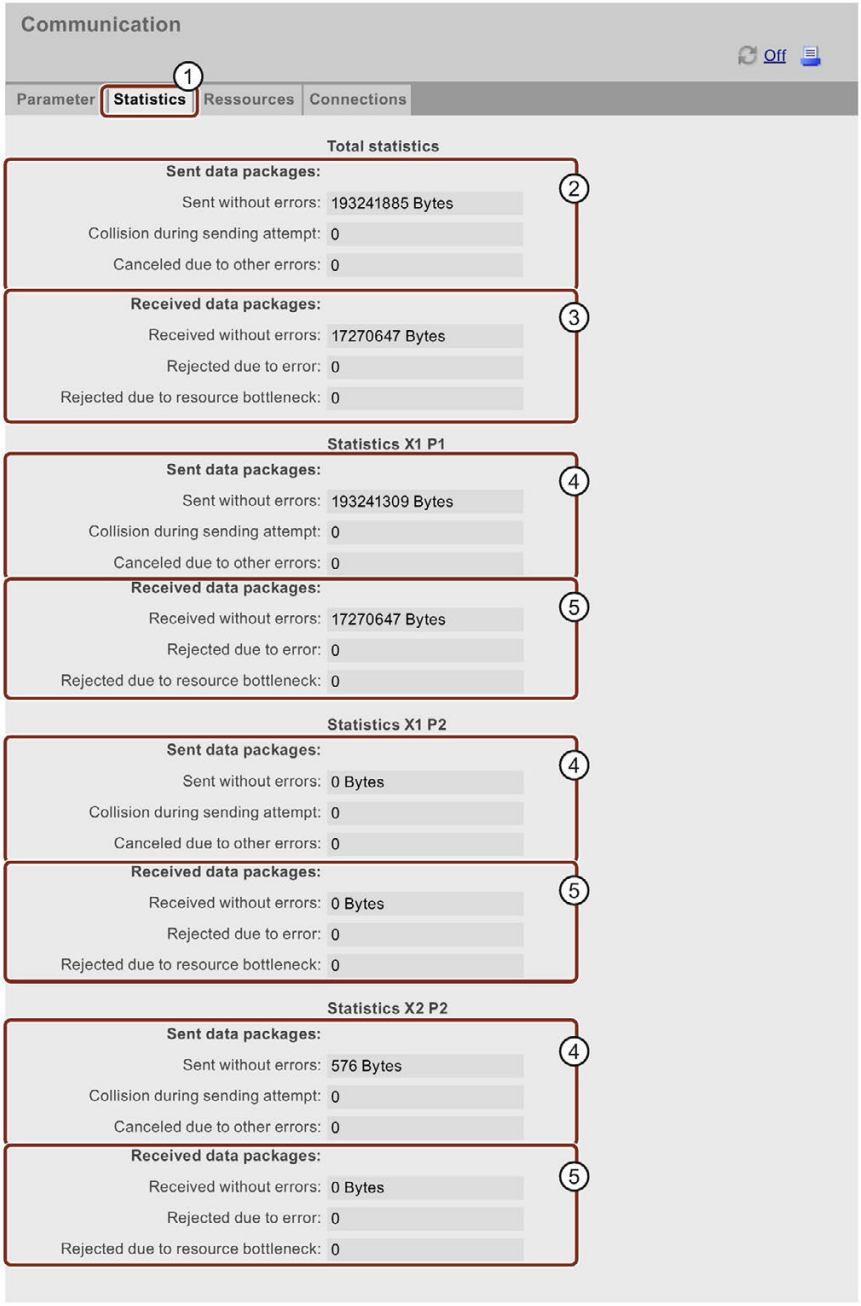


Figure 3-21 "Statistics" tab with key data on data transmission

② "Total statistics - Sent data packages"

You can assess the data transmission on the transmit line based on the key data in this info box.

③ "Total statistics - Received data packages"

You can assess the data transmission on the receive line based on the key data in this info box.

④ "Statistics Port x - Sent data packages"

You can assess the data transmission on the transmit line for each port based on the key data in this info box.

⑤ "Statistics port x - Received data packages"

You can assess the data transmission on the receive line for each port based on the key data in this info box.

① The "Resources" tab

For information about the resource consumption of the connections, refer to the "Resources" tab.

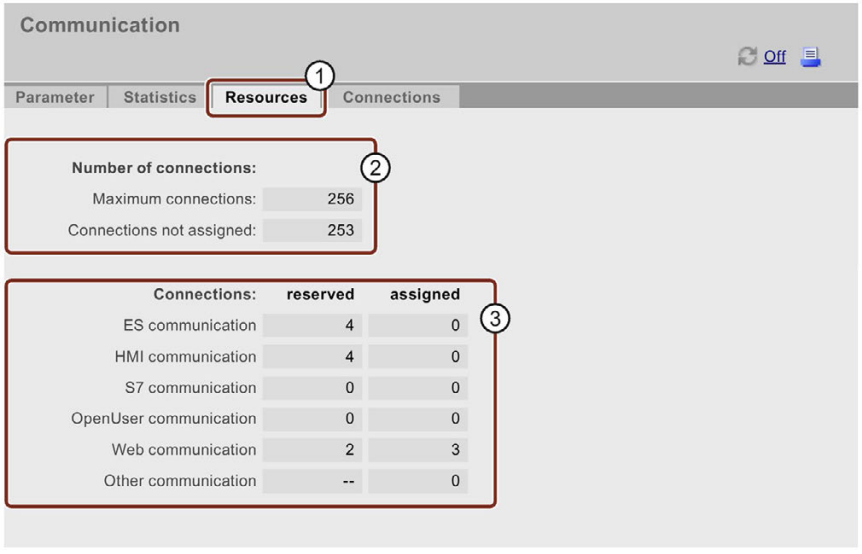


Figure 3-22 "Resources" tab

② Number of connections

Under "Number of connections", you will find information on the maximum number of connections and the number of connections not assigned.

③ Connections

The item "Connections" provides information on the number of connections reserved or used for ES, HMI, S7, OpenUser, web communication and other communication functions.

① "Connections" tab

The "Connections" tab contains information on the status of the communication connections.

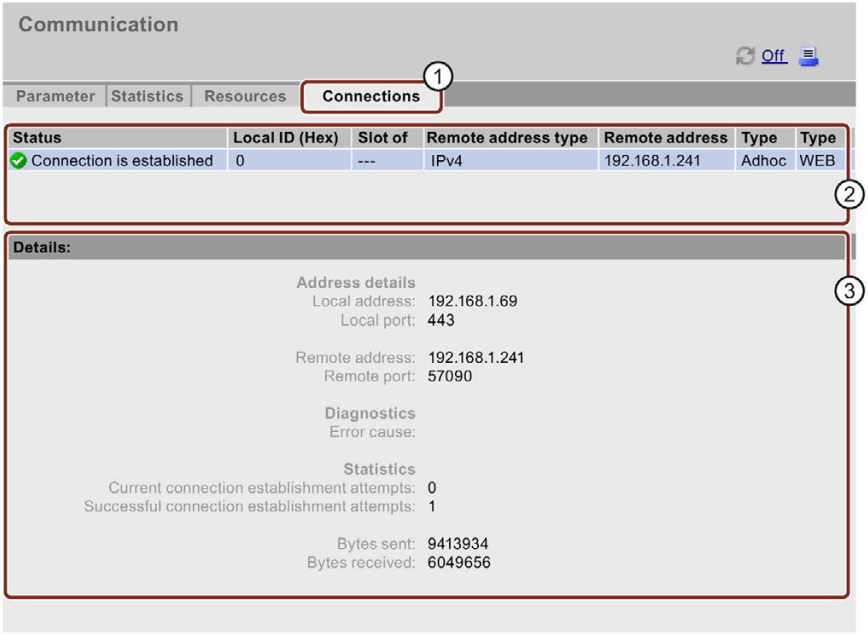


Figure 3-23 "Connections" tab

② Status

Under "Status", you will find an overview of the communication connections being established and the already established communication connections.

For each connection, the table contains the following information: status of the connection, local ID, slot of gateway, remote address (IP address), the corresponding remote address type, method of connection, and type of connection.

③ Details

Under "Details", you will find detailed information about the selected connection.

Reference

For an explanation of the error message displayed when a connection is interrupted or an attempt to establish a connection fails, refer to the STEP 7 online help.

3.8 Topology

3.8.1 Introduction

Topology of the PROFINET devices

The "Topology" web page provides information on the topological configuration and status of the PROFINET devices on your PROFINET IO system.

There are three tabs for the following views:

- Graphical view (set and actual topology)
- Table view (actual topology only)
- Status overview (excluding topological correlations)

You can print the table view and status overview. Before printing, use the print preview of your browser and, if necessary, correct the format.

Set topology

The set topology is displayed if you have topologically interconnected the connections in the configuration with STEP 7.

This view identifies the topological assignment of PROFINET devices that have failed, the differences between the set and actual topology, and interchanged ports.

Note

The configured set topology is always displayed by default in the following scenarios:

- When the "Topology" web page is called via the navigation bar
- When you change from the overview of PROFINET IO devices on the "Module information" web page to the "Topology" web page by means of the "Topology" link.

If a set topology was not configured, the actual topology is displayed.

Actual topology

Displays the current topological structure of the "configured" PROFINET devices of a PROFINET IO system and the directly adjacent, non-configured PROFINET devices (display of the neighbor relationships, provided these can be determined; but the status of these adjacent PROFINET devices is not displayed).

3.8.2 Graphical view

Requirements

For error-free operation of the topology, the following conditions must be met:

- You have made the Language settings (Page 29).
- In the Topology Editor of STEP 7, you configured the topological interconnection of ports (requirement for display of the set topology and the corresponding topological target connections).
- The project has been compiled in STEP 7.
- The project is completely loaded.

Set and actual topology - graphical view

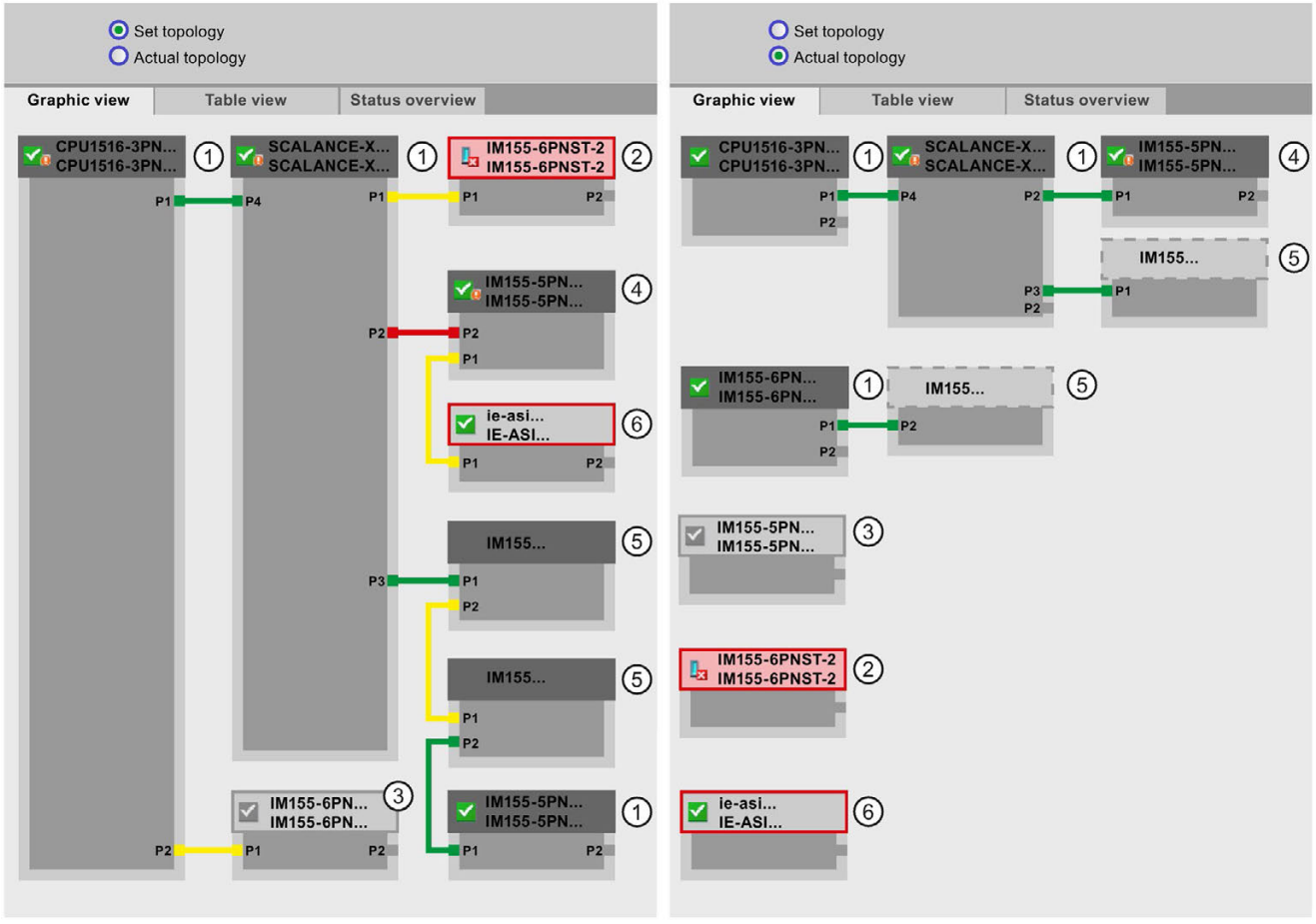


Figure 3-24 Graphical view - Set and actual topology

Meaning of the colored connections in the set/actual topology:

Table 3- 2 Meaning of the colored connections in the set/actual topology

Connection	Meaning	
	Set topology	Actual topology
Green	The current actual connection matches the configured target connection.	Connections detected
Red	Mismatch between the current actual connection and the configured target connection (e.g., port interchanged).	-
Yellow	Connection diagnostics not possible. Causes: • Malfunction of communication with a device (e.g., cable was removed) • Connection to a passive component (e.g., switches or cables) • Connection to devices/PROFINET devices on a different IO controller or IO subsystem.	-

① Configured and accessible PROFINET devices

Configured and accessible PROFINET devices are displayed in dark gray. Connections indicate the ports used to connect the PROFINET devices of a station.

② Configured but inaccessible PROFINET devices

Configured but inaccessible PROFINET devices are indicated in pink with red frame (e.g., device failure, cable disconnected).

③ Deactivated devices

All deactivated, configured PROFINET devices are displayed in light gray.

④ Interchanged ports

Interchanged ports are highlighted in red in the set topology view. The actual topology view indicates the actually connected ports, while the set topology view displays the configured target connections.

⑤ PROFINET devices of a different PROFINET IO subsystem

- In the set topology:

  A PROFINET device of a different PROFINET IO subsystem is indicated by means of a green link (or red link for interchanged ports) if it is available on the bus and directly adjacent to an accessible configured PROFINET device ①. If the PROFINET device of a different PROFINET IO subsystem is inaccessible, it is identified by means of a yellow connecting line.
  The connection between two PROFINET devices which both belong to a different PROFINET IO subsystem cannot be identified and is always indicated in yellow color.

- In the actual topology:

  The PROFINET device of a different PROFINET IO subsystem is not displayed unless it is directly adjacent to a configured PROFINET device. The PROFINET device is shown in light gray with a dashed line around the device header.

The status of PROFINET devices of a different PROFINET IO subsystem is **not** displayed in the device header.

⑥ Displaying faulty neighbor relationships

Devices from which the relation data could not be read completely or with error are highlighted in light gray with a red frame.

Note

Displaying faulty neighbor relationships

If a device does not have the matching firmware, the relationships cannot be displayed correctly. This means a firmware update of the respective device is required in case a faulty neighbor relationship is displayed.

Views after changes to the configuration

- If a device fails, it remains at the same position in the "Set topology" view. This error state is indicated with a red border around the device header and the icon .
- If a device fails, it is displayed in the "Actual topology" view. This error state is indicated separately in the bottom area with a red border around the device header and the icon .

Link between the "Topology" and "Module information" web pages

The two web pages, "Topology" and "Module information", are linked. A click on the header of a selected module in the topology view automatically takes you to this module on the "Module information" web page.

You can find additional information on this in the section Module information (Page 41).

Reference

Additional examples for graphical topology view are available in the section Examples for graphical topology views (Page 61).

3.8.3 Tabular view

Topology - tabular view

The "Tabular view" always shows the "Actual topology".

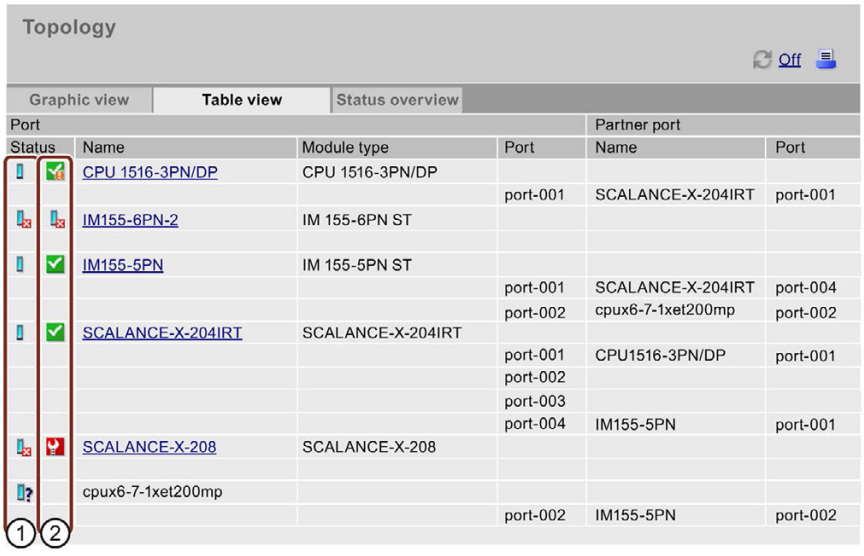


Figure 3-25 Topology - tabular view

① Meaning of the symbols relating to the status of the PROFINET devices

Table 3- 3 Meaning of the symbols relating to the status of the PROFINET devices

Symbol	Meaning
	Configured and accessible PROFINET devices
	Unconfigured and accessible PROFINET devices
	Configured but inaccessible PROFINET devices
	Devices for which neighbor relations cannot be determined, or for which the neighbor relationship could not be read out completely, or only with errors

② Meaning of the symbols relating to the module status of the PROFINET devices

Table 3- 4 Meaning of the symbols relating to the module status of the PROFINET devices

Symbol	Color	Meaning
	green	Component is OK.
	gray	Deactivated PROFIBUS slaves or PROFINET devices
	black	State cannot be determined • For example, "Status cannot be determined" is always displayed while the CPU is in STOP mode, or during startup evaluation of "Report system error" for all configured I/O modules and I/O systems after a CPU restart. • However, this status can also be displayed temporarily during operation if a diagnostics interrupt burst occurs at all modules. • It is not possible to determine the status of modules on a subsystem that is connected to a CP.
	red	Component failed or is not reachable • "Not reachable" is displayed for e.g. a module that has been removed or a module that has been configured but does not exist.
	green	Maintenance required (Maintenance Required)
	yellow	Maintenance demanded (Maintenance Demanded)
	red	Error - component faulty or not available due to an incorrect type.
	-	A module in a lower module level does not have the status "Component OK".

Reference

For additional information on the "Report System Error" function, refer to the STEP 7 online help, keyword: "System diagnostics".

3.8.4 Status overview

Topology - status overview

The "Status overview" provides a clear presentation of all PROFINET IO devices/PROFINET devices (without connection relations) on one page. A quick error diagnostics is possible based on the symbols that show the module statuses.

The overview also provides a link of the modules to the "Module information (Page 41)" website.

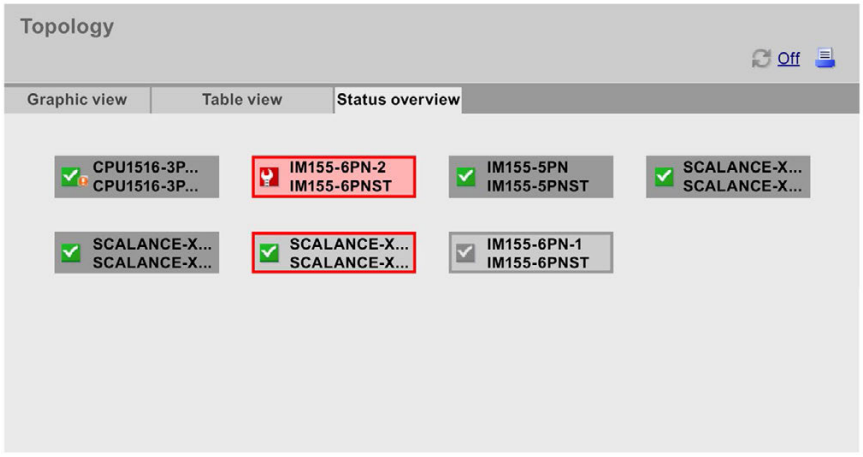


Figure 3-26 Topology - status overview

3.8.5 Examples for graphical topology views

The following section shows, as an example, some displays of the different topology views for a simple project.

"Set topology" is OK

Here you see the connections as they are configured in the topology editor by STEP 7. The configuration and wiring match.

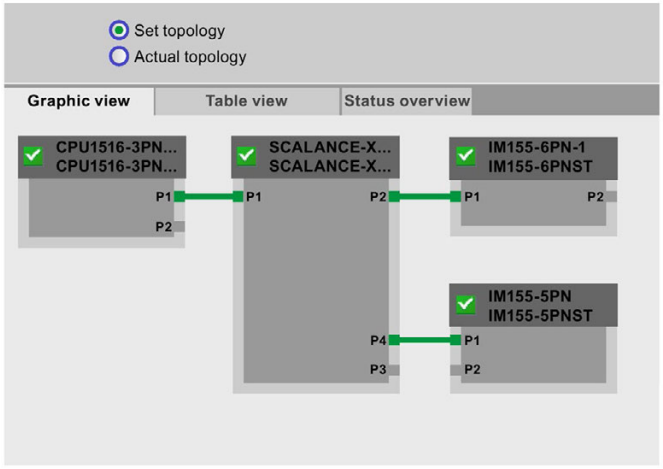


Figure 3-27 "Set topology" is OK

"Actual topology" is OK

Shows the actual layout of all configured devices that can be reached topologically.

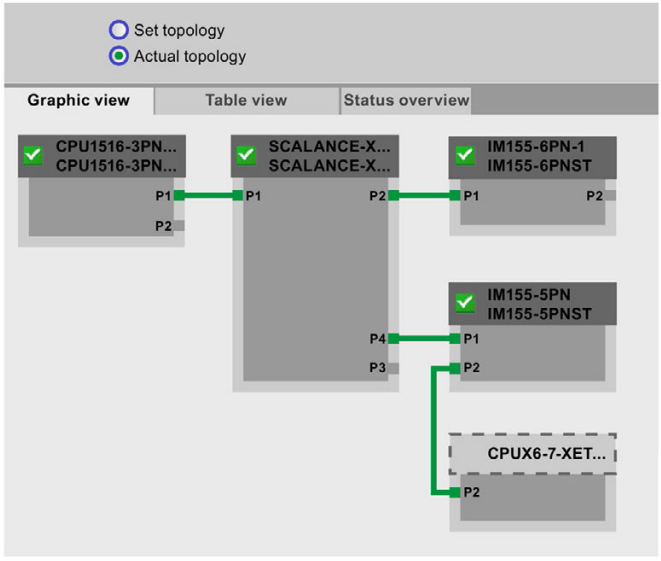


Figure 3-28 "Actual topology" is OK

"Set topology" with failed device

If a device has failed in the meantime, this device remains in the same place in the "Set topology" view. The failed device is displayed with a red border around the device header and the icon.

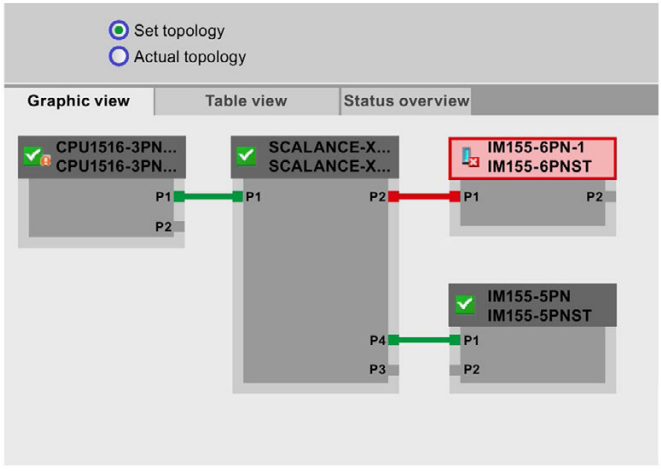


Figure 3-29 "Set topology" with failed device

"Actual topology" with failed device

In the "Actual topology" view, the device that has failed in the meantime is displayed separately in the bottom area of the view. The failed device is displayed with a red border around the device header and the icon.

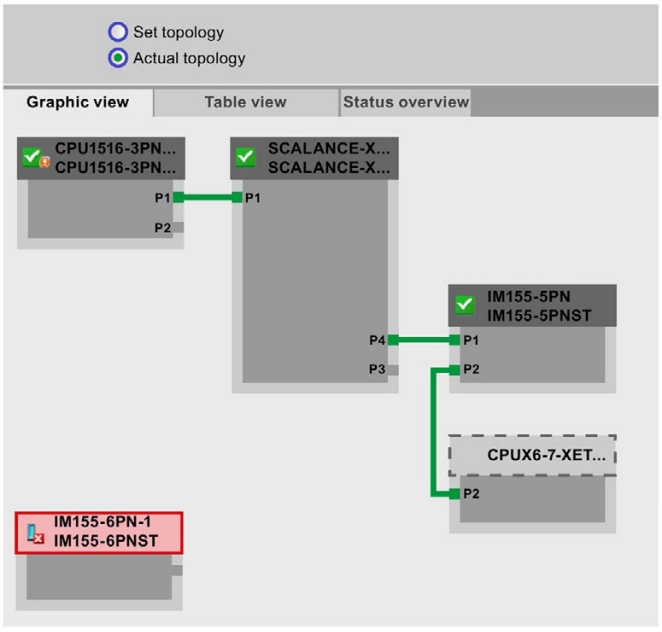


Figure 3-30 "Actual topology" with failed device

"Set topology" with interchanged ports

If a port was interchanged for a configured, directly adjacent PROFINET device, this device remains in the same place in the "Set topology" view. The interchanged connection is indicated by a red line.

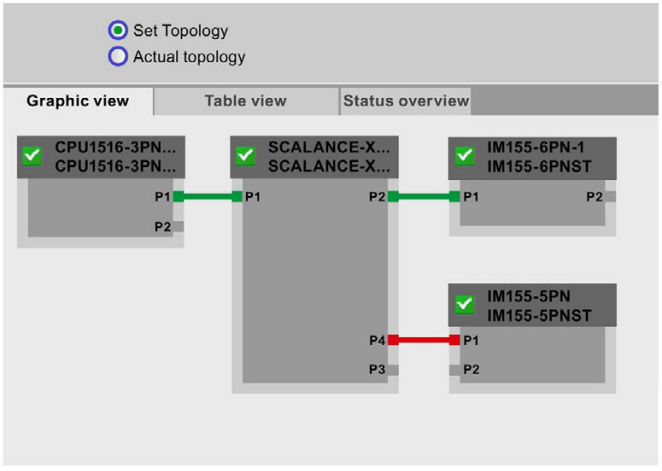


Figure 3-31 "Set topology" with interchanged ports

3.9 Tag status

Tag status

The browser outputs the tag status on the web page of the same name.

Note

Saving the tag status as a bookmark

When the page is exited, the entries made on it are not saved. If you want to monitor the same entered tags again later on, then create a bookmark in your Web browser for the "Tag status" page. Otherwise, you will have to enter the tags again when the page is reopened.

If you have defined your user page as start page of the Web server, you cannot access the tag status via the saved bookmarks. You can find additional information in section Defining the user page as start page (Page 85).

Note

Selected tag addresses are copied to the URL

The maximum number of characters for the URL of the tag status page is 2083. You can see the URL which corresponds to your current tag status page in the address bar of your Web browser.

To monitor several tags, we recommend the use of the watch tables (Page 66).

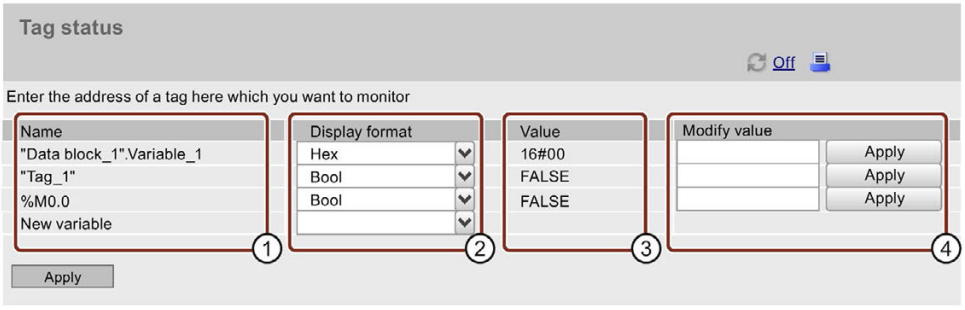


Figure 3-32 Tag status

① "Name"

In the "Name" text box, enter the address of the tag whose behavior you want to monitor. This may be a symbolic or absolute address.

- PLC tags (inputs and outputs, bit memories, times and counters) and DB tags in blocks with standard access have an absolute and a symbolic address.
- DB tags in blocks with optimized access have a symbolic address and no absolute address.

Example for access to the absolute address of a data block with standard access:
The absolute address consists of the preceding address ID %, the number of the data block and the absolute address of the tags in the data block, separated by a period: `%DB1.DBX1.0` = absolute addressing of the tags "DBX1.0" in the global data block "DB1".

Invalid entries are displayed in red font.

② "Display format"

Using the drop-down list box, select the desired display format of the respective tag. If the tag cannot be displayed in the desired format, it will be displayed in hexadecimal format.

③ "Value"

Under "Value", the value of the corresponding operand is displayed in the selected format.

④ "Modify value"

You can change the value of tags and write them to the CPU in this column. To transfer several changed values in one operation, click the "Apply" button below the table.

To be able to read values and write values to the CPU, you need to have configured a user with the appropriate access rights in STEP 7.

To write F-tags, you must also have assigned the access authorization "F-Admin"; see "Amending user management" in the section Configuring the Web server (Page 19).

If the value you entered is not valid (e.g. binary value in a BOOL field), the entry is not applied and the corresponding input field remains empty. A specific message relating to this is not output.

You can change the values of the following data types:

- Bool, Byte
- DWord, LWord, Word
- Int, DInt, LInt, SInt, UDInt, UInt, ULInt, USInt
- Real, LReal
- LDT
- Counter, Date
- Time, LTime, Time_Of_Day, LTime_Of_Day, Timer
- S5Time
- Char, WChar, String

Note

The following generally applies: To be able to write data, the "Referrer" transfer must be activated in your Web browser (this is the default in all common browsers).

Special considerations when changing languages

You can change the language, e.g., from German to English, in the upper right corner. Note that the German mnemonics differ from those of the other languages.

For monitoring available data types

In principle, all data types of PLC tags that can be monitored in STEP 7 can also be monitored via the Web server.

Note that structured data types such as ARRAY, STRUCT and DTL are not available as data types for PLC tags because of their data volume.

Reference

You can find additional information on the available data types in the STEP 7 online help, keyword: "Overview of the valid data types".

3.10 Watch tables

Watch tables

The browser displays the content of the configured, web-enabled watch tables on the web page of the same name.

Note

Please note that you can observe a maximum of 50 of the watch tables configured in STEP 7 in the Web server.

Each of these tables is displayed in the Web server with a maximum of 200 entries.

If you are monitoring many large watch tables in the Web server, the update time may increase due to the large data volumes.

The number of watch tables you can monitor also depends on the size of the SIMATIC memory card used.
If the available memory is exceeded by the configured alarms and tags, only incomplete watch tables will be displayed in the Web browser.

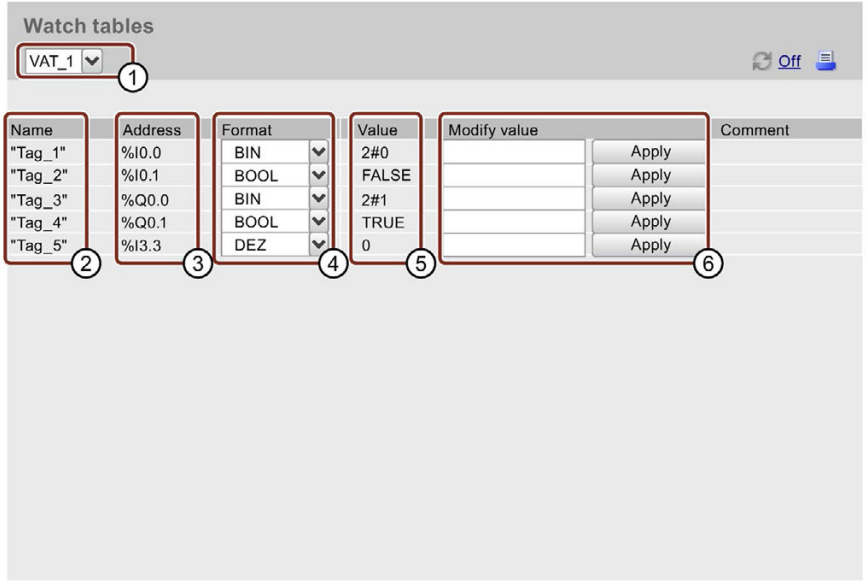


Figure 3-33 Watch tables

① Selection

Select one of the configured watch tables from the drop-down list.

② "Name"

The symbolic name of the tag is shown in this info box.

③ "Address"

The absolute address of the tags is displayed within this info field (if present, e.g. for inputs or outputs; DB tags in blocks with optimized access have no absolute address).

③ "Format"

Select the display format of the respective tag from the drop-down list.

⑤ "Value"

This column shows the values in the corresponding display format.

⑥ "Modify value"

You can change the value of tags and write them to the CPU in this column.

To be able to read values and write values to the CPU, you need to have configured a user with the appropriate access rights in STEP 7.

To write F-tags, you must also have assigned the access authorization "F-Admin"; see "Amending user management" in the section Configuring the Web server (Page 19).

If the value you entered is not valid (e.g. binary value in a BOOL field), the entry is not applied and the corresponding input field remains empty. A specific message relating to this is not output.

Note

The following generally applies: To be able to write data, the "Referrer" transfer must be activated in your Web browser (this is the default in all common browsers).

Note that the comments are displayed in the project language of the STEP 7 project that is assigned to the current user interface language of the Web server. You can find out how to assign project languages to interface languages in section Language settings (Page 29).

Reference

You can find additional information on the available data types in the STEP 7 online help, keyword: "Overview of the valid data types".

3.11 User pages

User pages

In the "User pages" area of the Web server you can upload HTML pages you have created yourself for reading out data of the target system.

Figure 3-34 User pages

You create the pages with an HTML editor of your choice from which you generate data blocks (Web control DB and Fragment DBs) in STEP 7 and download them to the CPU. The "WWW" instruction synchronizes the user program with the Web server on the CPU and initializes the Web server. With the first call of the "WWW" instruction, the link to the user page is displayed on the web page of the CPU. A click on the link opens the user page in a new window.

Note

Write access to user pages allows the process parameters and, thus, the operation of the CPU to be influenced.
To prevent external manipulation, always assign a password for users with write access to user pages in the user management. You will find information on user management in section Configuring the Web server (Page 19) under "Amending user management".

Requirements

- You have assigned symbolic names to the tags you want to use on your web page in STEP 7 .
- In the Inspector window under "Properties > General > Web server", you have at least:
  - Activated the Web server
  - Assigned read-only or read and write permissions to the users for user pages (see section Configuring the Web server (Page 19))
- You have completed all necessary communication settings (IP address parameter, subnet mask, etc.).
- You have downloaded the configuration.
- You have created your user page in an HTML editor of your choice:
  - Automatic HTML pages, if you want to **disable** control of the page layout by means of the user program (requires at least one call of SFC 99).
    Changes in mode from RUN to STOP do not affect the call of the user pages.
  - Manual HTML pages, if you want to **enable** control of the page layout by means of the user program (cyclic call of SFC 99 required).

Creating user pages

You can use any HTML editor to create your own user page(s). Make sure that your HTML code complies with the standards of the W3C (World Wide Web Consortium), because STEP 7 does not check the HTML syntax in any way. In addition to the simple HTML code, you can also use JavaScript commands in your user pages.

Proceed as follows:

1. Create the HTML file for your user page with an HTML editor.
   To allow data from the CPU to be output on your web page, integrate the AWP commands as HTML comments (see section AWP commands (Page 70)).
2. Store the HTML file and all associated source files (e.g., *.gif, *.jpg, *.js, etc.) in a directory on your PG/PC and note the storage path.
3. Call the "WWW" instruction in STEP 7 and program it (see section Programming the WWW instruction (Page 83)).
4. Configure the user page in STEP 7 (see section Configuring user pages (Page 82)). In this way, you compile the contents of your HTML files, among other things, into data blocks.
5. Download the configuration and the user program to the CPU.
6. Open your user page with your display device by means of a web browser in the Web server of the CPU.

Note

Extensive HTML pages, especially those with a lot of images, take up a lot of space in the load memory. Make sure you select a SIMATIC memory card with enough memory to provide sufficient load memory.

If the **sum of the HTML pages >** 1 MB, performance losses may occur as only 1 MB data is saved in the cache.

We recommend that you create **each individual file of an HTML page** with a size not exceeding 512 KB; otherwise, problems can occur when sending the file from the Web server to the browser. You can view the size of the respective file in the file explorer of the directory.

Updating user pages

User pages are not updated automatically in the browser. You can program the HTML code so that the pages are updated automatically.

Pages which read out data from the controller are always up-to-date due to regular updates.

Note

If the HTML page contains form fields for data input, automatic update can impair the correct data input by the user.

To update the entire page automatically, you can add the following instruction to the **<head>** area of your HTML page, whereby the number "10" stands for the update interval in seconds:

```
<meta http-equiv="refresh" content="10">
```

References

The description of a user page is available in the section Example of a user page (Page 87).

Additional help for visualization with user pages is available in the application examples on the Internet:

- S7-1200 and STEP 7 V11 (http://support.automation.siemens.com/WW/view/en/58862931)
- S7-1200 / S7-1500 and STEP 7 as of V13 SP1 (https://support.industry.siemens.com/cs/de/en/view/68011496)
- S7-300 / S7-400 and STEP 7 as of V5.5 (http://support.automation.siemens.com/WW/view/en/44212999)

You will find more information on JavaScript commands in the ECMAScript specification on the Internet (http://www.ecma-international.org/ecma-262/5.1/).

For more information about how to automatically update web pages and how to incorporate user pages with relative path names, refer to the FAQ with entry ID 62543256 on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/62543256) Internet page.

See also

Properties of the Web server (Page 15)

3.11.1 AWP commands

Overview

Automation Web Programming (AWP) commands are a special command syntax for data exchange between CPU and user page (HTML file).

AWP commands are entered as HTML comments and offer the following options for your user pages:

- Reading PLC tags
- Writing PLC tags
- Reading special tags
- Writing special tags
- Defining enum types
- Assigning enum types to tags
- Defining data block fragments
- Importing data block fragments
- Accessing the values of an array
- Accessing the values of a PLC tag of STRUCT data type

General syntax

All AWP commands, except for the command for reading a PLC tag, have this structure:
`<!-- AWP_< command name and parameter> -->`

Files including AWP commands:

- must be UTF-8 encoded.
  To define UTF-8 as character set of the page, add the following line to your HTML code:
  `<meta http-equiv="content-type" content="text/html; charset utf-8">`

  Note
  Saving the HTML page
  Make sure that you save the file in the editor in UTF 8 character encoding as well.

- may not include the following sequence:]]>
- may not include the following sequence outside "read tag areas" (:="<Varname>":):
- depending on the use, must identify special characters in tag names or data block names with character escape sequences or quotation marks
- are case-sensitive
- should be additionally enclosed by JavaScript comments ("/*...*/") in JavaScript files

Overview of AWP commands

Table 3- 5 AWP commands

Function	Representation
Reading PLC tags	`:=<Varname>:`
Writing PLC tags	`<!-- AWP_In_Variable Name='<Varname1>' -->`
Reading special tags	`<!-- AWP_Out_Variable Name='<Typ>:<Name>' -->`
Writing special tags	`<!-- AWP_In_Variable Name='<Typ>:<Name>' -->`
Defining enum types	`<!-- AWP_Enum_Def Name='<Name Enum-Typ>' Values='0: "<Text 1>",1:"<Text 2>",...,x:"<Text y>"' -->`
Assigning enum types to tags	`<!-- AWP_Enum_Ref Name='<Varname>' Enum='<Name Enum-Typ>' -->`
Defining data block fragments	`<!-- AWP_Start_Fragment Name='<Name>'[Type=<Typ>] [ID=<Id>] -->`
Importing data block fragments	`<!-- AWP_Import_Fragment Name='<Name>' -->`

Accessing the values of an array	`<!-- AWP_Start_Array Name='"<DB name>".<array name>' -->`
	`...`
	`<!-- AWP_End_Array -->`

Accessing the values of a PLC tag of STRUCT data type	`<!-- AWP_Start_Struct Name='"<DB name>".<struct name>' --> ...` `<!-- AWP_End_Struct -->`

3.11.1.1 PLC tags

Introduction to PLC tags

User pages can read PLC tags from the CPU and write data to the CPU.

To do so, PLC tags must:

- be enclosed by double quotation marks ("...").
- also be enclosed by single quotation marks ('" ... "') or with quotation marks masked with a backslash ("\" ... "\").
- be specified by a PLC tag name.
- if the PLC tag name includes the characters \ (backslash) or ', identify these characters with the escape sequence \\ or \' as normal characters of the PLC tag name.
- be enclosed with single quotation marks ('...'), if an absolute address (input, output, bit memory) is used in the AWP command.

Reading PLC tags

These out-tags (output direction as seen from the controller) are inserted at any place in the HTML text with the syntax described below.

Syntax

```
:=<Varname>:
```

<Varname> corresponds to the tag to be read from your STEP 7 project and can be a simple shared tag or a complete tag path to a structural element. Make sure that you use the name of the data block and not its number when you use data blocks.

Examples

```
:="Conveying speed":
:="My_datablock".bitmemory1:
:=%MW100:
```

Reading tags of the String and Character type

Below, these types of quotation marks are used in the explanation: single quotation marks ('), double quotation marks (").

As of firmware V1.6, with the "Read PLC tags" function, the CPU outputs tags of the String or Character type enclosed in single quotation marks to the browser.
For example:

- "Varname".MyString = ABC string tag
- You read the tag in HTML using the function :="Varname".MyString:
- The Web server outputs the character string 'ABC' to the browser

Using String or Character tags in expressions

On your HTML page, you use an expression in which the character string for reading a tag is enclosed in quotation marks, for example in forms.

Possible HTML code used:
```
<input type="text" name="appfield" value="myvalue">
```

If you read the displayed value for the "value" attribute from a PLC tag in this expression, the HTML code appears as follows:
```
<input type="text" name="appfield" value=":="Varname".MyString:">
```

By reading the PLC tag, the Web server outputs the value 'ABC'. In HTML, the code is then represented as follows:
```
<input type="text" name="appfield" value=" 'ABC' ">
```

If you have used single quotation marks instead of double quotation marks in your HTML code to enclose the attributes, the Web server passes on the content of the tags enclosed in two single quotation marks to the browser. As a result of this, the browser does not output the content of the String or Character tag, since two consecutive single quotation marks each form a closed sequence. The values to be read are located between these sequences and are not output by the browser.

In this context, note in particular that the character string with double quotation marks is not identical to two single quotation marks even if they appear to be identical.

Note

The code is not adapted automatically during an update to firmware as of V1.6.
Adapt your HTML code if you have used single quotation marks to enclose attributes for the "Read PLC tags" function.

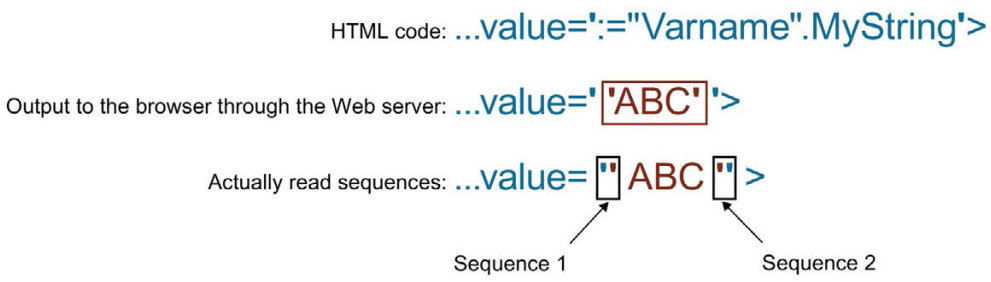


Figure 3-35 Example of HTML code with attribute in single quotation marks

Writing PLC tags

These in-tags (input direction as seen from the controller) are set on the browser page. This can take place in a form on your HTML page, for example, with text input or list selection boxes that correspond to the tags that can be written.

The tags are either set in the HTTP Header (per cookie or POST method) or in the URL (GET method) by the browser in the HTTP request and are then written by the Web server into the respective PLC tag.

Note

Write access during operation

For data to be written from a user page to the CPU, a user must have the required write permissions and be logged on as this user. This applies to all write accesses of web pages to the CPU.

Syntax

```
<!-- AWP_In_Variable Name='"<Varname1>"' Name='"<Varname2>"'
Name='"<Varname3>"' -->
```

If the name of the tag that you are using for the web application is not identical with the name of the PLC tag, you can assign it to a PLC tag with the "Use" parameter.

```
<!-- AWP_In_Variable Name='<Varname_Webapp>' Use='<PLC_Varname>' -->
```

Examples with HTML input boxes

```
<!-- AWP_In_Variable Name='"Target_Level"' -->
<form method="post">
<p>Input Target Level: <input name='"Target_Level"'
type="text"><input type="submit" value="Write to PLC"> </p>
</form>

<!-- AWP_In_Variable Name='"Data_block_1".Braking' -->
<form method="post">
<p>Braking: <input name='"Data_block_1".Braking' type="text"> <input
type="submit" value="Write to PLC"></p>
</form>
```

Examples with HTML drop-down list

```
<!-- AWP_In_Variable Name='"Data_block_1".ManualOverrideEnable' -->
<form method="post">
<select name='"Data_block_1".ManualOverrideEnable'>
<option value=1>Yes</option>
<option value=0>No</option>
</select><input type="submit" value="submit setting"> </form>
```

3.11.1.2 Special tags

Special tags

Special tags are mainly the HTTP tags specified in the definitions of the World Wide Web Consortium (W3C). Special tags are also used for cookies and server tags.

Reading special tags

The Web server can read PLC tags and transfer them to special tags in the HTTP response header. You can, for example, read out a path name from a PLC tag to redirect the URL to another storage location with the special tag "HEADER:Storage location".

Syntax

```
<!-- AWP_Out_Varible Name='<Type>:<Name>' Use='<Varname>' -->
```

<Type> corresponds to the type of special tag.
Options are:

- HEADER
- COOKIE_VALUE
- COOKIE_EXPIRES

<Name> corresponds to the name of the HEADER tag or the cookie:

- HEADER tags:
  - Status: HTTP status code (if no other value was set, status code 302 is returned).
  - Location: path for redirection to another page. Status code 302 must be set.
  - Retry-After: time for which the service is most likely not available. Status code 503 must be set.
- COOKIE_VALUE:name: value of the named cookie.
- COOKIE_EXPIRES:name: expiration time of the named cookie in seconds.

Examples

The HTTP HEADER tag is written to the PLC tag of the same name:

```
<!-- AWP_Out_Variable Name='"HEADER:Status"' -->
```

If the name of the special tag is not identical with the name of the PLC tag, you can assign it to a PLC tag with the "Use" parameter:

```
<!-- AWP_Out_Variable Name='"HEADER:Status"' Use='"Status"' -->
```

Writing special tags

The Web server gives you the option to write values of special tags written in the HTTP header in the CPU. You can, for example, save information on the cookie of a user page or on the user that accesses a page in STEP 7.

Syntax

```
<!-- AWP_In_Variable Name='<Type>:<Name>' Use='Varname' -->
```

<Type> corresponds to the type of special tag.
Options are:

- HEADER
- SERVER
- COOKIE_VALUE

<Name> corresponds to the name of the HEADER tag or the cookie:

- HEADER tags:
  - Accept-Language: accepted or preferred language
  - User-Agent: information on the browser
  - Authorization: credentials for a requested resource
- SERVER tags:
  - current_user_id: Indicates whether a user is logged on:
    current_user_id=0: No user is logged on / access by "Everybody" user.
    current_user_id=1: At least one user is logged on.
  - current_user_name: user name of the logged-on user
- COOKIE_VALUE:name: value of the named cookie.

Examples

The HTTP-SERVER tag is written to the PLC tag of the same name:

```
<!-- AWP_In_Variable Name='"SERVER:current_user_id"' -->
```

The HTTP-SERVER tag is written to the PLC tag "My_userID":

```
<!-- AWP_In_Variable Name='"SERVER:current_user_id"'
Use='"My_userID"' -->
```

3.11.1.3 Enum types

Enumeration types (enum types)

Enum types convert numerical values from the PLC program into texts or vice versa. The numerical values may also be assigned for use with several languages.

Define enum types

You can define enum types in your user pages and assign the values in an AWP command.

Syntax

```
<!-- AWP_Enum_Def_Name='<Name Enum-Typ>' Values='0:"<Text_1>",
1:"<Text_2>",...,x:"<Text_y>"' -->
```

Examples

To store German values as HTML file in the "de" folder of the HTML directory:

```
<!-- AWP_Enum_Def Name="Enum1" Values='0:"on", 1:"off", 2:"Fault"' -
->
```

To store English values as HTML file in the "en" folder of the HTML directory:

```
<!-- AWP_Enum_Def Name="Enum1" Values='0:"on", 1:"off", 2:"error"' -
->
```

Assigning enum types to tags

The assignment of tags from the user program to the individual enum types takes place by means of a separate AWP command. The used tag can be used at a different location of the user pages in a read operation or in a write operation.

For a read operation, the Web server replaces the value read from the CPU with the enum text value defined correspondingly. For a write operation, the Web server replaces the defined enum text value with the corresponding integer value of the enumeration before the value is written to the CPU.

Syntax

```
<!-- AWP_Enum_Ref_Name='<Varname>' Enum="<Enum-Type>" -->
```

<Varname> is the symbolic tag name from the user program; <Enum-Type> the previously specified name of the enum type.

Example for a declaration

```
<!-- AWP_Enum_Ref_Name='"Alarm"' Enum="AlarmEnum" -->
```

Example for use when reading a tag

```
<!-- AWP_Enum_Def Name='AlarmEnum' Values='0:"No alarms",
1:"Container is full", 2:"Container is empty"' -->
<!-- AWP_Enum_Ref Name='"Alarm"' Enum="AlarmEnum" -->
...
<p> The current value of "Alarm" is :="Alarm": </p>
```

If the value of "Alarm" in the CPU is 2, the HTML page shows 'The current value of "Alarm" is container is empty' because the definition of the enum type assigns the numerical value 2 to the character sequence "Container is empty".

Example for use when writing a tag

```
<!-- AWP_Enum_Def Name='AlarmEnum' Values='0:"No alarms",
1:"Container is full", 2:"Container is empty"' -->
<!-- AWP_In_Variable_Name='"Alarm"' -->
<!-- AWP_Enum_Ref Name='"Alarm"' Enum="AlarmEnum" -->
...
<form method="post">
<p><input type="hidden" name ='"Alarm"' value='Container is full'
/></p>
<p><input type="submit" value='Set container is full' /></p>
</form>
```

The value 1 is written to the PLC tag "Alarm" because the definition of the enum type assigns the numerical value 1 the text "Container is full".

Keep in mind that the name specified in "AWP_In_Variable" must be exactly the same in "AWP_Enum_Ref".

3.11.1.4 Fragments

Fragments

Fragments are "short paragraphs" of a website that the CPU processes separately.

Fragments are usually entire pages, but they can be individual elements, such as files (e.g. images) or documents.

Note

In each fragment in which enum texts are referenced by a PLC tag, this PLC tag must be assigned to the enum type name with the appropriate AWP command.

Defining fragments

A fragment extends to the beginning of the next fragment or to the end of the file.

Syntax

```
<!-- AWP_Start_Fragment_Name='<Name>' [Type="<Typ>"] [ID="<Id>"] -->
```

This command specifies the start of a fragment.

- <Name> Specifies the name of the fragment. The name must start with a letter [a-zA-Z] or an underscore (_). This first character can be followed by letters, underscores or numbers [0-9].
- <Type> Specifies the type of the fragment.
  - "manual": The user program is notified of the request for a fragment and can react accordingly. The function of the fragment must be controlled with STEP 7 and the tags of the control DB.
  - "automatic": The page is automatically processed (default)

- <Id> You can specify a numerical ID for the fragment. If no ID is assigned, the fragment is automatically assigned an ID. For manual pages (<Type>=manual), the fragment can be addressed with this ID in the user program of the CPU.

  Note
  ID assignment

  Set the ID as low as possible because the highest ID influences the size of the Web control DB.

- <Modus>
  - "visible": The contents of the fragment are displayed on the user page (default).
  - "hidden": The contents of the fragment are **not** displayed on the user page.

Importing fragments

You can specify a fragment in an HTML page and import this fragment into other websites.

Note

Ensure that no AWP command for importing fragments is positioned between an enum assignment and enum usage, because this import can result in the enum assignment being located in a different fragment than the enum usage.

Example

A company logo is to be displayed on all websites of a web application.

The HTML code for the fragment that displays the company logo exists only once. You can import the fragment as often and into as many HTML files as necessary.

Syntax

```
<!-- AWP_Import_Fragment_Name='<Name>' -->
```

<Name> corresponds to the name of the fragment to be imported.

Example

HTML code within a website that creates a fragment for displaying an image:

```
<!-- AWP_Start_Fragment Name='My_company_logo' -->
<p><img src="Company logo.jpg"></p>
```

HTML code that imports the created fragment into another website:

```
<!-- AWP_Import_Fragment Name='My_company_logo' -->
```

3.11.1.5 Arrays

Arrays

The Web server provides the user program commands AWP_Start_Array and AWP_End_Array for accessing all values of an array.

Only one-dimensional arrays are supported.

Multidimensional arrays of the form array[x][y] are not supported.

Syntax

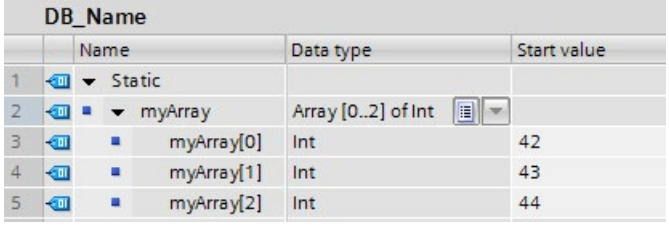
```
<!-- AWP_Start_Array Name='"<DB name>".<array name>' -->
... Content of the array, utilized keywords: ArrayIndex and value..
<!-- AWP_End_Array -->
```

Parameter

- <Name> defines the name of the array with the elements you want to access.
  - You require the DB name and the name of the array corresponding to the data block structure defined in STEP 7.
  - The name must be within single or double quotation marks.
  - The DB name is within double quotation marks.
- <ArrayIndex> Index of an array element
- <value> Value of an array element

Example

The example reads all elements of the "MyArray" structure in the "DB_Name" data block of the CPU and displays the index and the values of the tags on the user-defined web page.



DB_Name

	Name	Data type	Start value
1	Static		
2	myArray	Array [0..2] of Int	
3	myArray[0]	Int	42
4	myArray[1]	Int	43
5	myArray[2]	Int	44

```
<!-- AWP_Start_Array Name='"DB_Name".MyArray' -->
Index: :=ArrayIndex: Value: :=value:
<!-- AWP_End_Array -->
```

The code indicated above generates the following display:

Index: 1 Value: 42

Index: 2 Value: 43

Index: 3 Value: 44

Representation of arrays of the BOOL data type

The output of arrays of the BOOL type is always filled to the next full 8 bits. This particular feature only occurs with BOOL arrays.

Example:

```
"DB_1".bitArray is a BOOL array with 5 elements.
<!-- AWP_Start_Array Name='"DB_1".bitArray' -->
:=ArrayIndex: -> :=value:
<!-- AWP_End_Array -->
```

Edition:

0 -> Value from "DB_1".bitArray[0]

1 -> Value from "DB_1".bitArray[1]

2 -> Value from "DB_1".bitArray[2]

3 -> Value from "DB_1".bitArray[3]

4 -> Value from "DB_1".bitArray[4]

5 -> 0

6 -> 0

7 -> 0

3.11.1.6 Structures

Structures

The Web server provides user program commands for accessing structures in order to access the values of a PLC tag of the STRUCT data type.

Syntax

```
<!-- AWP_Start_Struct Name='"<DB name>".<struct name>' -->
... Content of structure ...
<!-- AWP_End_Struct -->
```

Parameter

- <Name> defines the name of the structure with the elements you want to access.
  - You require the DB name and the name of the structure corresponding to the data block structure defined in STEP 7.
  - The name must be within single or double quotation marks.
  - The DB name is within double quotation marks.

Example

The example reads elements of the "MyStruct" structure in the "DB_Name" data blocks of the CPU and displays the value of the tag on the user-defined web page.

DB_Name1

	Name	Data type	Start value
1	Static		
2	myStruct	Struct	
3	A	Int	0
4	B	Word	16#0
5	C	Bool	false

```
<!-- AWP_Start_Struct Name='"DB_Name".MyStruct' -->
:=A:
:=B:
:=C:
<!-- AWP_End_Struct -->
```

The code indicated above corresponds to the following commands:

```
:="DB_Name".MyStruct.A:
:="DB_Name".MyStruct.B:
:="DB_Name".MyStruct.C:
```

3.11.2 Configuring user pages

Configuring user pages

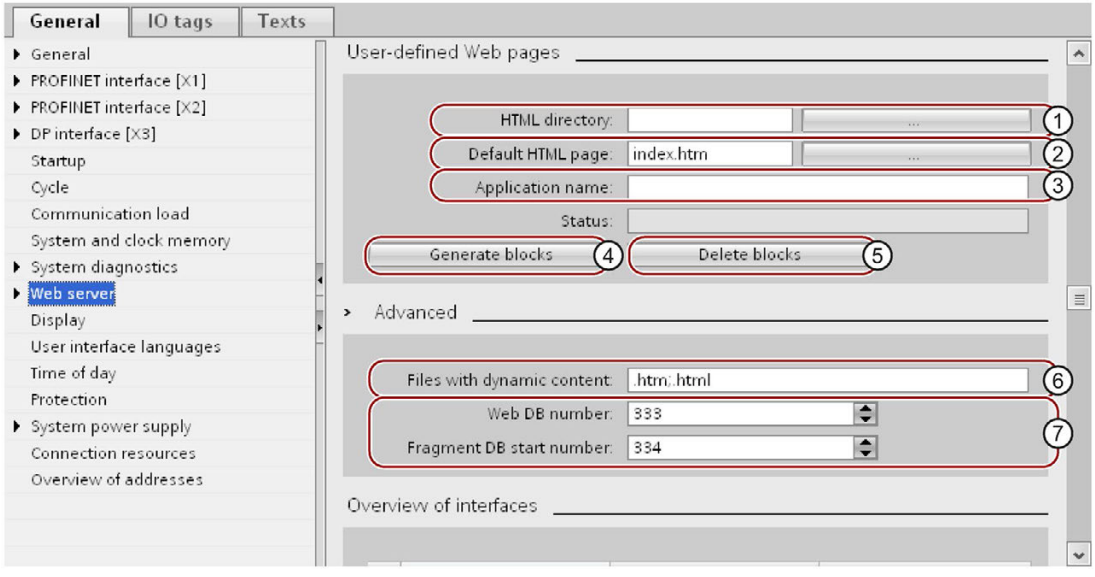


Figure 3-36 Configuring user pages in STEP 7

Proceed as follows to configure the user pages in STEP 7:

1. Select the CPU in the device configuration.
2. Open the settings in the Inspector window of the CPU under "Properties > General > Web server".
3. In the area "User pages" under ① "HTML directory", select the folder on your display device in which you have saved your HTML page.
4. Enter the name of the HTML page under ② "Start HTML page" that is to open when you start the application.
5. You can also specify a name for your application under ③ "Application name". This name is used to further divide or group the webpages. If an application name already exists, the URL is displayed in the following format: http://a.b.c.d/awp/<application name>/<page name>.html
6. In the "Extended" area, enter the file extensions that have to be checked for AWP commands in input box ⑥ "Files with dynamic contents". By default, STEP 7 analyses files with the extensions ".js", ".htm" and ".html". Here you can enter other file extensions that you have used when creating your user page.
7. You can accept the number for the Web DB ⑦ and the fragment DB start number ⑦ or you can assign a new number of your choice that is not assigned.
8. Click the button ④ "Create blocks" to create data blocks from the source files. The created data blocks are stored in the STEP 7 project tree in the folder "System blocks > Web server". These data blocks consist of a control data block (Web control DB) that controls the display of the webpages and one or several data block fragments (fragment DBs) with the compiled webpages.
9. In the network view, select the CPU you want to download and select the command "Download to device" in the "Online" menu to download the blocks. The compilation of the blocks is implicitly triggered before the download. If errors are signaled during this process, they must be remedied before you can download the configuration.

Deleting data blocks

Click the "Delete block" button ⑤ to delete previously generated data blocks. STEP 7 deletes the Web Control DB and all fragment DBs from the project containing your user pages.

3.11.3 Programming the WWW instruction

The WWW instruction

The WWW instruction initializes the Web server of the CPU or synchronizes the user pages with the user program in the CPU. The Web control DB is the input parameter for the WWW instruction and specifies the content of the pages as they are displayed in the fragment DBs as well as the status and control information. STEP 7 creates the Web control DB when you click the button "Create blocks".

Programming the WWW instruction

The user program must execute the WWW instruction so that the user pages can be accessed in the Web server.

Table 3- 6 WWW instruction

LAD/FBD	SCL	Description
	`ret_val :=WWW(ctrl_db:=uint_in_) ;`	Access to user pages by means of the Web server

Parameters

The table below shows the parameters of the WWW instruction.

Table 3- 7 Parameters

Parameters	Declaration	Data type	Description
CTRL_DB	Input	DB_WWW	Data block that describes the user pages (Web control DB)
RET_VAL	Output	INT	Error information

RET_VAL parameter

Table 3- 8 RET_VAL

Error code (W#16#...)	Explanation
0000	No error has occurred. There are no pending website requests that must be released by the user program.
00xy	x: indicates if an error occurred during initialization of the Web control DB (CTRL_DB): x=0: no errors. x=1: errors occurred. The error is encoded in the "CTRL_DB.last_error" byte of the Web control DB. y: Number of the pending request. Several requests are possible (e.g., request "0" and "1" are pending: y="3"). y="1": Request "0" y="2": Request "1" y="4": Request "2" y="8": Request "3"
803A	The specified Web Control DB does not exist on the CPU.
8081	Incorrect version or incorrect format of the Web Control DB.
80C1	There are no resources available to initialize the Web application.

3.11.4 Defining the user page as start page

Defining the user page as start page

In addition to the default intro page, you can also define the start page of your user pages as the start page of the Web server.

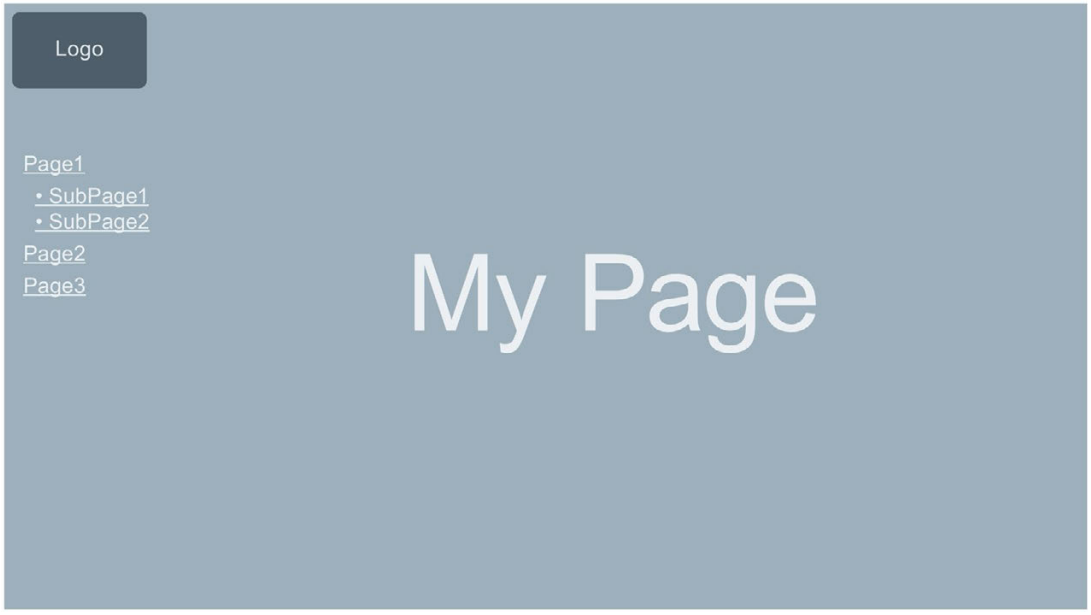


Figure 3-37 Example of user page as start page of the Web server

Requirements

The following requirements must be met before the user page is displayed as the start page of the Web server:

- You have configured the user page as the start page.
- You have configured a user in STEP 7 whom you have assigned at least the authorization "... open user-defined web pages".
- The CPU is in RUN mode.

Procedure

Proceed as follows to define the user pages in STEP 7 as start page of the Web server:

1. Select the CPU in the device configuration.
2. Open the settings in the Inspector window of the CPU under "Properties > General > Web server".
3. Select the entry "AWP1" in the area "Entry page" under "Select entry page".

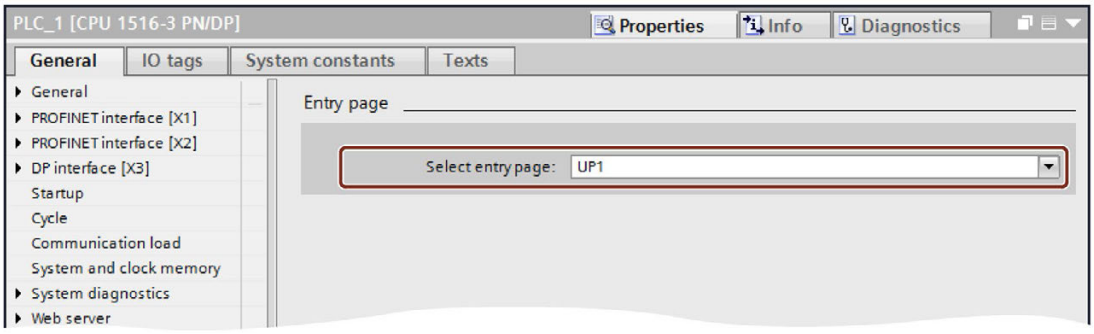


Figure 3-38 Setting user page in STEP 7 as start page

4. Download the configuration to the CPU.

If you now enter the IP address of the CPU in the browser, a connection is automatically established to your user pages.

If you want to access the web pages of your CPU again, link the web pages from your user pages, via the URL "http://a.b.c.d./Portal/Portal.mwsl?PriNav=Start" or "https://a.b.c.d/Portal/Portal.mwsl?PriNav=Start" for example. In this case, the information "a.b.c.d" represents, as an example, the IP address of the configured CPU.

Example of link in HTML:

```
<a href="/Portal/Portal.mwsl?PriNav=Start">SIMATIC web pages</a>
```

Note

If you define your user page as start page of the Web server, all direct access to the web pages of the CPU is disabled. This applies also to the bookmarks you saved for the web pages of the CPU as well as the page for reading out the service data.

Reading out service data

If you define your user page as start page of the Web server, all direct access to the web pages for reading out the service data is also disabled.
If you want to continue to read out service data via the Web server when servicing is required, here is how you can link the service data page directly to your user page.
Just as for the web pages of the CPU, link the service data page e.g. via the URL "http://a.b.c.d/save_service_data" or "https://a.b.c.d/save_service_data", the "a.b.c.d" here is an example of the IP address of the configured CPU.

Example of link in HTML:

```
<a href="/save_service_data">Service data</a>
```

Reference

You can find additional information on the topic of user page as start page in the FAQ with entry ID 67184104 on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/67184104) Internet page.

3.11.5 Example of a user page

3.11.5.1 Website for monitoring and controlling a wind turbine

Example of a user page

Here you see a user page for monitoring and controlling a wind turbine:

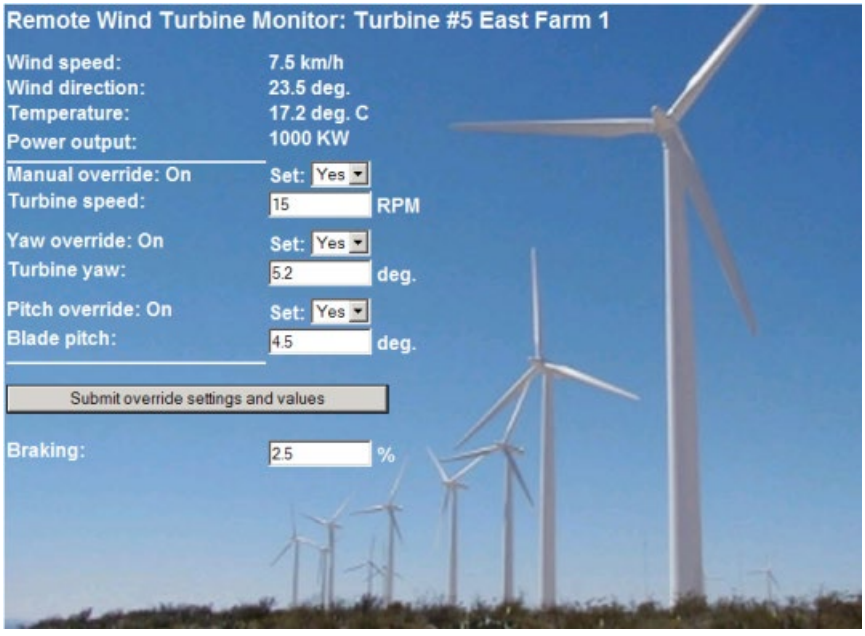


Figure 3-39 Overview of user page wind turbine

The user page was created in English in this example, but you can select any language you wish when you create your own user page.

In this application, each wind turbine of the wind farm has a data block in STEP 7 with specific data for the respective location and the turbine.

The user page gives you the option to access the turbine remotely with a display device. A user can open the standard websites for a CPU of a specific wind turbine and go to the "Remote Wind Turbine Monitor" user page to view the turbine data. A user with the corresponding access permissions can also set the turbine into the manually controlled mode and thus control the tags for speed, orientation and angle of attack of the turbine by means of the website. The user can also specify a brake value regardless of manual or automatic control of the turbine.

STEP 7 checks the Boolean values for override of the automatic control and, if set, uses the values for speed, orientation and angle of attack of the turbine as defined by the user.

Files used

Three files are used in the application example:

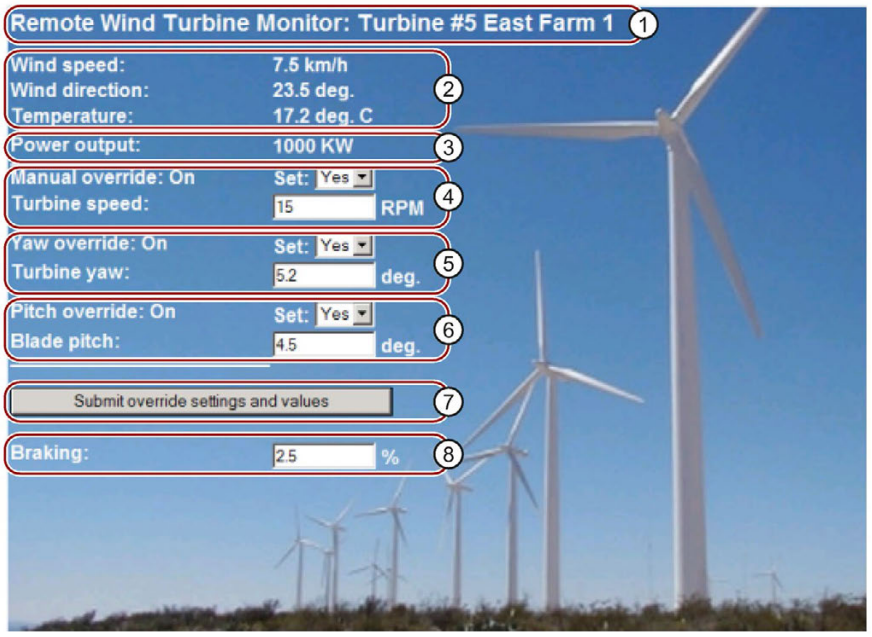
- Wind_turbine.html: The user page in the figure shown above. The control data is accessed by AWP commands.
- Wind_turbine.css: The Cascading Style Sheet which includes the formatting specifications of the user page. The use is optional but can simplify the design of the user page.
- Wind_turbine.jpg: The background image displayed on the user page. The use of images is optional, user pages with lots of images require a lot more memory in the load memory.

These files are not part of your installation but they are described as an example below.

Implementation

The user page uses AWP commands to read out values from the CPU as well as writing values to it. The user page also uses AWP commands for the definition of enum types, such as the assignment of tags to enum types for handling the ON/OFF settings.

The user page is structured as follows:



① Header of the website with number and location of the wind turbine.

② Atmospheric conditions at the turbine, wind speed, wind direction and current temperature are displayed.

③ Read-out power output.

④ Manual override: Activates manual override of the turbine. To make manual settings for speed, orientation and angle of attack, the STEP 7 user program requires that manual override has been activated.

⑤ Override of the orientation: Activates manual override of the turbine orientation.

⑥ Override of the angle of attack: Activates manual override of the angle of attack of the rotor blades.

⑦ By clicking this button, you transfer the override settings to the CPU.

⑧ Manual setting of a percentage value for braking. The setting "Manual override" is not required to enter a brake value.

Figure 3-40 Overview of user page wind turbine

The user page also uses an AWP command which writes the special tag into the tag table; it includes the user ID of the user who currently accesses the page.

3.11.5.2 Reading and displaying data from the CPU

Example HTML code for reading out and displaying data from the CPU

This part of the HTML code is used for displaying the power output on the user side.

The text "Power Output:" is displayed on the left-hand side; on the right-hand side, the value of the tags for the power output including the unit ("KW") is displayed.

The AWP command `:="Data_block_1".PowerOutput` executes the reading operation. The data block is referenced by its symbolic name here and not by its number ("Data_block_1" instead of "DB1").

The code used in the example is:

```
<tr style="height:2%;">
<td>
<p>Power output:</p>
</td>
<td>
<p style="margin-bottom:5px;"> :="Data_block_1".PowerOutput: KW</p>
</td>
</tr>
```

See also

PLC tags (Page 72)

3.11.5.3 Using enum types

Definition of enum types

The described user page uses enum types in three locations. "On" or "Off" is displayed for a Boolean value at these locations.

The enum type for "On" results in a value of 1; the enum type for "Off" results in a value of 0. The following excerpts from the HTML code of the user page show the declaration of an enum type with the name "OverrideStatus" and the values "0" and "1" for "Off" or "On" as well as the specification of an enum type reference of "OverrideStatus" for the tag "ManualOverrideEnable" in the data block "Data_block_1".

Note

Assignment of enum types

If the user page writes into a tag by using an enum type, there has to be a declaration "AWP_In_Variable" for each "AWP_Enum_Ref" declaration.

The code used in the example is:

```
<!-- AWP_In_Variable_Name='"Data_block_1".ManualOverrideEnable' -->
<!-- AWP_Enum_Def_Name="OverrideStatus" Values='0: "Off",1:"On"' -->
<!-- AWP_Enum_Ref_Name='"Data_block_1".ManualOverrideEnable'
Enum="OverrideStatus" -->
```

The following code describes a display box for displaying the current status of "ManualOverrideEnable". A normal read command for tags is used but because of the declared and referenced enum type, the website displays the values "On" and "Off" instead of "1" and "0".

```
<td style="width:24%; border-top-style: Solid; border-top-width:
2px; border-top-color: #ffffff;">
<p>Manual override: :="Data_block_1".ManualOverrideEnable:</p>
</td>
```

The following code describes a drop-down list for changing "ManualOverrideEnable" by the user. The drop-down list consists of the "Yes" and "No" options that are assigned to the "On" or "Off" values by means of the enum type reference. If you make no selection, the status remains the same.

```
<select name='"Data_block_1"ManualOverrideEnable'>
<option value=':"Data_block_1".ManualOverrideEnable:'> </option>
<option value="On">Yes</option>
<option selected value="Off">No</option>
</select>
```

The drop-down list is included in the form on the website. The form is uploaded, when the user clicks on the "Send" button. If the user has selected "Yes", the value "1" is written in the tag "ManualOverrideEnable" in the "Data_block_1" data block; if the user has selected "No", the value "0" is written.

3.11.5.4 Writing user inputs into the controller

Setting options

The user page "Remote Wind Turbine Monitor" includes different AWP commands for writing data into the controller. A user with the corresponding access permissions can control the wind turbine manually, activate the override for the turbine speed and the turbine orientation as well as the angle of attack of the rotor blades with the declaration of different "AWP_In_Variable" write commands. The user can also specify floating-point numbers for turbine speed, orientation angle of attack and percentage of braking. The user page uses an HTTP command in the format "POST" to write the tags into the controller.

The code used in the example for setting the brake value is:

```
<!-- AWP_In_Variable Name='"Data_block_1"' -->
...
<tr syte="vertical-align: top; height: 2%;">
<td style="width: 22%;"><p>Braking:</p></td>
<td>
<form method="POST">
<p><input name='"Data_block_1".Braking' size="10" type ="text">
%</p>
</form>
</td>
</tr>
```

This excerpt from the HTML code first defines a "AWP_In_Variable" for the "Data_block_1" data block which enables the user page to write any number of tags into the data block. The text "Braking:" is displayed on the left-hand side; on the right-hand side is a box in which the user can make entries for the "Braking" tag in the data block.

The user page reads out the actual braking value from the controller and displays it in the text box. A user with the corresponding access permissions can then write a brake value that controls the braking process into the data block of the CPU.

Note

Declaration of data blocks

If you declare an entire data block by means of a "AWP_In_Variable", each tag in the data block can be written by means of the user page. If only certain tags in the data block are to be writable, you declare this specifically using `<!-- AWP_In_Variable Name='"Data_block_1".Braking' -->`, for example.

3.11.5.5 Writing special tags

Using special tags

The user page "Remote Wind Turbine Monitor" writes the special tag "Server:current_user_id" into a tag of the CPU. The tag value contains the value "1" if a user is logged on and "0" if a user is not logged on. In this example, a user is logged on, so the tag value is set to "1". The special tag is written into the CPU by the user page and does not need a user interface.

The code used in the example is:

```
<!-- AWP_in_variable Name="SERVER:current_user_id" Use="User_ID" -->
```

3.11.5.6 HTML code of the user page "Remote Wind Turbine Monitor"

The complete HTML code of the example user page "Remote Wind Turbine Monitor" as well as the used Cascading Style Sheet (CSS) is listed below.

Wind_turbine.html

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd"><!--
This test program simulates a website for monitoring and operating a
wind turbine.
Required PLC tags and data block tags in STEP 7:
PLC tag:
User_ID: Int
Data blocks:
Data_block_1
Tags in Data_Block_1:
TurbineNumber: Int
WindSpeed: Real
WindDirection: Real
Temperature: Real
PowerOutput: Real
ManualOverrideEnable: Bool
TurbineSpeed: Real
YawOverride: Bool
Yaw: Real
PitchOverride: Bool
Pitch: Real
Braking: Real
The user-defined website shows the current values for the PLC data
and offers a drop-down list to specify the three Boolean values with
the assigned enumeration type. The selected Boolean values as well
as the data text boxes for speed, orientation and angle of attack of
the turbine are uploaded with the "Send" button. The brake value can
be specified without the "Send" button.
```

```
No actual STEP 7 program is required for using this page. The STEP 7
program would theoretically only respond to the values for speed,
orientation and angle of attack of the turbine, if the assigned
Boolean values were specified. The only requirement for STEP 7 is
that the WWW instruction is called with the DB number of the
generated data blocks for this page.
-->
-->
<!-- AWP_In_Variable Name='"Data_block_1"' -->
<!-- AWP_In_Variable Name='"Data_block_1".ManualOverrideEnable'
Enum="OverrideStatus" -->
<!-- AWP_In_Variable Name='"Data_block_1".PitchOverride'
Enum="OverrideStatus" -->
<!-- AWP_In_Variable Name='"Data_block_1".YawOverride'
Enum="OverrideStatus" -->
<!-- AWP_In_Variable Name="SERVER:current_user_id" Use="User_ID"-->
<!-- AWP_Enum_Def Name="OverrideStatus" Values='0:"Off",1:"On"' -->

<html>
<head>
<meta http-equiv="content-type" content="text/html;
charset=utf-8"><link rel="stylesheet" href="Wind_turbine.css">
<title>Remote monitoring of wind turbines
    </title>
 <body>
<table cellpadding="0" cellspacing="2">
<tr style="height: 2%;">
<td colspan="2">
<h2>Remote Wind Turbine Monitor: Turbine
#:="Data_block_1".TurbineNumber:</h2>
</td>
<tr style="height: 2%;"><td style="width: 25%;"><p>Wind speed:</p></
td>
<td><p> :="Data_block_1".WindSpeed: km/h</p></td>
</tr>
<tr style="height: 2%;">
<td style="width: 25%;"><p>Wind direction:</p></td>
<td><p> :="Data_block_1".WindDirection: deg.</p></td>
</tr>
<tr style="height: 2%;"><td style="width:
25%;"><p>Temperature:</p></
td>
<td><p> :="Data_block_1".Temperature: deg. C</p></td>
</tr>
<tr style="height: 2%;">
<td style="width: 25%;"><p>Power output:</p></td>
<td><p style="margin-bottom:5px;"> :="Data_block_1".PowerOutput:
kW</p>
</td>
</tr>
<form method="POST" action="">
<tr style="height: 2%;" >
<td style="width=25%; border-top-style: Solid; border-top-width:
2px; border-top-color: #ffffff;">
<p>Manual override: :="Data_block_1".ManualOverrideEnable:</p>
```

```
</td>
<td class="Text">Set:
<select name='"Data_block_1".ManualOverrideEnable'>
<option value=':="Data_block_1".ManualOverrideEnable:'> </option>
<option value="On">Yes</option>
<option value="Off">No</option>
</select>
</td>
</tr>
<tr style="vertical-align: top; height: 2%;"><td style="width:
25%;"><p>Turbine speed:</p></td>
<td>
<p style="margin-bottom:5px;"><input
name='"Data_block_1".TurbineSpeed' size="10"
value=':="Data_block_1".TurbineSpeed:' type="text"> RPM</p>
</td>
</tr>
<tr style="vertical-align: top; height: 2%;">
<td style="width: 25%;">
<p>Yaw override: :="Data_block_1".YawOverride: </p>
</td>
<td class="Text">Set:
<select name='"Data_block_1".YawOverride'>
<option value=':="Data_block_1".YawOverride:'> </option>
<option value="On">Yes</option>
<option value="Off">No</option>
</select>
</td>
</tr>
<tr style="vertical-align: top; height: 2%;">
<td style="width: 25%;">
<p>Turbine yaw:</p>
</td>
<td>
<p style="margin-bottom:5px;"><input name='"Data_block_1".Yaw'
size="10" value=':="Data_block_1".Yaw:' type="text"> deg.</p>
</td>
</tr>
<tr style="vertical-align: top; height: 2%;">
<td style="width: 25%;">
<p>Pitch override: :="Data_block_1".PitchOverride: </p>
</td>
<td class="Text">Set:
<select name='"Data_block_1".PitchOverride'>
<option value=':="Data_block_1".PitchOverride:'> </option>
<option value="On">Yes</option>
<option value="Off">No</option>
</select>
</td>
</tr>
<tr style="vertical-align: top; height: 2%;">
<td style="width=25%; border-bottom-style: Solid; border-
bottomwidth:
2px; border-bottom-color: #ffffff;">
<p>Blade pitch:</p>
```

```
</td>
<td>
<p style="margin-bottom:5px;"><input name='"Data_block_1".Pitch'
size="10" value=':="Data_block_1".Pitch:' type="text"> deg.</p>
</td>
</tr>
<tr style="height: 2%;">
<td colspan="2">
<input type="submit" value="Submit override settings and values">
</td>
</tr>
</form>
<tr style="vertical-align: top; height: 2%;">
<td style="width: 25%;"><p>Braking:</p></td>
<td>
<form method="POST" action="">
<p> <input name='"Data_block_1".Braking' size="10"
value=':="Data_block_1".Braking:' type="text"> %</p>
</form>
</td>
</tr>
</table>
</body>
</html>
```

Wind_turbine.css

```
BODY {
    background-image: url('./Wind_turbine.jpg')
    background-position: 0% 0%;
    background-repeat: no-repeat;
    background-size: cover;
H2 {
    font-family: Arial;
    font-weight: bold;
    font-size: 14.0pt;
    color: #FFFFFF;
    margin-top:0px;
    margin-bottom:10px;
}
P {
    font-family: Arial;
    font-weight: bold;
    color: #FFFFFF;
    font-size: 12.0pt;
    margin-top:0px;
    margin-bottom:0px;
}
TD.Text {
    font-family: Arial;
    font-weight: bold;
    color: #FFFFFF;
    font-size: 12.0pt;
    margin-top:0px;
    margin-bottom:0px;
}
```

3.12 Filebrowser

Requirements

Access rights must be assigned for the user in the user management.

Filebrowser

The browser displays the content of the SIMATIC memory card on the "Filebrowser" web page. This means, for example, that you can read and edit the log files generated by the CPU without having to use STEP 7.

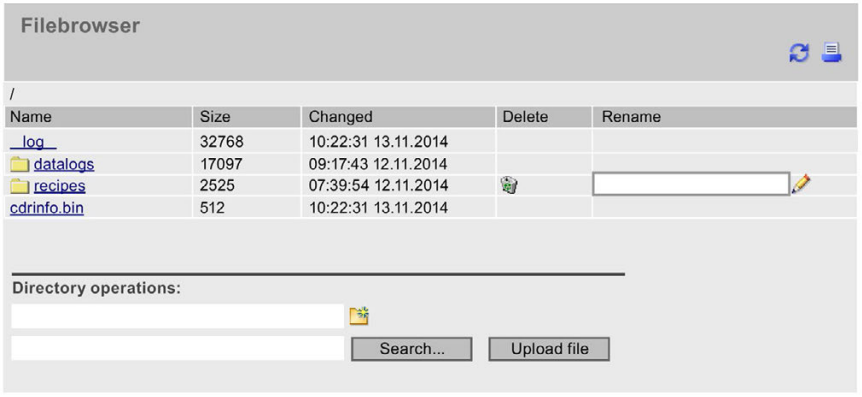


Figure 3-41 Filebrowser view

The Filebrowser lists all existing files and directories on the SIMATIC memory card. The files can be downloaded, deleted, renamed and uploaded; the directories can be created, deleted and renamed.

Note

The Filebrowser only grants you read access to the "DataLogs" and "Backups" directories.

Exception system files

The system files include the job file and all special directories including their contents to which the job file refers. System files are not displayed, and cannot be changed or deleted.

3.13 DataLogs

DataLogs

On the DataLogs web page, you can view all the DataLogs that you have created.

You can sort the DataLogs according to the individual parameters in ascending or descending order.
For this purpose, click on one of the parameters in the column header:

- Name
- Size
- Changed

You can download the relevant DataLog file by clicking the file name.

You can call (download) and empty the relevant DataLog file by clicking the icon . The file must be closed. The empty DataLog file is still maintained in the list of DataLogs.

Figure 3-42 DataLogs

NOTICE
If you open a large DataLog file via this web page, the processing times of the DataLog instructions that process this DataLog file can increase considerably. Although the processing time of the priority class (OB in which the DataLog instruction is called) does not increase, the output parameter BUSY is set for the duration of the processing.

3.14 Online backup

Backing up and restoring the CPU configuration

You can back up a CPU configuration using the Web server with the corresponding access rights. If necessary, you can also restore this configuration at a later time using the Web server.

You can create as many backups as you want and store a variety of configurations for a CPU.

NOTICE
Prior to every restoration of the CPU configuration, always first perform an online backup of the current CPU configuration and save this backup file to a local directory of your PC. This ensures that you can undo a restoration which failed (e.g. due to a damaged backup file) or which does not show the desired result.

Note

You can also perform online backup and restoration of the CPU configuration in STEP 7 (see online help for STEP 7, keyword: "Creating a backup of an S7 CPU").

With a backup using STEP 7, the backup file is saved within the STEP 7 project. With a backup using the Web server, the backup file is saved to a local directory of your PG/PC (e.g. "Downloads" directory). Web server backup files cannot be restored via STEP 7, nor can STEP 7 backup files be restored directly using the Web server.

To restore a STEP 7 backup file using the Web server, first save the STEP 7 backup file to a local directory of your PG/PC (e.g. "Downloads" directory). From there, you can restore the backup with the Web server.

Requirements

- You access the CPU via the secure transmission protocol "HTTPS".
- A valid CA-signed certificate is installed in the Web browser; see section Configuring the Web server (Page 19).

Online backup

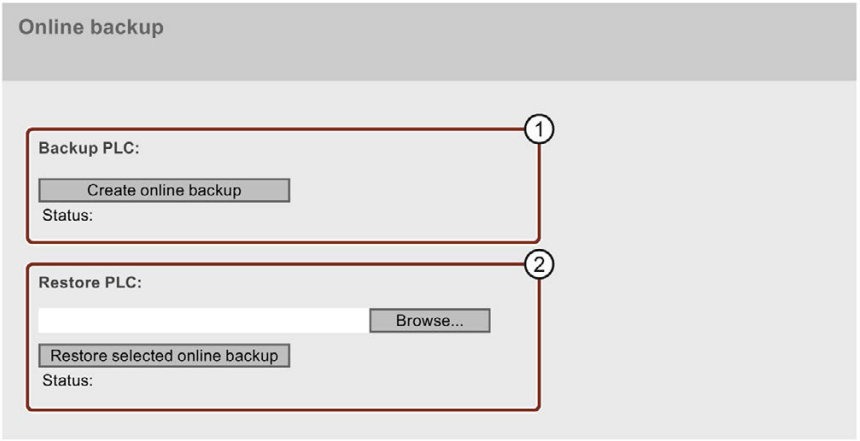


Figure 3-43 Online backup

① Perform online backup of the configuration

To perform an online backup of the CPU configuration, proceed as follows:

1. Click the "Create online backup" button in the "PLC backup" area.
2. If the CPU is in RUN mode, the following alarm is output:
   "Creation of an online backup requires PLC STOP. Do you want to set the PLC to STOP mode?"

   Acknowledge the alarm output by clicking "OK". The CPU is set to STOP mode and online backup is performed. (If you click "Cancel", the CPU remains in the current mode and the online backup is canceled.)
3. Save the backup file to a local directory of your PC.
4. Set the CPU back to RUN mode ("RUN" button in the "CPU operator panel" area of the start page).

Scope of the backup

The backup includes all data needed to restore a particular state of a CPU, i.e. the specific combination of the configuration of the CPU with the current values of the user-related retentive data.

The following data of the configuration of the CPU is backed up:

- The contents of the SIMATIC memory card, e.g. configuration, program code, recipes and archives, DataLogs

The following user-relevant retentive data is backed up:

- Retentive memory areas of data blocks, bit memories, counters and timers
- Front-panel settings, dynamic IP configuration data, operating hours counters, retentive Motion Control sensor data

Note:

- Entries in the diagnostic buffer are not included in the backup.
- The current time of day is not backed up for a SIMATIC S7-1500 CPU.
- The entire contents of the SIMATIC memory card are backed up, i.e. any data stored on the card (e.g. PDF files, GSD files).
- The backup file is assigned the name of the CPU and the project with the time and date of the backup, e.g. "2015-09-10_11-01_03_online backup_PLC69_machineControl.s7pbkp".
- The backup file of an F-CPU also contains the collective signature of the safety program in the file name. Check whether it is the expected F-collective signature.
- You can rename the backup, but you cannot make any changes to the contents of the backup.

② Restore the configuration

To restore the CPU configuration, follow these steps:

1. Enter the password of the currently logged-in user in the "PLC restore" area.
2. Click the "Browse" button and select the backup file of the configuration that you want to restore.
3. Click "Load online backup".
4. If the CPU is in RUN mode, the following alarm is output:
   "Download online backup to device. The CPU is set to STOP and the contents of the CPU will be overwritten. Do you want to continue?"

   If the CPU is already in STOP mode, the following alarm is output:
   "Download online backup to device. The contents of the CPU will be overwritten. Do you want to continue?"

   Acknowledge the alarm output by clicking "OK". The CPU is set to "STOP" mode if required, and the online backup is downloaded. (If you click "Cancel", the CPU remains in the current mode and downloading is canceled.)
5. An alarm informs you that you must not leave the web page during the "restore procedure". Acknowledge the alarm output by clicking "OK".

   The restoration of the CPU configuration starts and you will be continuously informed of the current status:

   – "Download of online backup has been started."
   – "Checking backup file."
   – "Formatting memory card and resetting CPU."

6. If you have started the restoration procedure with a user name and password defined in the Web server configuration, you will be asked to enter these again after restoration of the CPU. Enter the required information and click "Login".

   If you have started the restoration procedure as the user "Everybody" without a password (but with appropriate access rights), this prompt is not displayed.

   Note

   To restore the configuration of an F-CPU whose security program and/or password has been changed for the F-CPU in the meantime, you also need the access authorization "F-Admin"; see "Amending user management" in the section Configuring the Web server (Page 19).

   ⚠ WARNING

   The authorization "F-admin" for the Web server without password protection (User "Everybody") is only for test purposes, commissioning etc. i.e. only when the system is in productive operation. In this case, you have to ensure the security of the plant through other organizational measures, e.g. through spatial protection.

   Prior to the transition to productive operation, you must remove the right "F-Admin" for the user "Everybody".

   The password of the user of the Web server with the right "F-Admin" should only be accessible to authorized persons.

   The restoration of the CPU configuration starts and you will be continuously informed of the current status:

   – "Loading configuration."
   – "Resetting CPU."

   This may take a few minutes.

7. When the procedure is complete, you will be logged out and the "Reload page..." button will be displayed.

   If you did not receive an error message during the restoration procedure, the restoration of the CPU configuration was successfully completed and you will receive a corresponding message.

   Click the "Reload page..." button and log on to the newly downloaded CPU configuration with your user name and password.

   You will receive the following error message if:

   – the newly downloaded CPU configuration does not contain the same IP address as the former one
   – the Web server is deactivated in the newly downloaded CPU configuration
   – the browser does not receive a response from the CPU after 3 minutes

   Error message: "The CPU is not reachable anymore. Please check the IP address and the Web server configuration. The result of the restore can be checked in the ASLog."

3.15 Motion Control diagnostics

Overview

The Web server displays statuses, errors, technology alarms and the current values of the configured technology objects (TOs):

- Speed-controlled axis (TO_SpeedAxis)
- Positioning axis (TO_PositioningAxis)
- Synchronous axis (TO_SynchronousAxis)
- External encoder (TO_ExternalEncoder)
- Measuring input (TO_MeasuringInput)
- Output cam (TO_OutputCam)
- Cam track (TO_CamTrack)

The "Motion Control Diagnostics" web page provides detailed information on the configured technology objects in the following views:

- Diagnostics
- Service overview

Diagnostics

The "Diagnostics" view offers you:

- ① An overview list of the configured technology objects
- ② The status and error messages of a selected technology object
- ③ Values and limits of the status of a selected axis/cam

① "Diagnostics" view

Under "Status", you will find an overview list of the configured technology objects with the designation and type, which indicates whether the technology object in question is "released" and "referenced".

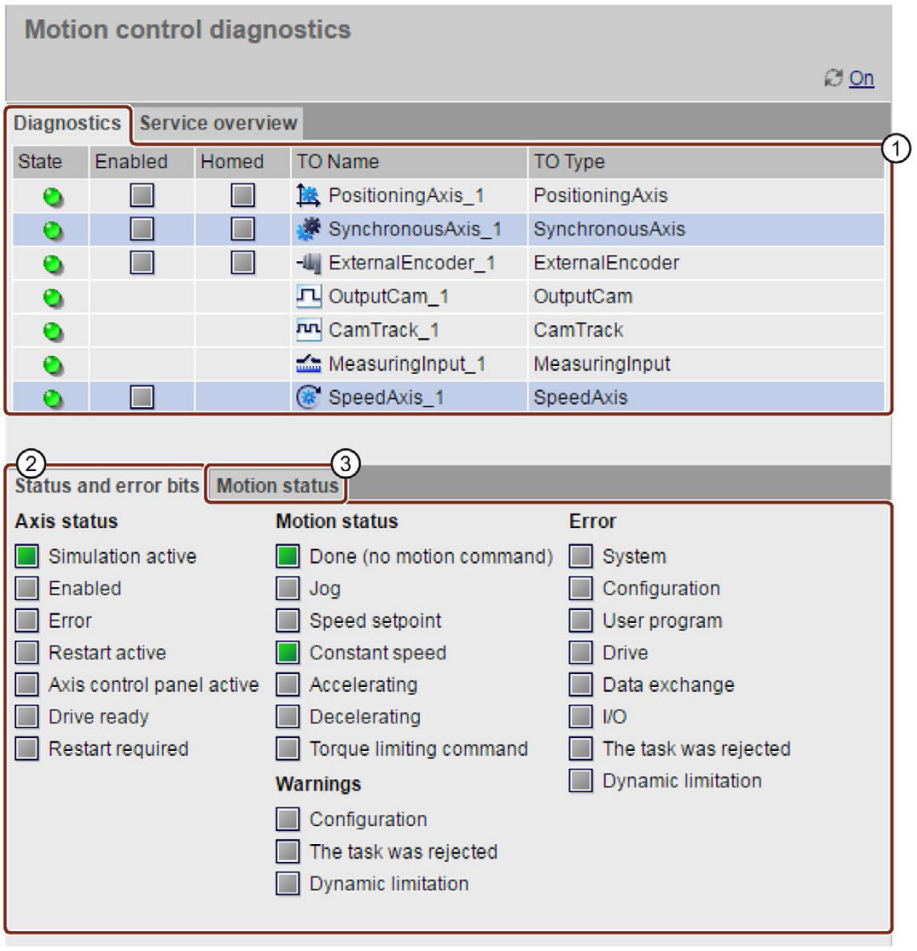


Figure 3-44 Motion Control diagnostics: Status and error bits

Meaning of the symbols in the "Status" column

Table 3- 9 Meaning of symbols

Symbol	Symbol color	Meaning
	Green	Component is OK
	Yellow	Warning pending
	Red	Error - component faulty or not available

Select the required technology object. The related diagnostics information is shown in the bottom tabs.

② "Status and error bits" tab

You use the "Status and error bits" tab to monitor the status and error messages for the technology object as in STEP 7.

③ "Motion status"/"Cam track status" tab

You use the "Motion status" tab to monitor the motion status of the axis as in STEP 7.

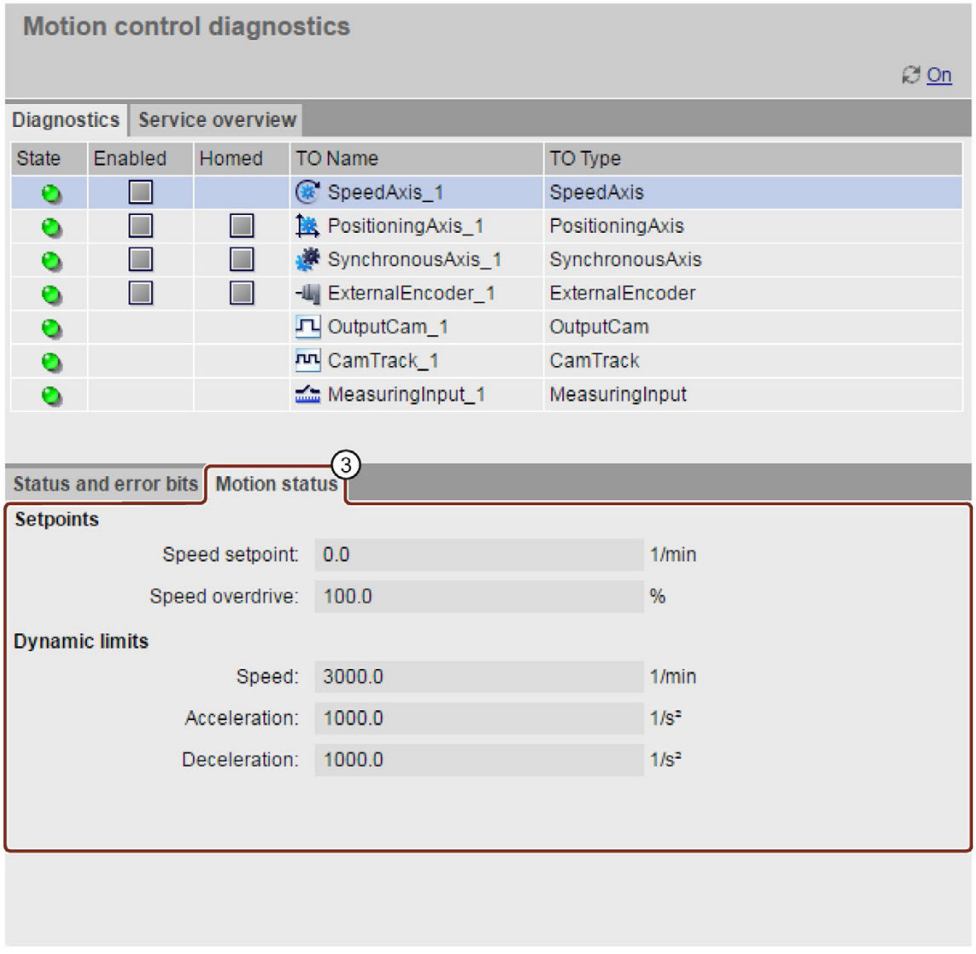


Figure 3-45 Motion Control diagnostics: Motion status

You use the "Cam track status" tab to monitor the cam track status as in STEP 7.

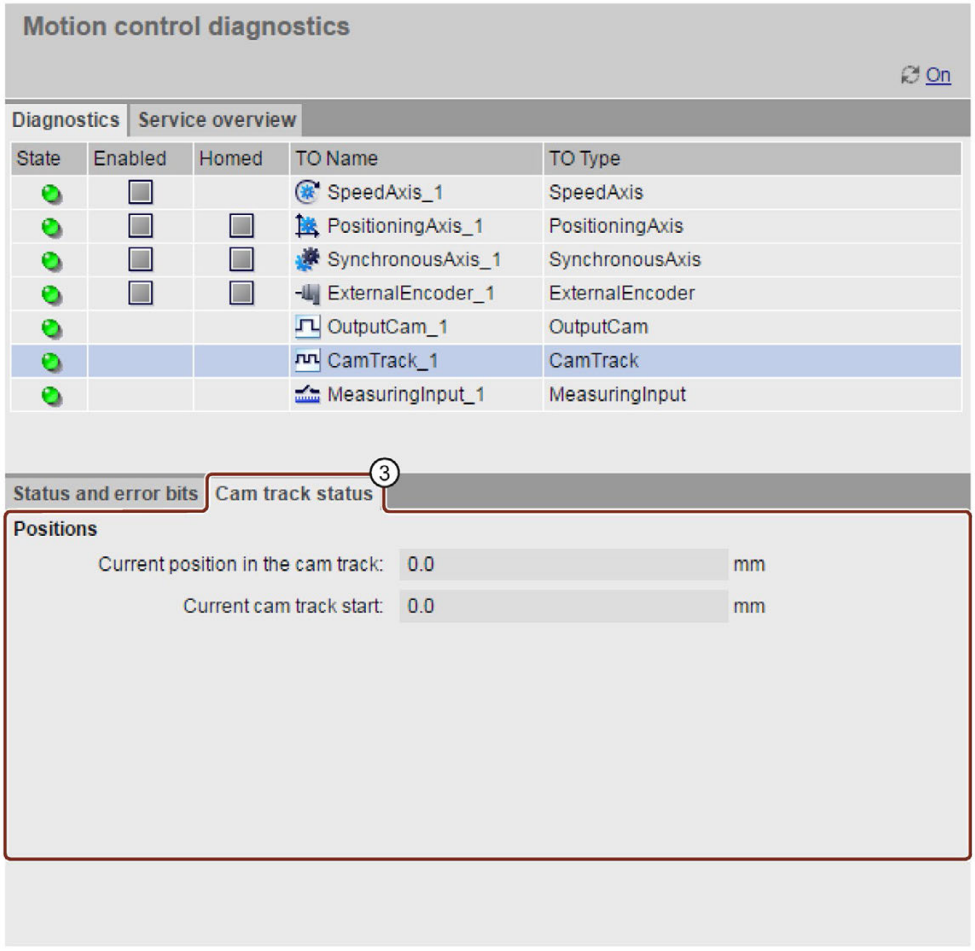


Figure 3-46 Motion Control diagnostics: Cam track status

Service overview

The "Service overview" view offers you:

- ① Diagnostics information for several technology objects
- ② A filter option for selecting the displayed technology objects

① "Service overview" view

The "Service overview" shows the diagnostics information for several technology objects in table form.

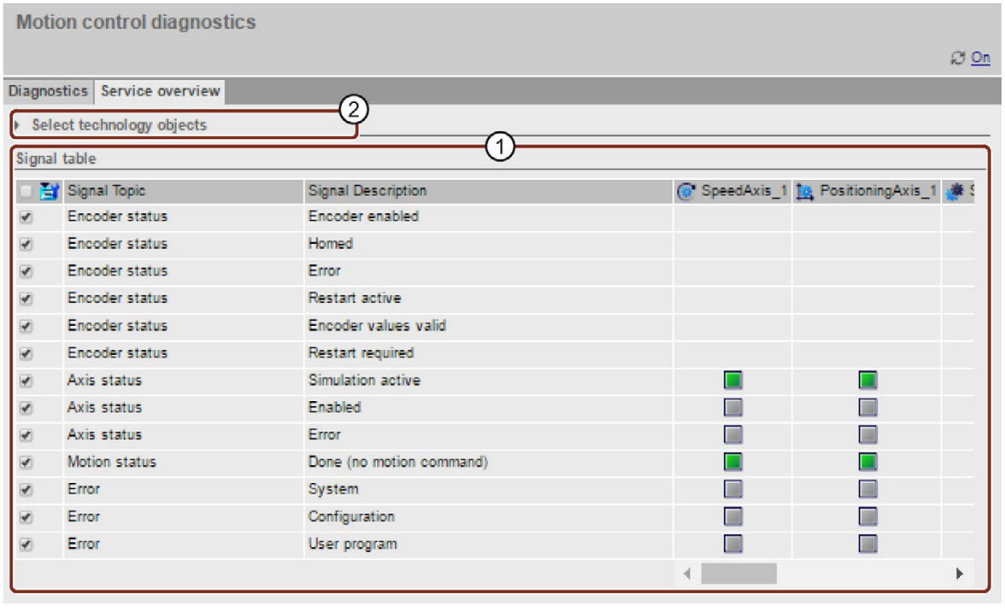
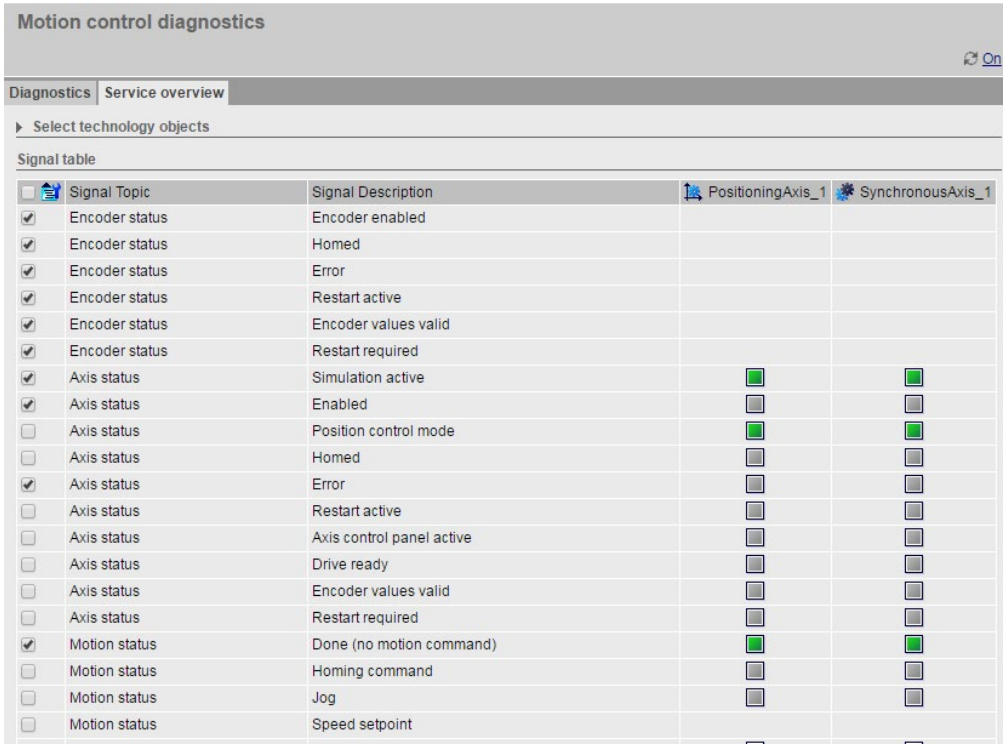


Figure 3-47 Motion Control diagnostics, service overview: Status and error information

To select the information to be displayed, click the list symbol in the first column of the table. Make your selection in the next window. Click the list symbol again to leave the selection window.



Signal Topic	Signal Description	PositioningAxis_1	SynchronousAxis_1
Encoder status	Encoder enabled		
Encoder status	Homed		
Encoder status	Error		
Encoder status	Restart active		
Encoder status	Encoder values valid		
Encoder status	Restart required		
Axis status	Simulation active		
Axis status	Enabled		
Axis status	Position control mode		
Axis status	Homed		
Axis status	Error		
Axis status	Restart active		
Axis status	Axis control panel active		
Axis status	Drive ready		
Axis status	Encoder values valid		
Axis status	Restart required		
Motion status	Done (no motion command)		
Motion status	Homing command		
Motion status	Jog		
Motion status	Speed setpoint		

Figure 3-48 Motion Control diagnostics, service overview: Configuring the status and error information

② Selection "Select technology objects"

You can make a selection of the displayed technology objects with the selection "Select technology objects".

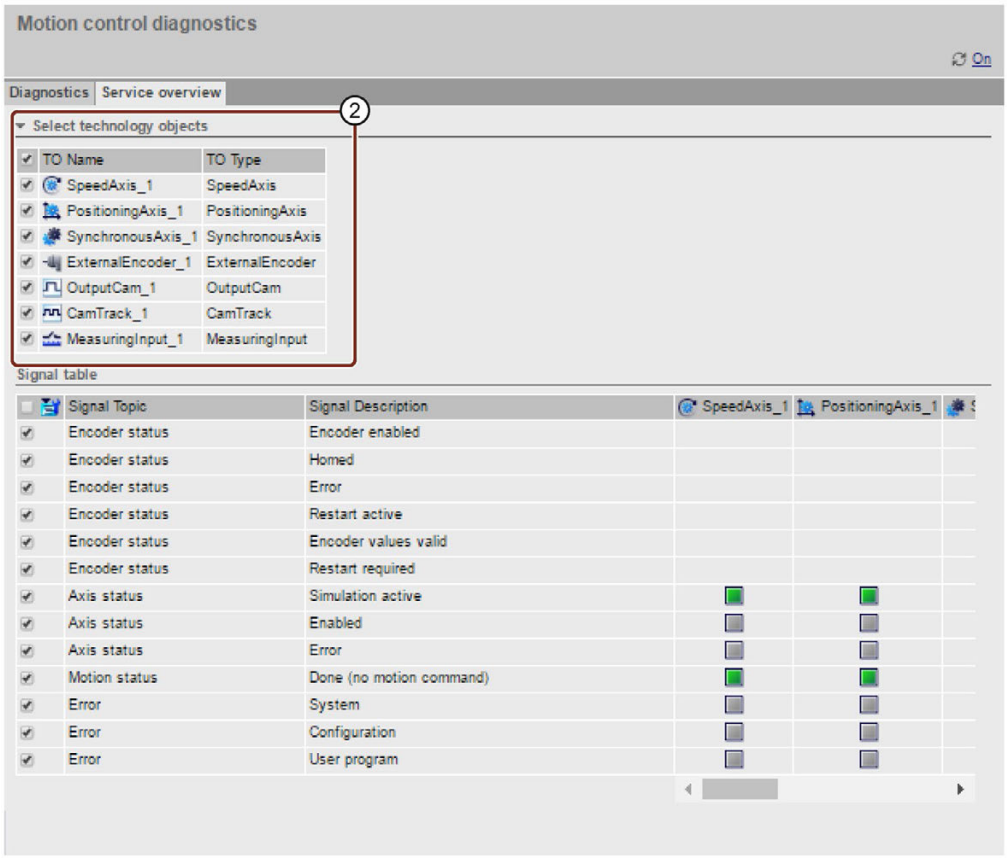


Figure 3-49 Motion Control diagnostics, service overview: Status and error information - Select technology objects

Reference

You can find explanations of the diagnostics functions "Status and error bits" and "Motion status"/Cam track status" of the individual technology objects in the online help for STEP 7.

3.16 Trace

Trace and logic analyzer function

You record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU.

The recordings are saved on the device and can be read out by users with appropriate access rights via the Web server and saved. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes in the Web server.

Requirements

- A trace configuration has been created, i.e. you have defined the recording and trigger conditions and selected the signals to be recorded.
  - Note: Only measurements which are saved on the SIMATIC memory card can be displayed on the "Trace" web page.

    For the CPU to save the measurements on the SIMATIC memory card, you must make the following settings for the trace configuration in STEP 7:

    1. Set the "Trigger mode" to "Trigger on tag".
    2. Select the "Save measurements on device (memory card)" check box.
- You have transferred the trace configuration to the device and activated it there.
- You have assigned the access right "Query diagnostics"; see section Configuring the Web server (Page 19).

Space requirements for storing trace recordings

You can use the "Save measurements on device (memory card)" function in STEP 7 to save trace recordings on your SIMATIC memory card.

Response when number reached

The "Deactivate recording" parameter repeats the measurements until the configured "Number of measurements" is reached.

The "Overwrite oldest recording" parameter replaces the oldest measurement with the latest measurement when the configured "Number of measurements" is reached. Note, however, that continuously writing data to the SIMATIC memory card shortens its service life.

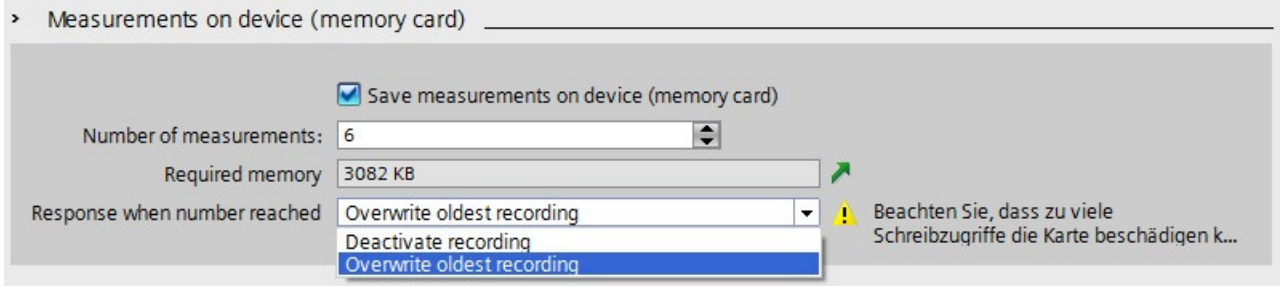


Figure 3-50 Dialog of settings for storing measurements on the memory card in STEP 7

Number of measurements

The CPU supports a maximum of 999 measurements. While the CPU writes the trace recordings to the load memory of the memory card, it pauses monitoring of the trigger conditions for the trace job. Once the CPU has finished saving the trace recordings, it continues with the monitoring of the trigger conditions.

NOTICE
Required memory on the SIMATIC memory card Note that the "Save measurements on device (memory card)" function needs >1024 KB of free space on your SIMATIC memory card. This amount of required space is independent of the size of the SIMATIC memory card you are using. If this space is no longer available, the CPU stops storing measurements on the memory card and writes a corresponding entry to the diagnostic buffer. Therefore, ensure that there is enough space on the SIMATIC memory card before running the "Save measurements on device (memory card)" function. Delete trace recordings no longer required from the SIMATIC memory card.

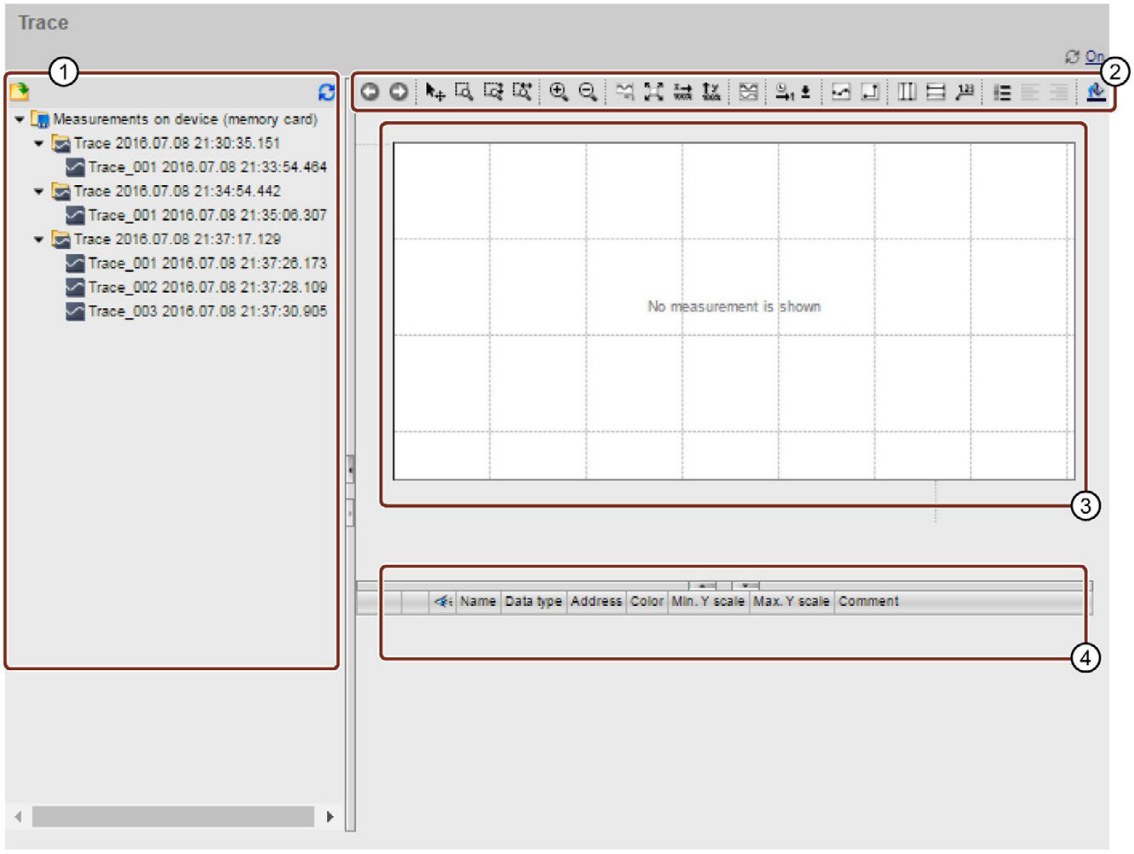
You can view the current values on the currently used space in the load memory in the "Memory" tab on the "Diagnostics" web page.

Additional information

The operation of the interface of the "Trace" web page largely corresponds to the operation of the trace function in STEP 7. See the Using the trace and logic analyzer function manual (https://support.industry.siemens.com/cs/ww/en/view/64897128) and the online help for STEP 7 for more on this.

Displaying the trace recordings

The web page of the trace and logic analyzer function consists of several areas. The example in the figure below shows how the Web server user interface is divided when the "Trace" web page is first called.



① Trace recordings
② Toolbar of the trend diagram
③ Trend diagram and bit track
④ Signal table

Figure 3-51 Trace start page without measurement

① Trace recordings

List of existing measurements, sorted by date and time of the trace recordings. A measurement always consists of a trace configuration with an associated recording.

The following table shows the special Web server shortcut menu commands in the Trace recordings area:

Table 3- 10 Web server shortcut menu commands in the trace recordings area

Shortcut menu command	Description
"Delete"	Deletes the selected measurement on the memory card of the CPU. A confirmation dialog opens. After deletion, the display in the trend diagram area is not automatically overwritten.
"Save as"	Saves the selected measurement in a csv file. The "Save as" dialog opens.
"Show chart"	Loads the selected measurement to the display area of the Web server.

1. Select a measurement and display it using the shortcut menu command "Show chart" or with a double click.

All signals of the measurement are displayed.

Some data types offer the display of individual bit tracks. You need to enable the individual bit tracks of the signal opened in the signal table using the icon.

You can adjust the display of the signals in the signal table and with the aid of the toolbar of the trend diagram.

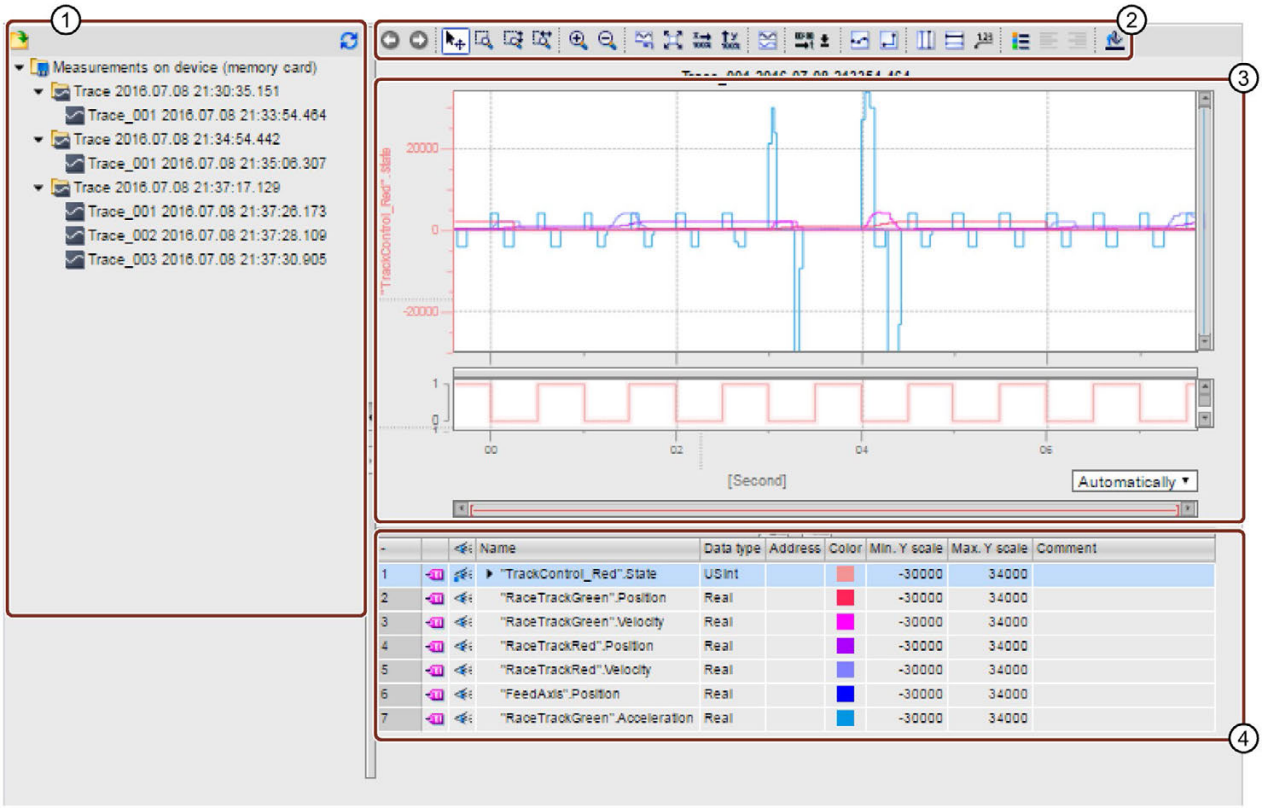


Figure 3-52 Trace measurement - All areas visible

You can increase or decrease the size of the three display areas:

- ① Trace recordings (you can minimize/maximize the area by clicking on the two small arrows)
- ② Toolbar of the trend diagram
- ③ Trend diagram and bit track (size can be changed)
- ④ Signal table (you can minimize/maximize the area by clicking on the two small arrows)

② Toolbar of the trend diagram

As in STEP 7, tools are available for adapting the display via buttons.

The following table shows the special Web server buttons in the trend diagram toolbar:

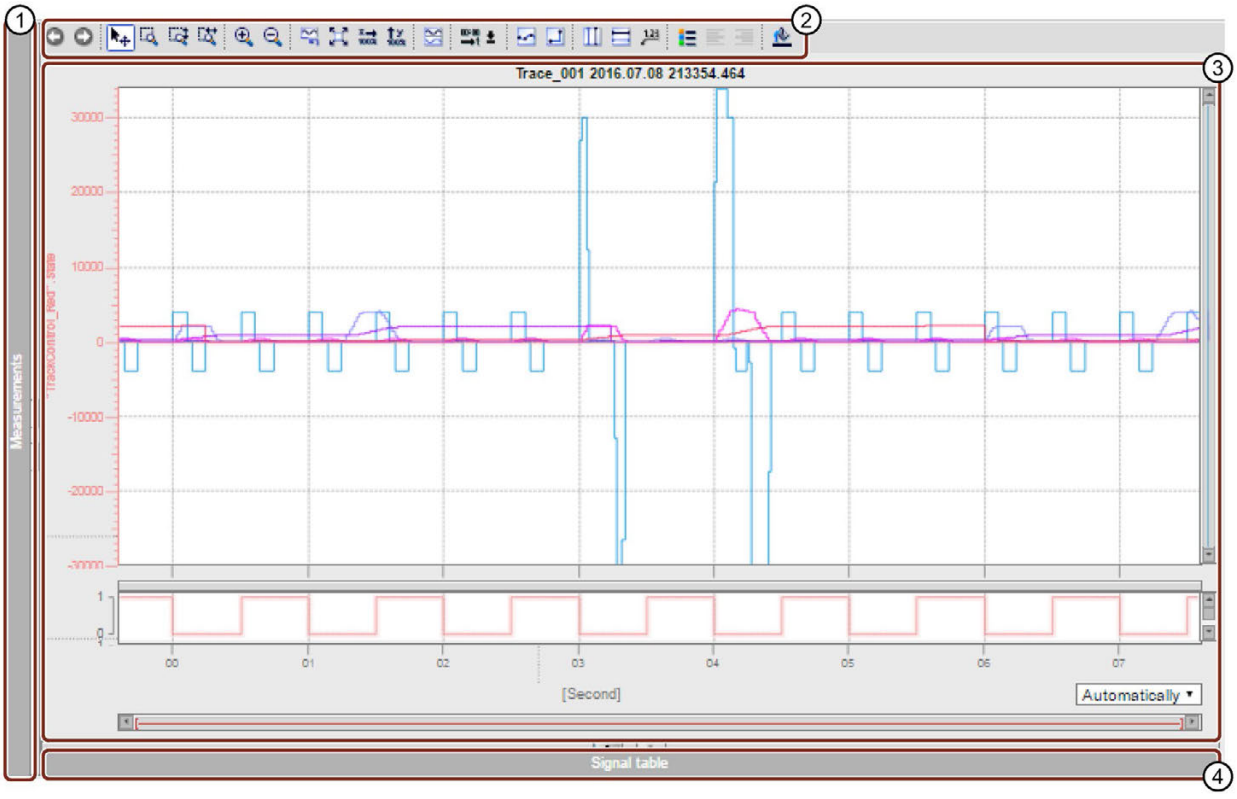
Table 3- 11 Web server symbols in the trend diagram toolbar

Symbol	Function	Description
	Move view	Moves the display with the mouse button pressed - corresponds to the symbol in STEP 7
	Restore standard view	Scaling and moves are canceled, the view is reset to the status at the time of loading of the measurement. (Hidden signals are also reset but remain disabled.)
	Display all	All signals are fully moved to the display area without changing the relative positions of the signals to each other.
	Scale X automatically	Automatic scaling of all visible signals in the horizontal X area
	Scale Y automatically	Automatic scaling of all visible signals of the current X area in vertical Y direction
/	Interpolation on/off	The data of the trend diagram is interpolated or not.
	Difference of the measurement cursor	Display of the difference of the horizontal and vertical measurement cursors and the Y values at the intersections with the vertical measurement cursors

All icons in the toolbar are equipped with tooltips.

③ Trend diagram

The trend diagram displays the selected signals of a recording. Bits are shown in the lower diagram as a bit track.



① Trace recordings (minimized)
② Toolbar of the trend diagram
③ Trend diagram and bit track
④ Signal table (minimized)

Figure 3-53 Trace measurement - only trend diagram visible

The following table shows the special Web server shortcut menu commands of a selected signal in the trend diagram:

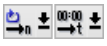
Table 3- 12 Web server shortcut menu commands in the trend diagram area

Shortcut menu command	Description
"Scale Y automatically"	Automatic scaling of the selected signal in Y direction.
"Hide signal"	Hides the selected signal in the trend diagram.

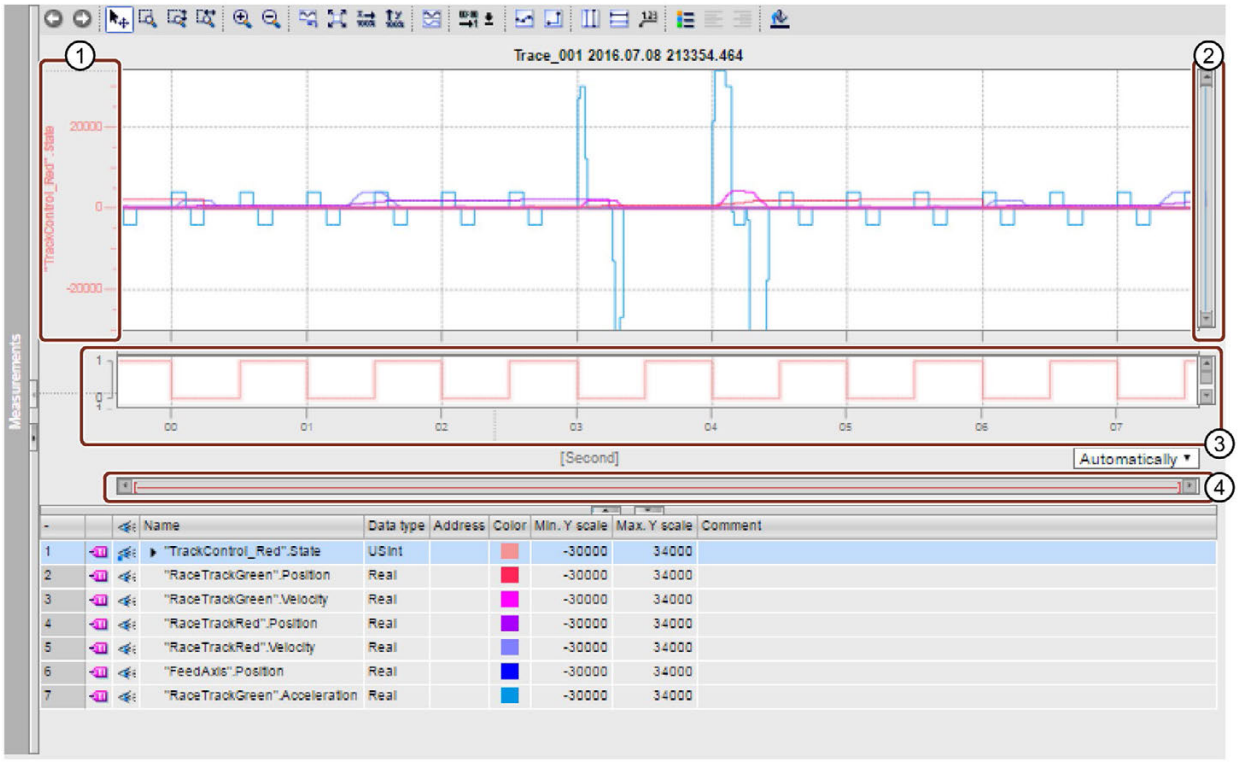
Use of the trend diagram

The display area can be zoomed as required. Measurement cursors can be used to select individual values for display in the signal table.

Table 3- 13 Measurement cursor symbols in the toolbar of the trend diagram

Symbol	Function	Description
	Vertical measurement cursor	Display of vertical measurement cursor The vertical position of the two measurement cursors can be moved with the mouse. The values of the signals and the difference between two measuring points are displayed in the signal table for all displayed signals and also in the trend diagram for the selected signal. The measuring point or the relative/absolute time to the measurement cursors is displayed depending on the set unit of the time axis in the movable pop-up window "Measuring points/Time values".
	Horizontal measurement cursor	Display of the horizontal measurement cursors The horizontal position of the two measurement cursors can be moved with the mouse. The Y values of the measurement cursor for the selected signal are displayed in the movable pop-up window "Y values".
	Unit switching of the time axis	Switching the unit of the time axis You can set the following units: • Measuring points • Time (relative time related to the trigger time) • Absolute time

The following image shows how you can change the display area of the trend diagram as required with rulers and scroll bars.



① Vertical ruler
② Vertical scroll bar
③ Horizontal ruler
④ Horizontal scroll bar

Figure 3-54 Trace measurement - rulers and scroll bars

Using the vertical ruler

- If you click the vertical ruler at the top or the bottom, you increase the size of the display at the top or bottom.
- If you click the vertical ruler at the top or the bottom while keeping the shift key pressed, you scale both ends.
- If you click the vertical ruler at the top or the bottom while keeping the Ctrl key pressed, you move the display up or down.

Using the horizontal ruler

- If you click the horizontal ruler on the left or the right, you increase the size of the display on the left or right.
- If you click the horizontal ruler on the left or right while keeping the shift key pressed, you scale both ends.
- If you click the horizontal ruler on the left or the right while keeping the Ctrl key pressed, you move the display to the left or right.

Using the mouse wheel

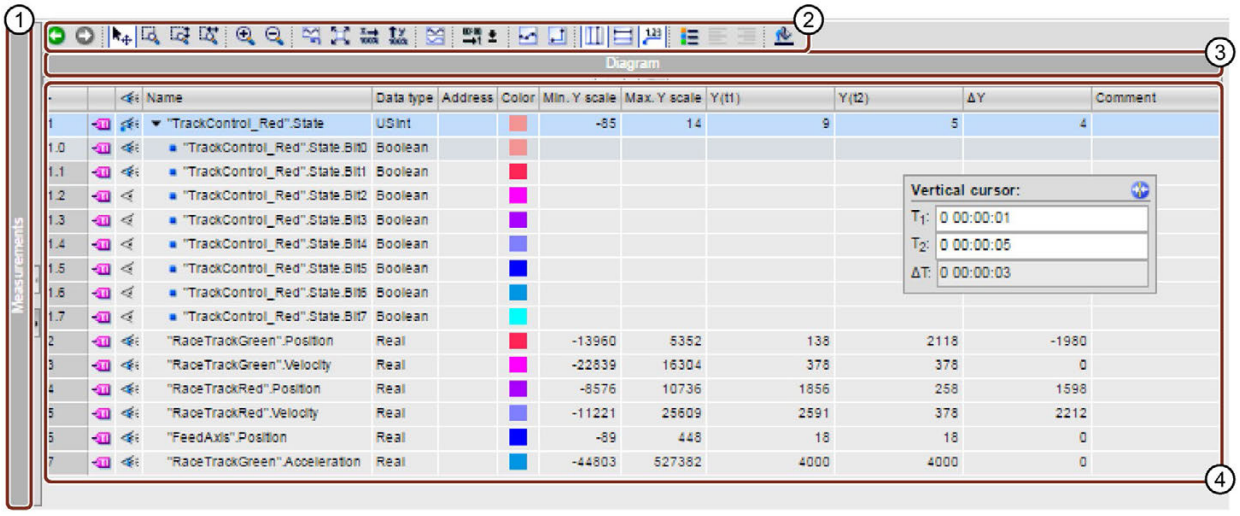
- If you activate the mouse wheel in the display, you move the display up or down.
- If you activate the mouse wheel in the display while keeping the shift key pressed, you move the display to the left or right.
- If you activate the mouse wheel in the display while keeping the Ctrl key pressed, you increase/reduce the size of the display at the position of the mouse pointer.

④ Signal table

The signal table lists the signals of the selected measurement and provides setting options for some properties.

Please note the different setting options between the Web server and STEP 7:

- More setting options for the color of the signal are available in the Web server than in STEP 7. For this purpose, click in the "Color" table column of a signal. The color selection dialog opens and you can select from several colors other than the TIA standard colors.
- Unlike in STEP 7, the "Signal group" table column for combining signals to form groups is **not** available in the Web server.



		Name	Data type	Address	Color	Min. Y scale	Max. Y scale	Y(t1)	Y(t2)	ΔY	Comment
1		"TrackControl_Red".State	USInt			-55	14	9	5	4	
1.0		"TrackControl_Red".State.Bit0	Boolean								
1.1		"TrackControl_Red".State.Bit1	Boolean								
1.2		"TrackControl_Red".State.Bit2	Boolean								
1.3		"TrackControl_Red".State.Bit3	Boolean								
1.4		"TrackControl_Red".State.Bit4	Boolean								
1.5		"TrackControl_Red".State.Bit5	Boolean								
1.6		"TrackControl_Red".State.Bit6	Boolean								
1.7		"TrackControl_Red".State.Bit7	Boolean								
2		"RaceTrackGreen".Position	Real			-13960	5352	138	2118	-1980	
3		"RaceTrackGreen".Velocity	Real			-22839	16304	378	378	0	
4		"RaceTrackRed".Position	Real			-8576	10736	1856	258	1598	
5		"RaceTrackRed".Velocity	Real			-11221	25609	2591	378	2212	
6		"FeedAxis".Position	Real			-89	448	18	18	0	
7		"RaceTrackGreen".Acceleration	Real			-44803	527382	4000	4000	0	

① Trace recordings (minimized)
② Toolbar of the trend diagram
③ Trend diagram and bit track (minimized)
④ Signal table

Figure 3-55 Trace measurement - only signal table visible

The following table shows the possible Web server shortcut menu commands in the signal table:

Table 3- 14 Web server shortcut menu commands in the signal table area

Shortcut menu command	Description
"Scale Y automatically"	Automatic scaling of the selected signal in Y direction.
"Show signal"	Shows the signal in the trend diagram.
"Hide signal"	Hides the signal in the trend diagram.
"Show all bits"	Displays all the bits of a signal.
"Hide all bits"	Hides all the bits of a signal.

3.17 Reading out service data

The Web server gives you the option to save service data. In addition to the content of the diagnostic buffer, they include additional information on the internal status of the CPU. If you should encounter a problem with the CPU that cannot be resolved otherwise, you therefore have the option to submit the service data to the Service&Support team.

Procedure

1. Enter the following address in the address bar of your web browser:
   "http://<CPU IP address>/save_service_data", e.g.,
   "http://192.168.3.141/save_service_data"
2. Your screen displays the service data page with a button for saving the service data.

3. Save the service data locally on your display device by clicking "Save ServiceData".

Result

The data is saved into a .dmp file with the following naming convention: "<MLFB><serial number><time stamp>.dmp". The user can change the file name at a later time.

Note

If you have defined your user page as the start page, observe the note on reading out service data in section Defining the user page as start page (Page 85).

3.18 Basic websites

Web pages with reduced contents

Basic websites are offered for display devices with smaller screens, for example HMI, on the Web server.
Basic websites are web pages with reduced content that are adapted to the requirements of small screens with low resolution.
These sites do not support JavaScript for the sake of fast access. This means that not all standard websites are available as basic websites. The basic website can also have fewer functions than the standard website.

The switch to basic websites takes place automatically for HMI devices.
You access basic websites from other end devices by entering the IP address of the configured and the extension "/basic" in the address bar of the Web browser, for example http://192.168.3.141/basic or https://192.168.3.141/basic.

The following standard websites are also available as basic websites:

- Start page (in Basic: "Status")
- Diagnostics (without the "Program protection", "Runtime information" and "Fail-safe" tabs)
- Diagnostics buffer
- Memory usage
- Module information
- Alarms (without acknowledgment option)
- Communication
- Tag status
- Watch tables
- User pages
- Filebrowser (read access only)
- DataLogs
- Intro

The basic websites are displayed as follows:

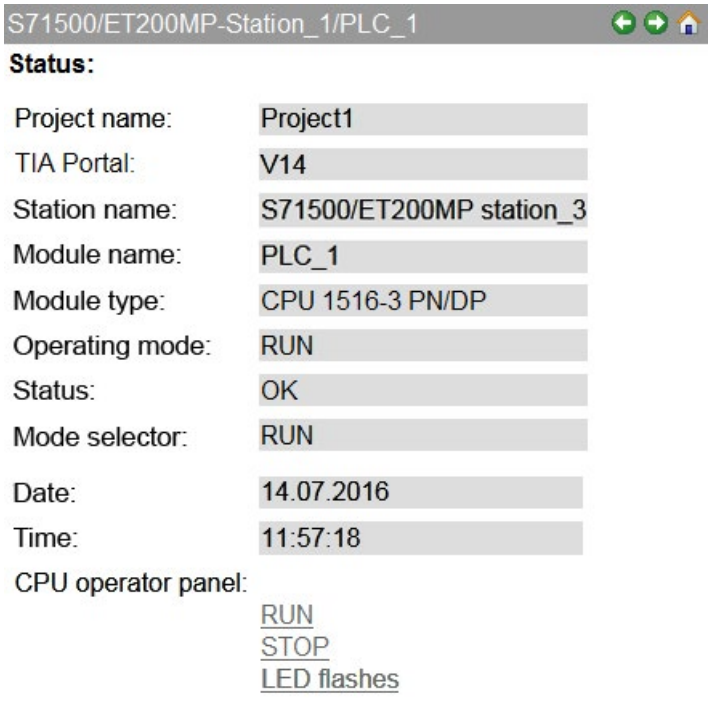


Figure 3-56 Example basic websites, "Status" web page

Glossary

Automation system

An automation system is a programmable logic controller that consists of at least one CPU, various input and output modules, as well as operating and monitoring devices.

AWP

Automation Web Programming

AWP commands

Special command syntax for data exchange between CPU and HTML file.

Configuration

Systematic arrangement of individual modules (design).

CSS

A CSS (Cascading Style Sheet) specifies how an area or content marked up in HTML is displayed.

Device

Device that can send, receive or amplify data via the bus, e.g., IO controller.

Diagnostics

The detection, localization, classification, visualization and further evaluation of errors, malfunction and alarms.

Diagnostics provides monitoring functions that run automatically during plant operation. This increases the availability of plants by reducing commissioning times and downtimes.

Firewall

A firewall is used to restrict the network access based on sender or target address of the used services. The firewall decides based on specified rules which of the network packets it handles are forwarded and which are not. This way the firewall tries to prevent unauthorized network access.

It is not the function of a firewall to detect attacks. It only implements rules for network communication.

HTTP

Hypertext Transfer Protocol (HTTP). Protocol for data transmission across a network.

HTTPS

Hypertext Transfer Protocol Secure (HTTPS). Protocol for tap-proof transmission of sensitive data across a network.

Identification data

Identification data is stored on a module, and contains information which supports the user in

- Checking the system configuration
- Locating hardware changes in a system
- Correcting errors in a system

Modules can be clearly identified online using the identification data.

Master

The master in possession of the token is an active device. This master has the option to receive data from other devices and to send data to other devices.

PROFIBUS

PROcess **FI**eld **BUS**, process and field bus standard specified in standard IEC 61784-1:2002 Ed1 CP 3/1. It specifies functional, electrical, and mechanical properties for a bit-serial field bus system.

PROFIBUS is available with the protocols DP (= Distributed I/O), FMS (= Fieldbus Message Specification), PA (= Process Automation), or TF (= Technological Functions).

PROFINET

Within the framework of Totally Integrated Automation (TIA), PROFINET represents the consistent continuation of:

- PROFIBUS DP, the established field bus
- Industrial Ethernet, the communications bus for the cell level

Experience gained from both systems was and is being integrated into PROFINET.

PROFINET as an Ethernet-based automation standard from PROFIBUS International (previously PROFIBUS User Organization) defines a vendor-independent communication, automation, and engineering model.

PROFINET component

A PROFINET component includes the entire data of the hardware configuration, the parameters of the modules, and the corresponding user program. The PROFINET component is made up as follows:

- Technological Function

  The (optional) technological (software) function includes the interface to other PROFINET components in the form of interconnectable inputs and outputs.

- Device

  The device is the representation of the physical programmable controller or field device including the I/O, sensors and actuators, mechanical parts, and the device firmware.

PROFINET IO

As part of PROFINET, PROFINET IO is a communication concept that is used to implement modular, distributed applications.

PROFINET IO allows you to create automation solutions which are familiar to you from PROFIBUS.

PROFINET IO is implemented by the PROFINET standard for automation devices on the one hand, and on the other hand by the engineering tool STEP 7.

That is, you have the same application view in STEP 7, regardless of whether you configure PROFINET or PROFIBUS devices. Programming your user program is essentially the same for PROFINET IO and PROFIBUS DP if you use the extended blocks and system status lists for PROFINET IO.

PROFINET IO controller

Device used to address connected I/O devices. This means that the IO controller exchanges input and output signals with assigned field devices. The IO controller is often the controller on which the automation program runs.

PROFINET IO device

A distributed field device that is assigned to one of the IO controllers (e.g., remote IO, valve terminals, frequency converters, switches).

URL

Uniform Resource Locator (URL). Identifies and localizes a source, such as a web page, uniquely via the method of access used and the location of the source in computer networks.

UTF-8

Abbreviation for 8-bit UCS (Universal Character Set) transformation format. Most popular coding of Unicode characters.

Each Unicode character is assigned a specially coded byte string of variable length in this format. UTF-8 supports up to four bytes on which all Unicode characters can be mapped.

Web browser

Web browsers are visualization programs for web pages and can communicate with Web servers.

Typical web browsers are, for example:

- Microsoft Internet Explorer
- Mozilla Firefox

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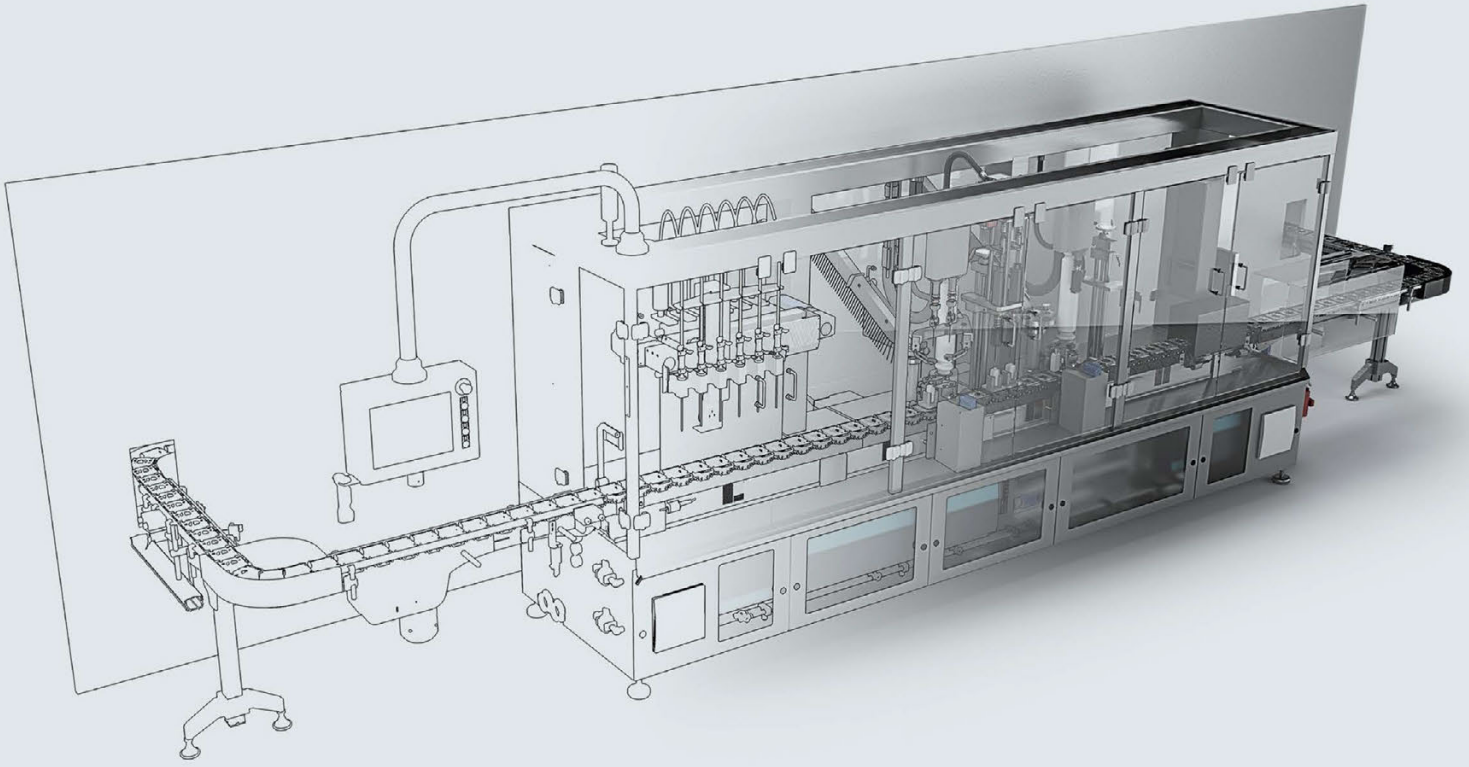

SIMATIC

S7-1500

S7-PLCSIM Advanced

Function manual

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S7-1500
S7-PLCSIM Advanced

Function Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This function manual describes the simulation software, S7-PLCSIM Advanced V1.0. It enables you to test your CPU programs on a simulated, virtual S7-1500 controller.

You can obtain updates to the function manual as downloads on the Internet (https://support.industry.siemens.com/cs/us/en/view/109739154).

Scope

This function manual is valid for the following order versions

- 6ES7823-1FA00-0YA5 - S7-PLCSIM Advanced V1.0 DVD
- 6ES7823-1FE00-0YA5 - S7-PLCSIM Advanced V1.0 Download

The articles each contain one license for one instance.

Basic knowledge required

The system may only be used by qualified staff.
The following knowledge is required:

- Industrial Automation and Automation Technology
- Programming with STEP 7 (TIA Portal)
- SIMATIC CPUs and CPU programming
- PC-based automation using S7-1500 and WinCC Runtime Advanced
- Development of software in C++ and C#
- PC technology
- Windows operating system

Conventions

Conventions STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

We also use abbreviate SIMATIC S7-PLCSIM Advanced V1.0 as "PLCSIM Advanced".

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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Guide

1

1.1 Documentation Guide S7 PLCSIM Advanced

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

Basic information

System manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200SP systems. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500 (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500 (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (https://support.industry.siemens.com/My/ww/en/).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

The TIA Selection Tool can be used to select, configure and order devices for Totally Integrated Automation (TIA). It assembles the configuration editors for automation technology already familiar into a single tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

1.2 S7 PLCSIM products

S7 PLCSIM Advanced

The version of S7-PLCSIM Advanced supports the following SIMATIC CPU series:

- S7-1500, S7-1500F, S7-1500C, S7-1500T and S7-1500TF
- ET 200SP and ET 200SP F

Communication

S7-PLCSIM Advanced supports communication via Softbus or TCP/IP.

S7 PLCSIM Advanced enables C++ and C# programs and simulation software to access SIMATIC CPU series supported by S7-PLCSIM Advanced via the user interface (API).

S7-PLCSIM Advanced and S7-PLCSIM V12 cannot be installed on the same PC or the same virtual machine. The communication between the two applications cannot be simulated.

S7-PLCSIM V5.4 SP7 is automatically installed with S7-PLCSIM Advanced. The communication between the two applications can be simulated.

S7-PLCSIM V14

The version of S7-PLCSIM supports the following SIMATIC CPU series:

- S7-1200 and S7-1200F
- S7-1500, S7-1500F, S7-1500C, S7-1500T and S7-1500TF
- ET 200SP and ET 200SP F

Communication

S7-PLCSIM V14 supports communication via Softbus.

S7-PLCSIM V5.x

S7-PLCSIM V5.x simulates the following SIMATIC CPU series:

- S7-300 and S7-300F
- S7-400 and S7-400F

S7-PLCSIM V5.x cannot be installed on the same PC or the same virtual machine S7-PLCSIM as of V12.

S7-PLCSIM V5.4 SP7 is automatically installed with S7-PLCSIM Advanced.

Communication

S7 PLCSIM V5.x can communicate via Softbus with instances of S7-PLCSIM as of V12.

S7-PLCSIM V5.4 SP7 can communicate via Softbus with instances of S7-PLCSIM Advanced.

Product overview

2

2.1 What is PLCSIM Advanced?

Simulation systems support the development of programs and the deployment in production that follows. In the automation world, a simulated test environment shortens commissioning times. It is possible to test the program after program changes in the virtual controller before it is loaded into the corresponding real controller and the plant is put into operation.

S7 PLCSIM Advanced

Using S7-PLCSIM Advanced, you can simulate your CPU programs on a virtual controller. You do not need a real controller for this. You can configure your CPU in STEP 7 V14, program your application logic and then load the hardware configuration and the program into the virtual controller. From there you can run your program logic, observe the effects of simulated inputs and outputs and adapt your programs.

In addition to communicating via Softbus, S7-PLCSIM Advanced provides a full Ethernet connection and can thus also communicate distributed.

User interface (API)

S7 PLCSIM Advanced enables interaction with native C++/C# programs or software via the user interface.

Application areas

- Software in the Loop-Simulation for virtual commissioning of machine tools
- In combination with third-party software:
  - Simulation of production machines and plants
  - Combined simulation of automation and mechanics

Advantages

The use of S7 PLCSIM Advanced offers numerous advantages:

- Improve quality of automation projects
- Accelerate time to market
- Reduce production times
- Reduce risk for commissioning
- Avoid costs for hardware in simulation environments
- Increase efficiency in maintenance

2.2 Security for PLCSIM Advanced

Restrictions for security

Note the following restrictions when using PLCSIM Advanced:

Authentication

- The user interfaces (API) do not have options for authentication and authorization. There is no protection using user accounts and passwords.
- The Runtime Manager communication is not protected by authentication.

Communication

- The multi-computer simulation communication is not encrypted.
- A TCP/IP port is opened on the PC for cross-network communication.
- The installed WinPCap component provides access to TCP/IP network communication.

Note

For cross-computer communication, it is recommended to use a closed simulation network that is not connected to a production network.

Know-how protection

Note

If know-how-protected blocks for the simulation support are enabled, the know-how protection is limited.

2.3 Simulations support

Requirement for simulation

Note

Enable simulation capability

To use a STEP 7 project with simulation, you must select the "Support simulation during block compilation" option in the "Protection" tab in the project properties.

Figure 2-1 Enable simulation capability

Know-how protection

If a know-how-protected block is to be used for the simulation, it must be unlocked by entering a password, to enable the "Simulation with SIMATIC S7-PLCSIM Advanced" option to be unlocked in the properties of the block in the tab "General > Compilation".

Global libraries

You cannot use know-how protection with global libraries, because the libraries are write-protected.

The "Simulation with SIMATIC S7-PLCSIM Advanced" option must be set when generating the blocks (source of the blocks).

2.4 Supported CPUs

Supported CPUs from the S7-1500 family

S7-PLCSIM Advanced V1.0 supports the simulation of the following CPUs (all firmware versions, V2.0 recommended):

Type		Article number
Standard CPUs	CPU 1511-1 PN	6ES7511-1AK01-0AB0
	CPU 1513-1 PN	6ES7513-1AL01-0AB0
	CPU 1515-2 PN	6ES7515-2AM01-0AB0
	CPU 1516-3 PN/DP	6ES7516-3AN01-0AB0
	CPU 1517-3 PN/DP[3]	6ES7517-3AP00-0AB0
	CPU 1518-4 PN/DP[3]	6ES7518-4AP00-0AB0
	CPU 1518-4 PN/DP ODK[2, 3]	6ES7518-4AP00-3AB0
Fail-safe CPUs	CPU 1511F-1 PN	6ES7511-1FK01-0AB0
	CPU 1513F-1 PN	6ES7513-1FL01-0AB0
	CPU 1515F-2 PN	6ES7515-2FM01-0AB0
	CPU 1516F-3 PN/DP	6ES7516-3FN01-0AB0
	CPU 1517F-3 PN/DP[3]	6ES7517-3FP00-0AB0
	CPU 1518F-4 PN/DP[3]	6ES7518-4FP00-0AB0
	CPU 1518F-4 PN/DP ODK[2, 3]	6ES7518-4FP00-3AB0
Compact CPUs[1]	CPU 1511C-1 PN	6ES7511-1CK00-0AB0
	CPU 1512C-1 PN	6ES7512-1CK00-0AB0
ET 200SP CPUs	CPU 1510SP-1 PN	6ES7510-1DJ01-0AB0
	CPU 1510SP F-1 PN	6ES7512-1SJ01-0AB0
	CPU 1512SP-1 PN	6ES7512-1DK01-0AB0
	CPU 1512SP F-1 PN	6ES7512-1SK01-0AB0
Technology CPUs	CPU 1511T-1 PN	6ES7511-1TK01-0AB0
	CPU 1515T-2 PN	6ES7515-2TM01-0AB0
	CPU 1517T-3 PN/DP[3, 4]	6ES7517-3TP00-0AB0
	CPU 1517TF-3 PN/DP[3, 4]	6ES7517-3UP00-0AB0

1 The on-board I/O within the compact CPUs is not simulated. The simulation interface corresponds to the process image.

2 The ODK functionality of this CPU is not simulated.

3 The simulation of this CPU only supports 5120 Motion Control resources.

4 The simulation of this CPU supports only 64 cams.

Unsupported CPUs

S7-PLCSIM Advanced V1.0 does not support the simulation of the following CPUs:

- S7-1200 CPUs
- ET 200pro, ET 200pro F CPUs
- ET 200SP Open Controller CPU 1515SP PC
- Software Controller

2.5 Differences between a simulated and a real CPU

The virtual controller cannot fully simulate a real CPU down to the individual details. Even if a program is downloaded without errors to the CPU and running successfully, this does not necessarily mean that the virtual controller in the simulation behaves exactly like a real CPU.

Deterministic

S7-PLCSIM Advanced runs on a PC with the Windows operating system. Therefore, the scan cycle time and the exact time of actions in S7-PLCSIM Advanced are not the same as when these actions run on physical hardware. This is because that several programs share the processing resources on your PC.

If your program depends heavily on the time required to execute actions, then make sure that you do not evaluate your program based only on the results of the simulation time.

Know-how protection

Projects with know-how protected blocks can only be simulated when they are enabled for simulation. You need the block password for this purpose.

Instructions

Instructions are simulated with a few exceptions, for example, interrupts. Programs that are based on the instructions behave different than real CPUs in the simulation.

See also

Restrictions for instructions (Page 306)

2.5.1 Restrictions for all supported CPUs

I/O

S7-PLCSIM Advanced simulates the real CPU, but not configured I/O modules and the on-board I/O of the compact CPUs.

Bus systems

S7-PLCSIM Advanced does not simulate bus systems (PROFINET IO, PROFIBUS DP, backplane bus).

Process image partitions

S7-PLCSIM Advanced always updates the address areas of the process image at the cycle control point. Process image partitions between two cycle control points are not updated.

Diagnostics

S7-PLCSIM Advanced cannot simulate the complete range of all the possible diagnostic buffer entries, for example, no entries that affect the real hardware. Most I/O and program errors are simulated.

Online and diagnostic functions

Some online and diagnostic functions are not very useful in the simulation and are therefore not supported. These include, for example, the functions "Format memory card" and "Firmware update".

Status indicators LED flashing

In STEP 7, you can have the LED displayed on an CPU flash using the "Extended download to device" dialog. S7-PLCSIM Advanced does not simulate this function.

Data logging

S7-PLCSIM Advanced does not simulated data logging, because this function writes all output to the SD memory card and S7-PLCSIM Advanced does not support the use of an SD memory card.

Recipes

S7-PLCSIM Advanced does not simulate the use of recipes.

Backup and Restore

S7-PLCSIM Advanced does not simulate the product property "Backup and Restore".

Limited support

S7-PLCSIM Advanced simulates some functions to a limited extent. You can find an overview in the section Restrictions (Page 302).

2.6 Simulating Motion Control

Restrictions

PLCSIM Advanced supports STEP 7 projects with configurations and functions for motion control for the CPUs S7-1500, S7-1500F, S7-1500C, S7-1500T, S7-1500T F, ET 200SP and ET 200SP F.

PLCSIM Advanced provides only limited support for technology objects in some CPUs, see Restrictions with Motion Control (Page 307).

Simulation with external simulation software

In a virtual S7-1500 controller, the technology objects are connected to the process image. Simulation software can thus access the process image via the user interfaces (API) of S7-PLCSIM Advanced and simulate the behavior of the other connected axes.

Simulation mode in STEP 7

The simulation mode is a standard function of the technology objects.

If you want to move an axis in simulation mode, select the "Activate simulation" check box in STEP 7 under "Technology Object > Configuration> Basic Parameters > Simulation". No additional setting is required for a virtual axis.

Feedback of the axis position

The speed setpoint of the simulated drive is integrated into the actual position value with a time delay (PT1). The result of this calculation is returned to the technology object as position actual value of the axis.

Reference point approach of the axis

If you selected "Use zero mark via PROFIdrive frame" in STEP 7 for the reference point approach, PLCSIM Advanced responds immediately to any active (mode 2, 3, 8) or passive (mode 4, 5) reference point approach command (MC_Home). The actual position is predefined as the reference point.

Additional information

Information on "Setting in the drive and encoder connection" for actual value calculation of a virtual axis and on the topic "Virtual axis/Simulation" is available in the S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109481326) function manual.

Installing

3

3.1 Introduction

3.1.1 System requirements

You need high-performance computer hardware if you intend to run multiple instances of PLCSIM Advanced at the same time or to simulate communication between PLCSIM Advanced V1.0 and HMI devices as of version 14.0.

Minimum requirements for hardware and software

Preferably, you should install PLCSIM Advanced on a stand-alone PC, independent of STEP 7. Alternatively, you can install PLCSIM Advanced on the configuration PC on which STEP 7 is already installed.

For PLCSIM Advanced to operate efficiently, the computer hardware and software must meet minimum requirements.

Table 3- 1 Minimum requirements for hardware and software

Hardware / software	Requirement
Processor	2.2 GHz Intel® Celeron® Dual Core
RAM	• 4 GB for one instance • 8 GB for 4 instances
Free hard disk space	5 GB
Operating system 64-bit version	• Windows 7 Home Premium SP1 • Windows 7 Professional SP1 • Windows 7 Enterprise SP1 • Windows 7 Ultimate SP1 • Windows Server 2012 R2 StdE (full installation)
Screen resolution	1024 x 768

Note

Make sure that the Windows operating system you are using is up to date.

Virtualization platforms

You can install STEP 7 and PLCSIM Advanced on a virtual machine. For this purpose, use one of the following virtualization platforms in the specified version or a newer version:

- VMware vSphere Hypervisor (ESXi) 6.0
- VMware Workstation 12 Pro
- VMware Workstation Player 12
- Microsoft Windows Server 2012 R2 Hyper-V

Guest operating systems

You can use the following guest operating systems on the selected virtualization platform for the installation of STEP 7 V14 and PLCSIM Advanced:

- Windows 7 Professional SP1 / Ultimate SP1 / Enterprise SP1 (64-Bit)
- Windows Server 2012 R2 (64-Bit)

3.1.2 Licenses

Floating license

S7 PLCSIM Advanced is supplied with a floating type license. These can be stored locally and shared for a network.

Note

A floating license is valid for **one** instance of a virtual controller within a PLCSIM Advanced installation.

Handling licenses

You can learn how to handle the licenses for S7 PLCSIM Advanced instances on the DVD in the description of the SIMATIC Automation License Manager (ALM).

API functions for licenses

- Return values for API function PowerOn() (Page 127) and callback function OnOperatingStateChanged (Page 228)
  - `SREC_OK` when a license is available.
  - `SREC_WARNING_TRIAL_MODE_ACTIVE` when no license is available, and an instance is started in a mode that allows unrestricted use of the instance for one hour.
- Return value for callback function `OnOperatingStateChanged`
  - `SREC_LICENSE_NOT_FOUND` when the instance is automatically shut down after expiration of the Trial mode.

Warning in spite of existing license

Note

A check is made for the presence of a license at power-up and after one hour during which you can test an instance without restriction (Trial Mode). When you import a license in the meantime, `SREC_WARNING_TRIAL_MODE_ACTIVE` is returned nevertheless.

3.1.3 Installation log

The log files contains automatically recorded information on the following installation processes:

- Installation of S7-PLCSIM Advanced
- Change or update of installation of S7-PLCSIM Advanced
- Repair of an existing installation of S7-PLCSIM Advanced
- Uninstallation of S7-PLCSIM Advanced

You can evaluate installation errors and warnings using the log files. You can troubleshoot the installation yourself or contact Siemens Technical Support. Product Support personnel need information from the installation log to analyze the problem. Send the folder with the log files as a ZIP file to Support.

Memory location of the installation log

The memory location of the log file depends on the operating system. To open the folder with the log files, enter the environment variable "%autinstlog%" in the address bar in Windows Explorer. Alternatively, you reach the appropriate directory by entering "cd %autinstlog%" in the command line.

The log files are named as follows:

- SIA_S7-PLCSIM_Advanced_V01@<DATE_TIME>.log
- SIA_S7-PLCSIM_Advanced_V01@<DATE_TIME>_summary.log

Setup_Report (CAB file)

An archive file with the installation log and all other required files is stored in CAB format. This archive file can be found at "%autinstlog%\Reports\Setup_report.cab".

If you need help during installation, send this CAB file to SIEMENS Technical Support. Technical Support personnel can troubleshoot your installation based on the information in the CAB file.

A separate CAB file with a date ID is saved for each installation.

3.2 Installation medium

After installing S7-PLCSIM Advanced, keep the installation medium in a secure, easily accessible place.

You can use the installation medium to change, repair or uninstall, if necessary.

3.3 Installing PLCSIM Advanced

S7-PLCSIM Advanced starts the installation automatically when you insert the installation medium in your DVD drive.

Installation requirements

Make sure that the following conditions are met before you begin the installation process:

- The hardware and software of the PC or Siemens Field PG meet the system requirements.
- The person who performs the installation has administrator rights on the respective computer.
- No other programs are active. This also applies to the Siemens Automation License Manager and other Siemens applications.
- All S7-PLCSIM versions V12 and higher are uninstalled.

Note

Security settings

For licensing via the ALM, when installing PLCSIM Advanced you must agree that port 4410 for TCP can be entered as an exception in the Windows Firewall (procedure step 7).

Installing S7-PLCSIM Advanced

To install PLCSIM Advanced, follow these steps:

1. Insert the installation medium into the DVD drive of your computer. The setup program is automatically started, provided you have not deactivated the Autostart function on the Field PG or PC. If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file. The "General settings" window is displayed.
2. The check box for the English is selected.
3. Click the "Read installation notes" button to display installation information. After you have read the notes, close the file.
4. Click the "Read Product Information" button to display the "Readme file". After you have read the information, close the file.
5. Click the "Browse" button if you want to change the default installation path. The installation path must not exceed 89 characters. The path name must not contain any UNICODE characters. If you select a different installation path than the default installation path, the desktop icon may not be displayed correctly.
6. Click "Next". The window with the security settings is displayed. To continue the installation, select the check box at the bottom of the screen to accept changes to the security and permissions settings of your system.
7. Click "Next". The window with the installation settings is displayed. You can save or print a report of the settings by clicking "Save report" or "Print report". Check the settings for correctness. If you want to make any changes, click "Back" until you reach the point in the installation process where you want to make changes. Once you have completed your changes, click "Next".
8. Your installation details are displayed in the overview screen. Click the "Install" button. The installation is then started and PLCSIM Advanced is installed on your computer.
9. After completion of the setup program, you must restart your computer. Select "Yes, I want to restart the computer now" to restart the computer immediately or select "No, I will restart computer later" to restart the computer later.
10. Click "Restart". If the computer is not restarted, click "Finish".

Error during installation of S7-PLCSIM Advanced

When S7-PLCSIM Advanced is installed, any existing installation of S7-PLCSIM is displayed.

A requirement for installation of S7-PLCSIM Advanced is that no other S7-PLCSIM installation is located on the same computer.

Even though no installation of S7-PLCSIM is displayed in the "Programs and Features" list, it is still possible that the computer has an existing installation.

Remedy

Run the setup for S7-PLCSIM V12 or V12 SP1 and uninstall the program.

When the setup is not available, download the setup files for S7-PLCSIM via Siemens Mall (https://support.industry.siemens.com/cs/document/65601780).

3.4 Changing PLCSIM Advanced

Requirements for changing the installation

The following conditions must be met before you can start changing the installation:

- The hardware and software of the computer meet the system requirements.
- You have administrator rights on the installation computer.
- No other programs are active.

Procedure for changing the installation

To change your PLCSIM Advanced installation, follow these steps:

1. Insert the installation medium into the drive. The setup program starts up automatically, provided you have not deactivated the Autostart function on the Field PG or PC.
   If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file.
2. Follow the prompts until you reach the "Configuration" window.
3. Select the "Change upgrade" check box.
4. Follow the remaining prompts to change your installation.
5. Complete the installation operation by restarting your computer.

Note

Target directory

You cannot change the target directory because you are changing an existing installation.

3.5 Repairing PLCSIM Advanced

If your installation becomes damaged, you can repair it with the PLCSIM Advanced data storage medium.

Requirements for repairing the installation

The following conditions must be met before you can start repairing the installation:

- The hardware and software meet the system requirements.
- You have administrator rights on the installation computer.
- No other programs are active.

Procedure for repairing the installation

To repair your installation, follow these steps:

1. Insert the installation medium into the drive. The setup program is automatically started, provided you have not deactivated the Autostart function on the Field PG or PC. If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file.
2. Follow the prompts until you reach the "Configuration" window. Select the "Repair" check box.
3. Follow the remaining prompts to repair your installation.
4. Complete the repair operation by restarting your computer.

3.6 Uninstalling PLCSIM Advanced

You have two options for uninstalling S7-PLCSIM Advanced on your computer:

- You uninstall the program using the Windows Control Panel.
- You uninstall the full product using the installation medium.

Uninstalling PLCSIM Advanced using the Windows Control Panel

To uninstall PLCSIM Advanced using the Windows Control Panel, follow these steps:

1. Double-click the "Programs and Features" option in the Windows Control Panel.
2. Right-click on "Siemens S7-PLCSIM Advanced V1.0" and select "Uninstall".
3. Follow the prompts for uninstallation.
4. Complete the uninstallation operation by restarting your computer.

   If you do not perform a restart, the Runtime Manager continues running.

If problems occur when uninstalling PLCSIM Advanced using the Windows Control Panel, use the installation medium for uninstalling.

Uninstalling PLCSIM Advanced using the installation medium

To uninstall PLCSIM Advanced using the installation medium, follow these steps:

1. Insert the installation medium into the drive. The setup program is started automatically, provided you have not deactivated the Autostart function on the programming device or PC. If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file.

   If you do not perform a restart, the Runtime Manager continues running.
2. Follow the prompts until you reach the "Configuration" window. Your previous installation is detected. Select the "Uninstall" check box.
3. Follow the prompts to uninstall PLCSIM Advanced.
4. Complete the uninstallation operation by restarting your computer.

   If you do not perform a restart, the Runtime Manager continues running.

Uninstalling additional software

When PLCSIM Advanced is uninstalled, the following software remains installed:

- Automation License Manager
- S7-PLCSIM V5.4
- .NET Framework
- WinPcap

If you also want to uninstall this software, use the Windows Control Panel.

Communication paths

4

Local and distributed communication

The following paths are open for communication between STEP 7 V14 and the instances of PLCSIM Advanced user interfaces:

Communication paths	Local	Local	Distributed
Protocol	Softbus	TCP/IP	TCP/IP
Communication interface in PLCSIM Advanced	PLCSIM	PLCSIM Virtual Ethernet Adapter	PLCSIM Virtual Ethernet Adapter
STEP 7 and instances	on a PC / VM	on a PC / VM	distributed
Communication...			
between STEP 7 and instances	Yes	Yes	Yes
among instances	Yes	Yes	Yes
possible via OPC UA server and Web server	No	Yes	Yes
between an instance and a real hardware CPU	No	No	Yes
between an instance and a real HMI V14	No	No	Yes
between an instance and a simulated HMI V14	Yes	Yes	No

Softbus

Softbus is a communication path via a virtual software interface.

The communication is limited to a local PC or a virtual machine. The advantage here is that no data can be accidentally downloaded to a hardware CPU or communicate with real hardware.

Select communication interface

You program the communication interface via the user interface (API) or select it in the Control Panel under "Online Access". The setting is valid for all generated instances. The default setting is the communication via "PLCSIM" (Softbus).

Additional network settings are necessary for the distributed communication via the "PLCSIM Virtual Ethernet Adapter" (TCP/IP).

API functions for selecting the communication interface

- GetCommunicationInterface() (Page 116)
- SetCommunicationInterface() (Page 116)
- CommunicationInterface { get; set; } (Page 117)

See also

Interfaces - Information and settings (Page 113)

S7 PLCSIM Advanced Control Panel (Page 46)

4.1 Local communication

Local communication can be performed via the Softbus protocol or TCP/IP.

For local communication, the PLCSIM Advanced instance is on the same PC or on the same virtualization platform (VMware) as STEP 7 or another communication partner.

Local communication via Softbus

For security reasons, the local communication is performed via Softbus in PLCSIM Advanced by default.

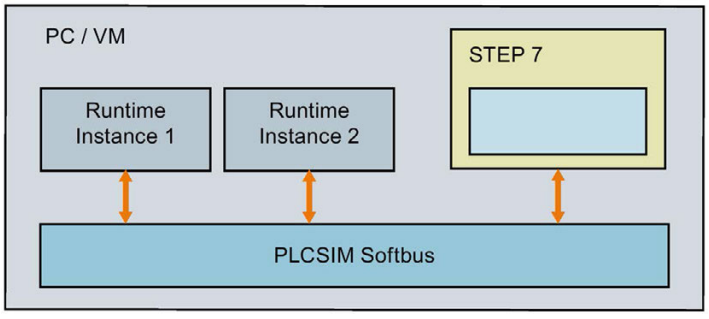


Figure 4-1 Local communication via Softbus

Local communication via TCP/IP

Communication is performed via the PLCSIM Virtual Ethernet Adapter, a virtual network interface that behaves like a real network interface.

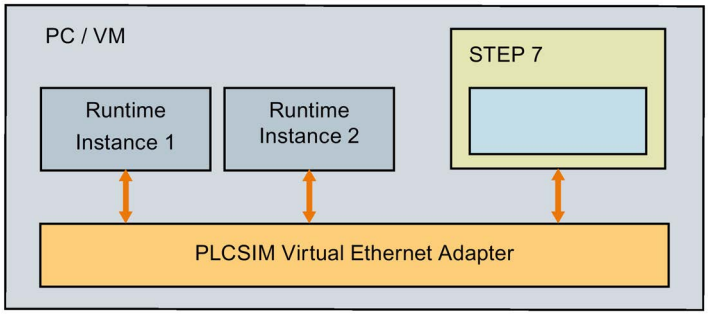


Figure 4-2 Local communication via TCP/IP

4.2 Communication via TCP / IP

Distributed communication

Distributed communication via TCP/IP means that the PLCSIM Advanced instances communicate with the other devices via the Virtual Switch . Communication is possible with real or simulated CPUs, real or simulated HMIs.

The PLCSIM Virtual Switch must be activated on the PLCSIM Virtual Ethernet Adapter for instances on the network to be visible.

Example 1: Distributed communication

In the following example, STEP 7 is on a PC and the PLCSIM Advanced instances are on another PC. The PCs are connected via the Ethernet adapter.

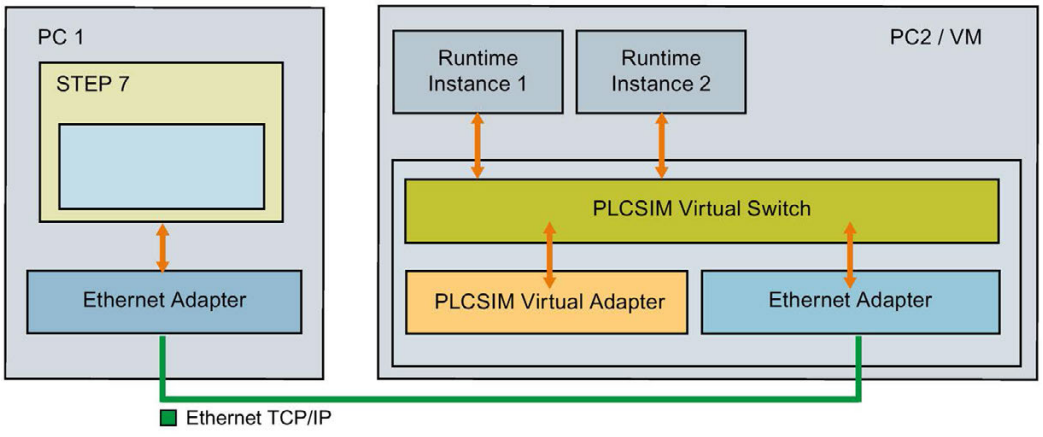


Figure 4-3 Distributed communication via Ethernet

Example 2: Distributed communication

In the following example, STEP 7 is on a PC and the PLCSIM Advanced instances are on a virtual machine on the same PC. PC and virtual machine are connected via the network adapters.

Recommendation

Use to ensure the VMware settings as the network adapter type for the Bridged Mode to ensure error-free operation.

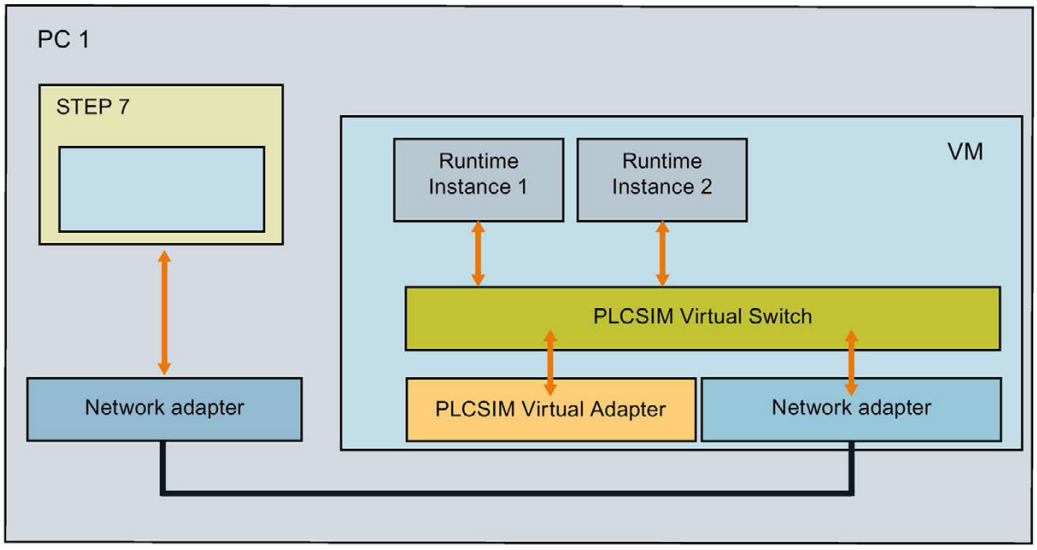


Figure 4-4 Distributed communication via network adapters

4.3 Enable distributed communication

By default, the PLCSIM Virtual Switch can only communicate locally. For a distributed, i.e. multi-computer, communication to be possible, you must activate the PLCSIM Virtual Switch for a real network adapter.

Note

Network adapter

Make sure that only one network adapter of the PLCSIM Virtual Switch is activated.

The Control Panel of PLCSIM Advanced checks the activation and may report an incorrect configuration (error code -50).

Activate PLCSIM Virtual Switch

To make the PLCSIM instances visible on the network and to reach other devices, activate the PLCSIM Virtual Switch in the Control Panel of PLCSIM Advanced or under Windows:

1. To do this, open the "Network and Sharing Center" in the Windows Control Panel.
2. Open the properties of the desired network adapter, for example, for the "Local Area Connection".
3. Select the check box for the "Siemens PLCSIM Virtual Switch" and confirm with OK.

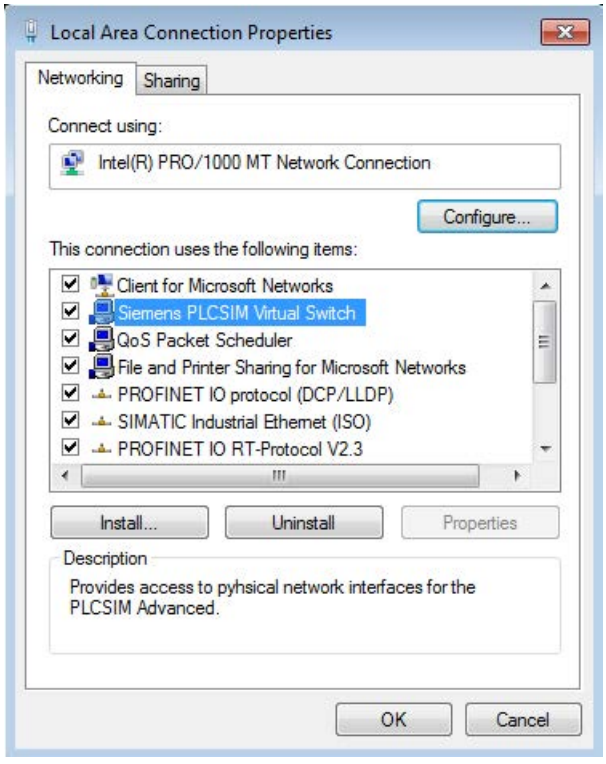


Figure 4-5 Activate PLCSIM Virtual Switch

Accessible devices

When the PLCSIM Virtual Switch is activated, STEP 7 shows the devices available on the Virtual Ethernet Adapter in the project tree.

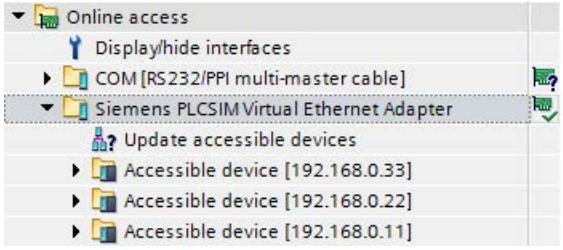


Figure 4-6 Accessible devices on the Virtual Ethernet Adapter

Simulate CPU 5

5.1 Basic procedure for the simulation

The following overview shows the basic steps to perform simulation with an instance of a virtual controller.

Requirements

The following requirements must be met for starting simulation via local communication:

- STEP 7 V14 and S7 PLCSIM V1.0 Advanced are installed on the same PC.
- The CPU hardware is configured in STEP 7.

Note

Enable simulation support

In the "Protection" tab in the properties of the project in STEP 7, select the check box "Support simulation during block compilation".

Create and activate an instance via the Control Panel

- Open PLCSIM Advanced Control Panel
- Open the "Start Virtual S7-1500 PLC" options
- Enter a name for an instance
- Select CPU type
- Create an instance using the "Start" button

In STEP 7, perform the download and start the simulation

- Download the program to the virtual controller
- Switch the controller to RUN to start the simulation
- Perform diagnostics
- ...

See also

Simulations support (Page 27)

5.2 User interface

5.2.1 S7 PLCSIM Advanced Symbol

After installing PLCSIM Advanced, the following icons are on the Windows desktop:

Figure 5-1 PLCSIM Advanced Symbol

After double-clicking the icon, the icon appears in the taskbar of the information area.

You can use Windows functions to permanently display the icon in the information area of the taskbar.

Opening a graphical interface

Right-clicking on the icon in the taskbar opens the graphical interface of PLCSIM Advanced, the Control Panel.

If the Control Panel is open, you can use the mouse-over function to display messages about the current status of the instances.

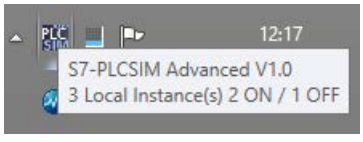
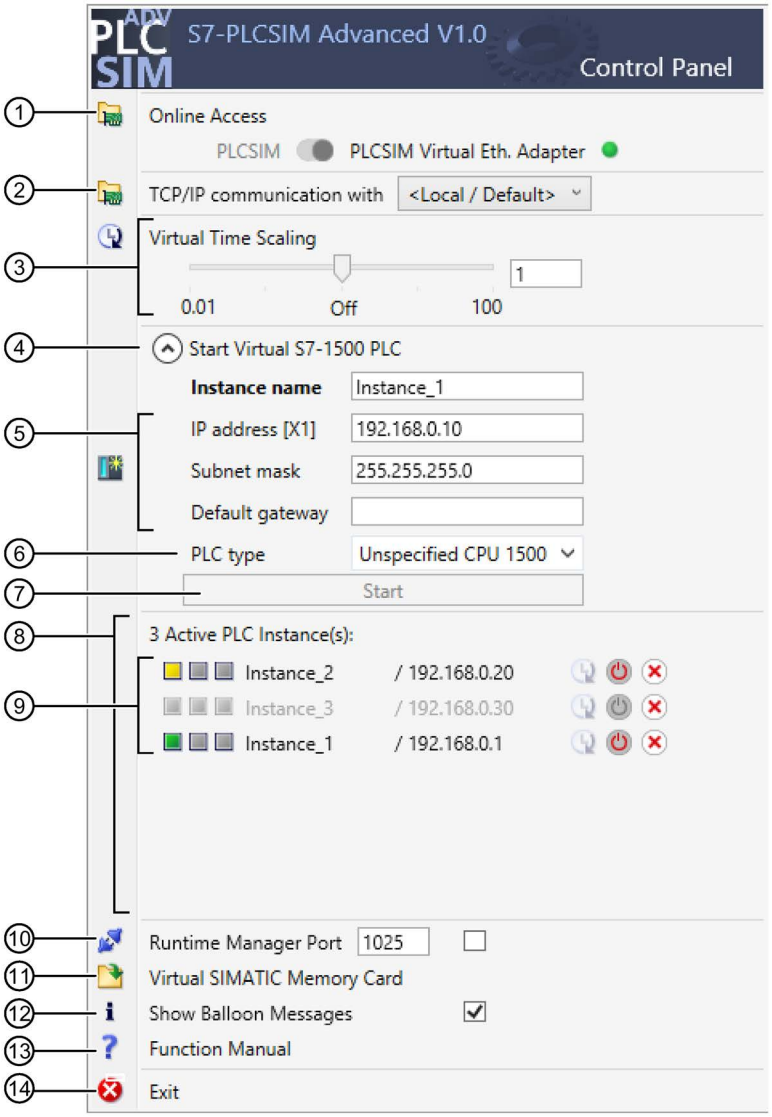


Figure 5-2 Example: Message in the taskbar

5.2.2 S7 PLCSIM Advanced Control Panel

Control Panel

The Control Panel is optional and is not needed to use PLCSIM Advanced via the API. It is available in English in version 1.0.



①	Online access	Switch to select the communication interface
②	TCP/IP communication	Selection of network adapter for distributed communication
③	Virtual time	Slider to adjust the scaling factor
④	**Start Virtual S7-1500 PLC**	
	Name of the instance	Here you enter a unique name for the instance. Enter a minimum of 3, a maximum of 64 characters. If the name is unique in the network, the "Start" button is enabled.
⑤	• IP address • Subnet mask • Standard gateway	The input boxes are visible when you switch the communication interface to "PLCSIM Virtual Ethernet Adapter".
⑥	CPU type	Here you select the type of CPU to be simulated.
⑦	"Start" button	Create with the button and start an instance with the entered name.
⑧	Instance list	The list shows the available **local** instances.
⑨	LED displays	The meaning of the LED is displayed when you move the mouse over it.

⑩	Runtime Manager Port	Here you open a port on the local PC.
⑪	Virtual SIMATIC Memory Card	Open an Explorer window here with the path to the virtual memory card.
⑫	Display messages	Here you disable the PLCSIM Advanced messages in the Windows task bar for the duration of the operation.
⑬	Function manual	This is where you open the S7 PLCSIM Advanced Function Manual in a standard PDF viewer.
⑭	Exit	Exit switches all instances off and closes the Control Panel.

Figure 5-3 Control Panel

Switch for communication interface

Use the switch to select the communication interface for all instances to be created:

- "PLCSIM corresponds to the local communication via Softbus (default).
- "PLCSIM Virtual Ethernet Adapter corresponds to the communication via TCP/IP.

The setting applies to all other instances. The selected communication interface for starting an instance is maintained until all instances are shut down.

When an instance is already started, it sets "its" communication interface as the default for other instances.

Change communication interface

To change the communication interface, switch off all instances and enable the other interface.

TCP/IP communication

You can select a real network adapter from the drop-down list during operation. You thus activate the PLCSIM Virtual Switch and establish TCP/IP communication between the instances and the real network.

The <Local> setting disables the PLCSIM Virtual Switch and disconnects the instances from the real network. Only local TCP/IP communication over virtual adapter is possible in this case.

Virtual time

Use the slider or the mouse wheel to select the scaling factor for the virtual time.

The selected scaling factor applies to the instances for which the virtual time is enabled.

Clicking on "Off" restores the default (1) again. For more information, seeVirtual time response (Page 58).

Create instance (local)

To create an instance, enter a unique name under "Instance Name". If the name already exists in the directory of the Virtual SIMATIC Memory Card, the existing instance is started.

In the "PLC-Type" drop-down list, select the Unspecified CPU 1500 or Unspecified ET 200SP CPU type. The CPU is named with the first download of the TIA Portal.

Recommendation: Create up to 4 local instances on your PC or visualization platform. Remote instances cannot be created through the Control Panel.

Instance list

The instance list contains the instances that are started locally on the PC or virtualization platform. Instances that have already been started on the runtime API are detected and displayed in the list.

The LED displays show the status of the instance that corresponds to those of the hardware CPU.
RUN and STOP are displayed depending on the current operating state of the instance.

You can "operate" the instance with icons:

Apply scaling factor for the virtual time, disable virtual time,

Switch on instance, Switch off instance,

Switch off instance and log out of the Runtime Manager

Runtime Manager Port

A remote connection can be established to another Runtime Manager via the specified port. The value must be greater than 1024.

If you select the check box, the port remains stored. You can use the remote connection without having to make this setting every time you start the Control Panel. To use this functionality, the Control Panel must be started and running in the background.

Virtual SIMATIC Memory Card

The user program, the hardware configuration and the retentive data are stored on the Virtual SIMATIC Memory Card. Click the link to open the directory.

Default path: ...\Documents\Siemens\Simatic\Simulation\Runtime\Persistence

Display messages

Each time the panel starts, help information and messages relating to the Control Panel are displayed, for example, when changing the IP address or when a license is missing. Disable the display if you do not need the messages.

Exit

- The command switches off all local instances on the PC or the VM and logs them off from the Runtime Manager.
- This command closes the Runtime Manager if there is no remote connections to other Runtime Managers.
- If the Runtime Manager has remote connections to instances on additional PCs, these instances and the Runtime Manager continue to run.

Minimize Control Panel

Clicking on an empty area on the desktop minimizes the Control Panel. The instances are not affected.

5.3 Download

Requirements

You can download the STEP 7 project to the virtual controller when the following conditions are met:

- The instance is created via the Control Panel.
- The check box "Support simulation during block compilation" is selected.

Select communication interface

In the Download dialog box, select the PG/PC interface:

- "PLCSIM" for download via Softbus
- "Siemens PLCSIM Virtual Ethernet Adapter" for download via TCP/IP

Display in the download dialog

The dialog in STEP 7 at the first download of the CPU shows the compatible PLCSIM Advanced instances.

If the instance has not yet been configured after the first download only **one** interface is visible and it appears with the device type "CPU-1500 Simulation".

If the instance has been configured, the number of interfaces visible is determined my the number the CPU type has.

The lifelist shows the interfaces of an instance with their IP addresses.

Perform download

1. Select the PG/PC interface.
2. Click "Download".

   → In the "Load preview" window, STEP 7 shows the message "The downloads are performed on a simulated CPU".

   → After the first download, the PLCSIM Advanced instance displays the CPU type.

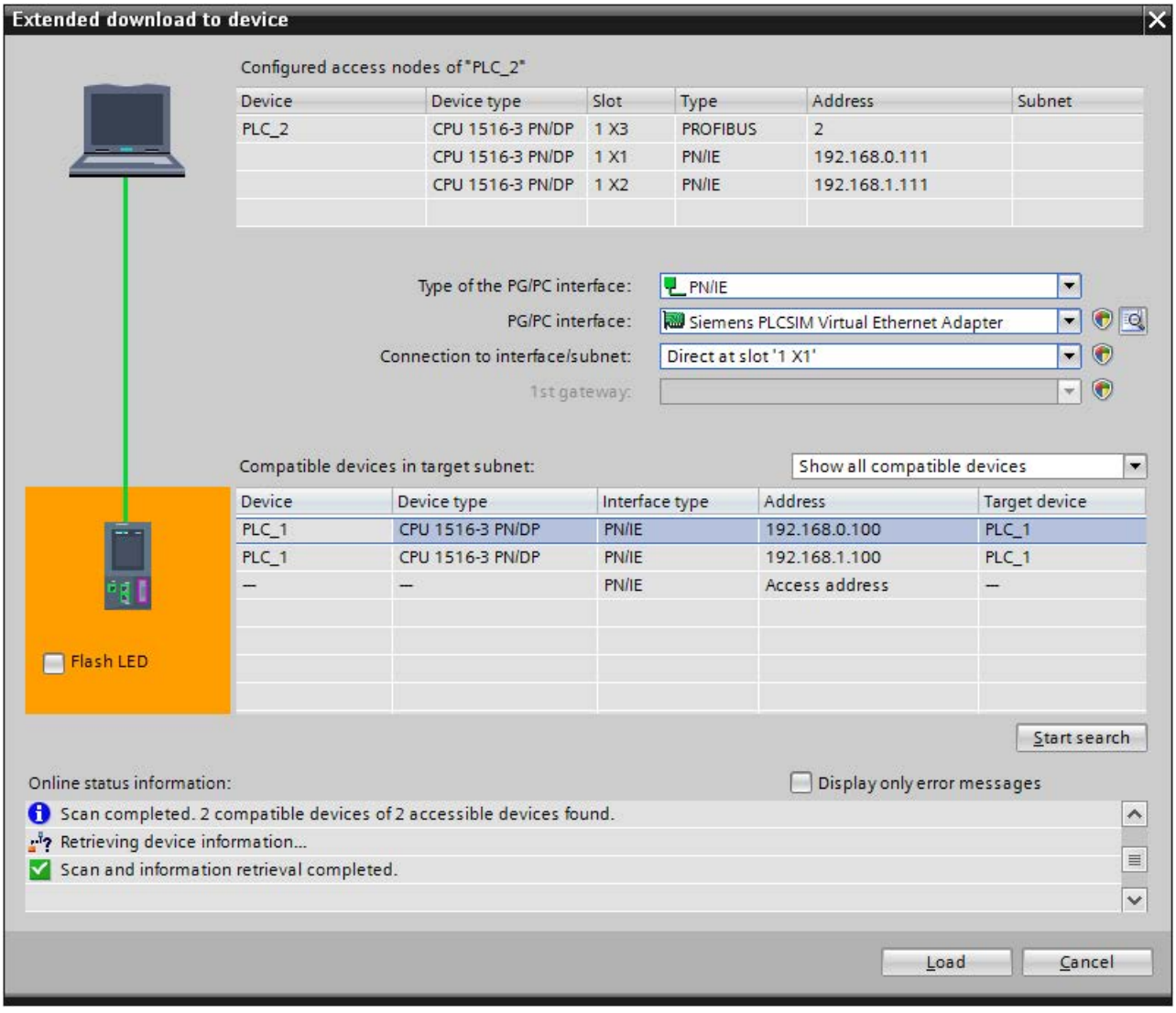


Figure 5-4 Example: Download via the "PLCSIM Virtual Ethernet Adapter" (TCP/IP) after naming

5.4 MAC address of the instances

Detect CPUs and instances

If Ethernet interfaces of CPUs and PLCSIM Advanced instances are mixed in a network, the instances can be recognized by the "PLCSIM" suffix on the station type.

Structure of the MAC address for an instance

The following figure shows the structure of the dynamically generated, locally managed MAC address:

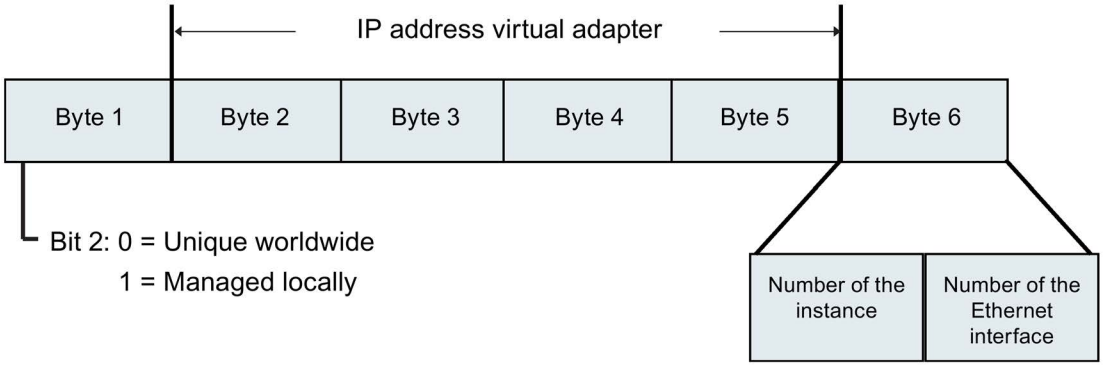


Figure 5-5 Structure of the MAC address for an instance

The MAC address tells you the PC on which a PLCSIM Advanced instance has been started.

Assignment of the Ethernet interfaces

Port configurations of the Ethernet interfaces cannot be simulated in PLCSIM Advanced V1.0. Topological interconnection is not supported. A MAC address for a port is reserved internally for each Ethernet interface.

Table 5- 1 Assignment of the Ethernet interfaces, for example, a CPU 1518-4 PN/DP

Ethernet interface	Last digit of the MAC Address
IE 1 IE 1 / Port 1	.....0 1
IE 2 IE 2 / Port 1	.....2 3
IE 3 IE 3 / Port 1	.....4 5

Example

02-C0-A8-00-83-10 means:

02 → locally managed MAC address of a PLCSIM Advanced instance

C0-A8-00-83 → IP of the Siemens PLCSIM Virtual Ethernet adapter = 192.168.0.131

1 → Instance 1

0 → Ethernet interface IE 1

If no Virtual SIMATIC Memory Card is loaded during startup of PLCSIM Advanced, the interfaces of PLCSIM Advanced display instances with their locally managed MAC address.

5.5 Simulate peripheral I/O

The Runtime API writes to and reads from a memory area. This memory is synchronized with the internal process image of the virtual S7-1500 controller at the cycle control point. The direct I/O accesses are made to this memory area. Only one process can access this memory at a given time.

The virtual controller must be in RUN to apply changes made by the API.

Note

Dominance of the API when synchronizing

The API dominates when synchronizing. If the user program writes to the same address range as the API, the changes of the API overwrite those of the virtual controller.

See also

Deviating I/O values in the STEP 7 user program (Page 310)

5.6 Simulate communication

5.6.1 Communication services that can be simulated

S7-PLCSIM Advanced V1.0 supports the following communication options:

Table 5- 2 Supported communication options

Communications options	Functionality / instructions
PG communication	On commissioning, testing, diagnostics
Open communication using TCP/IP	• TSEND_C / TRCV_C • TSEND / TRCV • TCON[1] • T_DISCON
Open communication using ISO-on-TCP	• TSEND_C / TRCV_C • TSEND / TRCV • TCON • T_DISCON
Open communication via UDP[2]	• TUSEND / TURCV • TCON • T_DISCON
Communication via Modbus TCP	• MB_CLIENT • MB_SERVER
E-mail[2]	• TMAIL_C
S7 communication	• PUT / GET • BSEND / BRCV • USEND / URCV
OPC UA Server[2]	Data exchange with OPC UA clients
Web server[2]	Data exchange via HTTP

[1] When the "PLCSIM" interface (Softbus) is set, communication is performed **internally** via ISO-on-TCP.

[2] Only via the communication interface "PLCSIM Virtual Ethernet Adapter" (TCP/IP)

Special conditions apply when communicating with TUSEND/TURCV, see Restrictions for communications services (Page 305).

5.6.2 Communication between instances

PLCSIM Advanced supports communication between instances. An instance may be a simulation in PLCSIM Advanced V1.0 or a simulation in WinCC Runtime as of V14.

You can run two instances of PLCSIM Advanced, which then communicate with each other. To enable instances to communicate with each other, they must have a unique IP address.

Each simulated CPU requires a unique IP address

If the CPUs have the same IP address, you cannot run multiple simulations. Each simulated CPU requires a unique IP address.

Make sure that the IP addresses in STEP 7 are unique before you start your simulations.

T-block instructions and UDP

S7-PLCSIM Advanced simulates T-block connections for which the UDP protocol is configured only via the communication interface "PLCSIM Virtual Ethernet Adapter" (TCP/IP).

T-block instructions and data segmentation

S7-PLCSIM Advanced implements T-block instructions with a data segmentation of 4 KB. A real CPU has data segmentation of 8192 bytes.

If you send more than 4 KB in a single TSEND instruction and receive data in ad hoc mode with a TRCV instruction, the TRCV instruction generates new data with only 4 KB. You must perform the TRCV instruction several times to receive additional bytes.

5.7 Provide project data offline for simulation

Simulations regardless of STEP 7

To perform simulations independent of STEP 7, you can save the user program and the hardware configuration in STEP 7 in a directory.

Provide project data offline

1. Create a "User-defined Card Reader" for your project data under Card Reader/USB storage in the project tree of STEP 7 for the CPU.
2. In the "Load preview" dialog for the target device, select "PLC Simulation Advanced" as an action, click in the selection field for this.
   → The project is saved to the <Virtual Memory Card>\SIMATIC.S7S\OMSSTORE directory.
3. Save the folder \SIMATIC.S7S with the project data to a medium of your choice.

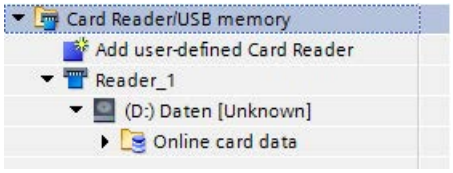


Figure 5-6 Add card reader

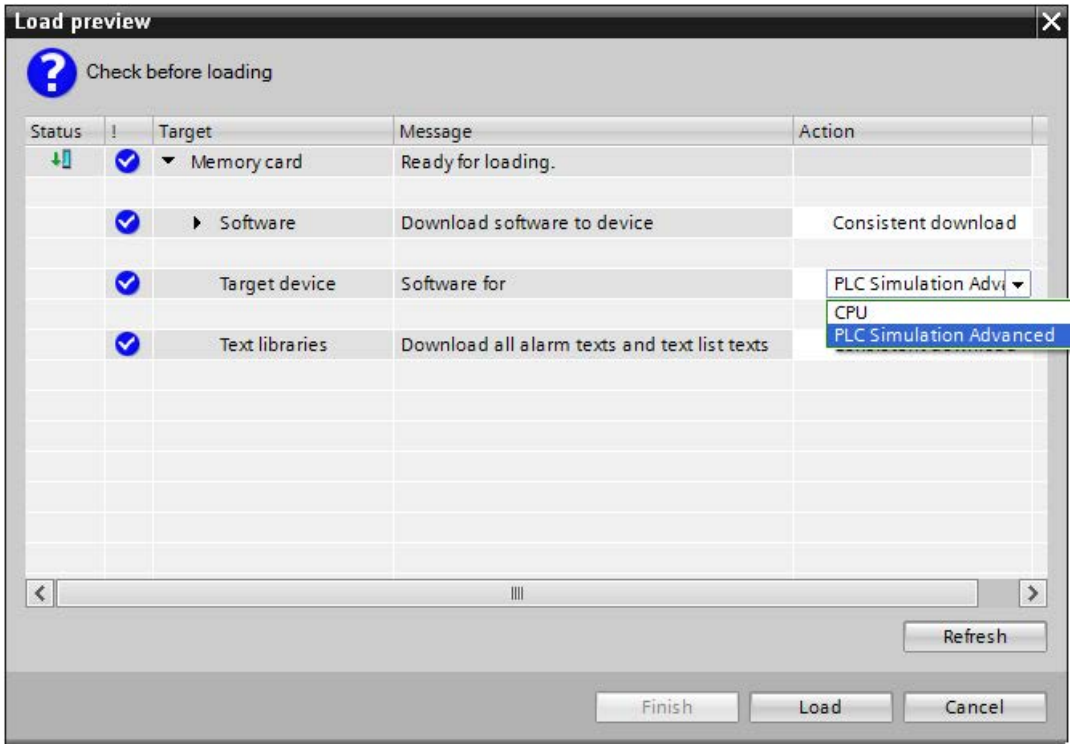


Figure 5-7 Preview of download dialog

Provide project data for simulation

1. On the PC on which PLCSIM Advanced is installed, create the directory \SIMATIC_MC in the directory in which the instance saves its data.
2. Move the \SIMATIC.S7S folder to the directory you have created.
   → The instances can be started with the project data.

API functions

The project data can be used for an instance via the user interface. Use of the following functions for this:

API functions

- GetStoragePath() (Page 123)
- StoragePath { get; set; } (Page 124)

See also

Controller - Information and settings (Page 119)

Virtual time response

6

The virtual controller uses internally two types of clocks for simulation: A virtual clock and a real clock. The virtual clock is always the basis for the user program. It is used by components that are relevant for running the STEP 7 user program, such as cyclic OBs, cycle time monitoring, minimum cycle time, virtual system time and time calculations. Also, the time between two cycle control points is measured in virtual time.

The virtual time can be accelerated or slowed for test purposes.

The real clock always runs unchanged. It is used by components that are not subject to control processes, for example, communication with STEP 7.

Virtual system time

When you start PLCSIM Advanced, the virtual system time of the virtual controller starts with the system time of Windows.

The virtual system time is based on the virtual clock, i.e. if a scaling factor is used, the system time runs correspondingly faster or slower.

All events that the virtual controller sends to the API provides a time stamp based on the system time.

Note

Difference between system time and local time

- System time: UTC ± 0 with daylight saving / standard time
- Local time: UTC ± time zone with daylight saving time / winter time

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API functions

- GetSystemTime() (Page 218)
- SetSystemTime() (Page 218)
- SystemTime { get; set; } (Page 218)

Time offset

Note

Keep in mind that the time information of virtual system time and real local time differs by the time offset that is formed in addition to the selected scaling factor from the time zone offset and the daylight saving time/standard time offset.

Scaling factor

Using a scaling factor, you can speed up or slow down the virtual clock of the virtual controller for simulations.

- The default is 1, i.e. the course of the virtual time corresponds to the course of real time.
- **Fast forward:** A scaling factor greater than 1 accelerates the virtual clock.

  Example: Scaling factor 2.0 → The virtual time is running twice as fast.
- **Slow motion**: A scaling factor less than 1 decelerates the virtual clock.

  Example: Scaling factor 0.5 → The progress of the virtual time slows down to 50%.

API functions

- GetScaleFactor() (Page 219)
- SetScaleFactor() (Page 219)
- ScaleFactor { get; set; } (Page 220)

See also

Settings for the virtual time (Page 218)

6.1 Speed up and slow down simulation

Influence of fast forward and slow motion

Simulations can be accelerated and slowed down. Fast forward and slow motion only affects time-based components, for example, cyclic OBs. Compared to the real time, they are performed more frequently with fast forward and less frequently with slow motion.

Fast forward and slow motion do not change the execution speed of the CPU machine codes. For example, the speed at which all operations of an OB1 cycle are executed does not change. The execution speed depends on the processor of the PC on which the virtual controller running. If you change the scaling factor, more or fewer cycle control points are reached in a given period of virtual time.

Fast forward

To speed up the virtual time, select a scaling factor greater than 1 in the Control Panel or in the API.

Note

CPU load of the PC

If the scaling factor is greater than 1, the CPU load of the PC on which the virtual controller is simulated increases considerably.

Note

Performance

The performance is depends on the size of your project, among other things.

If the scaling factor is too high and the cycle-time monitoring indicates that the PC was incapable of calculating the OB1 or cyclic OBs in the specified time, the virtual controller goes to STOP.

Recommendation: To avoid this, start with a small scaling factor and gradually increase it step-by-step while keeping the virtual controller in RUN.

Slow motion

To slow down the virtual time, select a scaling factor less than 1 in the Control Panel or in the API.

API functions

- GetScaleFactor() (Page 219)
- SetScaleFactor() (Page 219)
- ScaleFactor { get; set; } (Page 220)

See also

Cycle control (Page 221)

Settings for the virtual time (Page 218)

Error with overflow cyclical events (Page 309)

6.2 Stop simulation

Freeze state of the virtual controller

To stop a simulation and to synchronize a simulation partner, a virtual controller can be set to a freeze state via the user interface.

A triggered freeze state stops the virtual controller on the next cycle control point. The following occurs:

- The virtual time is stopped.
- No OBs running, not counters.
- The user program is no longer executed.
- The virtual controller is still accessible from the TIA Portal.
- The virtual controller is in a state consistent with input and output data.

Note

Freeze-state ≠ operating state

The freeze state is an internal operating state of the virtual controller. It does not correspond to RUN/STOP mode of a CPU. In the freeze state, the virtual controller maintains the last operating state.

- The LED display on the Control Panel and on the Web server accordingly shows RUN or STOP for instance.
- The instance shows `SROS_FREEZE` / `Freeze`, see EOperatingState (Page 288).

Trigger freeze state

To trigger the freeze state, following modes are available for the virtual controller:

- **Cycle-controlled operating mode** SingleStep and ExtendedSingleStep

  See Synchronize simulation partner cycle-controlled (Page 62).
- **Time-controlled mode** TimespanSynchronized

  See Synchronize simulation partner time-controlled (Page 64).

In **Default** mode, the virtual controller does not go into a freeze state.

API functions

- Settings for the cycle control (Page 221)
- GetOperatingMode() (Page 221)
- SetOperatingMode() (Page 221)
- OperatingMode { get; set; } (Page 221)

6.3 Synchronize simulation partner

6.3.1 Synchronize simulation partner cycle-controlled

Introduction

The virtual controller must be set to the freeze state for synchronization.

The SingleStep and ExtendedSingleStep modes of the virtual controller provides one way to synchronize several simulation partners (clients).

SingleStep operating mode

In this operating mode, the virtual controller at the cycle control point goes into a freeze state and sends an event to the API clients.

The freeze state is terminated when the virtual controller issues an API command, performs the next step or changes to the default mode.

API functions

- RunNextCycle() (Page 225)

ExtendedSingleStep operating mode

In this operating mode, the virtual controller at the cycle control point goes into a freeze state and sends an event to the API clients.

Compared to the SingleStep operating mode, an API function in this mode also overwrites the minimum cycle time of the OB1 cycle. When you define a minimum cycle time of 200 ms, the minimum distance between two cycle control points is 200 virtual milliseconds. The default mode is 100 ms.

The freeze state is terminated when the virtual controller issues an API command, performs the next step or changes to the default mode.

API functions

- GetOverwrittenMinimalCycleTime_ns() (Page 223)
- SetOverwrittenMinimalCycleTime_ns() (Page 223)
- OverwrittenMinimalCycleTime_ns { get; set; } (Page 224)
- RunNextCycle() (Page 225)

See also

Cycle control (Page 221)

6.3.2 Synchronize simulation partner time-controlled

Introduction

The TimespanSynchronized mode of the virtual controller provides one way to synchronize several simulation partners (clients).

TimespanSynchronized operating mode

At least two simulation clients synchronize based on a virtual time period for this mode. A simulation client can be an instance of a virtual controller or an API client (an application that uses the Runtime API). The synchronization must be performed by a synchronization master.

The synchronization master signals a simulation client that it is his turn to run over certain time period. The time period is specified by the master in nanoseconds. The client then runs for the expected length of time before he goes into the freeze state at the next cycle control point. Before switching to the freeze state, the client sends the master the exact amount of time that he currently needed. Thereafter, the master signals the next client to catch up.

API client as master

The API client as master signals each client when it should start. The master receives events from the clients when they occur.

An API client can only "time manage" instances of a virtual controller. The API client does not receive events from other API clients. It cannot send messages to other API clients.

API functions

- Settings for cycle control (Page 221)
- StartProcessing() (Page 226)
- RunNextCycle() (Page 225)

User interfaces (API) 7

7.1 Introduction

Components of the Simulation Runtime

The following components are relevant for handling the Simulation Runtime of PLCSIM Advanced:

- Runtime
  - Siemens.Simatic.Simulation.Runtime.Manager.exe
  - Siemens.Simatic.Simulation.Runtime.Instance.exe
- Libraries
  - Siemens.Simatic.Simulation.Runtime.Api.x86.dll
  - Siemens.Simatic.Simulation.Runtime.Api.x64.dll
  - SimulationRuntimeApi.h
- Documentation of interfaces with examples in native C++ and .NET (Managed Code)

Description

Runtime and libraries	Description
Siemens.Simatic.Simulation. Runtime.Manager.exe	A Windows process that runs in the background. Main component of Runtime that manages all other Runtime components. The process is started automatically as soon as an application attempts to initialize the Runtime API. It is ended automatically as soon as there is no longer any application running that initialized the Runtime API.
Siemens.Simatic.Simulation. Runtime.Instance.exe	The process of the instance that loads a DLL of a virtual controller. Each virtual controller generates its own process.
Siemens.Simatic.Simulation. Runtime.Api.x86.dll Siemens.Simatic.Simulation. Runtime.Api.x64.dll	API libraries that must load an application to use the Simulation Runtime. The libraries contain interfaces for native code and managed code. The "Runtime.Api.x86.dll" is loaded exclusively by 32-bit applications, and the "Runtime.Api.x64.dll" by 64-bit applications.
SimulationRuntimeApi.h	Header file that describes all data types that require a native C++ application to use the API library.

External applications and Simulation Runtime

The following figure schematically presents the access of external applications to Simulation Runtime via the Runtime API. The Simulation Runtime Manager manages the Runtime instances. These load the libraries of the virtual controllers.

An external application can be other simulation software or a GUI, for example.

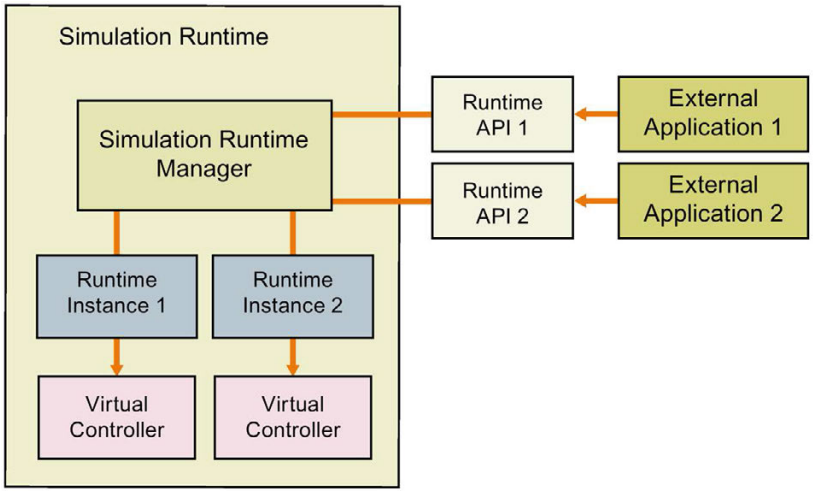
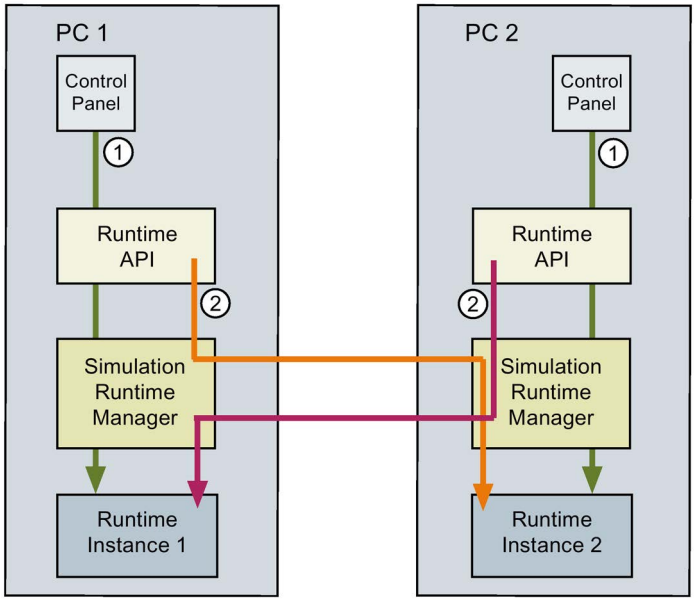


Figure 7-1 External applications and Simulation Runtime

7.1.1 Access to instances

Access via the Control Panel and the API

You can access only one instance that is available locally on the PC via the Control Panel. It does not matter on which PC an instance was created and started. With distributed communication, the Runtime API accesses the instance of the other PCs via the Simulation Runtime Manager.



① Access to a local instance via the Control Panel
② Access to a remote instance on the Runtime API

Figure 7-2 Access to instances with distributed communication

API functions

- Table 7-5 Overview of IRemoteRuntimeManager functions - Native C++ (Page 72)
- Table 7-9 Overview of IRemoteRuntimeManager functions - .NET (C#) (Page 75)
- Table 7-4 Overview of IInstances functions - Native C++ (Page 70)
- Table 7-8 Overview of IInstances functions - .NET (C#) (Page 74)

See also

Overview of user interfaces for managed code (Page 73)

S7 PLCSIM Advanced Control Panel (Page 46)

7.1.2 User interfaces (API)

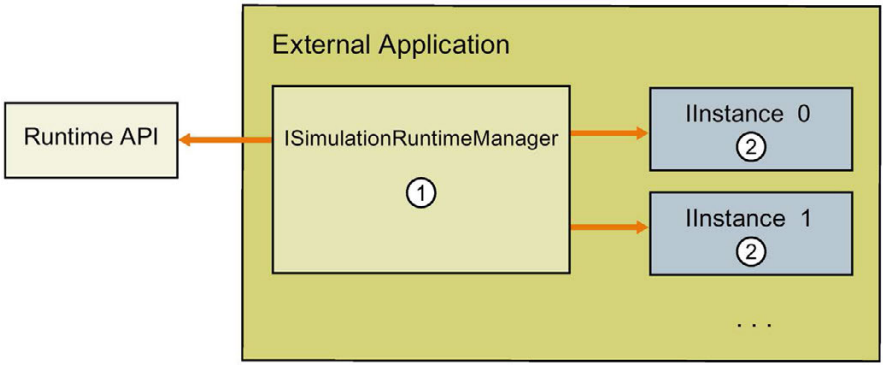
The user interfaces of Simulation Runtime include functions you use, for example, to create instances, to change the operating state of a virtual controller, or to exchange I/O data.

Simulation Runtime has the following user interfaces:

- ISimulationRuntimeManager
- IInstances
- IRemoteRuntimeManager

API and external applications

The Runtime API makes the interfaces available to an external application.



① **ISimulationRuntimeManager**

Interface of the Runtime Manager. It is used to register new Runtime instances, to search through existing Runtime instances, and to receive an interface of a registered instance.

Up to 16 instances can be registered in one Runtime Manager.

② **IInstances**

Interface of a Runtime instance. It is used to change the operating state of a virtual controller and to exchange I/O data.

Each instance has a unique name and an ID.

Figure 7-3 API and external applications

Access to API functions and data types

Required functions and data types are available for native C++ and .NET (C#).

- Overview of user interfaces for native C++ (Page 69)
- Overview of data types for native C++ (Page 76)
- Overview of user interfaces for managed code (Page 73)
- Overview of data types for managed code (Page 77)

Note

The list of tables in this manual gives you direct access to the description of the individual functions and data types.

7.1.3 Overview of user interfaces for native C++

Initializing and shutting down API

The following table shows which functions are available for initializing and shutting down the API for native C++.

Table 7- 1 Overview of initializing and shutting down API - Native C++

Actions	Functions
Initialize API	InitializeApi (Page 78) RuntimeApiEntry_Initialize (Page 79)
Shut down API (Page 81)	`DestroyInterface` `RuntimeApiEntry_DestroyInterface`
Unregister DLL API (Page 84)	`FreeApi` `ShutdownAndFreeApi`

Global functions

Table 7- 2 Overview of global functions - Native C++

Actions	Functions

Global functions (Page 86)	`GetNameOfAreaSection()`
	`GetNameOfCPUType()`
	`GetNameOfCommunicationInterface()`
	`GetNameOfDataType()`
	`GetNameOfLEDMode()`
	`GetNameOfLEDType()`
	`GetNameOfOperatingMode()`
	`GetNameOfOperatingState()`
	`GetNameOfPrimitiveDataType()`
	`GetNameOfTagListDetails()`
	`GetNameOfErrorCode()`
	`GetNameOfRuntimeConfigChanged()`
	`GetNameOfInstanceConfigChanged()`

API ISimulationRuntimeManager

The following table shows which functions are available for the API ISimulationRuntimeManager.

Table 7- 3 Overview of API ISimulationRuntimeManager functions - Native C++

Settings and information	Functions

Interface (Page 90)	`GetVersion()`
	`IsInitialized()`
	`IsRuntimeManagerAvailable()`
	`Shutdown()`

Simulation Runtime instances (Page 93)	`GetRegisteredInstancesCount()`
	`GetRegisteredInstanceInfoAt()`
	`RegisterInstance()`
	`RegisterCustomInstance()`
	`CreateInterface()`

Remote connections (Page 101)	`OpenPort()`
	`ClosePort()`
	`GetPort()`
	`GetRemoteConnectionsCount()`
	`GetRemoteConnectionInfoAt()`
	`RemoteConnect()`

Events	

OnConfigurationChanged (Page 106)	`RegisterOnConfigurationChangedCallback()`
	`UnregisterOnConfigurationChangedCallback()`
	`RegisterOnConfigurationChangedEvent()`
	`UnregisterOnConfigurationChangedEvent()`
	`WaitForOnConfigurationChangedEvent()`

OnRuntimeManagerLost (Page 110)	`RegisterOnRuntimeManagerLostCallback()`
	`UnregisterOnRuntimeManagerLostCallback()`
	`RegisterOnRuntimeManagerLostEvent()`
	`UnregisterOnRuntimeManagerLostEvent()`
	`WaitForOnRuntimeManagerLostEvent()`

API IInstances

The following table shows which functions are available for the API IInstances.

Table 7- 4 Overview of IInstances functions - Native C++

Settings and information	Functions

Interface (Page 113)	`GetID()`
	`GetName()`
	`GetCPUType()`
	`SetCPUType()`
	`GetCommunicationInterface()`
	`SetCommunicationInterface()`
	`GetInfo()`
	`UnregisterInstance()`

Controller (Page 119)	`GetControllerName()`
	`GetControllerShortDesignation()`
	`GetControllerIPCount()`
	`GetControllerIP()`
	`GetControllerIPSuite4()`
	`SetIPSuite()`
	`GetStoragePath()`
	`SetStoragePath()`
	`ArchiveStorage()`
	`RetrieveStorage()`

Settings and information	Functions

Operating state (Page 127)	`GetOperatingState()`
	`PowerOn()`
	`PowerOff()`
	`MemoryReset()`
	`Run()`
	`Stop()`

Tag list (Page 135)	`UpdateTagList()`
	`GetTagListStatus()`
	`GetTagInfoCount()`
	`GetTagInfos()`
	`CreateConfigurationFile()`

I/O access via address - Reading (Page 141)	`GetAreaSize()`
	`ReadBit()`
	`ReadByte()`
	`ReadBytes()`
	`ReadSignals()`

I/O access via address - Writing (Page 150)	`WriteBit()`
	`WriteByte()`
	`WriteBytes()`
	`WriteSignals()`

I/O access via tag name - Reading (Page 158)	`Read()`
	`ReadBool()`
	`ReadChar(), ReadWChar()`
	`ReadDouble()`
	`ReadFloat()`
	`ReadInt8(), ReadInt16(), ReadInt32(), ReadInt64()`
	`ReadUInt8(), ReadUInt16(), ReadUInt32(), ReadUInt64()`
	`ReadSignals()`

I/O access via tag name - Writing (Page 188)	`Write()`
	`WriteBool()`
	`WriteChar(), WriteWChar()`
	`WriteDouble()`
	`WriteFloat()`
	`WriteInt8(), WriteInt16(), WriteInt32(), WriteInt64(),`
	`WriteUInt8(),WriteUInt16(), WriteUInt32(), WriteUInt64()`
	`WriteSignals()`

Virtual time (Page 218)	`GetSystemTime()`
	`SetSystemTime()`
	`GetScaleFactor()`
	`SetScaleFactor()`

Cycle control (Page 221)	`GetOperatingMode()`
	`SetOperatingMode()`
	`SetAlwaysSendOnEndOfCycleEnabled()`
	`IsAlwaysSendOnEndOfCycleEnabled()`
	`GetOverwrittenMinimalCycleTime_ns()`
	`SetOverwrittenMinimalCycleTime_ns()`
	`RunNextCycle()`
	`StartProcessing()`

Events	

OnOperatingStateChanged (Page 228)	`RegisterOnOperatingStateChangedCallback()`
	`UnregisterOnOperatingStateChangedCallback()`
	`RegisterOnOperatingStateChangedEvent()`
	`UnregisterOnOperatingStateChangedEvent()`
	`WaitForOnOperatingStateChangedEvent()`

OnEndOfCycle (Page 232)	`RegisterOnEndOfCycleCallback()`
	`UnregisterOnEndOfCycleCallback()`
	`RegisterOnEndOfCycleEvent()`
	`UnregisterOnEndOfCycleEvent()`
	`WaitForOnEndOfCycleEvent()`

OnConfigurationChanging (Page 234)	`RegisterOnConfigurationChangingCallback()`
	`UnregisterOnConfigurationChangingCallback()`
	`RegisterOnConfigurationChangingEvent()`
	`UnregisterOnConfigurationChangingEvent()`
	`WaitForOnConfigurationChangingEvent()`

Settings and information	Functions

OnConfigurationChanged (Page 237)	`RegisterOnConfigurationChangedCallback()`
	`UnregisterOnConfigurationChangedCallback()`
	`RegisterOnConfigurationChangedEvent()`
	`UnregisterOnConfigurationChangedEvent()`
	`WaitForOnConfigurationChangedEvent()`

OnLedChanged (Page 239)	`RegisterOnLedChangedCallback()`
	`UnregisterOnLedChangedCallback()`
	`RegisterOnLedChangedEvent()`
	`UnregisterOnLedChangedEvent()`
	`WaitForOnLedChangedEvent()`

API IRemoteRuntimeManager

The following table shows which functions are available for the API IRemoteRuntimeManager (remote connections):

Table 7- 5 Overview of IRemoteRuntimeManager functions - Native C++

Settings and information	Functions

Interface (Page 242)	`GetVersion()`
	`GetIP()`
	`GetPort()`
	`GetRemoteComputerName()`
	`Disconnect()`

Simulation Runtime instances (Page 246)	`GetRegisteredInstancesCount()`
	`GetRegisteredInstanceInfoAt()`
	`RegisterInstance()`
	`RegisterCustomInstance()`
	`CreateInterface()`

Events	

OnConnectionLost (Page 254)	`RegisterOnConnectionLostCallback()`
	`UnregisterOnConnectionLostCallback()`
	`RegisterOnConnectionLostEvent()`
	`UnregisterOnConnectionLostEvent()`
	`WaitForOnConnectionLostEvent()`

7.1.4 Overview of user interfaces for managed code

Initializing and shutting down API

Table 7- 6 Overview of initializing and shutting down API - .NET (C#)

Actions	Functions
Initialize API (Page 80)	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeManager`
Shut down API (Page 86)	

API ISimulationRuntimeManager

The following table shows which functions are available for the API ISimulationRuntimeManager.

Table 7- 7 Overview of ISimulationRuntimeManager functions - .NET (C#)

Settings and information	Functions

Interface (Page 90)	`Version { get; }`
	`IsInitialized { get; }`
	`IsRuntimeManagerAvailable { get; }`
	`Shutdown()`

Simulation Runtime instances (Page 93)	`RegisterInstanceInfo { get; }`
	`RegisterInstance()`
	`RegisterCustomInstance()`
	`CreateInterface()`

Remote connections (Page 101)	`OpenPort()`
	`ClosePort()`
	`Port { get; }`
	`RemoteConnectionInfo { get; }`
	`RemoteConnect()`

Events	

OnConfigurationChanged (Page 106)	`OnConfigurationChanged`
	`RegisterOnConfigurationChangedEvent()`
	`UnregisterOnConfigurationChangedEvent()`
	`WaitForOnConfigurationChangedEvent()`

OnRuntimeManagerLost (Page 110)	`OnRuntimeManagerLost()`
	`RegisterOnRuntimeManagerLostEvent()`
	`UnregisterOnRuntimeManagerLostEvent()`
	`WaitForOnRuntimeManagerLostEvent()`

API IInstances

The following table shows which functions are available for the API IInstances.

Table 7- 8 Overview of IInstances functions - .NET (C#)

Settings and information	Functions

Interface (Page 113)	`Dispose ()`
	`ID { get; }`
	`Name { get; }`
	`CPUType { get; set; }`
	`CommunicationInterface { get; }`
	`Info { get; }`
	`UnregisterInstance()`

Controller - Information and settings (Page 119)	`ControllerName { get; }`
	`ControllerShortDesignation { get; }`
	`ControllerIPSuite4 { get; }`
	`SetIPSuite()`
	`StoragePath { get; set; }`
	`ArchiveStorage()`
	`RetrieveStorage()`

Operating state (Page 127)	`OperatingState { get; }`
	`PowerOn()`
	`PowerOff()`
	`MemoryReset()`
	`Run()`
	`Stop()`

Tag list (Page 135)	`UpdateTagList()`
	`GetTagListStatus()`
	`TagInfos { get; }`
	`CreateConfigurationFile()`

I/O access via address - Reading (Page 141)	`InputArea | MarkerArea | OutputArea { get; }`
	`AreaSize { get; }`
	`ReadBit()`
	`ReadByte()`
	`ReadBytes()`
	`ReadSignals()`

I/O access via address - Writing (Page 150)	`WriteBit()`
	`WriteByte()`
	`WriteBytes()`
	`WriteSignals()`

I/O access via tag name - Reading (Page 158)	`Read()`
	`ReadBool()`
	`ReadChar(), ReadWChar()`
	`ReadDouble()`
	`ReadFloat()`
	`ReadInt8(), ReadInt16(), ReadInt32(), ReadInt64()`
	`ReadUInt8(), ReadUInt16(), ReadUInt32(), ReadUInt64()`
	`ReadSignals()`

I/O access via tag name - Writing (Page 188)	`Write()`
	`WriteBool()`
	`WriteChar(), WriteWChar()`
	`WriteDouble()`
	`WriteFloat()`
	`WriteInt8(), WriteInt16(), WriteInt32(), WriteInt64(),`
	`WriteUInt8(),WriteUInt16(), WriteUInt32(), WriteUInt64()`
	`WriteSignals()`

Virtual time (Page 218)	`SystemTime { get; set; }` `ScaleFactor { get; set; }`

Cycle control (Page 221)	`OperatingMode { get; set; }`
	`IsAlwaysSendOnEndOfCycleEnabled { get; set; }`
	`OverwrittenMinimalCycleTime_ns { get; set; }`
	`RunNextCycle()`
	`StartProcessing()`

Settings and information	Functions
Events	

OnOperatingStateChanged (Page 228)	`OnOperatingStateChanged`
	`RegisterOnOperatingStateChangedEvent()`
	`UnregisterOnOperatingStateChangedEvent()`
	`WaitForOnOperatingStateChangedEvent()`

OnEndOfCycle (Page 232)	`OnEndOfCycle`
	`RegisterOnEndOfCycleEvent()`
	`UnregisterOnEndOfCycleEvent()`
	`WaitForOnEndOfCycleEvent()`

OnConfigurationChanging (Page 234)	`OnConfigurationChanging`
	`RegisterOnConfigurationChangingEvent()`
	`UnregisterOnConfigurationChangingEvent()`
	`WaitForOnConfigurationChangingEvent()`

OnConfigurationChanged (Page 106)	`OnConfigurationChanged`
	`RegisterOnConfigurationChangedEvent()`
	`UnregisterOnConfigurationChangedEvent()`
	`WaitForOnConfigurationChangedEvent()`

OnLedChanged (Page 239)	`OnLedChanged`
	`RegisterOnLedChangedEvent()`
	`UnregisterOnLedChangedEvent()`
	`WaitForOnLedChangedEvent()`

API IRemoteRuntimeManager

The following table shows which functions are available for the API IRemoteRuntimeManager.

Table 7- 9 Overview of IRemoteRuntimeManager functions - .NET (C#)

Settings and information	Functions

Interface (Page 242)	`Dispose()`
	`Version { get; }`
	`IP { get; }`
	`Port { get; }`
	`RemoteComputerName { get; }`
	`Disconnect()`

Simulation Runtime instances (Page 93)	`RegisterInstanceInfo { get; }`
	`RegisterInstance()`
	`RegisterCustomInstance()`
	`CreateInterface()`

Events	

OnConnectionLost() (Page 254)	`OnConnectionLost()`
	`RegisterOnConnectionLostEvent()`
	`UnregisterOnConnectionLostEvent()`
	`WaitForOnConnectionLostEvent()`

7.1.5 Overview of data types for native C++

The following table shows which data types are available for the simulation in Runtime Manager.

Table 7- 10 Overview of data types - Native C++

Data type	
DLL import functions (Page 258)	`ApiEntry_Initialize` `ApiEntry_DestroyInterface`

Event callback functions (Page 259)	`EventCallback_VOID`
	`EventCallback_II_SREC_ST`
	`EventCallback_II_SREC_ST_SROS_SROS`
	`EventCallback_II_SREC_ST_SRLT_SRLM`
	`EventCallback_II_SREC_ST_INT64_UINT32`
	`EventCallback_IRRTM`
	`EventCallback_SRCC_UINT32_UINT32_INT32`
	`EventCallback_II_SREC_ST_SRICC_UINT32_UINT32_UINT32_UINT32`

Definitions and constants (Page 271)	
Unions (Page 272)	`UIP` `UDataValue`

Structures (Page 274)	`SDataValue`
	`SDataValueByAddress`
	`SDataValueByName`
	`SConnectionInfo`
	`SInstanceInfo`
	`SDimension`
	`STagInfo`
	`SIP`
	`SIPSuite4`

Enumerations (Page 284)	`ERuntimeErrorCode`
	`EArea`
	`EOperatingState`
	`EOperatingMode`
	`ECPUType`
	`ECommunicationInterface`
	`ELEDType`
	`ELEDMode`
	`EPrimitiveDataTypes`
	`EDataType`
	`ETagListDetails`
	`ERuntimeConfigChanged`
	`EInstanceConfigChanged`

7.1.6 Overview of data types for managed code

The following table shows which data types are available for the simulation in Runtime Manager.

Table 7- 11 Overview of data types - .NET (C#)

Data type	
Delegate definitions (Page 265) - Event handler methods	Delegate_Void Delegate_II_EREC_DT Delegate_II_EREC_DT_EOS_EOS Delegate_II_EREC_DT_ELT_ELM Delegate_II_EREC_DT_INT64_UINT32 Delegate_IRRTM Delegate_SRCC_UINT32_UINT32_INT32 Delegate_II_EREC_DT_SRICC_UINT32_UINT32_UINT32_UINT32
Definitions and constants (Page 271)	
Structures (Page 274)	SDataValue SDataValueByAddress SDataValueByName SConnectionInfo SInstanceInfo SDimension STagInfo SIP SIPSuite4
Enumerations (Page 284)	ERuntimeErrorCode EArea EOperatingState EOperatingMode ECPUType ECommunicationInterface ELEDType ELEDMode EPrimitiveDataTypes EDataType ETagListDetails ERuntimeConfigChanged EInstanceConfigChanged

7.2 Initialize API

7.2.1 Native C++

7.2.1.1 InitializeApi()

Description

The `InitializeApi` function loads the API library (DLL) and initializes the API. The function loads the version of the DLL that is compatible with the architecture of your application. The DLL is loaded from the Startup directory of each application that calls this function or from the directory that provides the path parameter.

The function returns an interface to the Simulation Runtime Manager. Use this interface to create a new instance of the virtual controller or to obtain access to an existing instance.

Table 7- 12 InitializeApi() - Native C++

Syntax	`ERuntimeErrorCode InitializeApi(`
	`  ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface`
	`);`
	`ERuntimeErrorCode InitializeApi(`
	`  WCHAR* in_SimulationRuntimeApiDllPath,`
	`  ISimulationRuntimeManager** in-`
	`out_SimulationRuntimeManagerInterface`
	`);`	

Parameters	• `ISimulationRuntimeManager**` `out_SimulationRuntimeManagerInterface:` Pointer to a Runtime Manager interface pointer. The pointer must be initialized with `ZERO`. The interface is created within the function. See Data types (Page 257). • `WCHAR* in_SimulationRuntimeApiDllPath`: The path to the Runtime API library (DLL).	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the Runtime Manager interface does not equal `ZERO`.
	`SREC_WRONG_VERSION`	The required version of the interface is incompatible with the version used to compile the API.
	`SREC_CONNECTION_ERROR`	Unable to establish a connection to the Runtime Manager.
	`SREC_ERROR_LOADING_DLL`	The API library (DLL) cannot be loaded.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// Prepare The Variables`
	`ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;`
	`ISimulationRuntimeManager* api = ZERO;`
	
	`// Initialize The API And Get The RuntimeManager Interface`
	`result = InitializeApi(&api);`

Note

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

7.2.1.2 RuntimeApiEntry_Initialize

Description

Use the `RuntimeApiEntry_Initialize` function only if the API library (DLL) is to be loaded from a different directory than the Startup directory of the application that calls this function.

When the API is initialized, the API library is first loaded and the `Initialize` function is then imported and called.

The function returns an interface to the Simulation Runtime Manager. Use this interface to create a new instance of the virtual controller or to obtain access to an existing instance.

Table 7- 13 RuntimeApiEntry_Initialize - Native C++

Syntax	`__declspec(dllexport) ERuntimeErrorCode RuntimeApiEntry_Initialize(`
	`ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface,`
	`UINT32 in_InterfaceVersion`
	`);`	

Parameters	• `ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface:` Pointer to a Runtime Manager interface pointer. The pointer must be initialized with `NULL`. The interface is created within the function. See Data types (Page 257). • `UINT32 in_InterfaceVersion:` Version of the API interface to be downloaded: `DAPI_DLL_INTERFACE_VERSION`.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the Runtime Manager interface does not equal `NULL`.
	`SREC_WRONG_VERSION`	The required version of the interface is incompatible with the version used to compile the API.

	SREC_CONNECTION_ERROR	Unable to establish a connection to the Runtime Manager.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// Prepare The Variables`
	`ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;`
	`HMODULE dllHandle = NULL;`
	`ApiEntry_Initialize Initialize = NULL;`
	`ISimulationRuntimeManager* api = NULL;`
	
	`// Load The DLL And Import The "Initialize" Function (using the Win32 API)`
	`dllHandle = LoadLibrary(DAPI_DLL_NAME_X86);`
	`if ( dllHandle != NULL )`
	`{`
	`Initialize = (ApiEntry_Initialize)GetProcAddress(dllHandle, DAPI_ENTRY_INITIALIZE);`
	`}`
	
	`// Initialize The API And Get The RuntimeManager Interface`
	`if ( Initialize != NULL )`
	`{`
	`result = Initialize(&api, DAPI_DLL_INTERFACE_VERSION);`
	`}`	

Note

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

7.2.2 .NET (C#)

7.2.2.1 Initialize

Description

The entry point to the API is the static class
`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeManager`.
The API is initialized when a function of this class is used the first time.

Table 7- 14 Initialize - .NET (C#)

Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationInitializationException`	
	Runtime error code	Condition
	`ERuntimeError-Code.ConnectionError`	Unable to establish a connection to the Runtime Manager.

7.3 Shut down API

7.3.1 Native C++

Basic procedure for deleting the user interfaces

To delete all user interfaces, generally follow these steps:

1. Delete the interfaces IInstances and IRemoteRuntimeManager.
2. Call the `Shutdown()` function of the ISimulationRuntimeManager interface.
3. Delete the ISimulationRuntimeManager interface.
4. Unload the API library (DLL) with the Win32 API-Funktion `FreeLibrary()`.

Deleting the user interfaces via functions

Deleting the user interfaces is also possible via functions.

If the API was initialized using the `InitializeApi()` function, you delete the user interfaces using the following functions:

- FreeApi() (Page 84)
- ShutdownAndFreeApi() (Page 85)

7.3.1.1 DestroyInterface()

Description

A function pointer to the `RuntimeApiEntry_DestroyInterface` function. The function pointer `DestoyInterface()` is only valid if the `InitializeApi` function has been successfully called.

The function unloads the memory of an ISimulationRuntimeManager, IRemoteRuntimeManager or IInstance interface.

Table 7- 15 DestroyInterface() - Native C++

Syntax	`ERuntimeErrorCode DestroyInterface(`
	`  IBaseInterface* in_Interface`
	`);`	

Parameters	• `IBaseInterface* in_Interface:` The interface to be deleted.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the interface is `NULL`.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// The Interfaces`
	`ERuntimeErrorCode result;`
	`ISimulationRuntimeManager* api = NULL;`
	`IInstance* instance = NULL;`
	
	`// Init the DLL and create an instance`
	`result = InitializeApi(&api);`
	`result = api->RegisterInstance(&instance);`
	
	`// Destroy Instance Interfaces`
	`result = DestroyInterface(instance);`
	`instance = NULL;`	

7.3.1.2 RuntimeApiEntry_DestroyInterface

Description

Use the `RuntimeApiEntry_DestroyInterface` function only if the API library (DLL) is to be loaded from a different directory than the Startup directory of the application that calls this function.

If the API was initialized using the `InitializeApi` function, you select the DestroyInterface() (Page 82) function.

The function unloads the memory of an ISimulationRuntimeManager, IRemoteRuntimeManager or IInstance interface.

Table 7- 16 RuntimeApiEntry_DestroyInterface() - Native C++

Syntax	`__declspec(dllexport) ERuntimeErrorCode RuntimeApiEntry_DestroyInterface( IBaseInterface* in_Interface );`	
Parameters	• `IBaseInterface* in_Interface:` The interface to be deleted.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the interface is `NULL`.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// Prepare The Variables`
	`ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;`
	`HMODULE dllHandle = NULL;`
	`ApiEntry_DestroyInterface Destroy = NULL;`
	`IInstance* instance = NULL;`
	
	`// Load The DLL And Import The "DestroyInterface" Function (using the Win32 API)`
	`dllHandle = LoadLibraryA(DAPI_DLL_NAME_X86);`
	`if ( dllHandle != NULL )`
	`{`
	`Destroy = (ApiEntry_DestroyInterface)GetProcAddress(dllHandle, DAPI_ENTRY_DESTROY_INTERFACE);`
	`}`
	`…`
	`// Frees the memory of an IInstance interface`
	`result = Destroy(instance);`	

7.3.1.3 FreeApi()

Description

The `FreeApi()` function unloads the library of the Runtime API.

This function can only be called after the successful call of the `InitializeApi` function. If the `InitializeApi` function was not called, the library must be unloaded using the Win32 API function `FreeLibrary()`.

Table 7- 17 FreeApi() - Native C++

Syntax	`ERuntimeErrorCode FreeApi();`	
Parameters	None	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_API_NOT_INITIALIZED`	The `InitializeApi` function was not called successfully.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// The Interfaces`
	`ERuntimeErrorCode result;`
	`ISimulationRuntimeManager* api = NULL;`
	`IInstance* instance = NULL;`
	
	`// Init the API`
	`result = InitializeApi(&api);`
	
	`…`
	
	`// Shutdown The API`
	`api->Shutdown();`
	`result = DestroyInterface(api);`
	`api = NULL;`
	`result = FreeApi();`	

7.3.1.4 ShutdownAndFreeApi()

Description

The `ShutdownAndFreeApi()` function shuts down the Runtime API, deletes the IRuntimeManager interface and unloads the library of the Runtime API.

This function can only be called after the successful call of the `InitializeApi` function. If the `InitializeApi` function was not called, the library must be unloaded using the Win32 API-Funktion `FreeLibrary()`.

Table 7- 18 ShutdownAndFreeApi() - Native C++

Syntax	`ERuntimeErrorCode ShutdownAndFreeApi( ISimulationRuntimeManager* in_SimulationRuntimeManagerInterface );`	
Parameters	• `ISimulationRuntimeManager* in_SimulationRuntimeManagerInterface:` The interface of the Runtime Manager to be deleted.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_API_NOT_INITIALIZED`	The `InitializeApi` function was not called successfully.
	`SREC_WRONG_ARGUMENT`	The pointer to the interface is `NULL`.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// The Interfaces`
	`ERuntimeErrorCode result;`
	`ISimulationRuntimeManager* api = NULL;`
	`IInstance* instance = NULL;`
	
	`// Init the API`
	`result = InitializeApi(&api);`
	
	…
	
	`// Shutdown The API`
	`result = ShutdownAndFreeApi(api);`
	`api = NULL;`	

7.3.2 .NET (C#)

7.3.2.1 Shut down API

You can end the .NET components of the API in the following ways:

- By a clearing operation using the .NET Garbage Collector.
- For the IInstance and IRemoteRuntimeManager interfaces, by calling the Dispose (Page 113) function.

Manually clearing the API

To manually clear the API, follow these steps:

1. Delete all interfaces. Interfaces - Information and settings (Page 113)
2. Call the Shutdown() (Page 90) function of the ISimulationRuntimeManager interface.

7.4 Global functions (Native C++)

GetNameOfAreaSection()

Returns the name of the enumeration entry.

Table 7- 19 GetNameOfAreaSection() - Native C++

Syntax	`const WCHAR* GetNameOfAreaSection(`
	`  EArea in_AreaSection`
	`);`

Parameters	• `EArea in_AreaSection:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfCPUType()

Returns the name of the enumeration entry.

Table 7- 20 GetNameOfCPUType() - Native C++

Syntax	`const WCHAR* GetNameOfCPUType(`
	`  ECPUType in_CPUType`
	`);`

Parameters	• `ECPUType in_CPUType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfCommunicationInterface()

Returns the name of the enumeration entry.

Table 7- 21 GetNameOfCommunicationInterface() - Native C++

Syntax	`const WCHAR* GetNameOfCommunicationInterface( ECommunicationInterface in_CommunicationInterface );`
Parameters	• `ECommunicationInterface in_CommunicationInterface:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfDataType()

Returns the name of the enumeration entry.

Table 7- 22 GetNameOfDataType() - Native C++

Syntax	`const WCHAR* GetNameOfDataType( EDataType in_DataType );`
Parameters	• `EDataType in_DataType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfErrorCode()

Returns the name of the enumeration entry.

Table 7- 23 GetNameOfErrorCode() - Native C++

Syntax	`const WCHAR* GetNameOfErrorCode( ERuntimeErrorCode in_ErrorCode );`
Parameters	• `ERuntimeErrorCode in_ErrorCode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfLEDMode()

Returns the name of the enumeration entry.

Table 7- 24 GetNameOfLEDMode() - Native C++

Syntax	`const WCHAR* GetNameOfLEDMode( ELEDMode in_LEDMode );`
Parameters	• `ELEDMode in_LEDMode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfLEDType()

Returns the name of the enumeration entry.

Table 7- 25 GetNameOfLEDType() - Native C++

Syntax	`const WCHAR* GetNameOfLEDType( ELEDType in_LEDType );`
Parameters	• `ELEDType in_LEDType:` Enumeration entry.
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfOperatingMode()

Returns the name of the enumeration entry.

Table 7- 26 GetNameOfOperatingMode() - Native C++

Syntax	`const WCHAR* GetNameOfOperatingMode( EOperatingMode in_OperatingMode );`
Parameters	• `EOperatingMode in_OperatingMode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfErrorCode()

Returns the name of the enumeration entry.

Table 7- 27 GetNameOfErrorCode() - Native C++

Syntax	`const WCHAR* GetNameOfErrorCode( ERuntimeErrorCode in_ErrorCode );`
Parameters	• `ERuntimeErrorCode in_ErrorCode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfOperatingState

Returns the name of the enumeration entry.

Table 7- 28 GetNameOfOperatingState() - Native C++

Syntax	`const WCHAR* GetNameOfOperatingState( EOperatingState in_OperatingState );`
Parameters	• `EOperatingState in_OperatingState:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfPrimitiveDataType

Returns the name of the enumeration entry.

Table 7- 29 GetNameOfPrimitiveDataType() - Native C++

Syntax	`const WCHAR* GetNameOfPrimitiveDataType( EPrimitiveDataType in_DataType );`
Parameters	• `EPrimitiveDataType in_DataType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfTagListDetails

Returns the name of the enumeration entry.

Table 7- 30 GetNameOfTagListDetails() - Native C++

Syntax	`const WCHAR* GetNameOfTagListDetails( ETagListDetails in_TagListDetails );`
Parameters	• `ETagListDetails in_TagListDetails:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfRuntimeConfigChanged()

Returns the name of the enumeration entry.

Table 7- 31 GetNameOfRuntimeConfigChanged() - Native C++

Syntax	`const WCHAR* GetNameOfRuntimeConfigChanged( ERuntimeConfigChanged in_RuntimeConfigChanged); );`
Parameters	• `ERuntimeConfigChanged in_RuntimeConfigChanged:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfInstanceConfigChanged()

Returns the name of the enumeration entry.

Table 7- 32 GetNameOfInstanceConfigChanged() - Native C++

Syntax	`const WCHAR* GetNameOfInstanceConfigChanged( EInstanceConfigChanged in_InstanceConfigChanged); );`
Parameters	• `EInstanceConfigChanged in_InstanceConfigChanged:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

See also

EPrimitiveDataType (Page 294)

EDataType (Page 296)

7.5 API ISimulationRuntimeManager

7.5.1 Interfaces - Information and settings

GetVersion() / Version { get; }

Returns the version of Runtime Manager. If the function fails, version 0.0 is returned.

Table 7- 33 GetVersion() - Native C++

Syntax	`UINT32 GetVersion();`
Parameters	None
Return values	`UINT32`: Runtime Manager Version (`HIWORD` = Major, `LOWORD` = Minor)

Table 7- 34 Version { get; } - .NET (C#)

Syntax	`UInt32 Version { get; }`
Parameters	None
Return values	`Uint32`: Runtime Manager Version (`HIWORD` = Major, `LOWORD` = Minor)

IsInitialized() / IsInitialized { get; }

Returns a value that indicates whether the API was successfully initialized.

Table 7- 35 IsInitialized() - Native C++

Syntax	`bool IsInitialized();`
Parameters	None
Return values	• `false`: If the API was not initialized. • `true`: If the API was initialized.

Table 7- 36 IsInitialized { get; } - .NET (C#)

Syntax	`bool IsInitialized { get; }`
Parameters	None
Return values	• `false`: If the API was not initialized. • `true`: If the API was initialized.

IsRuntimeManagerAvailable() / IsRuntimeManagerAvailable { get; }

The function returns `false` when the connection to Runtime Manager is interrupted. This happens only when the Runtime Manager process is closed.

Subscribe to the `OnRuntimeManagerLost()` event to find out whether the connection is interrupted. See Events (Page 106).

Table 7- 37 IsRuntimeManagerAvailable() - Native C++

Syntax	`bool IsRuntimeManagerAvailable();`
Parameters	None
Return values	• `false`: If the connection is interrupted. • `true`: If the connection is active.

Table 7- 38 IsRuntimeManagerAvailable { get; } - .NET (C#)

Syntax	`bool IsRuntimeManagerAvailable{ get; }`
Parameters	None
Return values	• `false`: If the connection is interrupted. • `true`: If the connection is active.

Shutdown()

Ends communication with Runtime Manager and clears the interfaces.

Call this function in the following cases:

- Immediately before the API library (DLL) is unregistered (native C++).
- When your application is no longer using Runtime Manager.

Table 7- 39 Shutdown() - Native C++

Syntax	`ERuntimeErrorCode Shutdown()`	
Parameters	None	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.

Table 7- 40 Shutdown() - .NET (C#)

Syntax	`void Shutdown()`
Parameters	None
Return values	None

7.5.2 Simulation Runtime instances

GetRegisteredInstancesCount()

Returns the number of instances that are registered in Runtime Manager. If the function fails, the return value is 0.

Table 7- 41 GetRegisteredInstancesCount() - Native C++

Syntax	`UINT32 GetRegisteredInstancesCount();`
Parameters	None
Return values	`UINT32`: Number of available instances.

GetRegisteredInstanceInfoAt()

Returns information about an already registered instance. You can use the ID or name to create an interface of this instance, see `CreateInterface()`.

Table 7- 42 GetRegisteredInstanceInfoAt() - Native C++

Syntax	`ERuntimeErrorCode GetRegisteredInstanceInfoAt(`
	`  UINT32 in_Index,`
	`  SInstanceInfo* out_InstanceInfo`
	`);`	

Parameters	• `UINT32 in_Index:` Index of the created instance from which you want to receive the information. The index must be less than the value you receive when you call `GetRegisteredInstanceCount()`. • `SInstanceInfo* out_InstanceInfo:` The information with name and ID of the instance. See Data types (Page 271).	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX OUT_OF_RANGE`	There is no instance information for this index.

RegisteredInstanceInfo { get; }

Returns information about all already registered instances. Use the ID or name of this instance to create an interface of this instance, see `CreateInterface()`.

Table 7- 43 RegisteredInstanceInfo { get; } - .NET (C#)

Syntax	`SInstanceInfo[] RegisteredInstanceInfo { get; }`	
Parameters	None	
Return values	`SInstanceInfo[]`: An array of information about all registered instances.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

RegisterInstance()

Registers a new instance of a virtual controller in Runtime Manager. Creates and returns an interface of this instance.

Table 7- 44 RegisterInstance() - Native C++

Syntax	`ERuntimeErrorCode RegisterInstance(`
	`  IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode RegisterInstance(`
	`  WCHAR* in_InstanceName,`
	`  IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode RegisterInstance(`
	`  ECPUType in_CPUType,`
	`  IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode RegisterInstance(`
	`  ECPUType in_CPUType,`
	`  WCHAR* in_InstanceName,`
	`  IInstance** out_InstanceInterface`
	`);`	

Parameters	• `ECPUType in_CPUType:` Defines which CPU type is simulated at the start of the instance. The default setting is `"SRCT_1500_Unspecified"`. When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies. • `WCHAR* in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 271). • `IInstance** out_InstanceInterface:` Pointer to a Simulation Runtime interface pointer. The pointer must be initialized with `ZERO`. The interface is created within the function.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The name or the IInstance pointer is invalid.
	`SREC_LIMIT_REACHED`	There are already 16 instances registered in Runtime Manager.
	`SREC_ALREADY_EXISTS`	An instance with this name already exists.

Example C++	`ISimulationRuntimeManager * api = ZERO;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`// Example: How To Create And Register An Instance`
	`IInstance* psa = ZERO;`
	`if (result == SREC_OK)`
	`{`
	`  result = api->RegisterInstance(&psa);`
	`}`	

Note
Native C++

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

Table 7- 45 RegisterInstance() - .NET (C#)

Syntax	`IInstance RegisterInstance();`
	`IInstance RegisterInstance(`
	`  string in_InstanceName`
	`);`
	`IInstance RegisterInstance(`
	`  ECPUType in_CPUType`
	`);`
	`IInstance RegisterInstance(`
	`  ECPUType in_CPUType`
	`  string in_InstanceName`
	`);`	

Parameters	• `ECPUType in_CPUType:` Defines which CPU type is simulated at the start of the instance. The default setting is `"ECPUType.Unspecified"`. When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies. • `string in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 271).	
Return values	If the function is successful, an interface of a virtual controller, otherwise a null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name is invalid.
	`ERuntimeErrorCode.LimitReached`	There are already 16 instances registered in Runtime Manager.
	`ERuntimeErrorCode.AlreadyExists`	An instance with this name already exists.

RegisterCustomInstance()

Registers a new instance of a virtual controller in Runtime Manager. Creates and returns an interface of this instance.

Table 7- 46 RegisterCustomInstance() - Native C++

Syntax	ERuntimeErrorCode RegisterCustomInstance(WCHAR* in_VplcDll, IInstance** out_InstanceInterface); ERuntimeErrorCode RegisterCustomInstance(WCHAR* in_VplcDll, WCHAR* in_InstanceName, IInstance** out_InstanceInterface);	
Parameters	• WCHAR* in_VplcDll: The complete path to the DLL of the virtual controller that Siemens.Simatic.Simulation.Runtime.Instance.exe loads at PowerOn. • WCHAR* in_InstanceName: Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name "Instance_#" (# is the ID of the instance). If this name already exists, the name "Instance_#.#" is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than DINSTANCE_NAME_LENGTH. See Data types (Page 271). • IInstance** out_InstanceInterface: Pointer to a Simulation Runtime interface pointer. The pointer must be initialized with ZERO. The interface is created within the function.	
Return values	Runtime error code	Condition
	SREC_OK	The function is successful.
	SREC_TIMEOUT	The function does not return on time.
	SREC_WRONG_ARGUMENT	The DLL name, the instance name or the IInstance pointer is invalid.
	SREC_LIMIT_REACHED	There are already 16 instances registered in Runtime Manager.
	SREC_ALREADY_EXISTS	An instance with this name already exists.

Example C++	ISimulationRuntimeManager * api = ZERO;
	ERuntimeErrorCode result = Initialize(&api);
	
	// Example: How To Create And Register An Instance
	IInstance* psa = ZERO;
	if (result == SREC_OK)
	{
	result = api->**RegisterCustomInstance**("C:\\Temp\\vplc.dll");
	}	

Note
Native C++

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

Table 7- 47 RegisterCustomInstance() - .NET (C#)

Syntax	`IInstance RegisterCustomInstance(`
	` string in_VplcDll`
	`);`
	`IInstance RegisterCustomInstance(`
	` string in_VplcDll,`
	` string in_InstanceName`
	`);`	

Parameters	• `string in_VplcDll:` The complete path to the DLL of the virtual controller that Siemens.Simatic.Simulation.Runtime.Instance.exe loads at PowerOn. • `string in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 271).	
Return values	If the function is successful, an interface of a virtual controller; otherwise a Null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name or the ID is invalid.
	`ERuntimeErrorCode.LimitReached`	There are already 16 instances registered in Runtime Manager.
	`ERuntimeErrorCode.AlreadyExists`	An instance with this name already exists.

CreateInterface()

Creates and returns an interface of an already registered instance of a virtual controller.

The instance could have been registered via the application or another application that uses the Simulation Runtime API.

Table 7- 48 CreateInterface() - Native C++

Syntax	`ERuntimeErrorCode CreateInterface(`
	` WCHAR* in_InstanceName,`
	` IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode CreateInterface(`
	` INT32 in_InstanceID,`
	` IInstance** out_InstanceInterface`
	`);`	

Parameters	• `INT32 in_InstanceID:` The ID of the registered instance from which you want to receive the interface. • `WCHAR* in_InstanceName:` The name of the registered instance from which you want to receive the interface. • `IInstance** out_InstanceInterface:` Pointer to a Simulation Runtime interface pointer. The pointer **must** be initialized with `ZERO`. The interface is created within the function.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The name, the ID or the IInstance pointer is invalid.
	`SREC_DOES_NOT_EXIST`	The instance is not registered in Runtime Manager.

Example C++	`ISimulationRuntimeManager * api = ZERO;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IInstance* psa1 = ZERO;`
	`IInstance* psa2 = ZERO;`
	`if (result == SREC_OK)`
	`{`
	` result = api->CreateInterface(0, &psa1);`
	` result = api->CreateInterface(0, &psa2); // psa2 will be the same as psa1`
	`}`	

Example C++	`ISimulationRuntimeManager * api = ZERO;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IInstance* psa = ZERO;`
	`if (result == SREC_OK)`
	`{`
	` result = api->CreateInterface(L"My SimulationRuntime Instance", &psa);`
	`}`	

Note
Native C++

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

Table 7- 49 CreateInterface() - .NET (C#)

Syntax	`IInstance CreateInterface(`
	` string in_InstanceName`
	`);`
	`IInstance CreateInterface(`
	` INT32 in_InstanceID`
	`);`	

Parameters	• `INT32 in_InstanceID:` The ID of the registered instance from which you want to receive the interface. • `string in_InstanceName:` The name of the registered instance from which you want to receive the interface.	
Return values	If the function is successful, an interface of a virtual controller; otherwise a Null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name or the ID is invalid.
	`ERuntimeErrorCode.DoesNotExists`	The instance is not registered in Runtime Manager.

7.5.3 Remote connections

OpenPort()

Opens a port to which another Runtime Manager can connect.

Table 7- 50 OpenPort() - Native C++

Syntax	`ERuntimeErrorCode OpenPort( UINT16 in_Port );`	
Parameters	• `UINT16 in_Port:` The port. The value must be greater than 1024.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_ALREADY_EXISTS`	A port is already open.
	`SREC_WRONG_ARGUMENT`	The port is invalid.
	`SREC_CONNECTION_ERROR`	The port cannot be opened.

Table 7- 51 OpenPort() - .NET (C#)

Syntax	`void OpenPort( UInt16 in_Port );`	
Parameters	• `UInt16 in_Port:` The port. The value must be greater than 1024.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.AlreadyExists`	A port is already open.
	`ERuntimeErrorCode.WrongArgument`	The port is invalid.
	`ERuntimeError-Code.ConnectionError`	The port cannot be opened.

ClosePort()

Closes an open port and all open connections that another Runtime Manager has created to this open port.

Table 7- 52 ClosePort() - Native C++

Syntax	`ERuntimeErrorCode ClosePort();`	
Parameters	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WARNING_INVALID_CALL`	No port is open.

Table 7- 53 ClosePort() - .NET (C#)

Syntax	`void ClosePort(`
	`  UInt16 in_Port`
	`);`

Parameters	None
Return values	None
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`
	Runtime error code / Condition
	`ERuntimeErrorCode.Timeout` — The function does not return on time.

GetPort() / Port { get; }

Returns the open port. If no port is open or the function fails, the return value is 0.

Table 7- 54 GetPort() - Native C++

Syntax	`UINT16 GetPort();`
Parameters	None
Return values	`UINT16`: The open port. 0, if no port is open.

Table 7- 55 Port { get; } - .NET (C#)

Syntax	`UInt16 Port { get; }`
Parameters	None
Return values	`UInt16`: The open port. 0, if no port is open.
Exceptions	None

GetRemoteConnectionsCount()

Supplies the number of open remote connections.

Table 7- 56 GetRemoteConnectionsCount() - Native C++

Syntax	`UINT32 GetRemoteConnectionsCount();`
Parameters	None
Return values	`UINT32`: Number of open remote connections.

GetRemoteConnectionInfoAt()

Returns information about an open connection.

Table 7- 57 GetRemoteConnectionInfoAt()- Native C++

Syntax	`ERuntimeErrorCode GetRemoteConnectionInfoAt(`
	`  UINT32 in_Index,`
	`  SConnectionInfo* out_ConnectionInfo`
	`);`	

Parameters	• `UINT32 in_Index:` Index of the connection information that is expected. • `SConnectionInfo* out_ConnectionInfo:` The connection information for this index.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	Connection information for this index does not exist.

RemoteConnectionInfo { get; }

Returns an array of information about all open connections.

Table 7- 58 RemoteConnectionInfo { get; } - .NET (C#)

Syntax	`SConnectionInfo[] RemoteConnectionInfo { get; }`	
Parameters	None	
Return values	`SConnectionInfo[]`: An array of information about all open connections.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

RemoteConnect()

Creates a new connection to a remote Runtime Manager or uses an existing connection to create an IRemoteRuntimeManager interface.

Table 7- 59 RemoteConnect() - Native C++

Syntax	`ERuntimeErrorCode RemoteConnect(`
	` UINT8 in_IP3,`
	` UINT8 in_IP2,`
	` UINT8 in_IP1,`
	` UINT8 in_IP0,`
	` UINT16 in_Port,`
	` IRemoteRuntimeManager** out_RemoteRuntimeManagerInterface`
	`ERuntimeErrorCode RemoteConnect(`
	` UIP in_IP,`
	` UINT16 in_Port,`
	` IRemoteRuntimeManager** out_RunTimeManagerInterface`
	`);`	

Parameters	• `UINT8 in_IP3:` First part of the IP address of the remote PC. • `UINT8 in_IP2:` Second part of the IP address of the remote PC. • `UINT8 in_IP1:` Third part of the IP address of the remote PC. `UINT8 in_IP0:` Last part of the IP address of the remote PC. • `UIP in_IP:` IP address of the remote PC. • `UINT16 in_Port:` The port that is open on the remote PC. • `IRemoteRuntimeManager** out_RemoteRuntimeManagerInterface:` Pointer to a remote Runtime Manager interface pointer. The pointer **must** be initialized with `ZERO`. The interface is created in the function.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_CONNECTION_ERROR`	The connection to the remote Runtime Manager cannot be established.
	`SREC_WRONG_ARGUMENT`	IP, port or IInstance pointer is invalid.

Example C++	`ISimulationRuntimeManager* api = ZERO;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IRemoteRuntimeManager * client = ZERO;`
	
	`if (result == SREC_OK)`
	`{`
	` result = api->RemoteConnect(192,203,145,144, 4444, &client);`
	`}`	

Note

Native C++

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

Table 7- 60 RemoteConnect() - .NET (C#)

Syntax	`IRemoteRuntimeManager RemoteConnect(`
	`  string in_ConnectionString`
	`);`
	`IRemoteRuntimeManager RemoteConnect(`
	`  SIP in_IP,`
	`  UInt16 in_Port`
	`);`
	`IRemoteRuntimeManager RemoteConnect(`
	`  Byte in_IP3,`
	`  Byte in_IP2,`
	`  Byte in_IP1,`
	`  Byte in_IP0,`
	`  UInt16 in_Port`
	`);`	

Parameters	• `Byte in_IP3:` First part of the IP address of the remote PC. • `Byte in_IP2:` Second part of the IP address of the remote PC. • `Byte in_IP1:` Third part of the IP address of the remote PC. • `Byte in_IP0:` Last part of the IP address of the remote PC. • `string in_ConnectionString:` A string in the form of "<IP3>.<IP2>.<IP1>.<IP0>:<Port>" Example: "182.203.145.144:4444". • `SIP in_IP:` IP address of the remote PC. • `UInt16 in_Port:` The port that is open on the remote PC.	
Return values	`IRemoteRuntimeManager:` Interface to the remote Runtime Manager.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.ConnectionError`	Connection to the remote Runtime Manager cannot be established.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	IP or port is invalid.

See also

Data types (Page 257)

Tag list (Page 135)

7.5.4 Events

Events for the ISimulationRuntimeManager interface

The following events are differentiated in the API:

Table 7- 61 Events for the ISimulationRuntimeManager interface

Event	Cause
OnConfigurationChanged (Page 106)	This event is triggered at a change of the Runtime Manager configuration. For example, when a new instance is registered, an instance is removed or a connection to a client is established. The Control Panel uses such an event to update the list of available instances.
OnRuntimeManagerLost (Page 110)	The event is triggered when the connection to Runtime Manager is interrupted.

7.5.4.1 OnConfigurationChanged

OnConfigurationChanged

Registers or unregisters an event handler method.

Table 7- 62 OnConfigurationChanged - .NET (C#)

Syntax	`event Delegate_SRCC_UINT32_UINT32_INT32 OnConfigurationChanged;`
Parameters	None. See Delegate_SRCC_UINT32_UINT32_INT32 (Page 269).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnConfigurationChangedCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. The registration of a new callback function causes the previous callback function to be deleted.

Table 7- 63 RegisterOnConfigurationChangedCallback() - Native C++

Syntax	`void RegisterOnConfigurationChangedCallback(`
	`  EventCallback_SRCC_UINT32_UINT32_INT32 in_CallbackFunction`
	`);`

Parameters	• `EventCallback_SRCC_UINT32_UINT32_INT32 in_CallbackFunction`: A callback function to subscribe to an event. See EventCallback_SRCC_UINT32_UINT32_INT32 (Page 263).
Return values	None
Note	The event handler method runs in a separate thread.

RegisterOnConfigurationChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 7- 64 RegisterOnConfigurationChangedEvent() - Native C++

Syntax	`void RegisterOnConfigurationChangedEvent();`
	`void RegisterOnConfigurationChangedEvent(`
	`  HANDLE* in_Event`
	`);`

Parameters	• `None`: An internal event object is registered. • `HANDLE* in_Event`: A handle for a user-specific event object. The event object is registered.
Return values	None

Table 7- 65 RegisterOnConfigurationChangedEvent() - .NET (C#)

Syntax	`void RegisterOnConfigurationChangedEvent();`
Parameters	None
Return values	None

UnregisterOnConfigurationChangedCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 66 UnregisterOnConfigurationChangedCallback() - Native C++

Syntax	`void UnregisterOnConfigurationChangedCallback();`
Parameters	None
Return values	None

UnregisterOnConfigurationChangedEvent()

Unregisters the event object.

Table 7- 67 UnregisterOnConfigurationChangedEvent() - Native C++

Syntax	`void UnregisterOnConfigurationChangedEvent();`
Parameters	None
Return values	None

Table 7- 68 UnregisterOnConfigurationChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnConfigurationChangedEvent();`
Parameters	None
Return values	None

WaitForOnConfigurationChangedEvent()

The function blocks the program until the registered event object is set to the signaled state or the timeout interval is exceeded.

Table 7- 69 WaitForOnConfigurationChangedEvent() - Native C++

Syntax	`bool WaitForOnConfigurationChangedEvent();`
	`bool WaitForOnConfigurationChangedEvent(`
	`  UINT32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 7- 70 WaitForOnConfigurationChangedEvent - .NET (C#)

Syntax	`bool WaitForOnConfigurationChangedEvent();`
	`bool WaitForOnConfigurationChangedEvent(`
	`  UInt32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

7.5.4.2 OnRuntimeManagerLost

OnRuntimeManagerLost

Registers or unregisters an event handler method.

Table 7- 71 OnRuntimeManagerLost - .NET (C#)

Syntax	`event Delegate_Void OnRuntimeManagerLost;`
Parameters	None. See Delegate_Void (Page 265).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnRuntimeManagerLostCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. The registration of a new callback function causes the previous callback function to be deleted.

Table 7- 72 RegisterOnRuntimeManagerLostCallback() - Native C++

Syntax	`void RegisterOnRuntimeManagerLostCallback(`
	`  EventCallback_VOID in_CallbackFunction`
	`);`

Parameters	• `EventCallback_VOID in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_VOID (Page 259).
Return values	None
Note	The event handler method runs in a separate thread.

RegisterOnRuntimeManagerLostEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 7- 73 RegisterOnRuntimeManagerLostEvent() - Native C++

Syntax	`void RegisterOnRuntimeManagerLostEvent();`
	`void RegisterOnRuntimeManagerLostEvent(`
	`  HANDLE* in_Event`
	`);`

Parameters	• `None:` An internal event handle is registered. • `HANDLE* in_Event:` A user-specific event handle is registered.
Return values	None

Table 7- 74 RegisterOnRuntimeManagerLostEvent() - .NET (C#)

Syntax	`void RegisterOnRuntimeManagerLostEvent();`
Parameters	None
Return values	None

UnregisterOnRuntimeManagerLostCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 75 UnregisterOnRuntimeManagerLostCallback() - Native C++

Syntax	`void UnregisterOnRuntimeManagerLostCallback();`
Parameters	None
Return values	None

UnregisterOnRuntimeManagerLostEvent()

Unregisters the event object.

Table 7- 76 UnregisterOnRuntimeManagerLostEvent() - Native C++

Syntax	`void UnregisterOnRuntimeManagerLostEvent();`
Parameters	None
Return values	None

Table 7- 77 UnregisterOnRuntimeManagerLostEvent() - .NET (C#)

Syntax	`void UnregisterOnRuntimeManagerLostEvent();`
Parameters	None
Return values	None

WaitForOnRuntimeManagerLostEvent()

The function will block the program until the registered event object is set to the signaled state or the timeout interval is exceeded.

Table 7- 78 WaitForOnRuntimeManagerLostEvent() - Native C++

Syntax	`bool WaitForOnRuntimeManagerLostEvent();`
	`bool WaitForOnRuntimeManagerLostEvent(`
	`  UINT32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined timeout interval.

Table 7- 79 WaitForOnRuntimeManagerLostEvent() - .NET (C#)

Syntax	`bool WaitForOnRuntimeManagerLostEvent();`
	`bool WaitForOnRuntimeManagerLostEvent(`
	`  UInt32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined timeout interval.

7.6 API IInstances

7.6.1 Interfaces - Information and settings

Dispose()

Deletes the managed interface and unloads the native components of the user interfaces.

Table 7- 80 Dispose() - .NET (C#)

Syntax	`void Dispose()`
Parameters	None
Return values	None

GetID() / ID { get; }

Returns the instance ID. The ID is assigned by Runtime Manager when the instance is registered.

Table 7- 81 GetID() - Native C++

Syntax	`INT32 GetID();`
Parameters	None
Return values	`INT32`: Instance ID

Table 7- 82 ID { get; } - .NET (C#)

Syntax	`UInt32 ID { get; }`
Parameters	None
Return values	`Uint32`: Instance ID
Exceptions	None

GetName() / Name { get; }

Returns the name of the instance.

Table 7- 83 GetName() - Native C++

Syntax	`ERuntimeErrorCode GetName(`
	` WCHAR inout_Name[],`
	` UINT32 in_ArrayLength`
	`);`	

Parameters	• `WCHAR inout_Name[]:` A user-allocated storage for the name of the instance. The field length should be at least as long as `DINSTANCE_NAME_MAX_LENGTH`. See Definitions and constants (Page 271). • `UINT32 in_ArrayLength:` Field length (Wide character)	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_ARGUMENT`	The name does not fit in the storage.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->RegisterInstance(&psa);`
	`}`
	
	`WCHAR name[DINSTANCE_NAME_MAX_LENGTH];`
	`if (result == SREC_OK)`
	`{`
	` result = psa->GetName(name, DINSTANCE_NAME_MAX_LENGTH);`
	`}`	

Table 7- 84 Name { get; } - .NET (C#)

Syntax	`string Name { get; }`	
Parameters	None	
Return values	Name of the instance.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.

GetCPUType()

Returns the CPU type of the virtual controller.

Table 7- 85 GetCPUType() - Native C++

Syntax	`ECPUType GetCPUType();`
Parameters	None
Return values	An enumeration element that defines the CPU type. See ECPUType (Page 289).

SetCPUType()

Sets the CPU type of the virtual controller. A change of CPU type occurs only when the controller is restarted.

Table 7- 86 SetCPUType() - Native C++

Syntax	`void SetCPUType(ECPUType in_Value);`
Parameters	• `ECPUType in_Value:` Defines which CPU type is simulated at the start of the instance. When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies.
Return values	None

CPUType { get; set; }

Returns or sets the CPU type of the virtual controller. A change of CPU type occurs only when the controller is restarted.

When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies.

Table 7- 87 CPUType { get; set; } - .NET (C#)

Syntax	`ECPUType CPUType { get; set; }`
Parameters	None
Return values	An enumeration element that defines the CPU type.
Exceptions	None

GetCommunicationInterface()

Returns the communication interface of the virtual controller: Local communication (Softbus) or TCPIP. A change of communication interface occurs only when the controller is restarted. All instances that are started must use the same communication interface.

PowerOn is prevented if a communication interface that is not used by the started instances is selected.

Table 7- 88 GetCommunicationInterface() - Native C++

Syntax	`ECommunicationInterface GetCommunicationInterface();`
Parameters	None
Return values	• `SRCI_NONE` Cannot be selected. Is returned if the instance interface is no longer valid. • `SRCI_SOFTBUS` Is returned if the virtual controller uses the Softbus. • `SRCI_TCPIP` Is returned if the virtual controller communicates over the virtual adapter.

SetCommunicationInterface()

Sets the communication interface of the virtual controller: Local communication (Softbus) or TCPIP. A change of communication interface occurs only when the controller is restarted. All instances that are started must use the same communication interface.

PowerOn is prevented if a communication interface that is not used by the started instances is selected.

Table 7- 89 SetCommunicationInterface() - Native C++

Syntax	`void SetCommunicationInterface(ECommunicationInterface in_Value);`
Parameters	• `SRCI_NONE` Cannot be selected. • `SRCI_SOFTBUS` Is set to activate communication via Softbus. • `SRCI_TCPIP` Is set to activate communication over the virtual adapter.
Return values	None

CommunicationInterface { get; set; }

Sets or returns the communication interface of the virtual controller: Local communication (Softbus) or TCPIP. A change of communication interface occurs only when the controller is restarted. All instances that are started must use the same communication interface.

PowerOn is prevented if a communication interface that is not used by the started instances is selected.

Table 7- 90 CommunicationInterface { get; set; } - .NET (C#)

Syntax	`ECommunicationInterface CommunicationInterface { get; set; }`
Parameters	None
Return values	• `ECommunicationInterface.None` Cannot be selected. Is returned if the instance interface is no longer valid. • `ECommunicationInterface.Softbus` Is returned if the virtual controller uses the Softbus. • `ECommunicationInterface.TCPIP` Is returned if the virtual controller communicates over the virtual adapter.
Exceptions	None

GetInfo() / Info { get; }

Returns a structure that provides information about the instance.

Table 7- 91 GetInfo() - Native C++

Syntax	`SInstanceInfo GetInfo();`
Parameters	None
Return values	`SInstanceInfo`: A structure that provides information about the instance. See SInstanceInfo (Page 278).

Table 7- 92 Info { get; } - .NET (C#)

Syntax	`SInstanceInfo Info { get; }`
Parameters	None
Return values	`SInstanceInfo`: A structure that provides information about the instance.
Exceptions	None

UnregisterInstance()

Unregisters this instance from Runtime Manager.

Note

Loss of the interfaces

Other applications that are connected to this instance will lose their interface to this instance.

Table 7- 93 UnregisterInstance() - Native C++

Syntax	`ERuntimeErrorCode UnregisterInstance();`	
Parameters	None	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 7- 94 UnregisterInstance() - .NET (C#)

Syntax	`void UnregisterInstance();`	
Parameters	None	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

7.6.2 Controller - Information and settings

GetControllerName() / ControllerName { get; }

Returns the downloaded name of the virtual controller.

Table 7- 95 GetControllerName() - Native C++

Syntax	`ERuntimeErrorCode GetControllerName( WCHAR inout_Name[], UINT32 in_ArrayLength );`	
Parameters	• `WCHAR inout_Name[]:` A user-allocated storage for the name. • `UINT32 in_ArrayLength:` The length of the storage.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	The name does not fit in the storage.

Table 7- 96 ControllerName { get; } - .NET (C#)

Syntax	`string ControllerName { get; }`	
Parameters	None	
Return values	`string:` The downloaded name of the virtual controller.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetControllerShortDesignation() / ControllerShortDesignation { get; }

Returns the downloaded short designation of the virtual controller.

Table 7- 97 GetControllerShortDesignation() - Native C++

Syntax	`ERuntimeErrorCode GetControllerShortDesignation( WCHAR inout_ShortDesignation[], UINT32 in_ArrayLength );`	
Parameters	• `WCHAR inout_ShortDesignation[]:` A user-allocated storage for the short designation. • `UINT32 in_ArrayLength:` The length of the storage.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	The name does not fit in the storage.

Table 7- 98 ControllerShortDesignation { get; } - .NET (C#)

Syntax	`string ControllerShortDesignation { get; }`	
Parameters	None	
Return values	`string:` The downloaded short designation of the virtual controller.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetControllerIPCount()

Returns the number of configured IP addresses of the virtual controller. If the function fails, the return value is 0.

Table 7- 99 GetControllerIPCount() - Native C++

Syntax	`UINT32 GetControllerIPCount();`
Parameters	None
Return values	`INT32:` Number of configured IP addresses of the virtual controller.

GetControllerIP() / ControllerIP { get; }

Returns a configured IP address of the instance.

Table 7- 100 GetControllerIP() - Native C++

Syntax	`UIP GetControllerIP();`
	`UIP GetControllerIP(`
	`  UINT32 in_Index`
	`);`

Parameters	• `WCHAR in_Index:` The index of the IP address you want to receive. The index must be less than the value you receive from `GetControllerIPCount()`. The default setting is 0.
Return values	`UIP`: IP address of the virtual controller. If the function fails, the return value is 0.

Table 7- 101 ControllerIP { get; } - .NET (C#)

Syntax	`string[] ControllerIP { get; }`
Parameters	None
Return values	`string`: All downloaded IP addresses of the virtual controller. If the function fails, the field is empty.
Exceptions	None

GetControllerIPSuite4() / ControllerIPSuite4 { get; }

Returns the IP suite instance. If the "Softbus" communication interface is used, the subnet mask and default gateway are 0.

Table 7- 102 GetControllerIPSuite4() Native C++

Syntax	`SIPSuite4 GetControllerIPSuite4();`
	`SIPSuite4 GetControllerIPSuite4(`
	`  UINT32 in_Index`
	`);`

Parameters	• `WCHAR in_Index:` The index of the IP address you want to receive. The index must be less than the value you receive from `GetControllerIPCount()`. The default setting is 0.
Return values	`SIPSuite4`: The IP suite of the virtual controller. If the function fails, the return values are 0.

Table 7- 103 ControllerIPSuite4 { get; } - .NET (#)

Syntax	`SIPSuite4[] ControllerIPSuite4 { get; };`
Parameters	None
Return values	`SIPSuite4[]`: All downloaded IP suites of the virtual controller. If the function fails, the field is empty.
Exceptions	None

SetIPSuite()

Sets the IP suite of the network interface of a virtual controller.

Table 7- 104 SetIPSuite() - Native C++

Syntax	`ERuntimeErrorCode SetIPSuite(`
	` UINT32 in_InterfaceID,`
	` SIPSuite4 in_IPSuite,`
	` bool in_IsRemanent`
	`);`	

Parameters	• `UINT32 in_InterfaceID:` The ID of the network interface. • `SIPSuite4 in_IPSuite:` The IP suite that is to be assigned to the network interface. The IP suite contains the IP address, the subnet mask and the standard gateway. If the communication interface is "Softbus", the subnet mask and standard gateway are ignored. • `bool in_IsRemanent:` If `true`, the IP suite is saved after restart of the virtual controller. If the communication interface is "Softbus", this flag is ignored.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	There is no network interface with this ID.
	`SREC_INVALID_OPERATING_STATE`	The virtual controller has not yet completed the boot process or is already in the shutdown phase.

Table 7- 105 SetIPSuite() - .NET (C#)

Syntax	`void SetIPSuite(`
	` UInt32 in_InterfaceID,`
	` SIPSuite4 in_IPSuite,`
	` bool in_IsRemanent );`

Parameters	• `UInt32 in_InterfaceID:` The ID of the network interface. • `SIPSuite4 in_IPSuite:` If the communication interface is "Softbus", the subnet mask and standard gateway are ignored. • `bool in_IsRemanent:` If `true`, the IP suite is saved after restart of the virtual controller. If the communication interface is "Softbus", this flag is ignored.

Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	There is no network interface with this ID.
	`ERuntimeError-Code.InvalidOperatingState`	The virtual controller has not yet completed the boot process or is already in the shutdown phase.

GetStoragePath()

Returns the full directory in which the instance stores its data.

Table 7- 106 GetStoragePath() - Native C++

Syntax	`ERuntimeErrorCode GetStoragePath( WCHAR inout_StoragePath[], UINT32 in_ArrayLength );`	
Parameters	• `WCHAR inout_StoragePath[]:` A user-allocated storage for the storage path. The length of the array should be at least as long as `DSTORAGE_PATH_MAX_LENGTH`. See Data types (Page 257). • `UINT32 in_ArrayLength:` Length of the array (Wide character)	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	The path does not fit in the storage.

SetStoragePath()

Sets the full path of the directory in which the instance stores its data. This can also be a network share.

Set the path before you start the instance. A change to the path takes effect only when the controller is restarted.

If no path is set, the default setting:
<My Documents>>\Siemens\Simatic\Simulation\Runtime\Persistence\<Instance Name> is used.

Table 7- 107 SetStoragePath() - Native C++

Syntax	`ERuntimeErrorCode SetStoragePath( WCHAR* in_StoragePath );`	
Parameters	• `WCHAR* in_StoragePath:` Full name of the storage path. The length of the name must be less than `DSTORAGE_PATH_MAX_LENGTH`. See Data types (Page 257).	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	The length of the path exceeds the limit.
	`SREC_WRONG_ARGUMENT`	The path contains invalid characters.

StoragePath { get; set; }

Returns or sets the full path of the directory in which the instance stores its retentive data. This can also be a network share.

Set the path before you start the instance. A change to the path takes effect only when the controller is restarted.

If no path is set, the default setting:
<My Documents>>\Siemens\Simatic\Simulation\Runtime\Persistence\<Instance Name> is used.

Table 7- 108 StoragePath { get; set; } - .NET (C#)

Syntax	`string StoragePath { get; set; }`	
Parameters	None	
Return values	`string`: The configured storage path.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.IndexOutOfRange`	The length of the path exceeds the limit.
	`ERuntimeErrorCode.WrongArgument`	The path contains invalid characters.

ArchiveStorage()

The user program, the hardware configuration and the retentive data are stored in a file, the Virtual SIMATIC Memory Card. `ArchiveStorage()` stores this file as a ZIP file. The instance of the virtual controller must be in OFF operating state for this.

Table 7- 109 ArchiveStorage() - Native C++

Syntax	`ERuntimeErrorCode ArchiveStorage(`
	`  WCHAR* in_FullFileName`
	`);`	

Parameters	• `WCHAR in_FullFileName:` The full path to the ZIP file.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INVALID_OPERATING_STATE`	The instance is not in OFF operating state.
	`SREC_INVALID_ARCHIVE_PATH`	The archive path is invalid.
	`SREC_CREATE_DIRECTORIES_FAILED`	The directory for the ZIP file could not be created.
	`SREC_ARCHIVE_STORAGE_FAILED`	The ZIP file could not be created.

Table 7- 110 ArchiveStorage() - .NET (C#)

Syntax	`void ArchiveStorage(`
	`  string in_ArchiveStorageFile`
	`);`	

Parameters	• `string in_ArchiveStorageFile:` The full path to the ZIP file. The path relates to directories of the computer on which the instance runs.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InvalidOperatingState`	The instance is not in OFF operating state.
	`ERuntimeError-` `Code.InvalidArchivePath`	The archive path is invalid.
	`ERuntimeError-` `Code.CreateDirectoriesFailed`	The directory for the ZIP file could not be created.
	`ERuntimeError-` `Code.ArchiveStorageNotCreated`	The ZIP file could not be created.

RetrieveStorage()

`RetrieveStorage()` creates a Virtual SIMATIC Memory Card from the archived ZIP file. The virtual controller must be in OFF operating state for this.

Table 7- 111 RetrieveStorage() - Native C++

Syntax	`ERuntimeErrorCode RetrieveStorage( WCHAR* in_FullFileName );`	
Parameters	• `WCHAR* in_FullFileName:` The full path to the ZIP file. The path relates to directories of the computer on which the instance runs.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INVALID_OPERATING_STATE`	The instance is not in OFF operating state.
	`SREC_INVALID_ARCHIVE_PATH`	The archive path is invalid.
	`SREC_DELETE_EXISTING_STORAGE_FAILED`	The old storage cannot be deleted.
	`SREC_RETRIEVE_STORAGE_FAILURE`	The ZIP file cannot be unzipped.

Table 7- 112 RetrieveStorage() - .NET (C#)

Syntax	`void RetrieveStorage( string in_ArchiveStorageFile );`	
Parameters	• `string in_ArchiveStorageFile:` The full path to the ZIP file.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InvalidOperatingState`	The instance is not in OFF operating state.
	`ERuntimeError-Code.InvalidArchivePath`	The archive path is invalid.
	`ERuntimeError-Code.DeleteExistingStorageFailed`	The old storage cannot be deleted.
	`ERuntimeError-Code.RetrieveStorageFailure`	The ZIP file cannot be unzipped.

7.6.3 Operating state

GetOperatingState() / OperatingState { get; }

Returns the operating state of the virtual controller. If the operating state changes, the event OnOperatingStateChanged() (Page 228) is triggered. For details about the operating state, see Data types (Page 287).

Table 7- 113 GetOperatingState() - Native C++

Syntax	`EOperatingState GetOperatingState();`
Parameters	None
Return values	• `SROS_INVALID_OPERATING_STATE:` If the function fails. • `SROS_OFF:` If the Simulation Runtime instance is not running. • `SROS_BOOTING:` If `PowerOn()` was called while in this state and the virtual controller is not yet ready to start the user program. • `SROS_STOP:` If the virtual controller is in STOP state. • `SROS_STARTUP:` If the user program is currently changing from STOP to RUN. • `SROS_RUN:` If the user program is running. • `SROS_FREEZE:` If the user program is being stopped (Freeze status). • `SROS_SHUTTING_DOWN:` If `PowerOff()` was called but the virtual controller is still in the Shutdown phase.

Table 7- 114 OperatingState { get; } - .NET (C#)

Syntax	`EOperatingState OperatingState { get; }`
Parameters	None
Return values	• `EOperatingState.InvalidOperatingState:` If the function fails. • `EOperatingState.Off:` If the Simulation Runtime instance is not running. • `EOperatingState.Booting:` If `PowerOn()` was called while in this state and the virtual controller is not yet ready to start the user program. • `EOperatingState.Stop:` If the virtual controller is in STOP state. • `EOperatingState.Startup:` If the user program is currently changing from STOP to RUN. • `EOperatingState.Run:` If the user program is running. • `EOperatingState.Freeze:` If the user program is being stopped (Freeze status). • `EOperatingState.ShuttingDown`: If `PowerOff()` was called but the virtual controller is still in the Shutdown phase.

PowerOn()

The function creates the process for the Simulation Runtime instance and starts the firmware of the virtual controller.

Table 7- 115 PowerOn() - Native C++

Syntax	`ERuntimeErrorCode PowerOn();`
	`ERuntimeErrorCode PowerOn(`
	`  UINT32 in_Timeout_ms`
	`);`	

Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. – Expected operating states if this function is successful: `{ SROS_STOP , SROS_RUN }`	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_ERROR_LOADING_DLL`	The Siemens.Simatic.Simulation.Runtime.Instance.exe cannot load the Siemens.Simatic.PlcSim.Vplc1500.dll.
	`SREC_STORAGE_PATH_ALREADY_IN_USE`	The selected path for this instance is already being used by another instance.
	`SREC_NO_STORAGE_PATH_SET`	The path could not be created. The length of the `DSTORAGE_PATH_MAX_LENGTH` characters may be exceeded.
	`SREC_WARNING_ALREADY_EXISTS`	Only one warning. The instance is started.
	`SREC_WARNING_TRIAL_MODE_ACTIVE`	No license available. You can use the instance without restrictions for a period of one hour. Afterwards, the instance is shut down. The warning occurs even when you import a license within this hour. The instance is then not shut down.
	`SREC_VIRTUAL_SWITCH_MISCONFIGURED`	The virtual switch is configured incorrectly.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is no longer running.

Table 7- 116 PowerOn() - .NET (C#)

Syntax	`ERuntimeErrorCode PowerOn();`
	`ERuntimeErrorCode PowerOn(`
	`  UInt32 in_Timeout_ms`
	`);`	

Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ EOperatingState.Run, EOperatingState.Stop }`	
Return values	Runtime error code	Condition
	`ERuntimeErrorCode.OK`	The function is successful.
	`ERuntimeError-Code.WarningAlreadyExists`	Only one warning. The instance is started.
	`ERuntimeError-Code.WarningTrialModeActive`	No license available. You can use the instance without restrictions for a period of one hour. Afterwards, the instance is shut down. The warning occurs even when you import a license within this hour. The instance is then not shut down.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeError-Code.ErrorLoadingDll`	The Siemens.Simatic.Simulation. Runtime.Instance.exe cannot load the Siemens.Simatic.PlcSim.Vplc1500.dll.
	`ERuntimeError-Code.StoragePathAlreadyInUse`	The selected path for this instance is already being used by another instance.
	`ERuntimeError-Code.NoStoragePathSet`	The path could not be created. The length of the `DSTORAGE_PATH_MAX_LENGTH` characters may be exceeded.
	`ERuntimeError-Code.VirtualSwitchMisconfigured`	The virtual switch is configured incorrectly.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is no longer running.

PowerOff()

Shuts down the Simulation Runtime and closes its process.

Table 7- 117 PowerOff() - Native C++

Syntax	`ERuntimeErrorCode PowerOff();`
	`ERuntimeErrorCode PowerOff(`
	`  UINT32 in_Timeout_ms`
	`);`	

Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ SROS_OFF }`	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.

Table 7- 118 PowerOff() - .NET (C#)

Syntax	`void PowerOff();`
	`void PowerOff(`
	`  UInt32 in_Timeout_ms`
	`);`	

Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ EOperatingState.Off }`	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.

MemoryReset()

Shuts down the virtual controller, closes its processes and performs a restart.

Table 7- 119 MemoryReset() - Native C++

Syntax	`ERuntimeErrorCode MemoryReset();`
	`ERuntimeErrorCode MemoryReset(`
	`  UINT32 in_Timeout_ms`
	`);`	

Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ SROS_STOP , SROS_RUN }`	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.

Table 7- 120 MemoryReset() - .NET (C#)

Syntax	`void MemoryReset();`
	`void MemoryReset(`
	`  UInt32 in_Timeout_ms`
	`);`	

Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ EOperatingState.Run, EOperatingState.Stop }`	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.

Run()

Calls on the virtual controller to change to RUN operating state.

Table 7- 121 Run() - Native C++

Syntax	`ERuntimeErrorCode Run();`
	`ERuntimeErrorCode Run(`
	`  UINT32 in_Timeout_ms`
	`);`	

Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ SROS_STOP , SROS_RUN }`	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.

Table 7- 122 Run() - .NET (C#)

Syntax	`void Run();`
	`void Run(`
	`  Uint32 in_Timeout_ms`
	`);`	

Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ EOperatingState.Run }`	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.

Stop()

Calls on the virtual controller to change to STOP operating state.

Table 7- 123 Stop() - Native C++

Syntax	`ERuntimeErrorCode Stop();`
	`ERuntimeErrorCode Stop(`
	`  UINT32 in_Timeout_ms`
	`);`	

Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ SROS_STOP }`	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.

Table 7- 124 Stop() - .NET (C#)

Syntax	`void Stop();`
	`void Stop(`
	`  bool in_IsSynchronous`
	`);`	

Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ EOperatingState.Stop }`	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.

7.6.4 Tag list

UpdateTagList()

The function reads the tags from the virtual controller and writes them to the shared storage arranged by name.

If the tag is an array or a structure, there are multiple entries.

In the case of a structure, there is an entry for the structure itself and an additional entry for each structure element.

Entry_1: "StructName"

Entry_2: "StructName.ElementName_1"

..

Entry_N: "StructName.ElementName_n"

In the case of an array, in this example a two-dimensional array, there is an entry for the array itself and an additional entry for each array element.

Entry_1: "ArrayName"

Entry_2: "ArrayName[a,b]", where {a} and {b} correspond to the first index of the respective dimension

..

Entry_N: "ArrayName[x,y]", where {x} and {y} correspond to the last index of the respective dimension

Memory for up to 500000 entries (not PLC tags) is reserved for the list. If the list becomes too large, the function returns the error/exception "NOT_ENOUGH_MEMORY".

If there are problems with the maximum number of entries and not all tags are needed, two filters can be used when refreshing the tag table.

Table 7- 125 UpdateTagList() - Native C++

Syntax	`ERuntimeErrorCode UpdateTagList();`
	`ERuntimeErrorCode UpdateTagList(`
	`  ETagListDetails in_TagListDetails`
	`);`
	`ERuntimeErrorCode UpdateTagList(`
	`  ETagListDetails in_TagListDetails,`
	`  bool in_IsHMIVisibleOnly`
	`);`	

Parameters	• `ETagListDetails in_TagListDetails:` Every combination of the following four areas: **IO**: Inputs and Outputs **M**: Bit memory **CT**: Counters and Timers **DB**: Data Blocks **Example: IOM** reads only the tags from the area Inputs / Outputs and Bit memory. The default setting is **IOMCTDB**. • `bool in_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are read. The default setting is `true`.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_NOT_ENOUGH_MEMORY`	More than 500000 entries are requested.

Table 7- 126 UpdateTagList() - .NET (C#)

Syntax	`void UpdateTagList();`
	`void UpdateTagList(`
	`  ETagListDetails in_TagListDetails`
	`);`
	`void UpdateTagList(`
	`  ETagListDetails in_TagListDetails,`
	`  bool in_IsHMIVisibleOnly`
	`);`	

Parameters	• `ETagListDetails in_TagListDetails:` Every combination of the following four areas: **IO**: Inputs and Outputs **M**: Bit memory **CT**: Counters and Timers **DB**: Data Blocks **Example: IOM** reads only the tags from the area Inputs / Outputs and Bit memory. The default setting is **IOMCTDB**. • `bool in_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are read. The default setting is `true`.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-Code.NotEnoughMemory`	More than 500000 entries are requested.

GetTagListStatus()

Returns the current update status of the tag list storage.

"`inout_TagListDetails`" is `NONE`, if the list needs to be updated.

Table 7- 127 GetTagListStatus() - Native C++

Syntax	`ERuntimeErrorCode GetTagListStatus(`
	` ETagListDetails* out_TagListDetails,`
	` bool* out_IsHMIVisibleOnly`
	`);`	

Parameters	• `ETagListDetails out_TagListDetails:` Status of the tag list details. `SRTLD_NONE` when an update of the list is required. • `bool out_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are available in the list.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 7- 128 GetTagListStatus() - .NET (C#)

Syntax	`void GetTagListStatus(`
	` out ETagListDetails out_TagListDetails,`
	` out bool out_IsHMIVisibleOnly`
	`);`	

Parameters	• `out ETagListDetails out_TagListDetails:` Status of the tag list details. `ETagListDetails.None` when an update of the list is required. • `out bool out_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are available in the list.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetTagInfoCount()

Returns the number of entries in the tag list storage. If the function fails, the return value is 0.

Table 7- 129 GetTagInfoCount() - Native C++

Syntax	`UINT32 GetTagInfoCount();`
Parameters	None
Return values	Number of entries in the tag list storage.

GetTagInfos() / TagInfos { get; }

Returns a list of all tags.

Table 7- 130 GetTagInfos() - Native C++

Syntax	`ERuntimeErrorCode GetTagInfos(`
	`  UINT32 in_BufferLength,`
	`  STagInfo* inout_TagInfos,`
	`  UINT32* out_TagCount`
	`);`	

Parameters	• `UINT32 in_BufferLength:` The number of elements that the storage can accommodate. • `STagInfo* inout_TagInfos:` The user-allocated storage that accommodates the tags. • `UINT32* out_TagCount:` Returns the number of tags that were written to the storage.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The elements do not fit in the storage.

Table 7- 131 TagInfos { get; } - .NET (C#)

Syntax	`STagInfo[] TagInfos { get; }`	
Parameters	None	
Return values	An array that contains all available entries of the storage.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.

CreateConfigurationFile()

Writes all entries from the tag list to an XML file.

Table 7- 132 CreateConfigurationFile() - Native C++

Syntax	`ERuntimeErrorCode CreateConfigurationFile( WCHAR* in_FullFileName );`	
Parameters	• `WCHAR* in_FullFileName:` Full file name of the XML file: <Path> + <File name> + <File extension>.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The file name is invalid.

Table 7- 133 CreateConfigurationFile() - .NET (C#)

Syntax	`void CreateConfigurationFile( string in_FullFileName );`	
Parameters	None	
Return values	• `string in_FullFileName:` File name of the XML file that is to be written to: <Path> + <File name> + <File extension>.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The file name is invalid.

7.6.5 I/O access

7.6.5.1 I/O access via address - Reading

InputArea { get; }, MarkerArea { get; }, OutputArea { get; }

Returns an interface that you use to call the following .NET functions of section "I/O access via address".

Table 7- 134 InputArea { get; } MarkerArea { get; } OutputArea { get; } - .NET (C#)

Syntax	`IIOArea InputArea { get; }`
	`IIOArea MarkerArea { get; }`
	`IIOArea OutputArea { get; }`

Parameters	None
Return values	`IIOArea`: The interface is used to call the "I/O access via address" functions.

GetAreaSize() / AreaSize { get; }

Returns the size of the area in bytes.

Table 7- 135 GetAreaSize() - Native C++

Syntax	`UINT32 GetAreaSize(`
	`  EArea in_Area`
	`);`

Parameters	• `EArea in_Area:` The area whose size you want to receive. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286).
Return values	`UINT32`: Size of the area in bytes. If the function was successful, the value is not equal to 0.

Table 7- 136 AreaSize { get; } - .NET (C#)

Syntax	`UInt32 InputArea.AreaSize { get; }`
	`UInt32 MarkerArea.AreaSize { get; }`
	`UInt32 OutputArea.AreaSize { get; }`

Parameters	None
Return values	`Uint32`: Size of the area in bytes. If the function was successful, the value is not equal to 0.

ReadBit()

Reads an individual bit from the area.

Note

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 137 ReadBit() - Native C++

Syntax	`ERuntimeErrorCode ReadBit(`
	` EArea in_Area,`
	` UINT32 in_Offset,`
	` UINT8 in_Bit,`
	` bool* out_Value`
	`);`	

Parameters	• `EArea in_Area:` The area from which you want to read. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT8 in_Bit:` The bit offset within the byte. The value must be between 0 and 7. • `bool* out_Value:` Returns the bit value.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invaid.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 7- 138 ReadBit() - .NET (C#)

Syntax	`bool InputArea.ReadBit(`
	` UInt32 in_Offset,`
	` Byte in_Bit`
	`);`
	`bool MarkerArea.ReadBit(`
	` UInt32 in_Offset,`
	` Byte in_Bit`
	`);`
	`bool OutputArea.ReadBit(`
	` UInt32 in_Offset,`
	` Byte in_Bit`
	`);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `Byte in_Bit:` The bit offset within the byte. The value must be between 0 and 7.	
Return values	`bool:` Bit value	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-Code.IndexOutOfRange`	Offset or bits are invaid.

ReadByte()

Reads an individual bit from the area.

Note

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 139 ReadByte() - Native C++

Syntax	`ERuntimeErrorCode ReadByte( EArea in_Area, UINT32 in_Offset, BYTE* out_Value);`	
Parameters	• `EArea in_Area:` The area from which you want to read. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `BYTE* out_Value:` Returns the byte value.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset is invalid.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 7- 140 ReadByte() - .NET (C#)

Syntax	`Byte InputArea.ReadByte(`
	`  UInt32 in_Offset`
	`);`
	`Byte MarkerArea.ReadByte(`
	`  UInt32 in_Offset`
	`);`
	`Byte OutputArea.ReadByte(`
	`  UInt32 in_Offset`
	`);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns.	
Return values	`Byte:` Byte value.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-Code.IndexOutOfRange`	Offset is invalid.

ReadBytes()

Reads a byte array from the area.

Note

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 141 ReadByte() - Native C++

Syntax	`ERuntimeErrorCode ReadBytes(`
	` EArea in_Area,`
	` UINT32 in_Offset,`
	` UINT32 in_BytesToRead,`
	` UINT32* out_BytesRead,`
	` BYTE inout_Values[]`
	`);`	

Parameters	• `EArea in_Area:` The area from which you want to read. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT32 in_BytesToRead:` Contains the size of the value storage. • `UINT32* out_BytesRead:` Returns the number of bytes that were just written to the value storage. • `BYTE inout_Values[]:` The storage for the bytes that are read from the area.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset is outside the area size. No byte could be read.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 7- 142 ReadBytes() - .NET (C#)

Syntax	`Byte[] InputArea.ReadBytes(`
	` UInt32 in_Offset,`
	` UInt32 in_BytesToRead`
	`);`
	`Byte[] MarkerArea.ReadBytes(`
	` UInt32 in_Offset,`
	` UInt32 in_BytesToRead`
	`);`
	`Byte[] OutputArea.ReadBytes(`
	` UInt32 in_Offset,`
	` UInt32 in_BytesToRead`
	`);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `UInt32 in_BytesToRead:` The number of bytes to be read.	
Return values	`Byte[]:` The read bytes.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-Code.IndexOutOfRange`	The offset is outside the area size. No byte could be read.

ReadSignals()

Reads a signal list altogether (structures and arrays). The function also takes into consideration the byte order (Endianness).

Only primitive data type signals are supported, but the function is not typical.

Note

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 143 ReadSignals() - Native C++

Syntax	`ERuntimeErrorCode ReadSignals(`
	` EArea in_Area,`
	` SDataValueByAddress* inout_Signals,`
	` UINT32 in_SignalCount`
	`);`	

Parameters	• `EArea in_Area:` The area from which you want to read. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `SDataValueByAddress* inout_Signals:` The signal list to be read. The result is stored in the structure. • `UINT32 in_SignalCount:` Number of signals in the list.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invaid.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 7- 144 ReadSignals() - .NET (C#)

Syntax	`void ReadSignals(`
	` ref SDataValueByAddress[] inout_Signals`
	`);`	

Parameters	• `ref SDataValueByAddress[] inout_Signals:` The signal list to be read.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-` `Code.IndexOutOfRange`	Offset or bits are invaid.

7.6.5.2 I/O access via address - Writing

WriteBit()

Writes an individual bit to the area.

Note
Data can be overwritten

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 145 WriteBit() - Native C++

Syntax	`ERuntimeErrorCode WriteBit(`
	` EArea in_Area,`
	` UINT32 in_Offset,`
	` UINT8 in_Bit,`
	` bool in_Value`
	`);`	

Parameters	• `EArea in_Area:` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT8 in_Bit:` The bit offset within the byte. The value must be between 0 and 7. • `bool in_Value:` Bit value.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invaid.
	`SREC_WRONG_ARGUMENT`	Area is invalid.

Table 7- 146 WriteBit() - .NET (C#)

Syntax	`void InputArea WriteBit(`
	` UInt32 in_Offset,`
	` Byte in_Bit,`
	` bool in_Value`
	`);`
	`void MarkerArea WriteBit(`
	` UInt32 in_Offset,`
	` Byte in_Bit,`
	` bool in_Value`
	`);`
	`void OutputArea WriteBit(`
	` UInt32 in_Offset,`
	` Byte in_Bit,`
	` bool in_Value`
	`);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `Byte in_Bit:` The bit offset within the byte. The value must be between 0 and 7. • `bool in_Value:` Bit value.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-Code.IndexOutOfRange`	Offset or bits are invaid.

WriteByte()

Writes an individual byte to the area.

Note

Data can be overwritten

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 147 WriteByte() - Native C++

Syntax	`ERuntimeErrorCode WriteByte( EArea in_Area, UINT32 in_Offset, BYTE in_Value);`	
Parameters	• `EArea in_Area:` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `BYTE in_Value:` Byte value.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset is invalid.
	`SREC_WRONG_ARGUMENT`	Area is invalid.

Table 7- 148 WriteByte() - .NET (C#)

Syntax	`void InputArea.WriteByte(`
	` UInt32 in_Offset,`
	` Byte in_Value`
	`);`
	`void MarkerArea.WriteByte(`
	` UInt32 in_Offset,`
	` Byte in_Value`
	`);`
	`void OutputArea.WriteByte(`
	` UInt32 in_Offset,`
	` Byte in_Value`
	`);`	

Parameters	• `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `BYTE in_Value:` Byte value.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-Code.IndexOutOfRange`	Offset is invalid.

WriteBytes()

Writes a byte array to the area.

Note

Data can be overwritten

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 149 WriteBytes() - Native C++

Syntax	`ERuntimeErrorCode WriteBytes(`
	` EArea in_Area,`
	` UINT32 in_Offset,`
	` UINT32 in_BytesToWrite,`
	` UINT32* out_BytesWritten,`
	` BYTE in_Values[])`
	`;`	

Parameters	• `EArea in_Area:` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT32 in_BytesToWrite:` Contains the size of the array value to be written. • `UINT32* out_BytesWritten:` Contains the number of bytes that were just written. • `BYTE in_Values[]:` Byte array that is to be written to the area.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset is outside the area size. No byte could be written.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 7- 150 WriteBytes() - .NET (C#)

Syntax	`UInt32 InputArea.WriteBytes(`
	` UInt32 in_Offset,`
	` Byte[] in_Values`
	`);`
	`UInt32 InputArea.WriteBytes(`
	` UInt32 in_Offset,`
	` UInt32 in_BytesToWrite,`
	` Byte[] in_Values`
	
	`);`
	`UInt32 MarkerArea.WriteBytes(`
	` UInt32 in_Offset,`
	` Byte[] in_Values`
	`);`
	`UInt32 MarkerArea.WriteBytes(`
	` UInt32 in_Offset,`
	` UInt32 in_BytesToWrite,`
	` Byte[] in_Values`
	`);`
	`UInt32 OutputArea.WriteBytes(`
	` UInt32 in_Offset,`
	` Byte[] in_Values`
	`);`
	`UInt32 OutputArea.WriteBytes(`
	` UInt32 in_Offset,`
	` UInt32 in_BytesToWrite,`
	` Byte[] in_Values`
	`);`

Parameters	• `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `UInt32 in_BytesToWrite:` Contains the number of bytes to be written. The value must be between 1 and the size of the array value. • `BYTE in_Value:` Byte value.
Return values	`Uint32:` Contains the number of bytes that were just written.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`

Runtime error code	Condition
`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
`ERuntimeErrorCode.Timeout`	The function does not return on time.
`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
`ERuntimeError-Code.IndexOutOfRange`	The offset is outside the area size. No byte could be written.

WriteSignals()

Writes a signal list altogether (structures and arrays). The function also takes into consideration the byte order (Endianness).

The function supports only primitive data type signals. The function is not typical, however.

Note

Data can be overwritten

The function allows access to the entire storage area of the virtual controller.

Recommendation: Therefore, use access via the tag name and not via the address areas.

Table 7- 151 WriteSignals() - Native C++

Syntax	`ERuntimeErrorCode WriteSignals(`
	` EArea in_Area,`
	` SDataValueByAddress* in_Signals,`
	` UINT32 in_SignalCount`
	`);`	

Parameters	• `EArea in_Area:` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 286). • `SDataValueByAddress* inout_Signals:` The signal list to be written. • `UINT32 in_SignalCount:` Number of signals in the list.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invaid.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 7- 152 WriteSignals() - .NET (C#)

Syntax	`void InputArea.WriteSignals(`
	`  SDataValueByAddress[] in_Signals`
	`);`
	`void MarkerArea.WriteSignals(`
	`  SDataValueByAddress[] in_Signals`
	`);`
	`void OutputArea.WriteSignals(`
	`  SDataValueByAddress[] in_Signals`
	`);`	

Parameters	• `SDataValueByAddress[] in_Signals:` The signal list to be written.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeError-` `Code.IndexOutOfRange`	Offset or bits are invaid.

7.6.5.3 I/O access via tag name - Reading

Read()

Reads the value of a PLC tag.

Table 7- 153 Read() - Native C++

Syntax	`ERuntimeErrorCode Read(`
	`  WCHAR* in_Tag,`
	`  SDataValue* inout_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `SDataValue* inout_Value:` Contains the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported. Structures and arrays can be read altogether with ReadSignals().	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 154 Read() - .NET (C#)

Syntax	`SDataValue Read(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`SDataValue:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types.
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadBool()

Reads the value of a PLC tag.

Table 7- 155 ReadBool() - Native C++

Syntax	`ERuntimeErrorCode ReadBool(`
	` WCHAR* in_Tag,`
	` bool* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `bool* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 156 ReadBool() - .NET (C#)

Syntax	`bool ReadBool(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`bool:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadInt8()

Reads the value of a PLC tag.

Table 7- 157 ReadInt8() - Native C++

Syntax	`ERuntimeErrorCode ReadInt8(`
	` WCHAR* in_Tag,`
	` INT8* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `INT8* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 158 ReadInt8() - .NET (C#)

Syntax	`Int8 ReadInt8(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Int8:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadInt16()

Reads the value of a PLC tag.

Table 7- 159 ReadInt16() - Native C++

Syntax	`ERuntimeErrorCode ReadInt16(`
	`  WCHAR* in_Tag,`
	`  INT16* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `INT16* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 160 ReadInt16() - .NET (C#)

Syntax	`Int16 ReadInt16(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Int16:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadInt32()

Reads the value of a PLC tag.

Table 7- 161 ReadInt32() - Native C++

Syntax	`ERuntimeErrorCode ReadInt32(`
	`  WCHAR* in_Tag,`
	`  INT32* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `INT32* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 162 ReadInt32() - .NET (C#)

Syntax	`Int32 ReadInt32(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Int32:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadInt64()

Reads the value of a PLC tag.

Table 7- 163 ReadInt64() - Native C++

Syntax	`ERuntimeErrorCode ReadInt64(`
	`  WCHAR* in_Tag,`
	`  INT64* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `INT64* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 164 ReadInt64() - .NET (C#)

Syntax	`Int64 ReadInt64(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Int64:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadUInt8()

Reads the value of a PLC tag.

Table 7- 165 ReadUInt8() - Native C++

Syntax	`ERuntimeErrorCode ReadUInt8(`
	` WCHAR* in_Tag,`
	` UINT8* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `UINT8* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 166 ReadUInt8() - .NET (C#)

Syntax	`UInt8 ReadUInt8(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`UInt8:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadUInt16()

Reads the value of a PLC tag.

Table 7- 167 ReadUInt16() - Native C++

Syntax	`ERuntimeErrorCode ReadUInt16(`
	` WCHAR* in_Tag,`
	` UINT16* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `UINT16* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 168 ReadUInt16() - .NET (C#)

Syntax	`UInt16 ReadUInt16(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`UInt16:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadUInt32()

Reads the value of a PLC tag.

Table 7- 169 ReadUInt32() - Native C++

Syntax	`ERuntimeErrorCode ReadUInt32(`
	` WCHAR* in_Tag,`
	` UINT32* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `UINT32* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 170 ReadUInt32() - .NET (C#)

Syntax	`UInt32 ReadUInt32(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Uint32:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadUInt64()

Reads the value of a PLC tag.

Table 7- 171 ReadInt64() - Native C++

Syntax	`ERuntimeErrorCode ReadUInt64(`
	`  WCHAR* in_Tag,`
	`  UINT64* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `UINT64* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 172 ReadUInt64() - .NET (C#)

Syntax	`UInt64 ReadUInt64(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`UInt64:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadFloat()

Reads the value of a PLC tag.

Table 7- 173 ReadFloat() - Native C++

Syntax	`ERuntimeErrorCode ReadFloat(`
	` WCHAR* in_Tag,`
	` float* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `float* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 174 ReadFloat() - .NET (C#)

Syntax	`float ReadFloat(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`float:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadDouble()

Reads the value of a PLC tag.

Table 7- 175 ReadDouble() - Native C++

Syntax	`ERuntimeErrorCode ReadDouble(`
	` WCHAR* in_Tag,`
	` double* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `double* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 176 ReadDouble() - .NET (C#)

Syntax	`double ReadDouble(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`double:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadChar()

Reads the value of a PLC tag.

Table 7- 177 ReadChar() - Native C++

Syntax	`ERuntimeErrorCode ReadChar(`
	` WCHAR* in_Tag,`
	` char* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `char* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 178 ReadChar() - .NET (C#)

Syntax	`sbyte ReadChar(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`sbyte:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadWChar()

Reads the value of a PLC tag.

Table 7- 179 ReadWChar() - Native C++

Syntax	`ERuntimeErrorCode ReadWChar(`
	` WCHAR* in_Tag,`
	` WCHAR* out_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `WCHAR* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 180 ReadWChar() - .NET (C#)

Syntax	`char ReadWChar(`
	`  string in_Tag`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`char:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

ReadSignals()

Reads multiple signals within an API call.

Reads multiple signals within a single API call.

Table 7- 181 ReadSignals() - Native C++

Syntax	`ERuntimeErrorCode ReadSignals(`
	` SDataValueByName* inout_Signals,`
	` UINT32 in_SignalCount`
	`);`	

Parameters	• `SDataValueByName* inout_Signals:` Contains the name, the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported. • `UINT32 in_SignalCount:` The number of signals to be read.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 182 ReadSignals() - .NET (C#)

Syntax	`void ReadSignals(`
	`  ref SDataValueByName[] inout_Signals`
	`)`	

Parameters	• `ref SDataValueByName[] inout_Signals:` Contains the name, the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported.	
Return values	`SDataValue`: Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

7.6.5.4 I/O access via tag name - Writing

Write()

Writes the value of a PLC tag.

Table 7- 183 Write() - Native C++

Syntax	`ERuntimeErrorCode Write(`
	` WCHAR* in_Tag,`
	` SDataValue* in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `SDataValue* in_Value:` Contains the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported. Structures and arrays can be written altogether with `WriteSignals()`.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_WRONG_ARGUMENT`	The expected type is `UNSPECIFIC`.

Table 7- 184 Write() - .NET (C#)

Syntax	`void Write(`
	` string in_Tag`
	` SDataValue in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `SDataValue in_Value:` Contains the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported. Structures and arrays can be written altogether with `WriteSignals()`.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.
	`ERuntimeErrorCode.WrongArgument`	The expected type is `UNSPECIFIC`.

WriteBool()

Writes the value of a PLC tag.

Table 7- 185 WriteBool() - Native C++

Syntax	`ERuntimeErrorCode WriteBool(`
	` WCHAR* in_Tag,`
	` bool in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `bool in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 186 WriteBool() - .NET (C#)

Syntax	`void WriteBool(`
	` string in_Tag`
	` bool in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `bool in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types.
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteInt8()

Writes the value of a PLC tag.

Table 7- 187 WriteInt8() - Native C++

Syntax	`ERuntimeErrorCode WriteInt8(`
	` WCHAR* in_Tag,`
	` INT8 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `INT8 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 188 WriteInt8() - .NET (C#)

Syntax	`void WriteInt8(`
	` string in_Tag`
	` Int8 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `Int8 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteInt16()

Writes the value of a PLC tag.

Table 7- 189 WriteInt16() - Native C++

Syntax	`ERuntimeErrorCode WriteInt16(`
	`  WCHAR* in_Tag,`
	`  INT16 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `INT16 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 190 WriteInt16() - .NET (C#)

Syntax	`void WriteInt16(`
	` string in_Tag`
	` Int16 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `Int16 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteInt32()

Writes the value of a PLC tag.

Table 7- 191 WriteInt32() - Native C++

Syntax	`ERuntimeErrorCode WriteInt32(`
	`  WCHAR* in_Tag,`
	`  INT32 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `INT32 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 192 WriteInt32() - .NET (C#)

Syntax	`void WriteInt32(`
	` string in_Tag`
	` Int32 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `Int32 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteInt64()

Writes the value of a PLC tag.

Table 7- 193 WriteInt64() - Native C++

Syntax	`ERuntimeErrorCode WriteInt64(`
	` WCHAR* in_Tag,`
	` INT64 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `INT64 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 194 WriteInt64() - .NET (C#)

Syntax	`void WriteInt64(`
	` string in_Tag`
	` Int64 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `Int64 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteInt8()

Writes the value of a PLC tag.

Table 7- 195 WriteUInt8() - Native C++

Syntax	`ERuntimeErrorCode WriteUInt8(`
	` WCHAR* in_Tag,`
	` UINT8 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `UINT8 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 196 WriteUInt8() - .NET (C#)

Syntax	`void WriteUInt8(`
	` string in_Tag`
	` UInt8 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `UInt8 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteUInt16()

Reads the value of a PLC tag.

Table 7- 197 WriteUInt16() - Native C++

Syntax	`ERuntimeErrorCode WriteUInt16(`
	` WCHAR* in_Tag,`
	` UINT16 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `UINT16 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 198 WriteUInt16() - .NET (C#)

Syntax	`void WriteUInt16(`
	` string in_Tag`
	` UInt16 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `UInt16 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteUInt32()

Writes the value of a PLC tag.

Table 7- 199 WriteUInt32() - Native C++

Syntax	`ERuntimeErrorCode WriteUInt32(`
	`  WCHAR* in_Tag,`
	`  UINT32 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `UINT32 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 200 WriteUInt32() - .NET (C#)

Syntax	`void WriteUInt32(`
	` string in_Tag`
	` UInt32 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `UInt32 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteUInt64()

Writes the value of a PLC tag.

Table 7- 201 WriteUInt64() - Native C++

Syntax	`ERuntimeErrorCode WriteUInt64(`
	`  WCHAR* in_Tag,`
	`  UINT64 in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `UINT64 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 202 WriteUInt64() - .NET (C#)

Syntax	`void WriteUInt64(`
	` string in_Tag`
	` UInt64 in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `UInt64 in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteFloat()

Writes the value of a PLC tag.

Table 7- 203 WriteFloat() - Native C++

Syntax	`ERuntimeErrorCode WriteFloat(`
	` WCHAR* in_Tag,`
	` float in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `float in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 204 WriteFloat() - .NET (C#)

Syntax	`void WriteFloat(`
	` string in_Tag`
	` float in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `float in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteDouble()

Writes the value of a PLC tag.

Table 7- 205 WriteDouble() - Native C++

Syntax	`ERuntimeErrorCode WriteDouble(`
	` WCHAR* in_Tag,`
	` double in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `double in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 206 WriteDouble() - .NET (C#)

Syntax	`void WriteDouble(`
	` string in_Tag`
	` double in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `double in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteChar()

Writes the value of a PLC tag.

Table 7- 207 WriteChar() - Native C++

Syntax	`ERuntimeErrorCode WriteChar(`
	` WCHAR* in_Tag,`
	` char in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `char in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 208 WriteChar() - .NET (C#)

Syntax	`void WriteChar(`
	` string in_Tag`
	` sbyte in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `sbyte in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteWChar()

Writes the value of a PLC tag.

Table 7- 209 WriteWChar() - Native C++

Syntax	`ERuntimeErrorCode WriteWChar(`
	`  WCHAR* in_Tag,`
	`  WCHAR in_Value`
	`);`	

Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `WCHAR in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.

Table 7- 210 WriteWChar() - .NET (C#)

Syntax	`void WriteWChar(`
	` string in_Tag`
	` char in_Value`
	`)`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `char in_Value:` Contains the value of the PLC tag.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMissmatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.

WriteSignals()

Writes multiple signals within an API call.

Table 7- 211 WriteSignals() - Native C++

Syntax	`ERuntimeErrorCode WriteSignals(`
	`  SDataValueByName* inout_Signals,`
	`  UINT32 in_SignalCount`
	`);`	

Parameters	• `SDataValueByName* inout_Signals:` Contains the name, the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported. • `UINT32 in_SignalCount:` Number of signals.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 294).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_WRONG_ARGUMENT`	The expected type is `UNSPECIFIC`.

Table 7- 212 WriteSignals() - .NET (C#)

Syntax	`void WriteSignals(`
	` SDataValueByName[] in_Signals`
	`)`	

Parameters	• `SDataValueByName:` Contains the name, the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types.
	`ERuntimeErrorCode.NotUpToData`	The stored tag list must be updated.
	`ERuntimeErrorCode.WrongArgument`	The expected type is `UNSPECIFIC`.

7.6.6 Settings for the virtual time

GetSystemTime()

Returns the virtual system time of the virtual controller. Returns an empty structure when the function fails.

Table 7- 213 GetSystemTime() - Native C++

Syntax	`SYSTEMTIME GetSystemTime();`
Parameters	None
Return values	`SYSTEMTIME`: System time of the virtual controller.

SetSystemTime()

Sets the virtual system time of the virtual controller. A system time between "Jan 1 1970 00:00:00:000" and "Dec 31 2200 23:59:59:999" is valid.

Table 7- 214 SetSystemTime() - Native C++

Syntax	`ERuntimeErrorCode SetSystemTime( SYSTEMTIME in_SystemTime );`	
Parameters	• `SYSTEMTIME in_SystemTime:` System time that is to be set for the virtual controller.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The value is outside the limits.

SystemTime { get; set; }

Sets or returns the virtual system time of the virtual controller. A system time between "Jan 1 1970 00:00:00:000" and "Dec 31 2200 23:59:59:999" is valid.

Table 7- 215 SystemTime { get; set; } - .NET (C#)

Syntax	`DateTime SystemTime { get; set; }`	
Parameters	None	
Return values	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The value is outside the limits.

GetScaleFactor()

Returns the scaling factor with which the virtual time advances.

Table 7- 216 GetScaleFactor() - Native C++

Syntax	`double GetScaleFactor();`
Parameters	None
Return values	`double`: Scaling factor of the virtual time.

SetScaleFactor()

Sets the scaling factor with which the virtual time advances.

Start with a small scaling factor and incrementally approach a scaling factor at which the virtual controller remains in RUN.

A value between 0.01 and 100 is valid. The default setting is 1.

- If the value is less than 1, the virtual time of the virtual controller runs X-times slower than the real time.
- If the value is greater than 1, the virtual time of the virtual controller runs X-times faster than the real time.

A change in the value during runtime only takes effect at the cycle control point.

Table 7- 217 SetScaleFactor() - Native C++

Syntax	`ERuntimeErrorCode SetScaleFactor ( double in_Value );`	
Parameters	• `double in_Value:` Scaling factor of the virtual time.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The value is outside the limits.

ScaleFactor { get; set; }

Sets or returns the scaling factor with which the virtual time advances.

Start with a small scaling factor and incrementally approach a scaling factor at which the virtual controller remains in RUN.

A value between 0.01 and 100 is valid. The default setting is 1.

- If the value is less than 1, the virtual time of the virtual controller runs X-times slower than the real time.
- If the value is greater than 1, the virtual time of the virtual controller runs X-times faster than the real time.

A change in the value during runtime only takes effect at the cycle control point.

Table 7- 218 ScaleFactor { get; set; } - .NET (C#)

Syntax	`double ScaleFactor { get; set; }`	
Parameters	None	
Return values	`double`: Scaling factor of the virtual time.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The value is outside the limits.

7.6.7 Cycle control

GetOperatingMode()

Returns the operating mode of the virtual controller.

Table 7- 219 GetOperatingMode() - Native C++

Syntax	`EOperatingMode GetOperatingMode();`
Parameters	None
Return values	`EOperatingMode`: Operating mode of the virtual controller

SetOperatingMode()

Sets the operating mode of the virtual controller.

A change in the value during runtime only takes effect at the cycle control point.

Table 7- 220 SetOperatingMode() - Native C++

Syntax	`void SetOperatingMode( EOperatingMode in_OperatingMode );`	
Parameters	• `EOperatingMode in_OperatingMode:` Operating mode of the virtual controller	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

OperatingMode { get; set; }

Returns or sets the operating mode of the virtual controller.

A change in the value during runtime only takes effect at the cycle control point.

Table 7- 221 OperatingMode { get; set; } - .NET (C#)

Syntax	`EOperatingMode OperatingMode { get; set; }`	
Parameters	None	
Return values	`EOperatingMode`: Operating mode of the virtual controller	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

SetAlwaysSendOnEndOfCycleEnabled()

Sets the `AlwaysSendOnEndOfCycle` *mode.* If the mode is set, the `OnEndOfCycle` event is triggered after every cycle end for each operating mode. If the event is also to be received in `Default` operating mode, set the return value to `true`. See OnEndOfCycle (Page 232).

Table 7- 222 SetAlwaysSendOnEndOfCycleEnabled() - Native C++

Syntax	`ERuntimeErrorCode SetAlwaysSendOnEndOfCycleEnabled( bool in_Enable );`	
Parameters	• `bool in_Enable:` If `true`, the `OnEndOfCycle` event is triggered after every cycle.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

IsAlwaysSendOnEndOfCycleEnabled()

Returns the `AlwaysSendOnEndOfCycle` mode. When the function fails, the return value is `false`.

Table 7- 223 IsAlwaysSendOnEndOfCycleEnabled() - Native C++

Syntax	`bool IsAlwaysSendOnEndOfCycleEnabled();`
Parameters	None
Return values	• `false`: The event is not triggered (unless the Sync-Freeze mode is active). • `true`: The event is triggered after every cycle.

IsAlwaysSendOnEndOfCycleEnabled { get; set; }

Returns or sets the `AlwaysSendOnEndOfCycle` *mode.* If the mode is set, the `OnEndOfCycle` event is triggered after every cycle end for each operating mode. If the event is also to be received in `Default` operating mode, set the return value to `true`. See OnEndOfCycle (Page 232).

Table 7- 224 IsAlwaysSendOnEndOfCycleEnabled { get; set; } - .NET (C#)

Syntax	`bool IsAlwaysSendOnEndOfCycleEnabled { get; set;}`	
Parameters	None	
Return values	• `false`: The event is not triggered (unless the Sync-Freeze mode is active). • `true`: The event is triggered after every cycle.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetOverwrittenMinimalCycleTime_ns()

Returns the overwritten minimum cycle time (in nanoseconds) that is used in the `ExtendedSingleStep` operating mode.

Table 7- 225 GetOverwrittenMinimalCycleTime_ns() - Native C++

Syntax	`INT64 GetOverwrittenMinimalCycleTime_ns();`
Parameters	None
Return values	`INT64`: The overwritten minimum cycle time in nanoseconds.

SetOverwrittenMinimalCycleTime_ns()

Sets the overwritten minimum cycle time (in nanoseconds) that is used in the `ExtendedSingleStep` operating mode.

A value between 0 and 6000000000 is valid. The default setting is 100 ms.

A change in the value during runtime only takes effect at the cycle control point.

Table 7- 226 SetOverwrittenMinimalCycleTime_ns() - Native C++

Syntax	`ERuntimeErrorCode SetOverwrittenMinimalCycleTime_ns( INT64 in_CycleTime_ns );`	
Parameters	• `INT64 in_CycleTime_ns:` The overwritten minimum cycle time in nanoseconds.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The value is outside the limits.

OverwrittenMinimalCycleTime_ns { get; set; }

Returns or sets the overwritten minimum cycle time in nanoseconds that is used in the `ExtendedSingleStep` operating mode.

A value between 0 and 6000000000 is valid. The default setting is 100 ms.

A change in the value during runtime only takes effect at the cycle control point.

Table 7- 227 OverwrittenMinimalCycleTime_ns { get; set; } - .NET (C#)

Syntax	`Int64 OverwrittenMinimalCycleTime_ns { get; set; }`	
Parameters	None	
Return values	`Int64:` The overwritten minimum cycle time in nanoseconds.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The value is outside the limits.

RunNextCycle()

If the virtual controller is being operated in `SingleStep` or `ExtendedSingleStep` operating mode, it is stopped at the cycle control point (Freeze state). The `RunNextCycle()` function is used to trigger the next cycle.

Table 7- 228 RunNextCycle() - Native C++

Syntax	`ERuntimeErrorCode RunNextCycle();`	
Parameters	None	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.

Table 7- 229 RunNextCycle() - .NET (C#)

Syntax	`void RunNextCycle();`	
Parameters	None	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-Code.InstanceNotRunning`	The process of the virtual controller is not running.

StartProcessing()

If the virtual controller is running in `TimespanSynchronized` operating mode, it is stopped at the cycle control point (Freeze state). The `StartProcessing()` function wakes up the virtual controller from the Freeze state. The virtual controller will now run for at least the requested time before it changes to Freeze state (stops) at the next cycle control point.

Table 7- 230 StartProcessing() - Native C++

Syntax	`ERuntimeErrorCode StartProcessing(`
	`  INT64 in_MinimalTimeToRun_ns`
	`);`	

Parameters	• `INT64 in_CycleTime_ns:` The minimum virtual time (in nanoseconds) that the virtual controller runs before it changes to Freeze state.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the virtual controller is not running.
	`SREC_WRONG_ARGUMENT`	The value is less than 0.

Table 7- 231 StartProcessing() - .NET (C#)

Syntax	`void StartProcessing(`
	`  Int64 in_MinimalTimeToRun_ns`
	`);`	

Parameters	• `Int64 in_CycleTime_ns:` The minimum virtual time (in nanoseconds) that the virtual controller runs before it changes to Freeze state.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeError-` `Code.InstanceNotRunning`	The process of the virtual controller is not running.
	`ERuntimeErrorCode.WrongArgument`	The value is less than 0.

Additional information

For more information, please refer to the section titled Time response (Page 58), Stopping the simulation (Page 61)

See also

OnOperatingStateChanged (Page 228)

7.6.8 Events

Events for IInstances

The following events are differentiated in the API:

Table 7- 232 Events for the IInstances interface

Event	Cause
OnOperatingStateChanged (Page 228)	This event is always triggered when the operating state of the virtual controller has changed.
OnEndOfCycle (Page 232)	This event is triggered when the virtual controller reaches the end of the main cycle. If the virtual controller is being operated in Default operating mode, the `AlwaysSendOnEndOfCycle` flag must be set to receive the event. See AlwaysSendOnEndOfCycle (Page 221).
OnConfigurationChanging (Page 234)	This event is triggered when changing of the configuration of the virtual controller starts. • During power up from the Virtual SIMATIC Memory Card • At the start of a download When this event is triggered, the stored tag list is reset.
OnConfigurationChanged (Page 237)	This event is triggered when the configuration of the virtual controller has changed: • After power up from the Virtual SIMATIC Memory Card • At the end of a download • When the IP address changes
OnLedChanged (Page 239)	This event is triggered when the LED display of the virtual controller has changed.

7.6.8.1 OnOperatingStateChanged

OnOperatingStateChanged

Registers or unregisters an event handler method.

Table 7- 233 OnOperatingStateChanged - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_EOS_EOS OnOperatingStateChanged;`
Parameters	None. See Delegate_II_EREC_DT_EOS_EOS (Page 266).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnOperatingStateChangedCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. Registering a new callback function causes the previous callback function to be deleted.

Table 7- 234 RegisterOnOperatingStateChangedCallback() - Native C++

Syntax	`void RegisterOnOperatingStateChangedCallback(`
	`  EventCallback_II_SREC_ST_SROS_SROS in_CallbackFunction`
	`);`

Parameters	• `EventCallback_II_SREC_ST_SROS_SROS in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_SROS_SROS (Page 260).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnOperatingStateChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registering a new event object causes the previous event object to be deleted.

Table 7- 235 RegisterOnOperatingStateChangedEvent() - Native C++

Syntax	`void RegisterOnOperatingStateChangedEvent();`
	`void RegisterOnOperatingStateChangedEvent(`
	`HANDLE* in_Event`
	`);`

Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

Example C++	`// Thread 1 ----------`
	`ISimulationRuntimeManager * api = ZERO;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IInstance* psa = ZERO;`
	`if (result == SREC_OK)`
	`{`
	`result = api->RegisterInstance(&psa);`
	`}`
	
	`// Register the internal event object`
	`psa->RegisterOnOperatingStateChangedEvent();`
	
	`// Thread 2 ----------`
	`while (condition)`
	`{`
	`// Wait for the event to be set (timeout after 10s)`
	`bool isEventSet = psa->WaitForOnOperatingStateChangedEvent(10000);`
	`if (isEventSet)`
	`{`
	`// Do Something`
	`…`
	`}`
	`}`

Example C++	`// Thread 1 ----------------------------------------------------`
	`ISimulationRuntimeManager * api = ZERO;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IInstance* psa = ZERO;`
	`if (result == SREC_OK)`
	`{`
	` result = api->RegisterInstance(&psa);`
	`}`
	
	`// Create an event object`
	`HANDLE eventHandle = CreateEvent(ZERO, FALSE, FALSE, ZERO);`
	
	`// Register the user created event object`
	`psa->RegisterOnOperatingStateChangedEvent(&eventHandle);`
	
	`// Do Something`
	`…`
	`// Clean up the handle`
	`CloseHandle(eventHandle);`
	
	`// Thread 2 ----------------------------------------------------`
	`while (condition)`
	`{`
	` // Wait for the event to be set //OR:`
	` WaitForSingleObject(eventHandle, INFINITE); //psa->WaitForOnOperatingStateChangedEvent();`
	
	` // Do Something`
	` …`
	`}`

UnregisterOnOperatingStateChangedCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 236 UnregisterOnOperatingStateChangedCallback() - Native C++

Syntax	`void UnregisterOnOperatingStateChangedCallback();`
Parameters	None
Return values	None

UnregisterOnOperatingStateChangedEvent()

Unregisters the event object.

Table 7- 237 UnregisterOnOperatingStateChangedEvent() - Native C++

Syntax	`void UnregisterOnOperatingStateChangedEvent();`
Parameters	None
Return values	None

Table 7- 238 UnregisterOnOperatingStateChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnOperatingStateChangedEvent();`
Parameters	None
Return values	None

WaitForOnOperatingStateChangedEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 7- 239 WaitForOnOperatingStateChangedEvent() - Native C++

Syntax	`bool WaitForOnOperatingStateChangedEvent();`
	`bool WaitForOnOperatingStateChangedEvent(`
	`  UINT32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true`: If the event object was set to the signaled state. • `false`: If no event was received during the defined time limit.

Table 7- 240 WaitForOnOperatingStateChangedEvent() - .NET (C#)

Syntax	`bool WaitForOnOperatingStateChangedEvent();`
	`bool WaitForOnOperatingStateChangedEvent(`
	`  UInt32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true`: If the event object was set to the signaled state. • `false`: If no event was received during the defined time limit.

7.6.8.2 OnEndOfCycle

OnEndOfCycle

Registers or unregisters an event handler method.

Table 7- 241 OnEndOfCycle - .NET (C#)

Syntax	`event Delegate_II_EREC_DT OnEndOfCycle;`
Parameters	None. See Delegate_II_EREC_DT (Page 265).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnEndOfCycleCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. Registering a new callback function causes the previous callback function to be deleted.

Table 7- 242 RegisterOnEndOfCycleCallback() - Native C++

Syntax	`void RegisterOnEndOfCycleCallback(`
	`  EventCallback_II_SREC_ST in_CallbackFunction`
	`);`

Parameters	• `EventCallback_II_SREC_ST in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_II_SREC_ST (Page 259).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnEndOfCycleEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registering a new event object causes the previous event object to be deleted.

Table 7- 243 RegisterOnEndOfCycleEvent() - Native C++

Syntax	`void RegisterOnEndOfCycleEvent();`
	`void RegisterOnEndOfCycleEvent(`
	`  HANDLE* in_Event`
	`);`

Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

UnregisterOnEndOfCycleCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 244 UnregisterOnEndOfCycleCallback() - Native C++

Syntax	`void UnregisterOnEndOfCycleCallback();`
Parameters	None
Return values	None

UnregisterOnEndOfCycleEvent()

Unregisters the event object.

Table 7- 245 RegisterOnEndOfCycleEvent() - Native C++

Syntax	`void UnregisterOnEndOfCycleEvent();`
Parameters	None
Return values	None

Table 7- 246 UnregisterOnEndOfCycleEvent() - .NET (C#)

Syntax	`void UnregisterOnEndOfCycleEvent();`
Parameters	None
Return values	None

WaitForOnEndOfCycleEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 7- 247 WaitForOnEndOfCycleEvent() - Native C++

Syntax	`bool WaitForOnEndOfCycleEvent();`
	`bool WaitForOnEndOfCycleEvent(`
	`  UINT32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 7- 248 WaitForOnEndOfCycleEvent() - .NET (C#)

Syntax	`bool WaitForOnEndOfCycleEvent();`
	`bool WaitForOnEndOfCycleEvent(`
	`  UInt32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

7.6.8.3 OnConfigurationChanging

OnConfigurationChanging

Registers or unregisters an event handler method.

Table 7- 249 OnConfigurationChanging - .NET (C#)

Syntax	`event Delegate_II_EREC_DT OnConfigurationChanging;`
Parameters	None. See Delegate_II_EREC_DT (Page 265).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnConfigurationChangingCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. Registering a new callback function causes the previous callback function to be deleted.

Table 7- 250 RegisterOnConfigurationChangingCallback() - Native C++

Syntax	`void RegisterOnConfigurationChangingCallback( EventCallback_II_SREC_ST in_CallbackFunction );`
Parameters	• `EventCallback_II_SREC_ST in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_II_SREC_ST (Page 259).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnConfigurationChangingEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 7- 251 RegisterOnConfigurationChangingEvent() - Native C++

Syntax	`void RegisterOnConfigurationChangingEvent();` `void RegisterOnConfigurationChangingEvent( HANDLE* in_Event );`
Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

UnregisterOnConfigurationChangingCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 252 UnregisterOnConfigurationChangingCallback() - Native C++

Syntax	`void UnregisterOnConfigurationChangingCallback();`
Parameters	None
Return values	None

UnregisterOnConfigurationChangingEvent()

Unregisters the event object.

Table 7- 253 UnregisterOnConfigurationChangingEvent() - Native C++

Syntax	`void UnregisterOnConfigurationChangingEvent();`
Parameters	None
Return values	None

Table 7- 254 UnregisterOnConfigurationChangingEvent() - .NET (C#)

Syntax	`void UnregisterOnConfigurationChangingEvent();`
Parameters	None
Return values	None

WaitForOnConfigurationChangingEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 7- 255 WaitForOnConfigurationChangingEvent() - Native C++

Syntax	`bool WaitForOnConfigurationChangingEvent();`
	`bool WaitForOnConfigurationChangingEvent(`
	`  UINT32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 7- 256 WaitForOnConfigurationChangingEvent() - .NET (C#)

Syntax	`bool WaitForOnConfigurationChangingEvent();`
	`bool WaitForOnConfigurationChangingEvent(`
	`  UInt32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

7.6.8.4 OnConfigurationChanged

OnConfigurationChanged

Registers or unregisters an event handler method.

Table 7- 257 OnConfigurationChanged - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_SRICC_UINT32_UINT32_UINT32_UINT32 OnConfigurationChanged;`
Parameters	None. See Delegate_II_EREC_DT_SRICC_UINT32_UINT32_UINT32_UINT32 (Page 270).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnConfigurationChangedCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. Registering a new callback function causes the previous callback function to be deleted.

Table 7- 258 RegisterOnConfigurationChangedCallback() - Native C++

Syntax	`void RegisterOnConfigurationChangedCallback( EventCallback_SRCC_UINT32_UINT32_INT32 in_CallbackFunction );`
Parameters	• `EventCallback_SRCC_UINT32_UINT32_INT32 in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_SRCC_UINT32_UINT32_INT32 (Page 263).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnConfigurationChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registering a new event object causes the previous event object to be deleted.

Table 7- 259 RegisterOnConfigurationChangedEvent() - Native C++

Syntax	`void RegisterOnConfigurationChangedEvent();` `void RegisterOnConfigurationChangedEvent( HANDLE* in_Event );`
Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

UnregisterOnConfigurationChangedCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 260 UnregisterOnConfigurationChangedCallback() - Native C++

Syntax	`void UnregisterOnConfigurationChangedCallback();`
Parameters	None
Return values	None

UnregisterOnConfigurationChangedEvent()

Unregisters the event object.

Table 7- 261 UnregisterOnConfigurationChangedEvent() - Native C++

Syntax	`void UnregisterOnConfigurationChangedEvent();`
Parameters	None
Return values	None

Table 7- 262 UnregisterOnConfigurationChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnConfigurationChangedEvent();`
Parameters	None
Return values	None

WaitForOnConfigurationChangedEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 7- 263 WaitForOnConfigurationChangedEvent() - Native C++

Syntax	`bool WaitForOnConfigurationChangedEvent();`
	`bool WaitForOnConfigurationChangedEvent(`
	`  UINT32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 7- 264 WaitForOnConfigurationChangedEvent() - .NET (C#)

Syntax	`bool WaitForOnConfigurationChangedEvent();`
	`bool WaitForOnConfigurationChangedEvent(`
	`  UInt32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

7.6.8.5 OnLedChanged

OnLedChanged

Registers or unregisters an event handler method.

Table 7- 265 OnLedChanged - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_ELT_ELM OnLedChanged;`
Parameters	None. See Delegate_II_EREC_DT_ELT_ELM (Page 267).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnLedChangedCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. Registering a new callback function causes the previous callback function to be deleted.

Table 7- 266 RegisterOnLedChangedCallback() - Native C++

Syntax	`void RegisterOnLedChangedCallback(`
	`  EventCallback_II_SREC_ST_SRLT_SRLM in_CallbackFunction`
	`);`

Parameters	• `EventCallback_II_SREC_ST_SRLT_SRLM in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_II_SREC_ST_SRLT_SRLM (Page 261).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnLedChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registering a new event object causes the previous event object to be deleted.

Table 7- 267 RegisterOnLedChangedEvent() - Native C++

Syntax	`void RegisterOnLedChangedEvent();`
	`void RegisterOnLedChangedEvent(`
	`  HANDLE* in_Event`
	`);`

Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

UnregisterOnLedChangedCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 268 UnregisterOnLedChangedCallback() - Native C++

Syntax	`void UnregisterOnLedChangedCallback();`
Parameters	None
Return values	None

UnregisterOnLedChangedEvent()

Unregisters the event object.

Table 7- 269 UnregisterOnLedChangedEvent() - Native C++

Syntax	`void UnregisterOnLedChangedEvent();`
Parameters	None
Return values	None

Table 7- 270 UnregisterOnLedChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnLedChangedEvent();`
Parameters	None
Return values	None

WaitForOnLedChangedEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 7- 271 WaitForOnLedChangedEvent() - Native C++

Syntax	`bool WaitForOnLedChangedEvent();`
	`bool WaitForOnLedChangedEvent(`
	`  UINT32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 7- 272 WaitForOnLedChangedEvent() - .NET (C#)

Syntax	`bool WaitForOnLedChangedEvent();`
	`bool WaitForOnLedChangedEvent(`
	`  UInt32 in_Time_ms`
	`);`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

7.7 API IRemoteRuntimeManager

7.7.1 Interfaces - Information and settings

Dispose()

Deletes the managed interface and unloads the native components of the user interfaces.

Table 7- 273 Dispose() - .NET (C#)

Syntax	`void Dispose()`
Parameters	None
Return values	None

GetVersion()

Returns the version of the remote Runtime Manager. If the function fails, version 0.0 is returned.

Table 7- 274 GetVersion() - Native C++

Syntax	`UINT32 GetVersion();`
Parameters	None
Return values	`UINT32`: Remote Runtime Manager Version (`HIWORD` = Major, `LOWORD` = Minor)

Table 7- 275 Version { get; } - .NET (C#)

Syntax	`UInt32 Version { get; }`
Parameters	None
Return values	`Uint32`: Remote Runtime Manager Version (`HIWORD` = Major, `LOWORD` = Minor)

GetIP() / IP { get; }

Returns the IP address of the PC on which the remote Runtime Manager is running. If the function fails, the return value is 0.

Table 7- 276 GetIP() - Native C++

Syntax	`UIP GetIP();`
Parameters	None
Return values	`UIP`: Returns the IP address of the PC on which the Runtime Manager is running.

Table 7- 277 IP { get; } - .NET (C#)

Syntax	`SIP IP { get; }`
Parameters	None
Return values	`SIP`: Returns the IP address of the PC on which the Runtime Manager is running.

GetPort() / Port { get; }

Returns the open port of the PC on which the remote Runtime Manager is running. If the function fails, the return value is 0.

Table 7- 278 GetPort() - Native C++

Syntax	`UINT16 GetPort();`
Parameters	None
Return values	`UINT16`: Open port of the PC on which the remote Runtime Manager is running.

Table 7- 279 Port { get; } - .NET (C#)

Syntax	`UInt16 Port { get; }`
Parameters	None
Return values	`UInt16`: Open port of the PC on which the remote Runtime Manager is running.

GetRemoteComputerName() / RemoteComputerName { get; }

Returns the name of the PC on which the remote Runtime Manager is running.

Table 7- 280 GetRemoteComputerName() - Native C++

Syntax	`ERuntimeErrorCode GetRemoteComputerName(`
	`  WCHAR* inout_Name,`
	`  UINT32 in_ArrayLength`
	`);`	

Parameters	• `WCHAR* inout_Name:` A user-allocated array for the computer name. • `UINT32 in_ArrayLength:` The array length. The array should be longer than `MAX_COMPUTERNAME_LENGTH`.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_INDEX_OT_OF_RANGE`	The array is too small to accommodate the computer name.

Table 7- 281 RemoteComputerName { get; } - .NET (C#)

Syntax	`string RemoteComputerName { get; }`	
Parameters	None	
Return values	`string`: Name of the PC on which the remote Runtime Manager is running.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeError-` `Code.IndexOutOfRange`	The array is too small to accommodate the computer name.

Disconnect()

Closes the connection to the remote Runtime Manager.

Note

All applications that are connected to the remote Runtime Manager lose this connection.

Table 7- 282 Disconnect() - Native C++

Syntax	`ERuntimeErrorCode Disconnect();`	
Parameters	None	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 7- 283 Disconnect() - .NET (C#)

Syntax	`void Disconnect();`	
Parameters	None	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

7.7.2 Simulation Runtime instances

7.7.2.1 Simulation Runtime instances (remote)

GetRegisteredInstancesCount()

Returns the number of instances that are registered in Runtime Manager. If the function fails, the return value is 0.

Table 7- 284 GetRegisteredInstancesCount() - Native C++

Syntax	`UINT32 GetRegisteredInstancesCount();`
Parameters	None
Return values	`UINT32`: Number of available instances.

GetRegisteredInstanceInfoAt()

Returns information about an already registered instance.

You can use the ID or name to create an interface of this instance (see `CreateInterface()`).

Table 7- 285 GetRegisteredInstanceInfoAt() - Native C++

Syntax	`ERuntimeErrorCode GetRegisteredInstanceInfoAt(`
	`  UINT32 in_Index,`
	`  SInstanceInfo* out_InstanceInfo`
	`);`	

Parameters	• `UINT32 in_Index:` Index of the created instance from which you want to receive the information. The index must be less than the value you receive when you call `GetRegisteredInstanceCount()`. • `SInstanceInfo* out_InstanceInfo:` The information with name and ID of the instance. See SInstanceInfo (Page 278).	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX OUT_OF_RANGE`	There is no instance information for this index.

RegisteredInstanceInfo { get; }

Returns information about an already registered instance. You can use the ID or name of this instance to create an interface of this instance, see `CreateInterface()`.

Table 7- 286 RegisterInstanceInfo { get; } - .NET (C#)

Syntax	`SInstanceInfo[] RegisteredInstanceInfo { get; }`	
Parameters	None	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

RegisterInstance()

Registers a new instance of a virtual controller in Runtime Manager. Creates and returns an interface of this instance.

Table 7- 287 RegisterInstance() - Native C++

Syntax	`ERuntimeErrorCode RegisterInstance(`
	`  IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode RegisterInstance(`
	`  WCHAR* in_InstanceName,`
	`  IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode RegisterInstance(`
	`  ECPUType in_CPUType,`
	`  IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode RegisterInstance(`
	`  ECPUType in_CPUType,`
	`  WCHAR* in_InstanceName,`
	`  IInstance** out_InstanceInterface`
	`);`	

Parameters	• `ECPUType in_CPUType:` Defines which CPU type is simulated at the start of the instance. The default setting is `"SRCT_1500_Unspecified"`. When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies. • `WCHAR* in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 271). • `IInstance** out_InstanceInterface:` Pointer to a Simulation Runtime interface pointer. The pointer **must** be initialized with `NULL`. The interface is created within the function.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The name or the IInstance pointer is invalid.
	`SREC_LIMIT_REACHED`	There are already 16 instances registered in Runtime Manager.
	`SREC_ALREADY_EXISTS`	An instance with this name already exists.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`// Example: How To Create And Register An Instance`
	`// And To Get An Interface Of The Instance The Same Time`
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	`result = api->RegisterInstance(&psa);`
	`}`

Note

Native C++

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

Table 7- 288 RegisterInstance() - .NET (C#)

Syntax	`IInstance RegisterInstance();`
	`IInstance RegisterInstance(`
	`string in_InstanceName`
	`);`
	`IInstance RegisterInstance(`
	`ECPUType in_CPUType`
	`);`
	`IInstance RegisterInstance(`
	`ECPUType in_CPUType`
	`string in_InstanceName`
	`);`

Parameters	• `ECPUType in_CPUType:` Defines which CPU type is simulated at the start of the instance. The default setting is `"ECPUType.Unspecified"`. When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies. • `string in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 271).
Return values	If the function is successful, an interface of a virtual controller. Otherwise, a Null pointer.

Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name is invalid.
	`ERuntimeErrorCode.LimitReached`	There are already 16 instances registered in Runtime Manager.
	`ERuntimeErrorCode.AlreadyExists`	An instance with this name already exists.

RegisterCustomInstance()

Registers a new instance of a virtual controller in Runtime Manager. Creates and returns an interface of this instance.

Table 7- 289 RegisterCustomInstance() - Native C++

Syntax	`ERuntimeErrorCode RegisterCustomInstance(`
	` WCHAR* in_VplcDll,`
	` IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode RegisterCustomInstance(`
	` WCHAR* in_VplcDll,`
	` WCHAR* in_InstanceName,`
	` IInstance** out_InstanceInterface`
	`);`	

Parameters	• `WCHAR* in_VplcDll:` The complete path to the DLL of the virtual controller that Siemens.Simatic.Simulation.Runtime.Instance.exe loads at PowerOn. • `WCHAR* in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 271). • `IInstance** out_InstanceInterface:` Pointer to a Simulation Runtime interface pointer. The pointer must be initialized with `NULL`. The interface is created within the function.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The DLL name, the instance name or the IInstance pointer is invalid.
	`SREC_LIMIT_REACHED`	There are already 16 instances registered in Runtime Manager.
	`SREC_ALREADY_EXISTS`	An instance with this name already exists.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`// Example: How To Create And Register An Instance`
	`// And To Get An Interface Of The Instance The Same Time`
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	`result = api->RegisterCustomInstance("C:\\Temp\\vplc.dll");`
	`}`

Note

Native C++

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82).

Table 7- 290 RegisterCustomInstance() - .NET (C#)

Syntax	`IInstance RegisterCustomInstance(`
	`string in_VplcDll`
	`);`
	`IInstance RegisterCustomInstance(`
	`string in_VplcDll,`
	`string in_InstanceName`
	`);`	

Parameters	• `string in_VplcDll:` The complete path to the DLL of the virtual controller that Siemens.Simatic.Simulation.Runtime.Instance.exe loads at PowerOn. • `string in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 271).	
Return values	If the function is successful, an interface of a virtual controller; otherwise a Null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-Code.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name or the ID is invalid.
	`ERuntimeErrorCode.LimitReached`	There are already 16 instances registered in Runtime Manager.
	`ERuntimeErrorCode.AlreadyExists`	An instance with this name already exists.

CreateInterface()

Creates and returns an interface of an already registered instance of a virtual controller.

The instance could have been registered via the application or another application that uses the Simulation Runtime API.

Table 7- 291 CreateInterface() - Native C++

Syntax	`ERuntimeErrorCode CreateInterface(`
	` WCHAR* in_InstanceName,`
	` IInstance** out_InstanceInterface`
	`);`
	`ERuntimeErrorCode CreateInterface(`
	` INT32 in_InstanceID,`
	` IInstance** out_InstanceInterface`
	`);`	

Parameters	• `INT32 in_InstanceID:` The ID of the registered instance from which you want to receive the interface. • `WCHAR* in_InstanceName:` The name of the registered instance from which you want to receive the interface. • `IInstance** out_InstanceInterface:` Pointer to a Simulation Runtime interface pointer. The pointer must be initialized with `NULL`. The interface is created within the function.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The name, the ID or the IInstance- pointer is invalid.
	`SREC_DOES_NOT_EXIST`	The instance is not registered in Runtime Manager.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IInstance* psa1 = NULL;`
	`IInstance* psa2 = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->CreateInterface(0, &psa1);`
	` result = api->CreateInterface(0, &psa2); // psa2 will be the same as psa1`
	`}`	

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = Initialize(&api);`
	
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->CreateInterface(L"My SimulationRuntime Instance", &psa);`
	`}`	

Note

Native C++

If you no longer require the interface, delete it.

See DestroyInterface() (Page 82)

Table 7- 292 CreateInterface() - .NET (C#)

Syntax	`IInstance CreateInterface(`
	`  string in_InstanceName`
	`);`
	`IInstance CreateInterface(`
	`  INT32 in_InstanceID`
	`);`	

Parameters	• `INT32 in_InstanceID:` The ID of the registered instance from which you want to receive the interface. • `string in_InstanceName:` The name of the registered instance from which you want to receive the interface.	
Return values	If the function is successful, an interface of a virtual controller; otherwise a Null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeError-` `Code.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name or the ID is invalid.
	`ERuntimeErrorCode.DoesNotExists`	The instance is not registered in Runtime Manager.

7.7.3 Events

7.7.3.1 OnConnectionLost

Description

The event is triggered when the connection to the Remote Runtime Manager has been terminated.

OnConnectionLost

Registers or unregisters an event handler method.

Table 7- 293 OnConnectionLost - .NET (C#)

Syntax	`event Delegate_IRRTM OnConnectionLost;`
Parameters	None. See Delegate_IRRTM (Page 269)
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnConnectionLostCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. Registering a new callback function causes the previous callback function to be unregistered.

Table 7- 294 RegisterOnConnectionLostCallback() - Native C++

Syntax	`void RegisterOnConnectionLostCallback(`
	`  EventCallback_IRRTM in_CallbackFunction`
	`);`

Parameters	• `EventCallback_IRRTM in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_IRRTM (Page 263).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnConnectionLostEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 7- 295 RegisterOnConnectionLostEvent() - Native C++

Syntax	`void RegisterOnConnectionLostEvent();`
	`void RegisterOnConnectionLostEvent(`
	`  HANDLE* in_Event`
	`);`

Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

Table 7- 296 RegisterOnConnectionLostEvent() - .NET (C#)

Syntax	`void RegisterOnConnectionLostEvent();`
Parameters	None
Return values	None

UnregisterOnConnectionLostCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 7- 297 UnregisterOnConnectionLostCallback() - Native C++

Syntax	`void UnregisterOnConnectionLostCallback();`
Parameters	None
Return values	None

UnregisterOnConnectionLostEvent()

Unregisters the event object.

Table 7- 298 UnregisterOnConnectionLostEvent() - Native C++

Syntax	`void UnregisterOnConnectionLostEvent();`
Parameters	None
Return values	None

Table 7- 299 UnregisterOnConnectionLostEvent() - .NET (C#)

Syntax	`void UnregisterOnConnectionLostEvent();`
Parameters	None
Return values	None

WaitForOnConnectionLostEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 7- 300 WaitForOnConnectionLostEvent() - Native C++

Syntax	`bool WaitForOnConnectionLostEvent();`
	`bool WaitForOnConnectionLostEvent(`
	`  UINT32 in_Time_ms )`
	`;`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 7- 301 WaitForOnConnectionLostEvent() - .NET (C#)

Syntax	`bool WaitForOnConnectionLostEvent();`
	`bool WaitForOnConnectionLostEvent(`
	`  UInt32 in_Time_ms )`
	`;`

Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

7.8 Data types

Note

Unsupported data types

The Runtime API does not support the `STRING` and `WSTRING` data types.

Supported data types

In S7-PLCSIM Advanced V1.0, the Runtime API supports the data types of the S7-1500 CPUs.

Converting data types

When writing, data types are not transferred BCD-coded but mapped onto primitive data types.

The data types Counter, Date and Time must be transferred to the API BDC-coded so that the values are written to the counter and no incorrect values are returned when reading.

For these data types, you must perform a BCD conversion before writing and a BCD back-conversion after reading.

Example:

If the value 999 is transferred to the API as 2457_H, then `Write` modifies the value 2457_H to 999. Without BCD conversion, there is no `UInt16` value and `Write` writes no value at all.

Additional information

For information on data types and conversion, refer to section "Data types" in the STEP 7 V14 System Manual (https://support.industry.siemens.com/cs/document/109011420/step-7-professional-v13-1?dti=0&lc=en-WW // XmlEditor.InternalXmlClipboard:d59d29c4-ec28-6b28-3f63-754735fb2e2a).

7.8.1 DLL import functions (Native C++)

7.8.1.1 ApiEntry_Initialize

Description

Type of the central entry point for the API DLL.

Table 7- 302 ApiEntry_Initialize - Native C++

Syntax	`typedef ERuntimeErrorCode(*ApiEntry_Initialize)( ISimulationRuntimeManager** out_RuntimeManagerInterface );`	
Parameters	• `ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface:` Pointer to a Runtime Manager interface pointer. The pointer must be initialized with ZERO. The interface is created within the function. • `UINT32 in_InterfaceVersion:` Version of the API interface to be downloaded: `API_DLL_INTERFACE_VERSION`.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the Runtime Manager interface is ZERO.
	`SREC_WRONG_VERSION`	The version of the interface in use does not match the version of the API DLL.
	`SREC_CONNECTION_ERROR`	Unable to establish a connection to the Runtime Manager.

7.8.1.2 ApiEntry_DestroyInterface

Description

Type of the entry point for DestroyInterface (Page 82).

Table 7- 303 ApiEntry_DestroyInterface - Native C++

Syntax	`typedef ERuntimeErrorCode(*ApiEntry_DestroyInterface)( IBaseInterface* in_Interface );`	
Parameters	• `IBaseInterface* in_Interface:` The interface to be deleted.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the interface is ZERO.

7.8.2 Event callback functions (Native C++)

7.8.2.1 EventCallback_VOID

Description

Table 7- 304 EventCallback_VOID - Native C++

Syntax	`typedef void (*EventCallback_VOID)();`
Parameters	None
Return values	None

7.8.2.2 EventCallback_II_SREC_ST

Description

Table 7- 305 EventCallback_II_SREC_ST - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST)(`
	` IInstance* in_Sender,`
	` ERuntimeErrorCode in_ErrorCode,`
	` SYSTEMTIME in_SystemTime`
	`);`

Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the virtual controller at the time when this event was triggered.
Return values	None

7.8.2.3 EventCallback_II_SREC_ST_SROS_SROS

Description

Table 7- 306 EventCallback_II_SREC_ST_SROS_SROS - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_SROS_SROS)(`
	` IInstance* in_Sender,`
	` ERuntimeErrorCode in_ErrorCode,`
	` SYSTEMTIME in_SystemTime,`
	` EOperatingState in_PrevState,`
	` EOperatingState in_OperatingState`
	`);`	

Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the virtual controller at the time when this event was triggered. • `EOperatingState in_PrevState:` The operating state before the change. • `EOperatingState in_OperatingState:` The current operating state.	
Return values	None	
Error codes	Runntime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WARNING_TRIAL_MODE_ACTIVE`	No license available. You can use the instance without restrictions for a period of one hour. Afterwards, the instance is shut down.
	`SREC_LICENSE_NOT_FOUND`	Test mode has expired.
	`SREC_COMMUNICATION_INTERFACE_NOT_AVAILABLE`	A problem has occurred with the selected communication interface. Check your settings.

7.8.2.4 EventCallback_II_SREC_ST_SRLT_SRLM

Description

Table 7- 307 EventCallback_II_SREC_ST_SRLT_SRLM - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_SRLT_SRLM)(`
	` IInstance* in_Sender,`
	` ERuntimeErrorCode in_ErrorCode,`
	` SYSTEMTIME in_SystemTime,`
	` ELEDType in_LEDType,`
	` ELEDMode in_LEDMode,`
	`);`

Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the virtual controller at the time when this event was triggered. • `ELEDType in_LEDType:` The LED type that changed its state. • `ELEDMode in_LEDMode:` The new state of the LED display.
Return values	None

7.8.2.5 EventCallback_II_SREC_ST_INT64_UINT32

Description

Table 7- 308 EventCallback_II_SREC_ST_INT64_UINT32 - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_INT64_UINT32)(`
	`  IInstance* in_Sender,`
	`  ERuntimeErrorCode in_ErrorCode,`
	`  SYSTEMTIME in_SystemTime,`
	`  INT64 in_CycleTime_ns,`
	`  UINT32 in_CycleCount,`
	`);`

Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the virtual controller at the time when this event was triggered. • `INT64 in_CycleTime_ns:` The virtual time (in nanoseconds) since the last cycle control point. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, the value contains the virtual time (in nanoseconds) since the last event was received. • `UINT32 in_CycleCount:` The number of cycles since the last cycle control point. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, this value contains the number of cycles since the last event was received.
Return values	None

7.8.2.6 EventCallback_IRRTM

Description

Table 7- 309 EventCallback_IRRTM - Native C++

Syntax	`typedef void (*EventCallback_IRRTM)( IRemoteRuntimeManager* in_Sender );`
Parameters	• `IRemoteRuntimeManager* in_Sender:` An interface of the remote Runtime Manager that receives this event.
Return values	None

7.8.2.7 EventCallback_SRCC_UINT32_UINT32_INT32

Description

Table 7- 310 EventCallback_SRCC_UINT32_UINT32_INT32 - Native C++

Syntax	`ERuntimeConfigChanged in_RuntimeConfigChanged, UINT32 in_Param1, UINT32 in_Param2, INT32 in_Param3 );`			
Parameters	`ERuntimeConfigChanged in_RuntimeConfigChanged`	`UInt32 in_Param1`	`UInt32 in_Param2`	`Int32 in_Param3`
	`SRCC_INSTANCE_REGISTERED`	-	-	ID of the registered instance
	`SRCC_INSTANCE_UNREGISTERED`	-	-	ID of the unregistered instance
	`SRCC_CONNECTION_OPENED`	IP of the remote Runtime Manager	Port of the remote Runtime Manager	-
	`SRCC_CONNECTION_CLOSED`	IP of the remote Runtime Manager	Port of the remote Runtime Manager	-
	`SRCC_PORT_OPENED`	The open port	-	-
	`SRCC_PORT_CLOSED`	-	-	-
Return values	None			

7.8.2.8 EventCallback_II_SREC_ST_SRICC_UINT32_UINT32_UINT32_UINT32

Description

Table 7- 311 EventCallback_II_SREC_ST_SRICC_UINT32_UINT32_UINT32_UINT32 - Native C++

<table>
<tr><td>Syntax</td><td colspan="5">

```
typedef void
(*EventCallback_II_SREC_ST_SRICC_UINT32_UINT32_UINT32_UINT32)(
 IInstance* in_Sender,
 ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime,
 EInstanceConfigChanged in_InstanceConfigChanged,
 UINT32 in_Param1,
 UINT32 in_Param2,
 UINT32 in_Param3,
 UINT32 in_Param4
);
```

</td></tr>
<tr><td>Parameters</td><td colspan="5">

- `IInstance in_Sender:`

  An interface of the instance that receives this event.

- `ERuntimeErrorCode in_ErrorCode:`

  A possible error code.

- `SYSTEMTIME in_SystemTime:`

  The virtual system time of the virtual controller at the time when this event was triggered.

</td></tr>
<tr><td></td><td>EIn-
stanceCon-
figChanged
in_Instance
Con-
figChanged</td><td>UINT32
in_Param1</td><td>UINT32
in_Param2</td><td>UINT32
in_Param3</td><td>UINT32
in_Param4</td></tr>
<tr><td></td><td>SRICC_HARDW
ARE_SOFTWAR
E_CHANGED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td></td><td>SRICC_IP_CH
ANGED</td><td>The ID of the interface</td><td>The new IP</td><td>The new sub-net mask</td><td>The new standard gateway</td></tr>
<tr><td>Return values</td><td colspan="5">None</td></tr>
</table>

7.8.3 Delegate definitions (managed code)

7.8.3.1 Delegate_Void

Description

Table 7- 312 Delegate_Void - .NET (C#)

Syntax	`delegate void Delegate_Void();`
Parameters	None
Return values	None

7.8.3.2 Delegate_II_EREC_DT

Description

Table 7- 313 Delegate_II_EREC_DT - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT (`
	`  IInstance in_Sender,`
	`  ERuntimeErrorCode in_ErrorCode,`
	`  DateTime in_DateTime`
	`);`

Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the virtual controller at the time when this event was triggered.
Return values	None

7.8.3.3 Delegate_II_EREC_DT_EOS_EOS

Description

Table 7- 314 Delegate_II_EREC_DT_EOS_EOS - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_EOS_EOS(`
	`  IInstance in_Sender,`
	`  ERuntimeErrorCode in_ErrorCode,`
	`  DateTime in_DateTime,`
	`  EOperatingState in_PrevState,`
	`  EOperatingState in_OperatingState`
	`);`	

Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the virtual controller at the time when this event was triggered. • `EOperatingState in_PrevState:` The operating state before the change. • `EOperatingState in_OperatingState:` The current operating state.	
Return values	None	
Error codes	Runntime error code	Condition
	`ERuntimeErrorCode.OK`	The function is successful.
	`ERuntimeError-Code.WarningTrialModeActive`	No license available. You can use the instance without restrictions for a period of one hour. Afterwards, the instance is shut down.
	`ERuntimeError-Code.LicenseNotFound`	Test mode has expired.
	`ERuntimeError-Code.CommunicationInterfaceNotAvailable`	A problem has occurred with the selected communication interface. Check your settings.

7.8.3.4 Delegate_II_EREC_DT_ELT_ELM

Description

Table 7- 315 Delegate_II_EREC_DT_ELT_ELM - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_ELT_ELM(`
	` IInstance in_Sender,`
	` ERuntimeErrorCode in_ErrorCode,`
	` DateTime in_DateTime,`
	` ELEDType in_LEDType,`
	` ELEDMode in_LEDMode,`
	`);`

Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the virtual controller at the time when this event was triggered. • `ELEDType in_LEDType:` The LED type that changed its state. • `ELEDMode in_LEDMode:` The new state of the LED display.
Return values	None

7.8.3.5 Delegate_II_EREC_DT_INT64_UINT32

Description

Table 7- 316 Delegate_II_EREC_DT_INT64_UINT32 - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_INT64_UINT32(`
	` IInstance in_Sender,`
	` ERuntimeErrorCode in_ErrorCode,`
	` DateTime in_DateTime,`
	` Int64 in_CycleTime_ns,`
	` UInt32 in_CycleCount,`
	`);`

Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the virtual controller at the time when this event was triggered. • `Int64 in_CycleTime_ns:` The virtual time (in nanoseconds) since the last cycle control point. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, the value contains the virtual time (in nanoseconds) since the last event was received. • `UInt32 in_CycleCount:` The number of cycles since the last cycle control point. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, this value contains the number of cycles since the last event was received.
Return values	None

7.8.3.6 Delegate_IRRTM

Description

Table 7- 317 Delegate_IRRTM - .NET (C#)

Syntax	`delegate void Delegate_IRRTM(`
	`  IRemoteRuntimeManager in_Sender,`
	`);`

Parameters	• `IRemoteRuntimeManager in_Sender:` An interface of the remote Runtime Manager that receives this event.
Return values	None

7.8.3.7 Delegate_SRCC_UINT32_UINT32_INT32

Description

Table 7- 318 Delegate_SRCC_UINT32_UINT32_INT32 - .NET (C#)

Syntax	`delegate void Delegate_SRCC_UINT32_UINT32_INT32(`
	`  ERuntimeConfigChanged in_RuntimeConfigChanged,`
	`  UInt32 in_Param1,`
	`  UInt32 in_Param2,`
	`  Int32 in_Param3`
	`);`			

Parameters	`ERuntimeConfigChanged in_RuntimeConfigChanged`	`UInt32 in_Param1`	`UInt32 in_Param2`	`Int32 in_Param3`
	`InstanceRegistered`	-	-	ID of the registered instance
	`InstanceUnregistered`	-	-	ID of the unregistered instance
	`ConnectionOpened`	IP of the Remote Runtime Manager	Port of the remote Runtime Manager	-
	`Connection-Closed`	IP of the Remote Runtime Manager	Port of the remote Runtime Manager	-
	`PortOpened`	The open port	-	-
	`PortClosed`	-	-	-
Return values	None			

7.8.3.8 Delegate_II_EREC_DT_SRICC_UINT32_UINT32_UINT32_UINT32

Description

Table 7- 319 Delegate_II_EREC_DT_SRICC_UINT32_UINT32_UINT32_UINT32 - .NET (C#)

<table>
<tr><td>Syntax</td><td colspan="5">

```
delegate void Dele-
gate_II_EREC_DT_SRICC_UINT32_UINT32_UINT32_UINT32(
 IInstance in_Sender,
 ERuntimeErrorCode in_ErrorCode,
 DateTime in_DateTime,
 EInstanceConfigChanged in_InstanceConfigChanged,
 UInt32 in_Param1,
 UInt32 in_Param2,
 UInt32 in_Param3,
 UInt32 in_Param4
);
```

</td></tr>
<tr><td>Parameters</td><td colspan="5">

- `IInstance in_Sender:`

  An interface of the instance that receives this event.

- `ERuntimeErrorCode in_ErrorCode:`

  A possible error code.

- `DateTime in_DateTime:`

  The virtual system time of the virtual controller at the time when this event was triggered.

</td></tr>
<tr><td></td><td>EIn-
stanceCon-
figChanged
in_Instance
Con-
figChanged</td><td>UInt32
in_Param1</td><td>UInt32
in_Param2</td><td>UInt32
in_Param3</td><td>UInt32
in_Param4</td></tr>
<tr><td></td><td>Hard-
wareSoft-
wareChanged</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td></td><td>IPChanged</td><td>The ID of the interface</td><td>The new IP</td><td>The new sub-net mask</td><td>The new standard gateway</td></tr>
<tr><td>Return values</td><td colspan="5">None</td></tr>
</table>

7.8.4 Definitions and constants

The following identifiers are used in the API:

Table 7- 320 Definitions and constants - Native C++

Identifier	Value	Description
DINSTANCE_NAME_MAX_LENGTH	64	The unique name of an instance must be less than this value.
DSTORAGE_PATH_MAX_LENGTH	130	The maximum path length to the virtual memory card. Including ZERO termination.
DTAG_NAME_MAX_LENGTH	300	The maximum length of the name of a PLC tag. Including ZERO termination.
DTAG_ARRAY_DIMENSION	6	The maximum number of dimension for a multi-dimensional field.
DCONTROLLER_NAME_MAX_LENGTH	128	The maximum length of the controller name. Including ZERO termination.
DCONTROLLER_SHORT_DESIGNATION_MAX_LENGTH	32	The maximum length of the abbreviation of the controller (CPU type). Including ZERO termination.

Table 7- 321 Definitions and constants - .NET (C#)

Identifier	Value	Description
RuntimeConstants.InstanceNameLength	64	The unique name of an instance must be less than this value.
RuntimeConstants.StoragePathMaxLength	130	The maximum path length to the virtual memory card. Including ZERO termination.
RuntimeConstants.TagNameMaxLength	300	The maximum length of the name of a PLC tag. Including ZERO termination.
RuntimeConstants.TagArrayDimension	6	The maximum number of dimension for a multi-dimensional field.
RuntimeConstants.ControllerNameMaxLength	128	The maximum length of the controller name. Including ZERO termination.
RuntimeConstants.ControllerShortDesignationMaxLength	32	The maximum length of the abbreviation of the controller (CPU type). Including ZERO termination.

7.8.5 Unions (Native C++)

7.8.5.1 UIP

Description

Contains an IPv4 address.

Table 7- 322 UIP - Native C++

Syntax	`union UIP`
	`{`
	`DWORD IP;`
	`BYTE IPs[4];`
	`};`

Member	• `DWORD IP:` The IP address in a single DWORD • `BYTE IPs[4]:` The four elements of IP in descending order
Example	Example for an IP address: 192.168.0.1 UIP.IP = 0xC0A80001 UIP.IPs[3] = 192, UIP.IPs[2] = 168, UIP.IPs[1] = 0, UIP.IPs[0] = 1

7.8.5.2 UDataValue

Description

Contains the value of a PLC tag.

Table 7- 323 UDataValue - Native C++

Syntax	`union UDataValue`
	`{`
	`bool Bool;`
	`INT8 Int8;`
	`INT16 Int16;`
	`INT32 Int32;`
	`INT64 Int64;`
	`UINT8 UInt8;`
	`UINT16 UInt16;`
	`UINT32 UInt32;`
	`UINT64 UInt64;`
	`float Float;`
	`double Double;`
	`CHAR Char;`
	`WCHAR WChar;`
	`};`

Member	• `bool Bool:` 1 byte boolean value • `INT8 Int8:` 1 byte integer with sign • `INT16 Int16:` 2 byte integer with sign • `INT32 Int32:` 4 byte integer with sign • `INT64 Int64:` 8 byte integer with sign • `UINT8 UInt8:` 1 byte integer without sign • `UINT16 UInt16:` 2 byte integer without sign • `UINT32 UInt32:` 4 byte integer without sign • `UINT64 UInt64:` 8 byte integer without sign • `float Float:` 4 byte floating-point value • `double Double:` 8 byte floating-point value • `CHAR Char:` 1 byte value character • `WCHAR WChar:` 2 byte value character

7.8.6 Structures

7.8.6.1 SDataValue

Description

The structure contains the value and type of a PLC tag.

Table 7- 324 SDataValue - Native C++

Syntax	`struct SDataValue`
	`{`
	`UDataValue Value;`
	`EDataType Type;`
	`};`

Member	• `UDataValue Value:` The value of the PLC tags • `EPrimitiveDataType Type:` Type of PLC tag

Table 7- 325 SDataValue - .NET (C#)

Syntax	`struct SDataValue`
	`{`
	`bool Bool { get; set; }`
	`Int8 Int8 { get; set; }`
	`Int16 Int16 { get; set; }`
	`Int32 Int32 { get; set; }`
	`Int64 Int64 { get; set; }`
	`UInt8 UInt8 { get; set; }`
	`UInt16 UInt16 { get; set; }`
	`UInt32 UInt32 { get; set; }`
	`UInt64 UInt64 { get; set; }`
	`float Float { get; set; }`
	`double Double { get; set; }`
	`sbyte Char { get; set; }`
	`char WChar { get; set; }`
	`EPrimitiveDataType Type { get; set; }`
	`}`

Member	• `bool Bool:` 1 byte boolean value • `Int8 Int8:` 1 byte integer with sign • `Int16 Int16:` 2 byte integer with sign • `Int32 Int32:` 4 byte integer with sign • `Int64 Int64:` 8 byte integer with sign • `UntT8 UInt8:` 1 byte integer without sign • `UInt16 UInt16:` 2 byte integer without sign • `UInt32 UInt32:` 4 byte integer without sign • `UInt64 UInt64:` 8 byte integer without sign • `float Float:` 4 byte floating-point value • `double Double:` 8 byte floating-point value • `sbyte Char:` 1 byte value character • `char WChar:` 2 byte value character • `EPrimitiveDataType Type:` Type of PLC tag

7.8.6.2 SDataValueByAddress

Description

This structure represents a PLC tag that can be accessed via its address.

Table 7- 326 SDataValueByAddress - Native C++

Syntax	`struct SDataValueByAddress`
	`{`
	` UINT32 Offset;`
	` UINT8 Bit;`
	` SDataValue DataValue;`
	`};`

Table 7- 327 SDataValueByAddress - .NET (C#)

Syntax	`struct SDataValueByAddress`
	`{`
	` UInt32 Offset;`
	` UInt8 Bit;`
	` SDataValue DataValue;`
	`}`

7.8.6.3 SDataValueByName

Description

This structure represents a PLC tag that can be called by name.

Table 7- 328 SDataValueByName - Native C++

Syntax	`struct SDataValueByName`
	`{`
	` WCHAR Name[DTAG_NAME_MAX_LENGTH];`
	` SDataValue DataValue;`
	`};`

Table 7- 329 SDataValueByName - .NET (C#)

Syntax	`struct SDataValueByName`
	`{`
	` String Name;`
	` SDataValue DataValue;`
	`}`

7.8.6.4 SConnectionInfo

Description

This structure contains the IP address and port of a TCP/IP connection.

Table 7- 330 SConnectionInfo - Native C++

Syntax	`struct SConnectionInfo`
	`{`
	`  UIP IP;`
	`  WORD Port;`
	`};`

Table 7- 331 SConnectionInfo - .NET (C#)

Syntax	`struct SConnectionInfo`
	`{`
	`  SIP IP;`
	`  UInt16 Port;`
	`}`

7.8.6.5 SInstanceInfo

Description

This structure contains an IPv4 address.

Table 7- 332 SInstanceInfo - Native C++

Syntax	`struct SInstanceInfo`
	`{`
	`  INT32 ID;`
	`  WCHAR Name[DINSTANCE_NAME_MAX_LENGTH];`
	`};`

Member	• `INT32 ID:` The ID of the instance • `WCHAR Name[DINSTANCE_NAME_MAX_LENGTH]:` The name of the instance

Table 7- 333 SInstanceInfo - .NET (C#)

Syntax	`struct SInstanceInfo`
	`{`
	`  Int32 ID;`
	`  String Name;`
	`}`

Member	• `Int32 ID:` The ID of the instance • `String name:` The name of the instance

7.8.6.6 SDimension

Description

This structure contains information about the dimension of a field.

Table 7- 334 SDimension - Native C++

Syntax	`struct SDimension`
	`{`
	`  INT32 StartIndex;`
	`  UINT32 Count;`
	`};`

Table 7- 335 SDimension - .NET (C#)

Syntax	`struct SDimension`
	`{`
	`  Int32 StartIndex;`
	`  UInt32 Count;`
	`}`

7.8.6.7 STagInfo

Description

This structure contains information about a PLC tag.

Table 7- 336 STagInfo - Native C++

Syntax	`struct STagInfo`
	`{`
	` WCHAR Name[DTAG_NAME_MAX_LENGTH];`
	` EArea Area;`
	` EDataType DataType;`
	` PrimitiveDataType PrimitiveDataType;`
	` UINT16 Size;`
	` UINT32 Offset;`
	` UINT8 Bit;`
	` UINT8 DimensionCount;`
	` UINT32 Index;`
	` UINT32 ParentIndex;`
	` SDimension Dimension[DTAG_ARRAY_DIMENSION];`
	`};`

Member	• `WCHAR Name[DTAG_NAME_MAX_LENGTH]:` The name of the tag • `EArea area:` The CPU area where the tag is located. • `EDataType DataType:` The CPU data type of the tag • `EPrimitiveDataType PrimitiveDataType:` The primitive data type of the tag • `UINT16 size:` The size of the tag in bytes • `UINT32 offset:` The byte offset of the tag if it is not located in a data block. • `UINT8 bit:` The bit offset of the tag if it is not located in a data block. • `UINT8 DimensionCount:` The number of dimensions of the array. 0 if it is not a field for the tag. • `UINT32 index:` The index of the tag • `UINT32 ParentIndex:` If this tag is embedded in another tag (for example, an element of a structure), this value then displays the index of the parent tag. The value is 0 if the tag has no parent tag. • `SDimension Dimension[DTAG_ARRAY_DIMENSION]:` Information about each dimension of the field

Table 7- 337 STagInfo - .NET (C#)

Syntax	`public struct STagInfo`
	`{`
	`String Name;`
	`EArea Area;`
	`EDataType DataType;`
	`EPrimitiveDataType PrimitiveDataType;`
	`UInt16 Size;`
	`UInt32 Offset;`
	`UInt8 Bit;`
	`UInt32 Index;`
	`UInt32 ParentIndex;`
	`SDimension[] Dimension;`
	`}`

Member	• `String name:` The name of the tag • `EArea area:` The CPU area where the tag is located. • `EDataType DataType:` The CPU data type of the tag • `EPrimitiveDataType PrimitiveDataType:` The primitive data type of the tag • `UInt16 size:` The size of the tag in bytes. • `UInt32 offset:` The byte offset of the tag if it is not located in a data block. • `UInt8 bit:` The bit offset of the tag if it is not located in a data block. • `UInt32 index:` The index of the tag • `UInt32 ParentIndex:` If this tag is embedded in another tag (for example, an element of a structure), this value then displays the index of the parent tag. The value is 0 if the tag has no parent tag. • `SDimension[] Dimension:` Information about each dimension of the field. Empty, if the tag is not an array.

7.8.6.8 SIP

Description

This structure contains an IPv4 address.

Table 7- 338 SIP - .NET (C#)

Syntax	`struct SIP`
	`{`
	` byte[] IPArray { get; set; }`
	` UInt32 IPDWord { get; set; }`
	` string IPString { get; set; }`
	`}`

Member	• `UInt32 IPDWord`: The IP address in a single DWORD • `byte[] IPArray`: The four elements of IP in descending order • `string IPString`: The IPv4 address as a string
Example	Example for an IP address: 192.168.0.1 SIP.IPDWord = 0xC0A80001 SIP.IPArray[3] = 192, SIP.IPArray[2] = 168, SIP.IPArray[1] = 0, SIP.IPArray[0] = 1 SIP.IPString = "192.168.0.1"

7.8.6.9 SIPSuite4

Description

This structure contains an IPv4 suite.

Table 7- 339 SIPSuite4 - Native C++

Syntax	`struct SIPSuite4`
	`{`
	`  UIP IPAddress;`
	`  UIP SubnetMask;`
	`  UIP DefaultGateway;`
	`};`

Member	• `UIP IPAddress:` The IP address • `UIP SubnetMask:` The subnet mask • `UIP DefaultGateway:` The standard gateway

Table 7- 340 SIPSuite4 - .NET (C#)

Syntax	`struct SIPSuite4`
	`{`
	`  SIP IPAddress;`
	`  SIP SubnetMask;`
	`  SIP DefaultGateway;`
	`}`

Member	• `SIP IPAddress:` The IP address • `SIP SubnetMask:` The subnet mask • `SIP DefaultGateway:` The standard gateway

7.8.7 Enumerations

7.8.7.1 ERuntimeErrorCode

Description

This enumeration contains all error codes that are used by the Simulation Runtime API. Most API functions return one of these error codes. If the function is successful, the return value is always `SREC_OK`. Errors are returned with negative values, and alarms with positive values.

Table 7- 341 ERuntimeErrorCode - Native C++

Syntax	

```
enum ERuntimeErrorCode
{
 SREC_OK = 0,
 SREC_INVALID_ERROR_CODE = -1,
 SREC_NOT_IMPLEMENTED = -2,
 SREC_INDEX_OUT_OF_RANGE = -3,
 SREC_DOES_NOT_EXIST = -4,
 SREC_ALREADY_EXISTS = -5,
 SREC_UNKNOWN_MESSAGE_TYPE = -6,
 SREC_INVALID_MESSAGE_ID = -7,
 SREC_WRONG_ARGUMENT = -8,
 SREC_WRONG_PIPE = -9,
 SREC_CONNECTION_ERROR = -10,
 SREC_TIMEOUT = -11,
 SREC_MESSAGE_CORRUPT = -12,
 SREC_WRONG_VERSION = -13,
 SREC_INSTANCE_NOT_RUNNING = -14,
 SREC_INTERFACE_REMOVED = -15,
 SREC_SHARED_MEMORY_NOT_INITIALIZED = -16,
 SREC_API_NOT_INITIALIZED = -17,
 SREC_WARNING_ALREADY_EXISTS = 18,
 SREC_NOT_SUPPORTED = -19,
 SREC_WARNING_INVALID_CALL = 20,
 SREC_ERROR_LOADING_DLL = -21,
 SREC_SIGNAL_NAME_DOES_NOT_EXIST = -22,
 SREC_SIGNAL_TYPE_MISMATCH = -23,
 SREC_SIGNAL_CONFIGURATION_ERROR = -24,
 SREC_NO_SIGNAL_CONFIGURATION_LOADED = -25,
 SREC_CONFIGURED_CONNECTION_NOT_FOUND = -26,
 SREC_CONFIGURED_DEVICE_NOT_FOUND = -27,
 SREC_INVALID_CONFIGURATION = -28,
 SREC_TYPE_MISMATCH = -29,
 SREC_LICENSE_NOT_FOUND = -30,
 SREC_NO_LICENSE_AVAILABLE = -31,
 SREC_WRONG_COMMUNICATION_INTERFACE = -32,
 SREC_LIMIT_REACHED = -33,
 SREC_NO_STORAGE_PATH_SET = -34,
 SREC_STORAGE_PATH_ALREADY_IN_USE = -35,
 SREC_MESSAGE_INCOMPLETE = -36,
 SREC_ARCHIVE_STORAGE_NOT_CREATED = -37,
 SREC_RETRIEVE_STORAGE_FAILURE = -38
 SREC_INVALID_OPERATING_STATE = -39,
 SREC_INVALID_ARCHIVE_PATH = -40,
 SREC_DELETE_EXISTING_STORAGE_FAILED = -41,
 SREC_CREATE_DIRECTORIES_FAILED = -42,
 SREC_NOT_ENOUGH_MEMORY = -43,
 SREC_WARNING_TRIAL_MODE_ACTIVE = 44,
 SREC_NOT_RUNNING = -45,
 SREC_NOT_EMPTY = -46,
 SREC_NOT_UP_TO_DATE = -47,
 SREC_COMMUNICATION_INTERFACE_NOT_AVAILABLE = -48,
 SREC_WARNING_NOT_COMPLETE = 49,
 SREC_VIRTUAL_SWITCH_MISCONFIGURED = -50
};
```

Table 7- 342 ERuntimeErrorCode - .NET (C#)

Syntax	enum ERuntimeErrorCode
	{
	OK = 0,
	InvalidErrorCode = -1,
	NotImplemented = -2,
	IndexOutOfRange = -3,
	DoesNotExist = -4,
	AlreadyExists = -5,
	UnknownMessageType = -6,
	InvalidMessageId = -7,
	WrongArgument = -8,
	WrongPipe = -9,
	ConnectionError = -10,
	Timeout = -11,
	MessageCorrupt = -12,
	WrongVersion = -13,
	InstanceNotRunning = -14,
	InterfaceRemoved = -15,
	SharedMemoryNotInitialized = -16,
	ApiNotInitialized = -17,
	WarningAlreadyExists = 18,
	NotSupported = -19,
	WarningInvalidCall = 20,
	ErrorLoadingDll = -21,
	SignalNameDoesNotExist = -22,
	SignalTypeMismatch = -23,
	SignalConfigurationError = -24,
	NoSignalConfigurationLoaded = -25,
	ConfiguredConnectionNotFound = -26,
	ConfiguredDeviceNotFound = -27,
	InvalidConfiguration = -28,
	TypeMismatch = -29,
	LicenseNotFound = -30,
	NoLicenseAvailable = -31,
	WrongCommunicationInterface = -32,
	LimitReached = -33,
	NoStartupPathSet = -34,
	start StartupPathAlreadyInUse = -35,
	MesssageIncomplete = -36,
	archive ArchiveStorageNotCreated = -37,
	RetrieveStorageFailure = -38,
	InvalidOperatingState = -39,
	InvalidArchivePath = -40,
	DeleteExistingStorageFailed = -41,
	CreateDirectoriesFailed = -42,
	NotEnoughMemory = -43,
	WarningTrialModeActive = 44,
	NotRunning = -45,
	NotEmpty = -46,
	NotUpToData = -47,
	CommunicationInterfaceNotAvailable = -48,
	WarningNotComplete = 49,
	VirtualSwitchMisconfigured = -50
	}

7.8.7.2 EArea

Description

This list contains all PLC areas that contain the available PLC tags.

Table 7- 343 EArea - Native C++

Syntax	`enum EArea`
	`{`
	` SRA_INVALID_AREA = 0,`
	` SRA_INPUT = 1,`
	` SRA_MARKER = 2,`
	` SRA_OUTPUT = 3,`
	` SRA_COUNTER = 4,`
	` SRA_TIMER = 5,`
	` SRA_DATABLOCK = 6,`
	
	` SRA_ENUMERATION_SIZE = 7`
	`};`

Table 7- 344 EArea - .NET (C#)

Syntax	`public enum EArea`
	`{`
	` InvalidArea = 0,`
	` Input = 1,`
	` Marker = 2,`
	` Output = 3,`
	` Counter = 4,`
	` Timer = 5,`
	` DataBlock = 6,`
	`}`

7.8.7.3 EOperatingState

Description

This list contains all the operating states of a virtual controller.

Table 7- 345 EOperatingState - Native C++

Syntax	`enum EOperatingState`
	`{`
	` SROS_INVALID_OPERATING_STATE = 0,`
	` SROS_OFF = 1,`
	` SROS_BOOTING = 2,`
	` SROS_STOP = 3,`
	` SROS_STARTUP = 4,`
	` SROS_RUN = 5,`
	` SROS_FREEZE = 6,`
	` SROS_SHUTTING_DOWN = 7,`
	
	` SROS_ENUMERATION_SIZE = 8`
	`};`

Table 7- 346 EOperatingState - .NET (C#)

Syntax	`enum EOperatingState`
	`{`
	` InvalidOperatingState = 0,`
	` Off = 1,`
	` Booting = 2,`
	` Stop = 3,`
	` Startup = 4,`
	` Run = 5,`
	` Freeze = 6,`
	` ShuttingDown = 7`
	`}`

7.8.7.4 EOperatingMode

Description

This list contains all the operating modes of a virtual controller.

Table 7- 347 EOperatingMode - Native C++

Syntax	`enum EOperatingMode`
	`{`
	`SROM_DEFAULT = 0,`
	`SROM_SINGLE_STEP = 1,`
	`SROM_EXTENDED_SINGLE_STEP = 2,`
	`SROM_TIMESPAN_SYNCHNRONIZED = 3`
	`};`

Table 7- 348 EOperatingMode - .NET (C#)

Syntax	`enum EOperatingMode`
	`{`
	`Default = 0,`
	`SingleStep = 1,`
	`ExtendedSingleStep = 2,`
	`TimespanSynchronized = 3`
	`}`

7.8.7.5 ECPUType

Description

This list contains all CPU types that can be loaded in a virtual controller.

Table 7- 349 ECPUType - Native C++

Syntax	enum ECPUType
	{
	SRCT_1500_Unspecified = 0x000005DC,
	SRCT_1511 = 0x000005E7,
	SRCT_1511v2 = 0x010005E7,
	SRCT_1513 = 0x000005E9,
	SRCT_1513v2 = 0x010005E9,
	SRCT_1515 = 0x000005EB,
	SRCT_1515v2 = 0x010005EB,
	SRCT_1516 = 0x000005EC,
	SRCT_1516v2 = 0x010005EC,
	SRCT_1517 = 0x000005ED,
	SRCT_1518 = 0x000005EE,
	SRCT_1511C = 0x000405E7,
	SRCT_1512C = 0x000405E8,
	SRCT_1511F = 0x000105E7,
	SRCT_1511Fv2 = 0x010105E7,
	SRCT_1513F = 0x000105E9,
	SRCT_1513Fv2 = 0x010105E9,
	SRCT_1515F = 0x000105EB,
	SRCT_1515Fv2 = 0x010105EB,
	SRCT_1516F = 0x000105EC,
	SRCT_1516Fv2 = 0x010105EC,
	SRCT_1517F = 0x000105ED,
	SRCT_1518F = 0x000105EE,
	SRCT_1511T = 0x000805E7,
	SRCT_1515T = 0x000805EB,
	SRCT_1517T = 0x000805ED,
	SRCT_1517TF = 0x000905ED,
	SRCT_1518ODK = 0x001005EE,
	SRCT_1518FODK = 0x001105EE,
	SRCT_ET200SP_Unspecified = 0x000205DC,
	SRCT_1510SP = 0x000205E6,
	SRCT_1510SPv2 = 0x010205E6,
	SRCT_1512SP = 0x000205E8,
	SRCT_1512SPv2 = 0x010205E8,
	SRCT_1510SPF = 0x000305E6,
	SRCT_1510SPFv2 = 0x010305E6,
	SRCT_1512SPF = 0x000305E8,
	SRCT_1512SPFv2 = 0x010305E8
	};

Table 7- 350 ECPUType - .NET (C#)

Syntax	enum ECPUType
	{
	CPU1500_Unspecified = 0x000005DC,
	CPU1511 = 0x000005E7,
	CPU1511v2 = 0x010005E7,
	CPU1513 = 0x000005E9,
	CPU1513v2 = 0x010005E9,
	CPU1515 = 0x000005EB,
	CPU1515v2 = 0x010005EB,
	CPU1516 = 0x000005EC,
	CPU1516v2 = 0x010005EC,
	CPU1517 = 0x000005ED,
	CPU1518 = 0x000005EE,
	CPU1511C = 0x000405E7,
	CPU1512C = 0x000405E8,
	CPU1511F = 0x000105E7,
	CPU1511Fv2 = 0x010105E7,
	CPU1513F = 0x000105E9,
	CPU1513Fv2 = 0x010105E9,
	CPU1515F = 0x000105EB,
	CPU1515Fv2 = 0x010105EB,
	CPU1516F = 0x000105EC,
	CPU1516Fv2 = 0x010105EC,
	CPU1517F = 0x000105ED,
	CPU1518F = 0x000105EE,
	CPU1511T = 0x000805E7,
	CPU1515T = 0x000805EB,
	CPU1517T = 0x000805ED,
	CPU1517TF = 0x000905ED,
	CPU1518ODK = 0x001005EE,
	CPU1518FODK = 0x001105EE,
	CPUET200SP_Unspecified = 0x000205DC,
	CPU1510SP = 0x000205E6,
	CPU1510SPv2 = 0x010205E6,
	CPU1512SP = 0x000205E8,
	CPU1512SPv2 = 0x010205E8,
	CPU1510SPF = 0x000305E6,
	CPU1510SPFv2 = 0x010305E6,
	CPU1512SPF = 0x000305E8,
	CPU1512SPFv2 = 0x010305E8
	}

7.8.7.6 ECommunicationInterface

Description

This list shows the available communication interfaces of a virtual controller.

Table 7- 351 ECommunicationInterface - Native C++

Syntax	`enum ECommunicationInterface`
	`{`
	`SRCI_NONE = 0,`
	`SRCI_SOFTBUS = 1,`
	`SRCI_TCPIP = 2,`
	`SRCI_ENUMERATION_SIZE = 3`
	`};`

Table 7- 352 ECommunicationInterface - .NET (C#)

Syntax	`enum ECommunicationInterface`
	`{`
	`None = 0,`
	`Softbus = 1,`
	`TCPIP = 2,`
	`}`

7.8.7.7 ELEDType

Description

This list includes all types of LEDs of a virtual controller.

Table 7- 353 ELEDType - Native C++

Syntax	`enum ELEDType`
	`{`
	` SRLT_STOP = 0,`
	` SRLT_RUN = 1,`
	` SRLT_ERROR = 2,`
	` SRLT_MAINT = 3,`
	` SRLT_REDUND = 4,`
	` SRLT_FORCE = 5,`
	` SRLT_BUSF1 = 6,`
	` SRLT_BUSF2 = 7,`
	` SRLT_BUSF3 = 8,`
	` SRLT_BUSF4 = 9,`
	
	` SRLT_ENUMERATION_SIZE = 10`
	`};`

Table 7- 354 ELEDType - .NET (C#)

Syntax	`enum ELEDType`
	`{`
	` Stop = 0,`
	` Run = 1,`
	` Error = 2`
	` Maint = 3,`
	` Redund = 4,`
	` Force = 5,`
	` Busf1 = 6,`
	` Busf2 = 7,`
	` Busf3 = 8,`
	` Busf4 = 9`
	`}`

7.8.7.8 ELEDMode

Description

This list contains all the LED states of a virtual controller.

Table 7- 355 ELEDMode - Native C++

Syntax	`enum ELEDMode`
	`{`
	`SRLM_OFF = 0,`
	`SRLM_ON = 1,`
	`SRLM_FLASH_FAST = 2,`
	`SRLM_FLASH_SLOW = 3,`
	`SRLM_INVALID = 4`
	`};`

Table 7- 356 ELEDMode - .NET (C#)

Syntax	`enum ELEDMode`
	`{`
	`Off = 0,`
	`On = 1,`
	`FlashFast = 2,`
	`FlashSlow = 3,`
	`Invalid = 4`
	`}`

7.8.7.9 EPrimitiveDataType

Description

This list contains all the primitive data types that are used by the I/O access functions.

Table 7- 357 EPrimitiveDataType - Native C++

Syntax	`enum EPrimitiveDataType`
	`{`
	` SRPDT_UNSPECIFIC = 0,`
	` SRPDT_STRUCT = 1,`
	` SRPDT_BOOL = 2,`
	` SRPDT_INT8 = 3,`
	` SRPDT_INT16 = 4,`
	` SRPDT_INT32 = 5,`
	` SRPDT_INT64 = 6,`
	` SRPDT_UINT8 = 7,`
	` SRPDT_UINT16 = 8,`
	` SRPDT_UINT32 = 9,`
	` SRPDT_UINT64 = 10,`
	` SRPDT_FLOAT = 11,`
	` SRPDT_DOUBLE = 12,`
	` SRPDT_CHAR = 13,`
	` SRPDT_WCHAR = 14`
	`};`

Table 7- 358 EPrimitiveDataType - .NET (C#)

Syntax	`enum EPrimitiveDataType`
	`{`
	` Unspecific = 0,`
	` Struct = 1,`
	` Bool = 2,`
	` Int8 = 3,`
	` Int16 = 4,`
	` Int32 = 5,`
	` Int64 = 6,`
	` UInt8 = 7,`
	` UInt16 = 8,`
	` UInt32 = 9,`
	` UInt64 = 10,`
	` Float = 11,`
	` Double = 12,`
	` Char = 13,`
	` WChar = 14`
	`}`

Compatible primitive data types

The following tables shows the primitive data types of the user interface (API) and the data types of the PLCSIM Advanced instance that are configured in the stored tag list. The data types that can be used as compatible are marked with "X".

Table 7- 359 Compatible primitive data types - Reading

API	PLCSIM Advanced instance												
	Bool	INT8	INT16	INT32	INT64	UINT8	UINT16	UINT32	UINT64	Float	Double	Char	WChar
Bool	X												
INT8		X											
INT16		X	X			X							
INT32		X	X	X		X	X						
INT64		X	X	X	X	X	X	X					
UINT8						X							
UINT16						X	X						
UINT32						X	X	X					
UINT64						X	X	X	X				
Float										X			
Double											X		
Char												X	
WChar													X

Table 7- 360 Compatible primitive data types - Write

API	PLCSIM Advanced instance												
	Bool	INT8	INT16	INT32	INT64	UINT8	UINT16	UINT32	UINT64	Float	Double	Char	WChar
Bool	X												
INT8		X	X	X	X								
INT16			X	X	X								
INT32				X	X								
INT64					X								
UINT8			X	X	X	X	X	X	X				
UINT16							X	X	X				
UINT32								X	X				
UINT64									X				
Float										X			
Double											X		
Char												X	
WChar													X

7.8.7.10 EDataType

Description

This list contains all the CPU data types (STEP 7).

Table 7- 361 EDataType - Native C++

Syntax	enum EDataType
	{
	SRDT_UNKNOWN = 0,
	SRDT_BOOL = 1,
	SRDT_BYTE = 2,
	SRDT_CHAR = 3,
	SRDT_WORD = 4,
	SRDT_INT = 5,
	SRDT_DWORD = 6,
	SRDT_DINT = 7,
	SRDT_REAL = 8,
	SRDT_DATE = 9,
	SRDT_TIME_OF_DAY = 10,
	SRDT_TIME = 11,
	SRDT_S5TIME = 12,
	SRDT_DATE_AND_TIME = 14,
	SRDT_STRUCT = 17,
	SRDT_STRING = 19,
	SRDT_COUNTER = 28,
	SRDT_TIMER = 29,
	SRDT_IEC_Counter = 30,
	SRDT_IEC_Timer = 31,
	SRDT_LREAL = 48,
	SRDT_ULINT = 49,
	SRDT_LINT = 50,
	SRDT_LWORD = 51,
	SRDT_USINT = 52,
	SRDT_UINT = 53,
	SRDT_UDINT = 54,
	SRDT_SINT = 55,
	SRDT_WCHAR = 61,
	SRDT_WSTRING = 62,
	SRDT_LTIME = 64,
	SRDT_LTIME_OF_DAY = 65,
	SRDT_LDT = 66,
	SRDT_DTL = 67,
	SRDT_IEC_LTimer = 68,
	SRDT_IEC_SCounter = 69,
	SRDT_IEC_DCounter = 70,
	SRDT_IEC_LCounter = 71,
	SRDT_IEC_UCounter = 72,
	SRDT_IEC_USCounter = 73,
	SRDT_IEC_UDCounter = 74,
	SRDT_IEC_ULCounter = 75,
	SRDT_ERROR_STRUCT = 97,
	SRDT_NREF = 98,
	SRDT_CREF = 101,
	SRDT_AOM_IDENT = 128,
	SRDT_EVENT_ANY = 129,
	SRDT_EVENT_ATT = 130,
	SRDT_EVENT_HWINT = 131,
	SRDT_HW_ANY = 144,
	SRDT_HW_IOSYSTEM = 145,
	SRDT_HW_DPMASTER = 146,
	SRDT_HW_DEVICE = 147,
	SRDT_HW_DPSLAVE = 148,
	SRDT_HW_IO = 149,
	SRDT_HW_MODULE = 150,
	SRDT_HW_SUBMODULE = 151,
	SRDT_HW_HSC = 152,
	SRDT_HW_PWM = 153,
	SRDT_HW_PTO = 154,
	SRDT_HW_INTERFACE = 155,
	SRDT_HW_IEPORT = 156,
	SRDT_OB_ANY = 160,
	SRDT_OB_DELAY = 161,
	SRDT_OB_TOD = 162,
	SRDT_OB_CYCLIC = 163,
	SRDT_OB_ATT = 164,
	SRDT_CONN_ANY = 168,
	SRDT_CONN_PRG = 169,
	SRDT_CONN_OUC = 170,
	SRDT_CONN_R_ID = 171,
	SRDT_PORT = 173,
	SRDT_RTM = 174,
	SRDT_PIP = 175,
	SRDT_OB_PCYCLE = 192,
	SRDT_OB_HWINT = 193,
	SRDT_OB_DIAG = 195,
	SRDT_OB_TIMEERROR = 196,
	SRDT_OB_STARTUP = 197,
	SRDT_DB_ANY = 208,
	SRDT_DB_WWW = 209,
	SRDT_DB_DYN = 210,
	SRDT_DB = 257
	};

Table 7- 362 EDataType - .NET (C#)

Syntax	public enum EDataType
	{
	Unknown = 0,
	Bool = 1,
	Byte = 2,
	Char = 3,
	Word = 4,
	Int = 5,
	DWord = 6,
	DInt = 7,
	Real = 8,
	Date = 9,
	TimeOfDay = 10,
	Time = 11,
	S5Time = 12,
	DateAndTime = 14,
	Struct = 17,
	String = 19,
	Counter = 28,
	Timer = 29,
	IEC_Counter = 30,
	IEC_Timer = 31,
	LReal = 48,
	ULInt = 49,
	LInt = 50,
	LWord = 51,
	USInt = 52,
	UInt = 53,
	UDInt = 54,
	SInt = 55,
	WChar = 61,
	WString = 62,
	LTime = 64,
	LTimeOfDay = 65,
	LDT = 66,
	DTL = 67,
	IEC_LTimer = 68,
	IEC_SCounter = 69,
	IEC_DCounter = 70,
	IEC_LCounter = 71,
	IEC_UCounter = 72,
	IEC_USCounter = 73,
	IEC_UDCounte = 74,
	IEC_ULCounter = 75,
	ErrorStruct = 97,
	NREF = 98,
	CREF = 101,
	Aom_Ident = 128,
	Event_Any = 129,
	Event_Att = 130,
	Event_HwInt = 131,
	Hw_Any = 144,
	Hw_IoSystem = 145,
	Hw_DpMaster = 146,
	Hw_Device = 147,
	Hw_DpSlave = 148,
	Hw_Io = 149,
	Hw_Module = 150,
	Hw_SubModule = 151,
	Hw_Hsc = 152,
	Hw_Pwm = 153,
	Hw_Pto = 154,
	Hw_Interface = 155,
	Hw_IEPort = 156,
	OB_Any = 160,
	OB_Delay = 161,
	OB_Tod = 162,
	OB_Cyclic = 163,
	OB_Att = 164,
	Conn_Any = 168,
	Conn_Prg = 169,
	Conn_Ouc = 170,
	Conn_R_ID = 171,
	Port = 173,
	Rtm = 174,
	Pip = 175,
	OB_PCycle = 192,
	OB_HwInt = 193,
	OB_Diag = 195,
	OB_TimeError = 196,
	OB_Startup = 197,
	DB_Any = 208,
	DB_WWW = 209,
	DB_Dyn = 210,
	DB = 257
	}

7.8.7.11 ETagListDetails

Description

This list contains all PLC areas that can be used as a filter to update the tag table.

Table 7- 363 ETagListDetails - Native C++

Syntax	`enum ETagListDetails`
	`{`
	` SRTLD_NONE = 0,`
	` SRTLD_IO = 1,`
	` SRTLD_M = 2,`
	` SRTLD_IOM = 3,`
	` SRTLD_CT = 4,`
	` SRTLD_IOCT = 5,`
	` SRTLD_MCT = 6,`
	` SRTLD_IOMCT = 7,`
	` SRTLD_DB = 8,`
	` SRTLD_IODB = 9,`
	` SRTLD_MDB = 10,`
	` SRTLD_IOMDB = 11,`
	` SRTLD_CTDB = 12,`
	` SRTLD_IOCTDB = 13,`
	` SRTLD_MCTDB = 14,`
	` SRTLD_IOMCTDB = 15`
	`};`

Table 7- 364 ETagListDetails - .NET (C#)

Syntax	`enum ETagListDetails`
	`{`
	` None = 0,`
	` IO = 1,`
	` M = 2,`
	` IOM = 3,`
	` CT = 4,`
	` IOCT = 5,`
	` MCT = 6,`
	` IOMCT = 7,`
	` DB = 8,`
	` IODB = 9,`
	` MDB = 10,`
	` IOMDB = 11,`
	` CTDB = 12,`
	` IOCTDB = 13,`
	` MCTDB = 14,`
	` IOMCTDB = 15`
	`}`

7.8.7.12 ERuntimeConfigChanged

Description

This list contains all possible causes of a OnConfigurationChanged event that the Runtime Manager sends.

Table 7- 365 ERuntimeConfigChanged - Native C++

Syntax	`enum ERuntimeConfigChanged`
	`{`
	` SRCC_INSTANCE_REGISTERED = 0,`
	` SRCC_INSTANCE_UNREGISTERED = 1`
	` SRCC_CONNECTION_OPENED = 2,`
	` SRCC_CONNECTION_CLOSED = 3,`
	` SRCC_PORT_OPENED = 4,`
	` SRCC_PORT_CLOSED = 5`
	`};`

Table 7- 366 ERuntimeConfigChanged - .NET (C#)

Syntax	`enum ERuntimeConfigChanged`
	`{`
	` InstanceRegistered = 0,`
	` InstanceUnregistered = 1,`
	` ConnectionOpened = 2,`
	` ConnectionClosed = 3,`
	` PortOpened = 4,`
	` PortClosed = 5`
	`}`

7.8.7.13 EInstanceConfigChanged

Description

This list contains all possible causes for a OnConfigurationChanged event that the virtual controller sends.

Table 7- 367 EInstanceConfigChanged - Native C++

Syntax	`enum EInstanceConfigChanged`
	`{`
	` SRICC_HARDWARE_SOFTWARE_CHANGED = 0,`
	` SRICC_IP_CHANGED = 1`
	`};`

Table 7- 368 EInstanceConfigChanged - .NET (C#)

Syntax	`enum EInstanceConfigChanged`
	`{`
	` HardwareSoftwareChanged = 0,`
	` IPChanged = 1`
	`}`

Restrictions

8

8.1 Overview

Certain actions or events may lead to behavior in S7-PLCSIM Advanced or in STEP 7 which deviates from that of a hardware CPU. Restrictions and possible remedies can be found in the following sections:

- OPC UA server (Page 302)
- Web server (Page 304)
- Restrictions for communications services (Page 305)
- Restrictions for instructions (Page 306)
- Restrictions with Motion Control (Page 307)
- Restrictions to local communication via Softbus (Page 308)
- Error with overflow cyclical events (Page 309)
- Deviating I/O values in the STEP 7 user program (Page 310)
- Multiple simulations and possible collision of IP addresses (Page 310)
- Simulation in standby mode (Page 310)
- Error installing the antivirus software from Kaspersky (Page 311)

8.2 OPC UA server

With OPC UA, data exchange is performed through an open, standardized and manufacturer-independent communication protocol. The CPU acting as the OPC UA server can communicate with OPC UA clients, for example, with HMI panels V14 and SCADA systems.

For technical reasons, the security settings in PLCSIM Advanced differ from a hardware CPU. Some features are disabled for simulations or are available to a limited extent.

Configuring OPC UA server

Start the instances via the communication interface "PLCSIM Virtual Ethernet Adapter" (TCP/IP) to use the OPC UA server.

The OPC UA server functionality is not available if communication takes place via the Softbus.

OPC UA security settings

Based on the OPC UA security settings, the same settings can be made in STEP 7 for the hardware CPU. The data is not further processed by PLCSIM Advanced. This ensures that the user does not have his project change to perform a simulation.

Certificate

- **Server certificate**

  PLCSIM Advanced uses its own certificate in the firmware and not that of STEP 7. The certificate need not be changed for simulations. However, it does not have the same security level as a downloaded server certificate and cannot be used for secure connections!

- **Server Security Endpoints**

  PLCSIM Advanced only supports Security Endpoint "none".

- **Client certificate**

  PLCSIM Advanced does not evaluate certificates the imported and configured in STEP 7 . PLCSIM Advanced accepts all client certificates automatically. This setting cannot be changed.

- **User authentication**

  PLCSIM Advanced does not use the user name configured in STEP 7.

  Only one logon is possible as "guest" or "anonymous".

8.3 Web server

The Web server integrated in a CPU enables monitoring and administering of the CPU by authorized users over a network. This permits evaluation and diagnostics over long distances.

The simulation of the Web server is restricted under S7-PLCSIM V1.0 Advanced.

Each PLCSIM Advanced instance can simulate its own Web server.

The freeze state of a virtual controller is not shown as an internal operating state.

Configuring the Web server

S7 PLCSIM Advanced

Start the instances via the communication interface "PLCSIM Virtual Ethernet Adapter" (TCP/IP) to use the Web server.

The Web server functionality is not available if the communication is performed via the Softbus.

STEP 7

Configure the Web server in STEP 7 in the CPU properties.

Restricted Web server functionality

- Logon

  "PLCSIM" is preset as the user. There is no logon for users.

  A user configured in STEP 7 and his rights have no effect on the "PLCSIM" user.
- There is no access via the secure transmission protocol "HTTPS".
- The information may not be fully displayed on some websites due to different data handling.
- There is no topology information.
- "Online Backup&Restore" is not available.
- FW updates are not supported.

8.4 Restrictions for communications services

TUSEND / TURCV

When you run the UDP blocks TUSEND and TURCV via the "PLCSIM" communication interface (Softbus), you get error code 0x80C4 at the transmission end and receiving end:

Temporary communications error. The specified connection is temporarily down.

Remedy

Set "PLCSIM Virtual Ethernet Adapter" (TCP/IP) as the communication interface in PLCSIM Advanced.

8.5 Restrictions for instructions

S7-PLCSIM Advanced simulates instructions for CPUs S7-1500 and ET 200SP with a few exceptions, such as interrupts.

Some instructions are partially supported. For these, S7-PLCSIM Advanced checks the input parameters for validity and returns outputs that are valid but do not necessarily correspond to those that a real CPU with physical inputs/outputs would return.

Instructions not supported

Unsupported instructions are handled as not ready by S7-PLCSIM Advanced, their value is always "OK".

S7PLCSIM Advanced does not support the following instructions:

Table 8- 1 Instructions not supported

Instruction	Description
DIS_AIRT	Delay interrupts with higher priority and asynchronous errors
EN_AIRT	Activate interrupts with higher priority and asynchronous errors
DIS_IRT	Call new interrupts and disable asynchronous error
RE_TRIGR	Start time monitoring
WR_DPARM	Transfer data record
GETIO	Read process image
SETIO	Transfer process image
GETIO_PART	Read a part of the outputs of a DP standard slave / PROFINET IO device
SETIO_PART	Write a part of the outputs of a DP standard slave / PROFINET IO device
DPRD_DAT	Read consistent data of a standard DP slave
DPWR_DAT	Write consistent data to a standard DP slave
RD_OBINF	Read OB start information
DP_TOPOL	DP bus topology
PORT_CFG	Safety function
ATTACH	Assigning a hardware interrupt to an OB
DETACH	Removing the mapping between hardware interrupt and OB

8.6 Restrictions with Motion Control

8.6.1 Motion Control resources

There are motion control resources on each CPU that can be distributed to the technology objects.

Note

Maximum 5120 Motion Control resources

PLCSIM Advanced supports a maximum of 5120 motion control resources. The simulation of motion control is therefore restricted for the following CPUs:

Table 8- 2 CPUs with limited Motion Control resources

Type		Article number
Standard CPUs	CPU 1517-3 PN/DP	6ES7517-3AP00-0AB0
	CPU 1518-4 PN/DP	6ES7518-4AP00-0AB0
	CPU 1518-4 PN/DP ODK[1]	6ES7518-4AP00-3AB0
Fail-safe CPUs	CPU 1517F-3 PN/DP	6ES7517-3FP00-0AB0
	CPU 1518F-4 PN/DP	6ES7518-4FP00-0AB0
	CPU 1518F-4 PN/DP ODK[1]	6ES7518-4FP00-3AB0
Technology CPUs	CPU 1517T-3 PN/DP[2]	6ES7517-3TP00-0AB0
	CPU 1517TF-3 PN/DP[2]	6ES7517-3UP00-0AB0

1 The ODK functionality of this CPU is not simulated.

2 The simulation of this CPU supports only 64 cams.

Exceeding the quantity structure

STEP 7 checks whether the quantity structure for a configured CPU is complied with, and alerts you when it is exceeded. When you load a project into a CPU, another message appears.

Note

A project that uses more than 5120 motion control resources can be downloaded to a virtual controller. However, there is no message indicating that the quantity structure has been exceeded.

Only when the user program accesses the technology objects do you recognize by the error message at the block and the value 0 of the object that motion control objects cannot be used due to an overrun of the quantity structure.

8.6.2 Technology modules

PLCSIM Advanced simulates the real CPU, but not configured, connected technology modules or other I/O devices.

It is possible to download a project with technology modules for operation of motion control. However, the built-in logic of the technology modules is not part of the simulation, which is why the associated Motion Control instructions are not supported.

Additional information

For more information on Motion Control, refer to the following manuals:

- Device manuals to support SIMATIC controllers (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx)
- Function manual S7-1500 Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109739589)
- Function manual S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109481326)

8.7 Restrictions to local communication via Softbus

Identical IP addresses for instances

If the "PLCSIM" communication interface (Softbus) is set, then identical IP addresses are created automatically for all instances when creating the instances through the Control Panel.

In STEP 7, only one instance is therefore displayed in the lifelist.

Remedy

Use the API function `SetIPSuite()` to assign a unique address for each instance, then all instances are displayed in STEP 7 with their IP addresses.

API function

- SetIPSuite() (Page 122)

Online and diagnostics

If the "PLCSIM" (Softbus) communication interface is set, no details are displayed for the "Online and Diagnostics" function under the PROFINET interface (IP address, MAC address, etc.).

See also

Controller - Information and settings (Page 119)

8.8 Restrictions of security with VMware vSphere Hypervisor (ESXi)

When you use the virtualization platform VMware vSphere Hypervisor (ESXi), you must change the policy exception to communicate over TCP/IP.

Remedy

Accept the "Promiscuous mode and "Forged transmit" options for the Virtual Switch of the ESXi.

NOTICE
Restrictions of security For security reasons, Promiscuous mode is disabled by default. If you accept the Promiscuousmode, the real Ethernet adapter even receives telegrams that are not addressed to it.

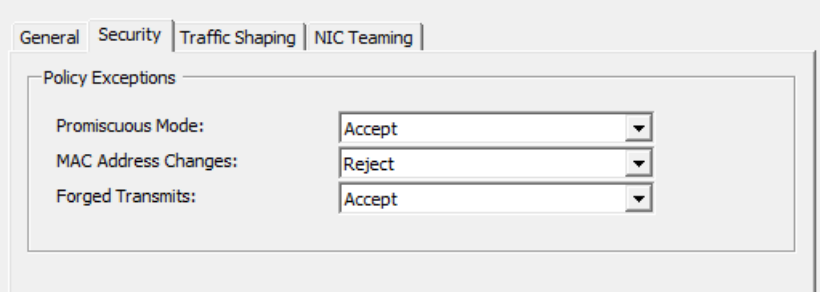


Figure 8-1 Policy exceptions for VMware vSphere Hypervisor (ESXi)

8.9 Error with overflow cyclical events

If your simulation contains cyclic interrupts, the queue of PLCSIM Advanced may overflow for cyclic events. Due to the execution speed of PLCSIM Advanced compared to real hardware, the time required to create the diagnostics buffer entry may be longer than the time until the next cyclic interrupt.

In this case, an additional entry is placed in the queue, causing another overflow. In the event of an overflow, PLCSIM Advanced provides visual information in the form of diagnostics buffer messages and a red error icon in the project tree.

See also

Speed up and slow down simulation (Page 60)

8.10 Deviating I/O values in the STEP 7 user program

Updated values

Each value change made by a STEP 7 user program in the I/O address areas is overwritten in the cycle control point with the updated value that was written via the API functions `Write...()`. The API functions `Read...()` only return this updated value and not the value from STEP 7 **for the input range**.

Non-updated values

If the value was not updated via the API functions `Write...()`, the API functions `Read...()` return the value from STEP 7 **for the output range**.

See also

Simulate peripheral I/O (Page 53)

8.11 Multiple simulations and possible collision of IP addresses

You can simultaneously simulate multiple CPUs, but each simulated CPU interface requires a unique IP address.

Make sure your CPUs have different IP addresses before starting the simulation.

8.12 Lacking access to an IP address

Special feature of distributed communication

If you use multiple network nodes on the same subnet through different virtual or real adapters, the operating system may search for the node on the wrong adapter.

Remedy

Repeat your requests or enter "arp -d <IP address>" in the command line editor of Windows.

8.13 Simulation in standby mode

If your computer or programming device goes into standby or hibernation mode, the simulation may be stopped. In this case, the communication between STEP 7 and S7-PLCSIM Advanced is stopped. When your computer or programming device starts up again, the communication may need to be reestablished. In some cases, it may also be necessary to open the simulation project again.

To prevent this situation, disable the standby mode on your computer or programming device.

8.14 Error installing the antivirus software from Kaspersky

When using the Anti-Virus virus scanner from Kaspersky, network settings may not be correctly during installation of PLCSIM Advanced. The result is that communication via TCP/IP cannot be used (error code -50 in the Control Panel).

Remedy

Check your network settings as described in the sectionEnable distributed communication (Page 43).

List of abbreviations

A

Abbreviation	Term
ALM	Automation License Manager Tool for managing license keys in STEP 7
API	Application Programming Interface user interface
arp	Address resolution protocol
BCD	Binary Coded Decimal
CPU	Central Processing Unit (Synonym for PLC)
ES	Engineering System
HMI	Human Machine Interface user interface
IE	Industrial Ethernet
GUI	Graphical User Interface
LAN	Local Area Network Computer network that is limited to a local area.
OB	Organization Block
ODK	Open Development Kit
OPC UA	Open Platform Communications Unified Architecture
PG	Programming device
PLC	Programmable Logic Controller
PN	PROFINET
RAM	Random Access Memory
RT	Runtime
TIA	Totally Integrated Automation
UTC	Coordinated Universal Time
VM	Virtual Machine
VPLC	Virtual Programmable Logic Controller
WinCC	Windows Control Center

SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro

Diagnostics

Function manual

Edition 09/2016

siemens.com

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SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro Diagnostics

Function Manual

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09/2016

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This function manual provides an overview of the diagnostics options for the automation system SIMATIC S7-1500, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL.

The documentation covers the following:

- Illustration of the uniformity and consistency of system diagnostics
- Overview of the options for establishing system diagnostics information

Basic knowledge required

The following knowledge is required in order to understand the function manual:

- General knowledge in the field of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of working with STEP 7 and WinCC
- Knowledge about the use of Microsoft Windows operating systems

Scope of the documentation

This documentation is the basic documentation for all products of the S7-1500, ET 200MP, ET 200SP and ET 200AL systems, as well as for CPU 1516pro-2 PN. The product documentation is based on this documentation.

What's new compared to the previous version of the function manual (06/2014 edition)

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Extended functionality of the Web server	• You obtain information about: – Know-how protection or copy protection of the PLC program – Program/communication load and cycle time – F-collective signatures, cycle times and runtimes of the F-runtime group(s) (with an F-CPU) • You can monitor statuses, errors, technology alarms and the current values of technology objects (TOs) with the Web server. • You can read, view and save trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance without STEP 7. • You can set four additional languages for the Web interface.	Section Diagnostics information using the web server (Page 49), Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual, Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/ww/en/view/64897128) function manual
	Assignment of different project languages extended	You can assign up to three different project languages for comments and alarm texts to the user interface languages of display devices.	Section Editing alarms in the alarm editor (Page 78)
Changed contents	Scope of the function manual expanded to include CPU 1516pro-2 PN	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in the CPU 1516pro-2 PN (degree of protection IP65, IP66 and IP67).	Operating instructions CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)
	Security events added	You know which types of events are registered as security events in the diagnostics buffer and can configure group alarms for them.	Section CPU diagnostics buffer (Page 43)
	Influence of the value status explained	You know which factors influence the bit in the value status and can take this into account during configuration.	Section System diagnostics using process image inputs (Page 72)
	Note added on the maximum configuration limits of program alarms.		Section Creating alarms with the "Program_Alarm" instruction (Page 76).

Conventions

STEP 7: We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This document contains illustrations of the described devices. The illustrations may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

Note

A note contains important information on the product, on the handling of the product or on the section of the documentation to which particular attention should be paid.

See also

SIMATIC Portal (http://www.siemens.com/simatic-tech-doku-portal)

Catalog (http://mall.automation.siemens.com)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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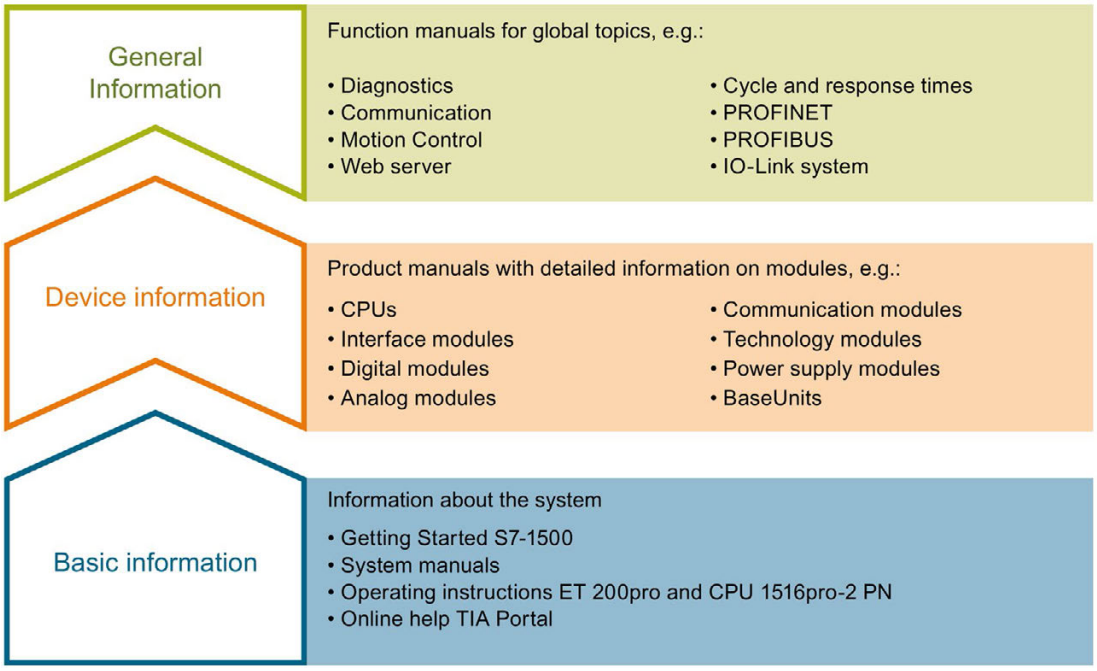
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

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You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Overview of system diagnostics

2

2.1 Properties of system diagnostics

Introduction

In the SIMATIC environment, the term "system diagnostics" refers to diagnostics of devices and modules.

All SIMATIC products have integrated diagnostic functions that you can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information. You can minimize unscheduled standstill times with plant-wide diagnostics.

The SIMATIC automation system monitors the following states in the running plant:

- Device failure/recovery
- Insert/remove event
- Module fault
- I/O access error
- Channel fault
- Parameter assignment error
- Failure of the external auxiliary voltage

Properties ofSIMATIC system diagnostics

- Integrated as standard in the hardware
- System-wide across bus limits
- Automatic localization of the error source
- Automatic output of the cause of the error in plain text
- Plant-wide diagnostics of all components
- Archiving and logging of alarms
- Configurability of alarms

Consistent diagnostics from the field level all the way to the management level

The various diagnostics media give you a uniform view of maintenance-related information of every automation component in the plant: System status (module and network status, alarms for system errors) are available plant-wide in a uniform display.

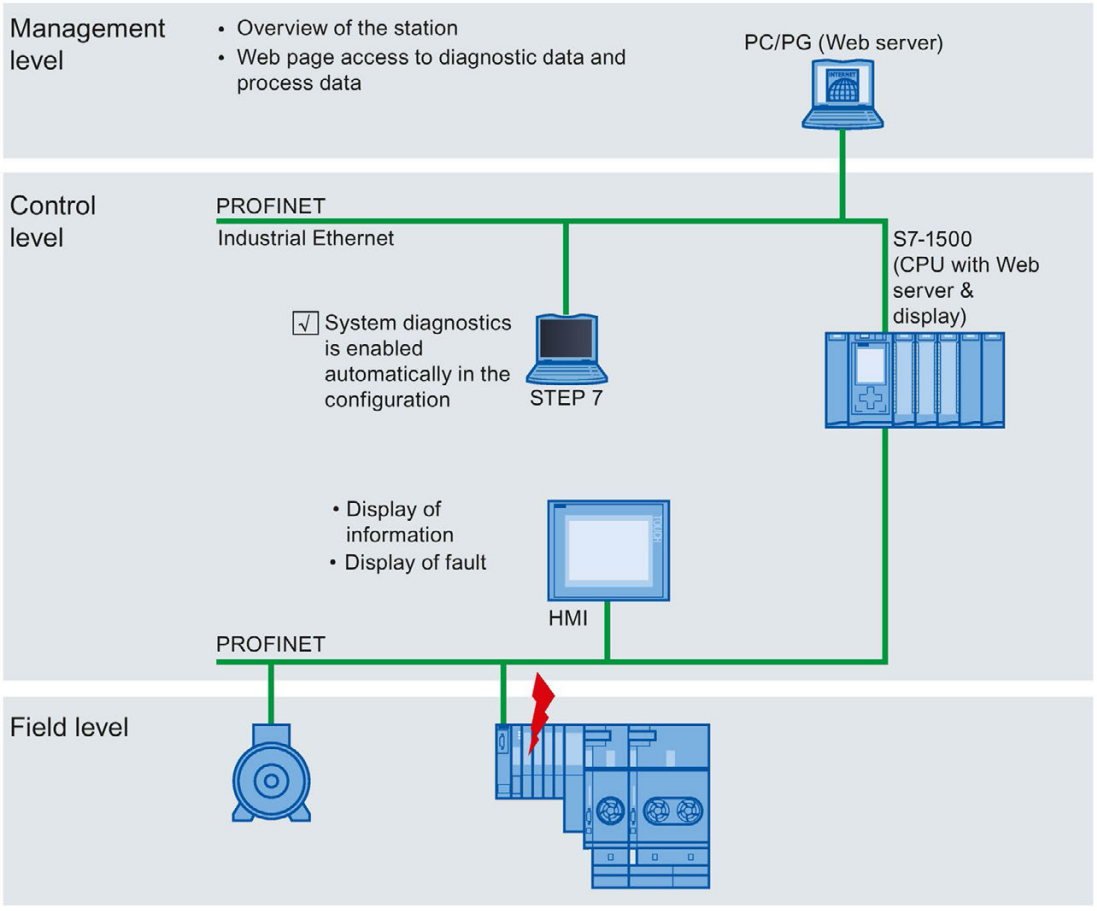


Figure 2-1 Overview of system diagnostics in a plant

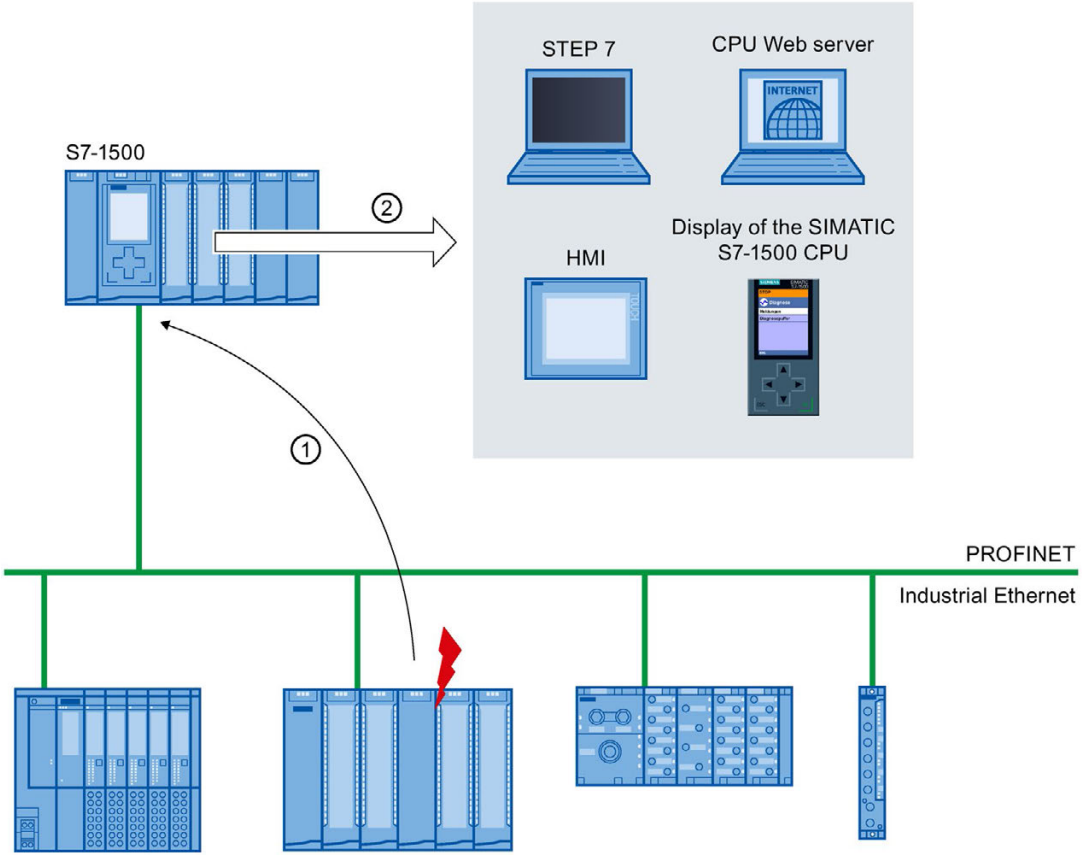
2.2 Benefits of innovative system diagnostics

System diagnostics is also possible in STOP

The system diagnostics is integrated in the firmware of the CPU and works independently of the cyclic user program. This means it is also available in the STOP CPU operating mode. Faults are detected immediately and signaled to the higher-level HMI devices, the Web server and the display of the SIMATIC S7-1500 CPU, even in STOP mode. This makes system diagnostics consistent with the actual plant state at all times.

Uniform display concept

All clients of a system are provided with diagnostics information by a uniform mechanism. The same system diagnostics information is used regardless of the display medium.



Step	Description
①	The device detects an error and sends diagnostics data to the assigned CPU.
②	The CPU informs the connected display media. The display of the system diagnostics is updated.

Figure 2-2 Sequence of the system diagnostics

Quick start

3

Introduction

The following chapters of this documentation describe the different options for establishing system diagnostics. All described options can be used independently of one another.

This chapter gives you an overview of the basic procedure to get initial diagnostics information fast.

Note

System diagnostics is generally available for the devices of the SIMATIC series.

3.1 Using the display of the CPU

The display of the SIMATIC S7-1500 CPU offers a fast and direct option to get diagnostics information. You can call up status information in different menus on the display.

Requirements

- A project has been created.
- The project has been downloaded to the CPU.

Determining diagnostics information using the display of the SIMATIC S7-1500 CPU

To determine diagnostics information using the display, follow these steps:

1. Select the "Diagnostics" menu on the display.
2. Select the "Diagnostics buffer" command from the "Diagnostics" menu.

Figure 3-1 Display of SIMATIC S7-1500 CPU

Result

The diagnostics events are displayed in the diagnostics buffer in the sequence in which they occur.

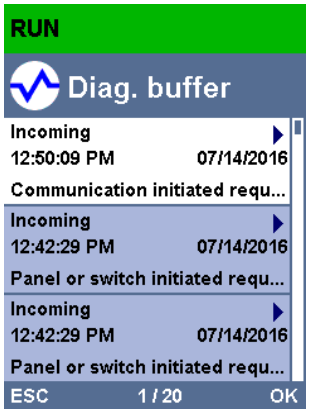


Figure 3-2 Display of the diagnostics buffer in the display of the SIMATIC S7-1500 CPU

Note

Automatic updating of diagnostics information

You set automatic updating of the diagnostics information under: "Display" > "DiagnosticRefresh".

Additional information

You can find information about the configuration of alarms in the section Configuring alarms for system diagnostics (Page 24).

3.2 Using STEP 7

Getting started with STEP 7 gives you fast access to detailed diagnostics information.

Requirements

- A project has been created.
- The project has been downloaded to the CPU.
- An error has occurred.
- The programming device must be able to establish a connection to the CPU via an interface.

Determining diagnostics information using STEP 7

To determine diagnostics information using STEP 7, follow these steps:

1. Open the respective project in STEP 7.
2. Open the portal view of STEP 7.
3. Select the "Online & Diagnostics" portal.
4. Select the "Online status" action.

   The "Select device" dialog opens. The dialog is an image of the configured devices in the project.

Figure 3-3 Device selection for online connection in the portal view

5. Activate the "Go online" option button for the device that you want to use to establish an online connection.
6. Click on the "Go online" button.

7. The "Go online" dialog opens.

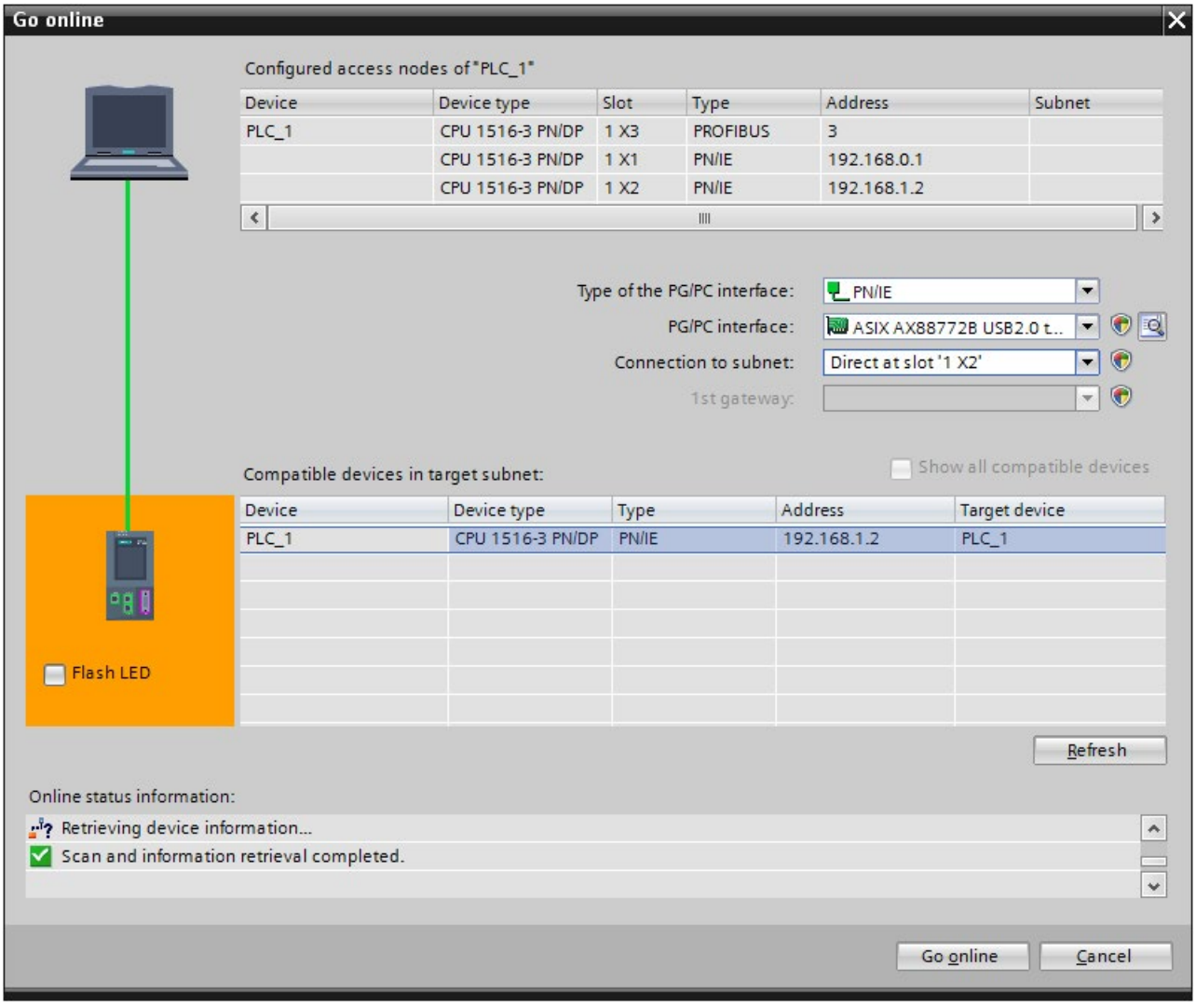


Figure 3-4 Establishing an online connection

8. Make the settings for the interface.

9. Click on the "Go online" button.

   The project view of STEP 7 opens. The network view is opened in the work area.

   The symbols in the project tree provide initial information about the faulty modules.

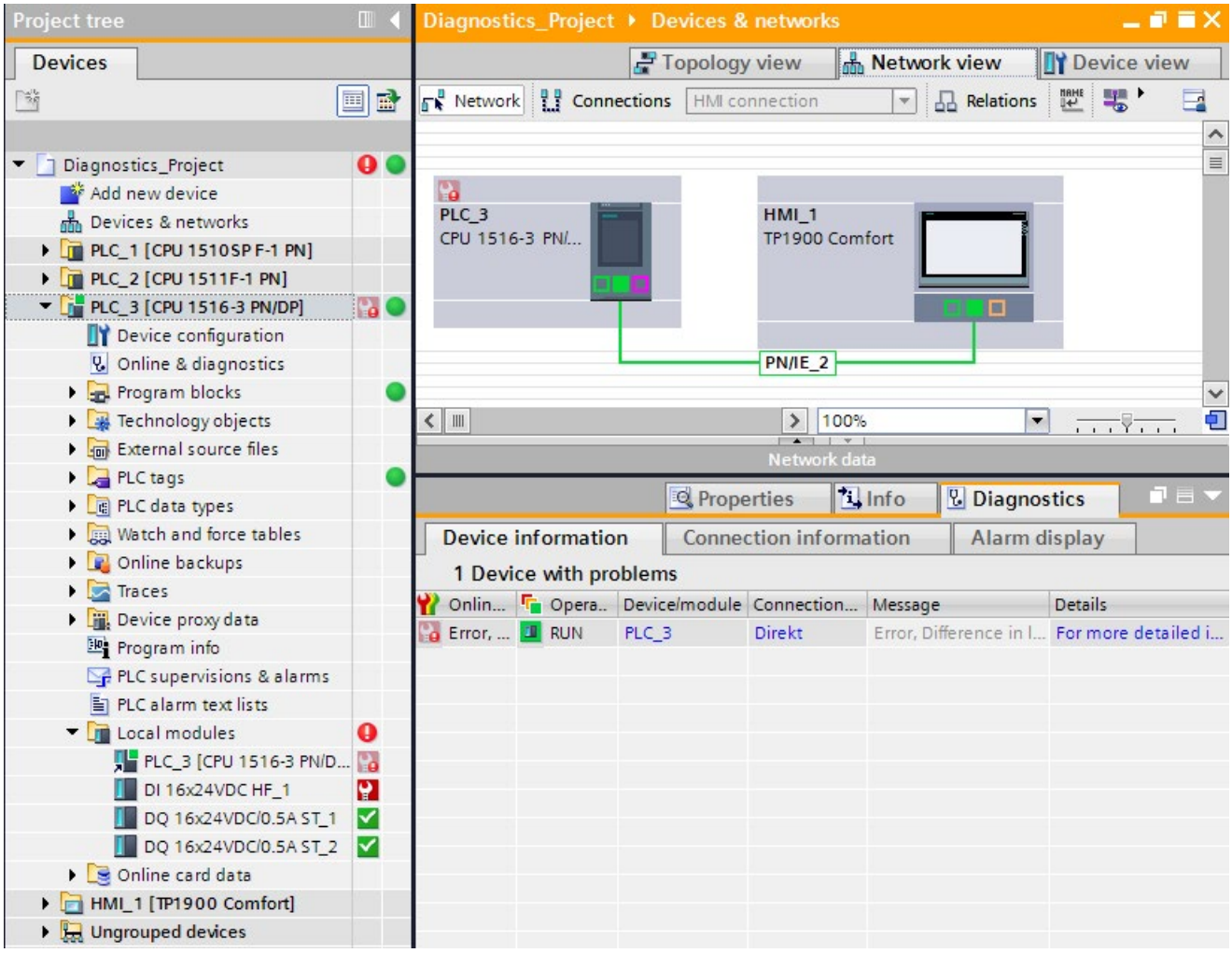


Figure 3-5 Display of the fault in the network view

10. Double-click the device which displays an alarm message to access the faulty module directly. This is the CPU in the example.

    The device view of the CPU is opened in the work area. In this view you can see directly in which module the error has occurred.

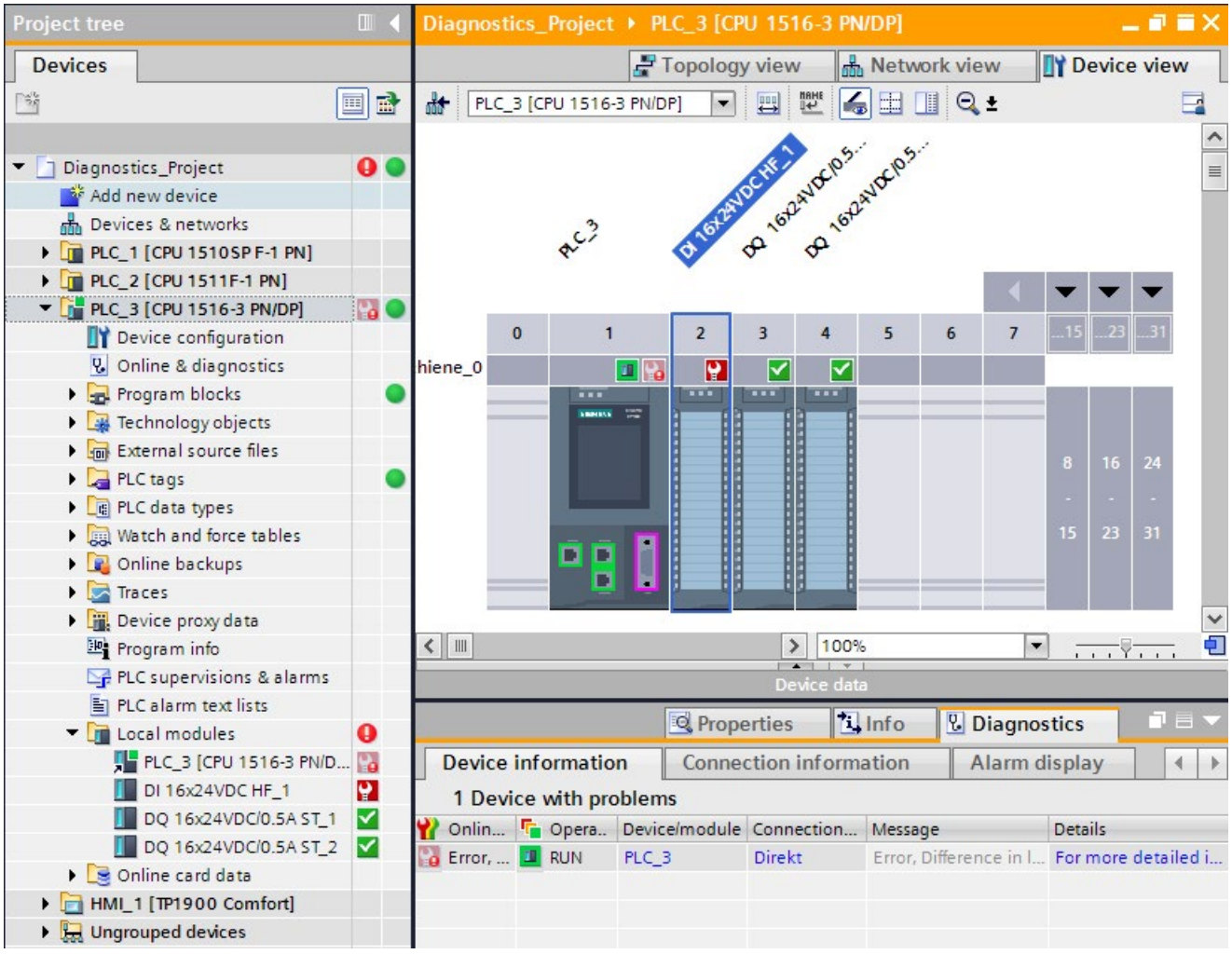


Figure 3-6 Display of the faulty module in the device view

11. Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

Result

The link in the "Details" table column takes you to the online and diagnostics view of the device and to the diagnostics buffer there, for example. This includes more information on all diagnostics events in the order in which they occurred.

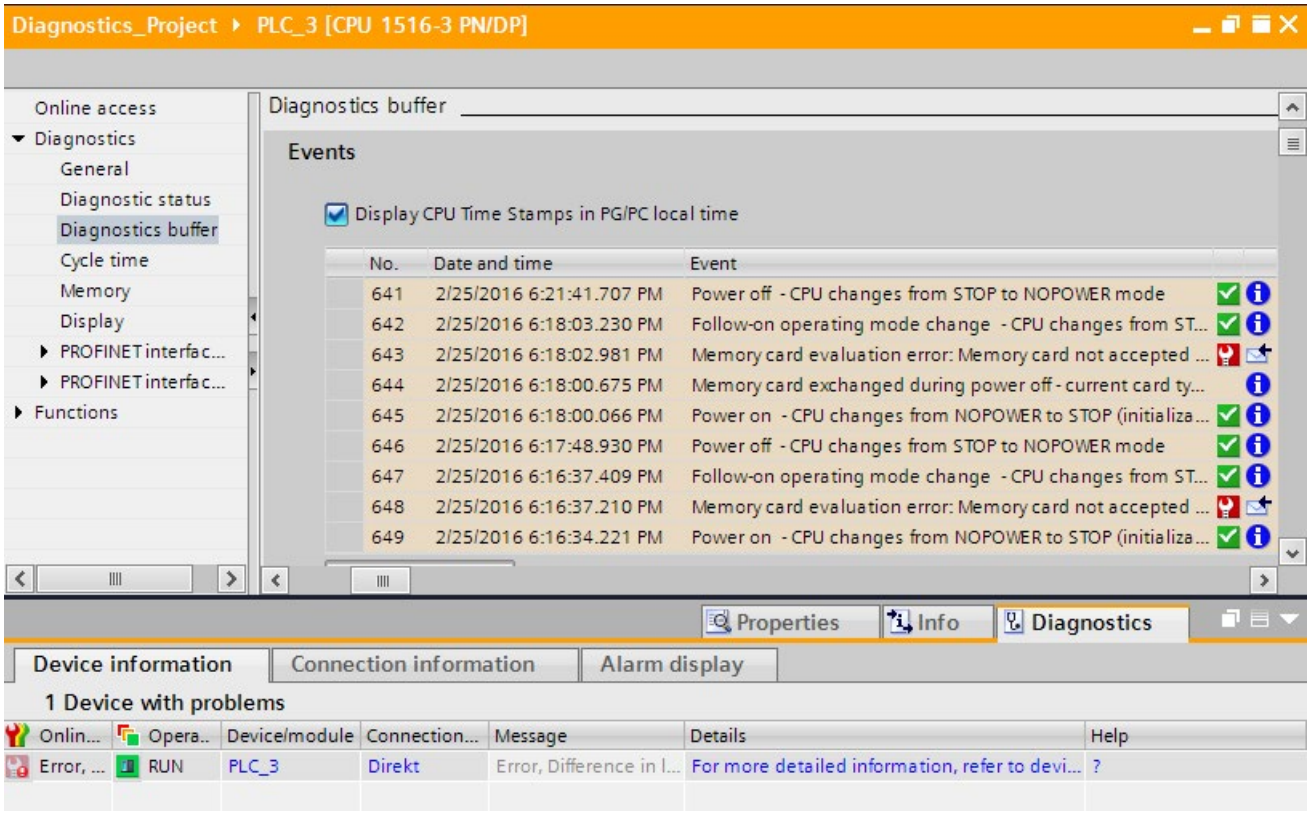


Figure 3-7 Diagnostics buffer with detailed error description

Note

Symbols and their meaning

You can find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 30) and in the online help for STEP 7.

Setting and determining system diagnostics

4

Introduction

System diagnostics is generally available for the devices of the SIMATIC series.

In the properties of each individual CPU, you can specify if you want to receive alarms for system diagnostics on your display device. Alarms are provided on the display of the SIMATIC S7-1500 CPU, the CPU Web server and the HMI device. Alarms are enabled by default. If you do not want to receive alarms for system diagnostics on your display devices, you can disable the sending of alarms.

4.1 Configuring alarms for system diagnostics

Predefined alarm texts are available for establishing the system diagnostics.

Requirements

- STEP 7 is open.
- A project is open.

Procedure

To make alarm settings for system diagnostics of the project in STEP 7, follow these steps:

1. Open the "Common data" folder in the project tree.
2. Double-click the "System diagnostics settings" entry.

   You now have access to the alarm settings. System diagnostics is enabled by default. System diagnostics cannot be disabled for the use of a CPU from the SIMATIC S7-1500 product series.

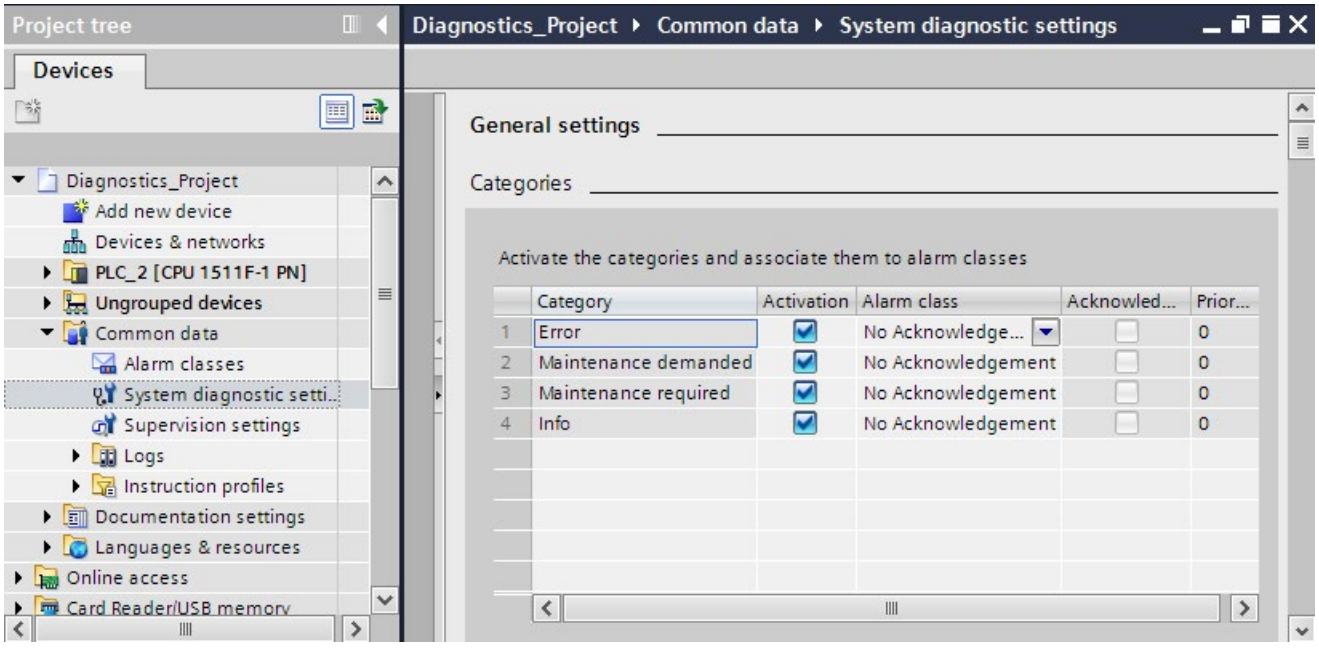


Figure 4-1 Properties of system diagnostics and alarm settings

3. In the settings, specify the alarm category that is to be displayed and if it needs to be acknowledged.

   The check boxes in the "Activation" column are enabled by default. When you disable all check boxes, the status of the HMI system diagnostics view is still updated with the "Info Report" functionality.

Result

You have configured the alarms for system diagnostics of the project in STEP 7.

The settings are saved with the project and become effective after the compiling and downloading of the hardware configuration to the involved components.

Maintenance events (maintenance demanded, maintenance required) are entered in the alarm buffer of the CPU just like any other event.

4.2 Options for displaying system diagnostics

Example

This section includes a diagnostics example to show how system diagnostics is established with the help of different display options. The example includes a CPU from the SIMATIC S7-1500 product series that is connected to an ET 200S distributed I/O system and an HMI Comfort Panel via PROFINET.

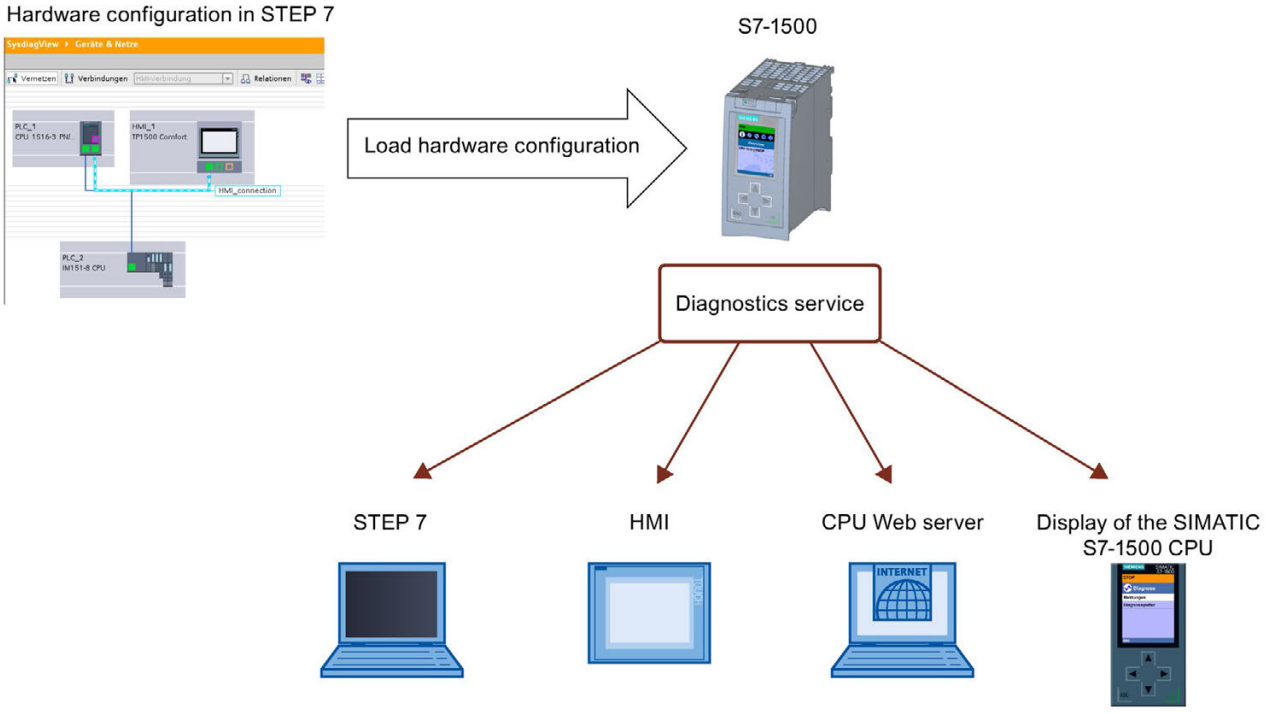


Figure 4-2 System diagnostics display options

The following sections include figures that illustrate how diagnostics information is displayed with the help of different display options.

- Using the LEDs on the hardware (Page 27)
- Local error analysis via the display of the CPU (Page 28)
- Using STEP 7 as of V12 (Page 30)
- Remote diagnostics using the Web server (Page 49)
- Stationary system diagnostics using the HMI diagnostics view (Page 59)

4.2.1 Diagnostics information at the devices

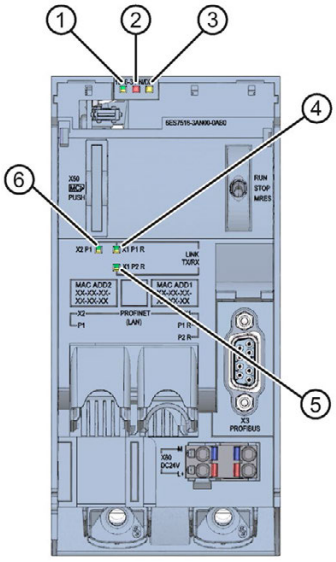
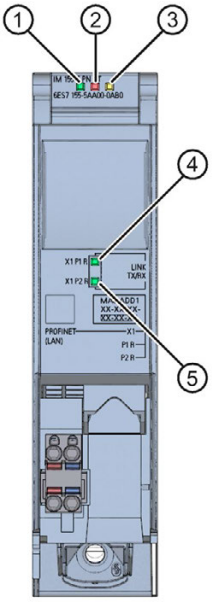
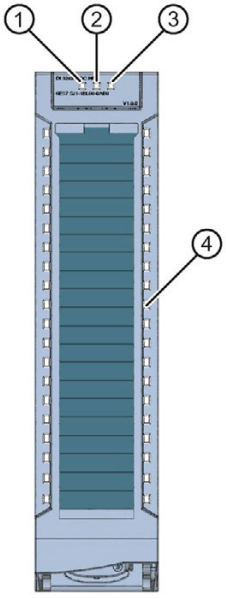
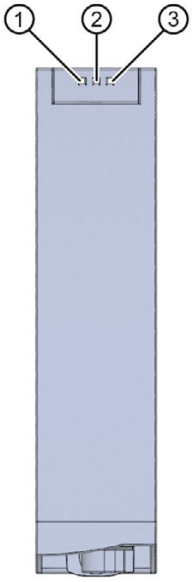
4.2.1.1 LEDs

Overview

All hardware components, such as CPUs, interface modules and modules, provide information about their operating mode as well as internal and external errors through their LEDs. Diagnostics by means of LEDs is an initial tool for error localization.

The graphics below include examples for the arrangement of LEDs on some modules.

Table 4- 1 LED displays on the modules

	CPU 1516-3 PN/DP	IM 155-5 PN ST	DI 32x24VDC HF	PS 25W 24VDC
				
①	RUN/STOP LED (two-colored LED: green/yellow)	RUN LED (two-colored LED: green/yellow)	RUN LED (single-colored LED: green)	RUN LED (single-colored LED: green)
②	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)
③	MAINT LED (single-colored LED: yellow)	MAINT LED (single-colored LED: yellow)	without function	MAINT LED (single-colored LED: yellow)
④	X1 P1 (two-colored LED: green/yellow)	X1 P1 (single-colored LED: green)	LED CHx (two-colored LED: green/red)	
⑤	X1 P2 (two-colored LED: green/yellow)	X1 P2 (single-colored LED: green)		
⑥	X2 P1 (two-colored LED: green/yellow)			

Additional information

The meaning of the individual LED displays, their different combinations and the remedial measures resulting from them in case of errors are device-specific. The explanation can be found in the manuals of the modules.

4.2.1.2 Display of the CPU

Introduction

Each CPU in the S7-1500 automation system has a front cover with a display and operating keys. You can display status information in various menus on the display of the CPU. You use the operating keys to navigate through the menus.

Figure 4-3 Display - diagnostics screen

Display options

The display of the SIMATIC S7-1500 CPU shows the following diagnostics information:

- CPU operating mode

"Diagnostics" menu

- Active diagnostic alarms
- Information entered in the diagnostics buffer
- Error and alarm texts (system diagnostics alarms)
- Watch tables
- Information on the cycle times of the user program
- Utilization of the CPU memory

"Modules" menu

- Information on modules and the network
- Detailed device view with diagnostics symbols
- Order number, CPU version and central I/O modules
- Module status for central and distributed modules
- Information about the currently installed firmware

Additional information

For additional information on the topic "Functions and operation of the display of the SIMATIC S7-1500 CPU", see the documentation for the S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792).

You can find detailed information on the individual options, a training course and a simulation of the available menu commands of the display for the CPU in the SIMATIC S7-1500 Display Simulator (http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_en.html).

4.2.2 Diagnostics information in STEP 7

4.2.2.1 Explanation of diagnostics symbols

Diagnostics symbols for modules and devices

When the online connection to a device is established in STEP 7, the diagnostics status of the device and its lower-level components and, if applicable, the device operating mode are also determined. The following table shows the possible symbols and their meaning.

Table 4- 2 Diagnostics symbols for modules and devices

Symbol	Meaning
	The connection with a CPU is being established.
	The CPU is not reachable at the set address.
	The configured CPU and the CPU actually present are of incompatible types. Example: An existing CPU 315-2 DP is incompatible with a configured CPU 1516-3 PN/DP.
	On establishment of the online connection to a protected CPU, the password dialog was terminated without specification of the correct password.
	No fault
	Maintenance required
	Maintenance demanded
	Error
	The module or device is deactivated.
	The module or the device cannot be reached from the CPU (valid for modules and devices below a CPU).
	Diagnostics data is not available because the current online configuration data differ from the offline configuration data.
	The configured module or device and the module or device actually present are incompatible (valid for modules or devices under a CPU).
	The configured module does not support display of the diagnostics status (valid for modules under a CPU).
	The connection is established, but the module status has not yet been determined or is unknown.
	Hardware error in lower-level component: A hardware fault has occurred in at least one lower-level hardware component (occurs as a separate symbol only in the project tree).

Symbols for the comparison status

The diagnostics symbols can be combined at the bottom right with additional smaller symbols that indicate the result of the online/offline comparison. The following table shows the possible comparison symbols and their meaning.

Table 4- 3 Symbols for the comparison status

Symbol	Meaning
	Hardware error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level hardware component.
	Software error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level software component.
	Online and offline versions of the object are different
	Object only exists online
	Object only exists offline
	Online and offline versions of the object are the same

Operating mode symbols for CPUs and CPs

The following table shows the possible symbols and their respective operating states.

Table 4- 4 Operating mode symbols for CPUs and CPs

Symbol	Operating mode
	RUN
	STOP
	STARTUP
	DEFECTIVE
	Unknown operating mode
	The configured module does not support display of the operating mode.

Event table

The following information is displayed in the table for each diagnostics event:

- Sequential number of the entry

  The first entry contains the latest event.
- Date and time of the diagnostics event

  If no date and time are shown, the module has no integrated clock.
- Short designation of the event and, if applicable, the reaction of the CPU
- Symbol for information on incoming/outgoing status

The following table shows the possible symbols and their meaning.

Table 4- 5 Symbols in the event table

Symbol	Meaning
	Incoming event
	Outgoing event
	Incoming event for which there is no independent outgoing event
	User-defined diagnostics event

Additional information

For additional information on the individual symbols, please refer to the online help for STEP 7.

4.2.2.2 Accessible devices (without project)

Accessible devices

Accessible devices are all devices that are connected to a PG/PC either directly by an interface or by means of a subnet and that are switched on. These devices can display diagnostic information even without an offline project.

Requirements

- STEP 7 is open.
- The portal view or project view is open.

Procedure

To display diagnostic information for specific devices even without an offline project, follow these steps:

1. Establish a connection to the respective CPU.
2. Select the command "Accessible devices" from the "Online" menu.

   The "Accessible devices" dialog opens.

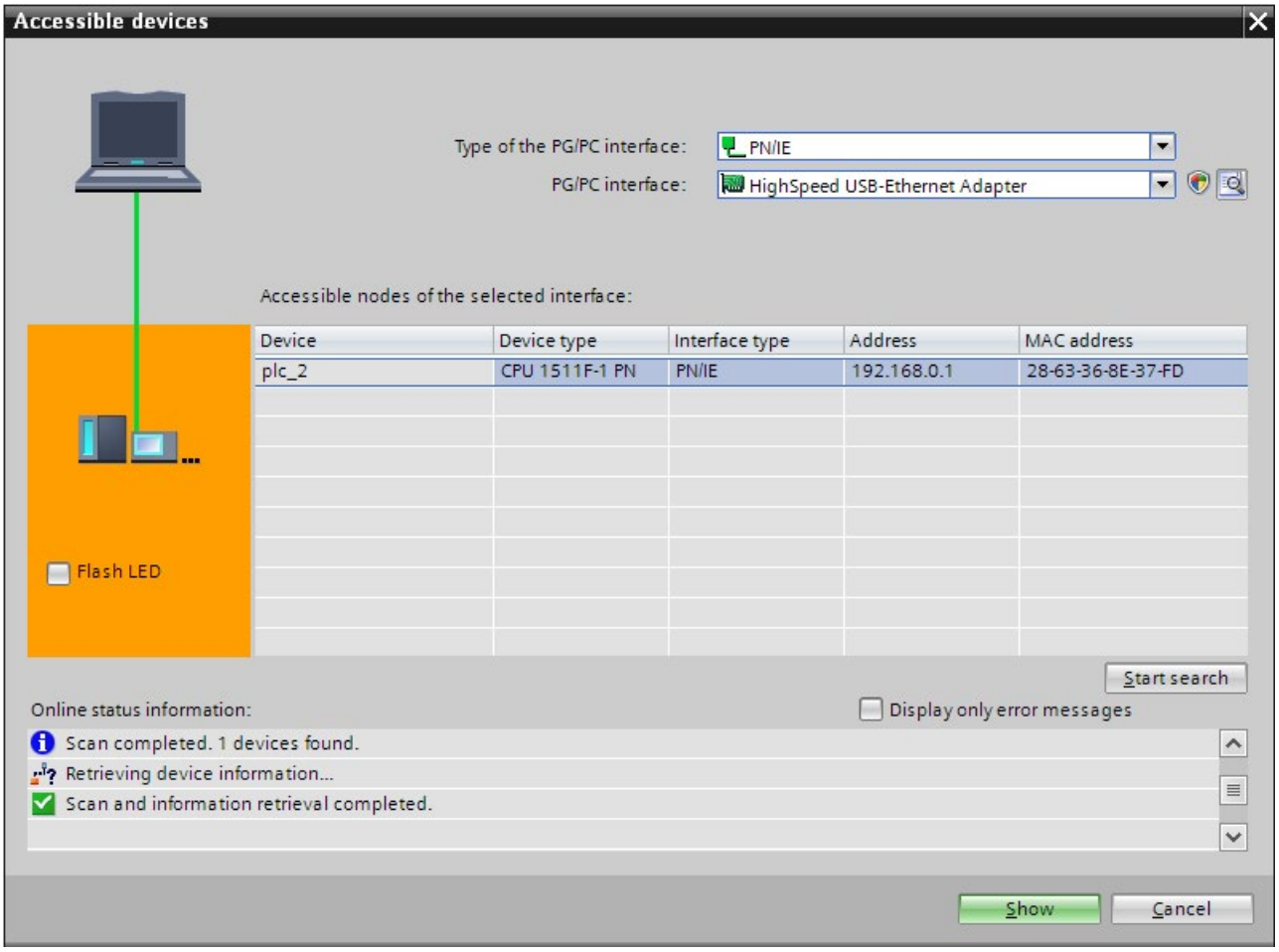


Figure 4-4 "Accessible devices" dialog

3. Make the settings for the interface.
4. Select the respective device under "Accessible nodes of the selected interface".
5. Confirm the dialog with the "Display" button.

Result

The device is displayed in the project tree. You open the diagnostic information in the work area with a double-click on "Online & Diagnostics".

Information is available on the diagnostic status, cycle times, memory usage and the diagnostics buffer.

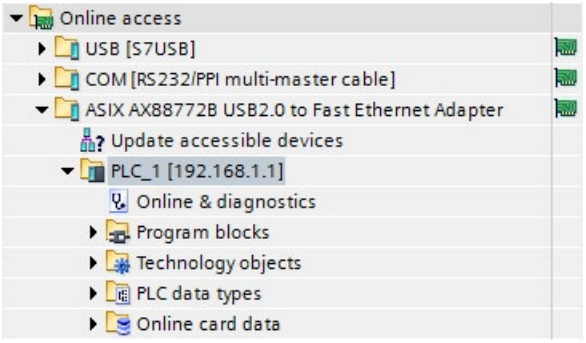


Figure 4-5 Device in the project tree

4.2.2.3 Devices & networks

Devices & networks - Go online

You can get an overview of the current state of your automation system in the device view or network view.

You implement the following tasks in the device view:

- Device configuration and parameter assignment
- Module configuration and parameter assignment

You implement the following tasks in the network view:

- Device configuration and parameter assignment
- Networking devices

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.

Procedure

To get an overview of the current state of your automation system, follow these steps:

1. Open the "Network view" in the working area.
2. Select the CPU.
3. Click the "Go online" Go online button in the toolbar.

   The "Go online" dialog opens.

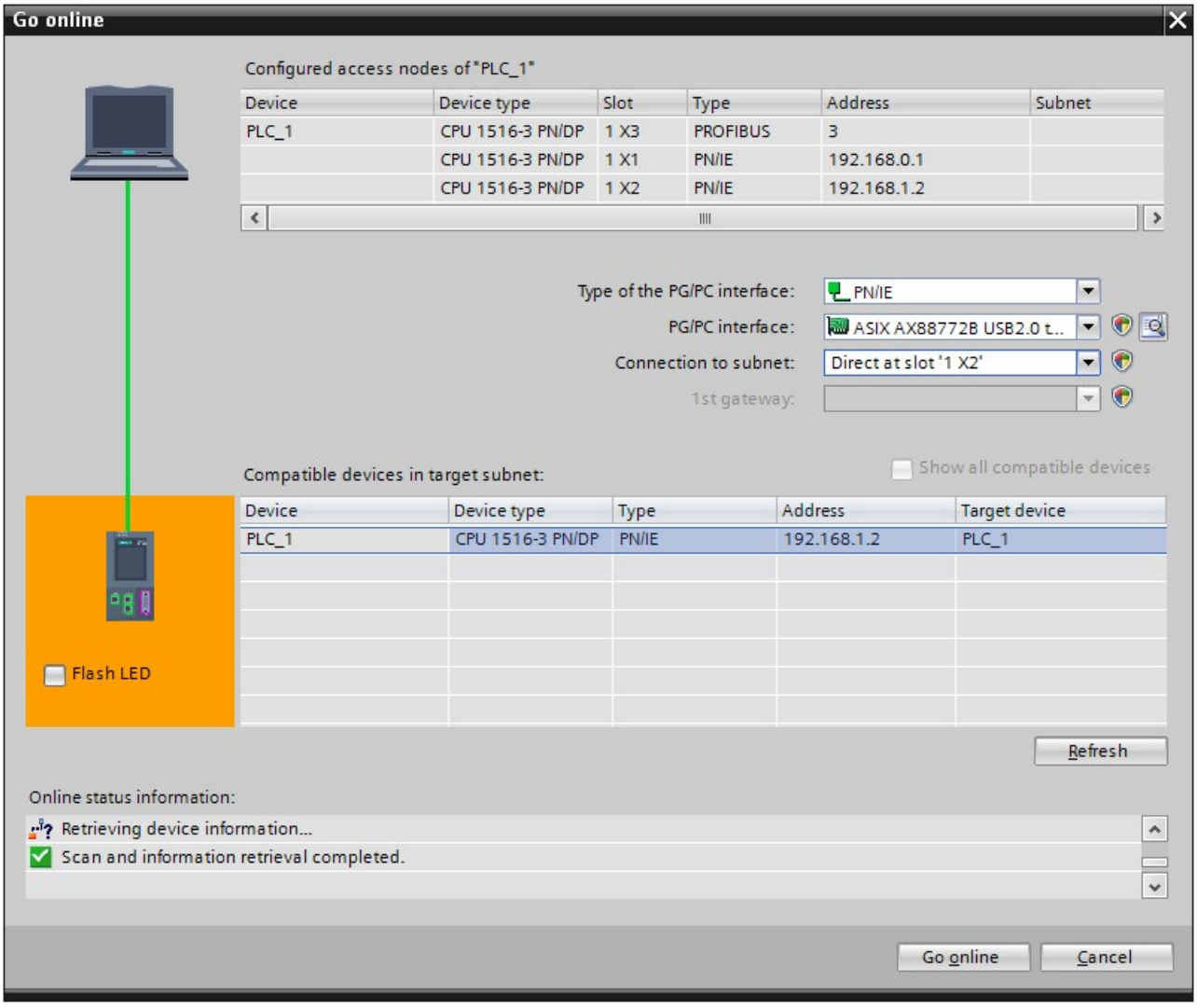


Figure 4-6 Go online

4. Make the settings for the interface.
5. Select the respective device under "Compatible devices in the target subnet".
6. Confirm the dialog with the "Connect" button.

   The online mode is started.

Result

The connected devices are now displayed with diagnostic information in the network view in the working area. Here you get an overview of the current state of your automation device.

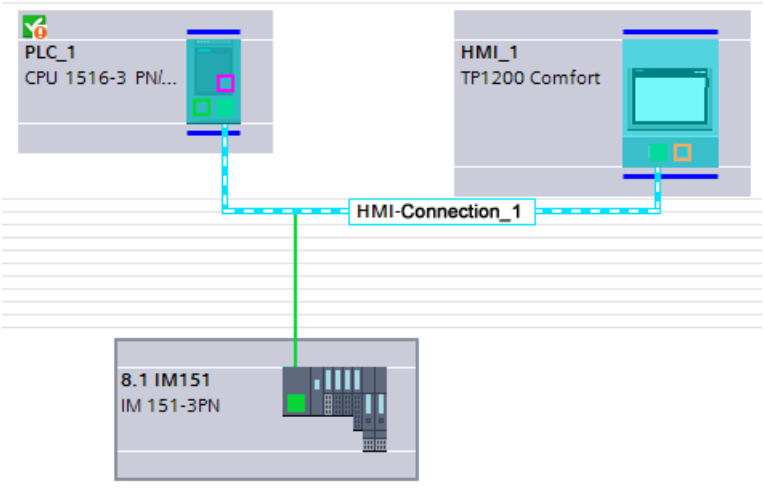


Figure 4-7 CPU with diagnostic information

You get to the "Device view" with a double-click on the device. The diagnostic information for the individual modules is displayed in this view.

Note

Symbols and their meaning

You will find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 30) and in the online help for STEP 7.

4.2.2.4 Online & diagnostics

Online mode

In online mode there is an online connection between your PG/PC and one or several devices. Depending on the properties of a device, you are offered specific diagnostics options and certain functions in online mode.

- Diagnostics
  - General module information
  - Diagnostics status
  - Cycle time
  - Memory
  - Diagnostics buffer
  - Display
  - Interface information (e.g. IP parameter, port information)
- Functions
  - Assign IP address
  - Set time and date of the CPU
  - Firmware update (e.g. for PLC, display)
  - Assign device name
  - Reset to factory settings
  - Format memory card
  - Save service data

To establish an online connection at least one PG/PC interface must be installed that is physically connected with a device, for example, with an Ethernet cable. The current online status of a device is indicated by a symbol to the right of the device in the project tree.

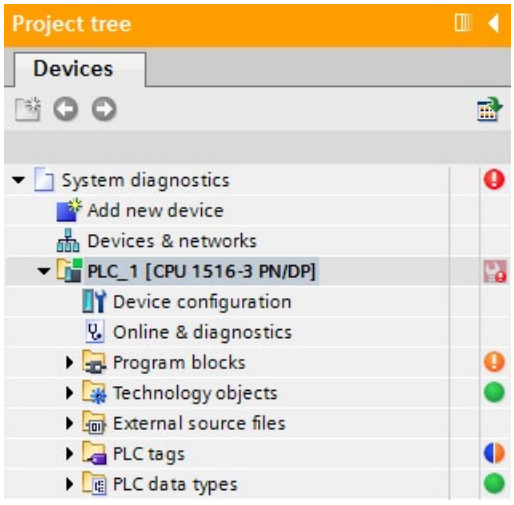


Figure 4-8 Partial view of network view

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.

Procedure

To display an overview of the faulty devices, follow these steps:

1. Select the affected device folder in the project tree.
2. Select the shortcut menu command "Online & Diagnostics".

   The online and diagnostics view of the module to be diagnosed is started.

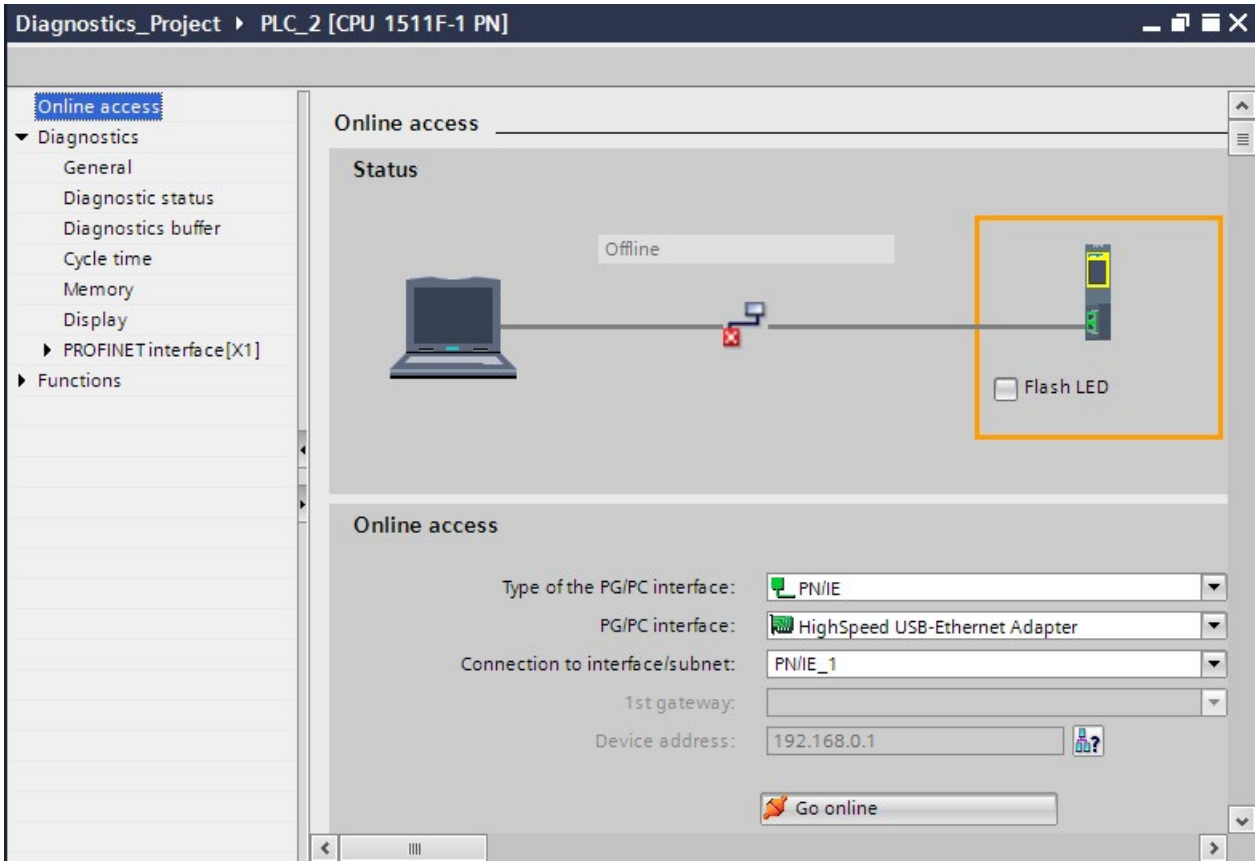


Figure 4-9 Setting online access

3. Make the settings for the interface.

   Here you can change an interface access that has already been set for an online connection that was successfully established previously.
4. Click on the "Go online" button.

   The online connection is established.

Result

You can find detailed diagnostics information on each device in the Inspector window, in the "Diagnostics" section of the area navigation on the "Properties" tab.

4.2.2.5 "Diagnostics" tab in the Inspector window

"Diagnostics" tab in the Inspector window

The "Diagnostics" tab of the Inspector window includes information on diagnostics events and configured alarm events.

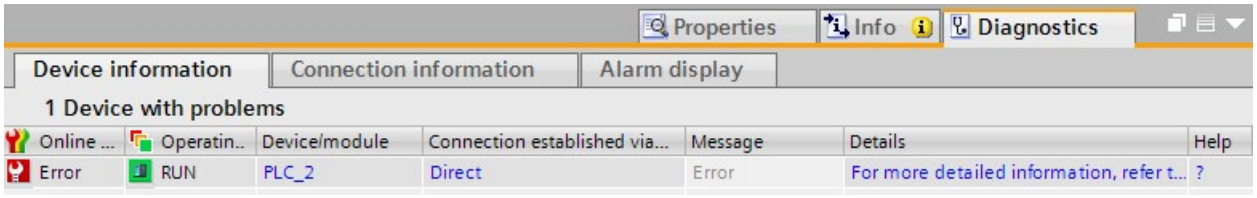


Figure 4-10 Diagnostics in the Inspector window, "Device information" tab

Note

Symbols and their meaning

You can find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 30) and in the online help for STEP 7.

Subordinate "Device information" tab

This tab gives you an overview of faulty devices to which an online connection exists or has existed. The table provides the following diagnostics information on the faulty devices:

- Online status: Includes the online status as diagnostics symbol and in words
- Operating mode: Includes the operating mode as symbol and in words
- Device/module: Name of the affected device or the affected module
- Connection established via ...: Specifies the path used to establish the connection to the failed device.
- Alarm: This explains the entry in the previous columns and displays an alarm, if necessary
- Details: The link opens the online and diagnostics view associated with the device or puts it in the foreground.
  If the device cannot be reached, the link opens the "Go online" dialog.
- Help: The link provides additional information on the fault.

Note

Communication and access errors

Errors that occur in the user program (e.g., communication errors, access errors) are not reported in the "Diagnostics" tab of the device information. You must read out the diagnostics buffer of the CPU in the online and diagnostics view to get this information. The link in the "Details" column opens the diagnostics buffer.

Subordinate "Connection information" tab

The "Connection information" tab displays detailed diagnostics information for connections.

There will only be information on the "Connection information" tab if there is an active online connection to at least one end point of the relevant connection.

If a connection has been selected (connection table), the tab contains the following groups:

- Connection details
- Address details of the connection

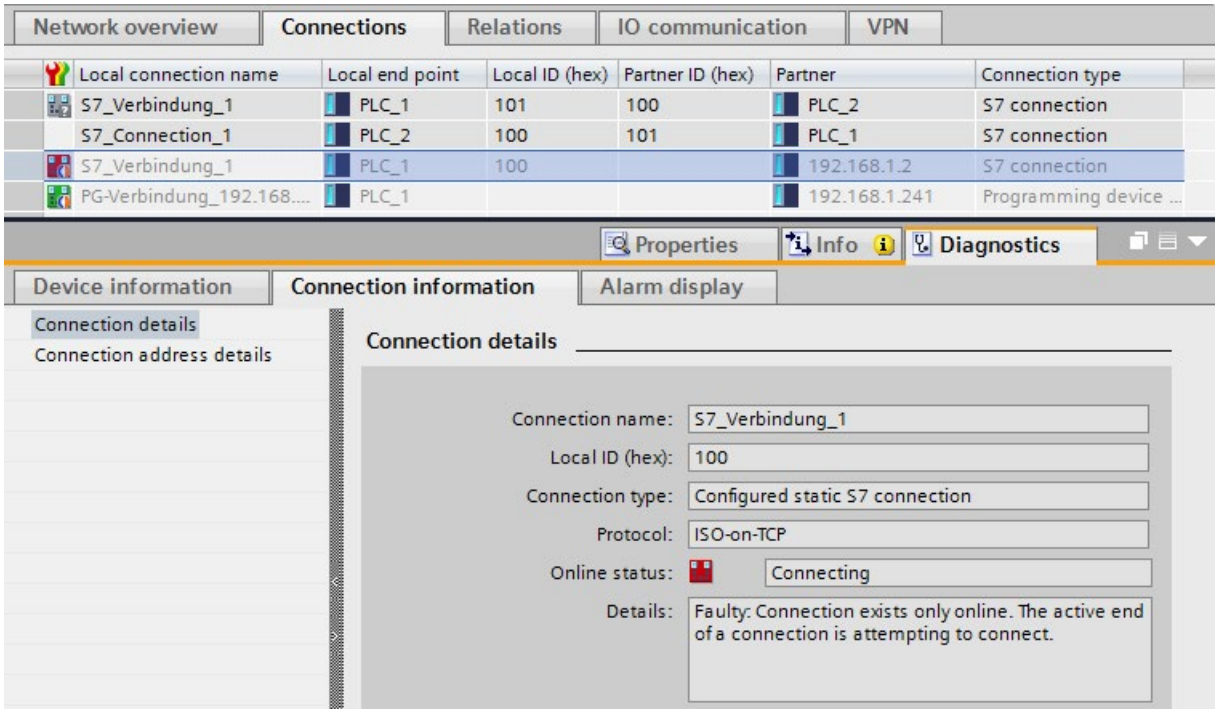


Figure 4-11 "Connection information" tab and open connection overview

If a module has been selected (network view), the tab contains the following group:

- Connection resources

Subordinate "Alarm display" tab

System diagnostics alarms are output in the "Alarm display" tab.

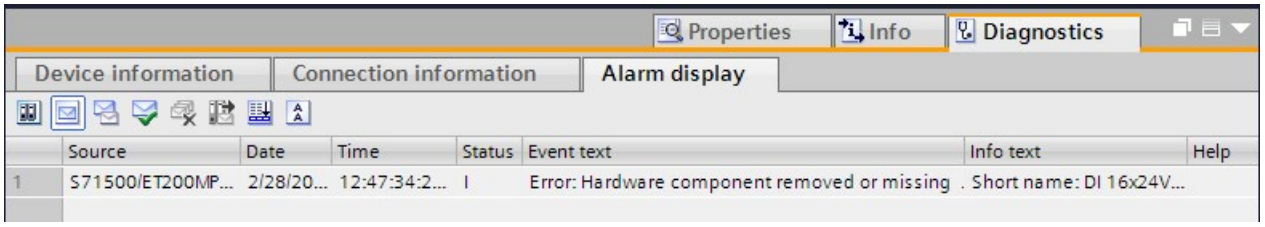


Figure 4-12 "Alarm display" tab

To receive alarms in STEP 7, follow these steps:

1. Open the project view.
2. Select the required CPU in the project tree.
3. To connect online with the respective CPU, select the shortcut menu command "Go online".
4. Select the required CPU once again in the project tree and select the shortcut menu command "Receive alarms".

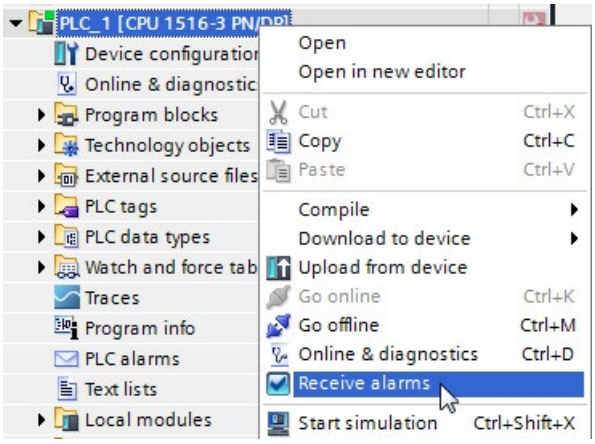


Figure 4-13 Receive alarms

5. Alarms are now displayed in the alarm display. "Archive view" is enabled by default.
6. To display the latest alarms, click the "Active alarms" icon .

4.2.2.6 CPU diagnostics buffer

Definition

Each CPU and some other modules have their own diagnostics buffer, in which detailed information on all diagnostic events is entered in the order in which they occurred.

The CPU diagnostics buffer can be displayed on all display media (STEP 7, SIMATIC HMI devices, SIMATIC S7-1500 Web server and display of the CPU).

Diagnostic events

The entries available in the diagnostics buffer include:

- Internal and external errors on a module
- System errors in the CPU
- Operating mode transitions (e.g., from RUN to STOP)
- Errors in the user program
- Removal/insertion of modules
- Security events

The contents of the diagnostics buffer are stored in the retentive memory in case of a memory reset of the CPU. Errors or events can be evaluated even after a longer period of time thanks to the diagnostics buffer to determine the cause of a STOP or to trace the occurrence of a single diagnostic event and to be able to assign it.

Procedure

To display the diagnostics buffer of a CPU in STEP 7, follow these steps:

1. Select the respective CPU.
2. Select the shortcut menu command "Online & Diagnostics".

   The "Online access" view is opened in the work area.

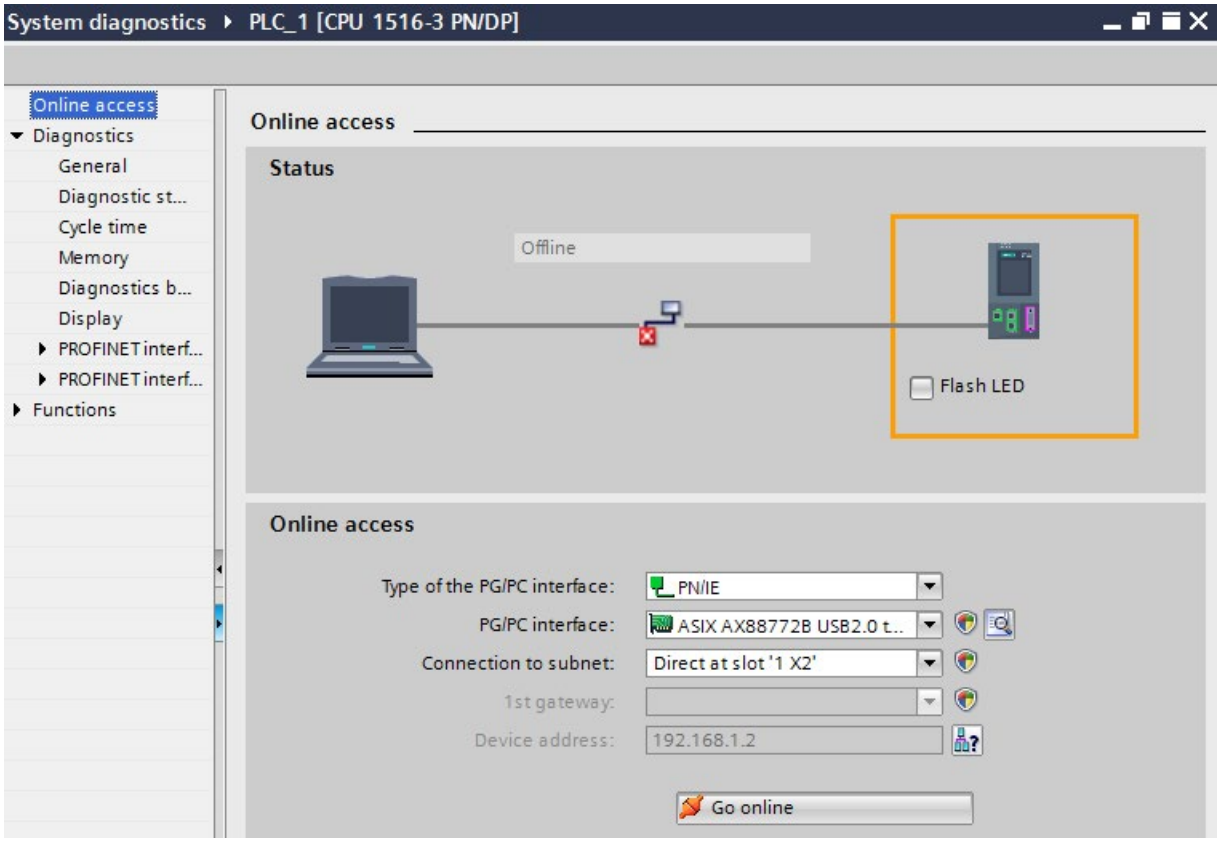


Figure 4-14 Setting up online access

3. Set the interface.

4. Click Go online.
5. Select the area "Diagnostics buffer".

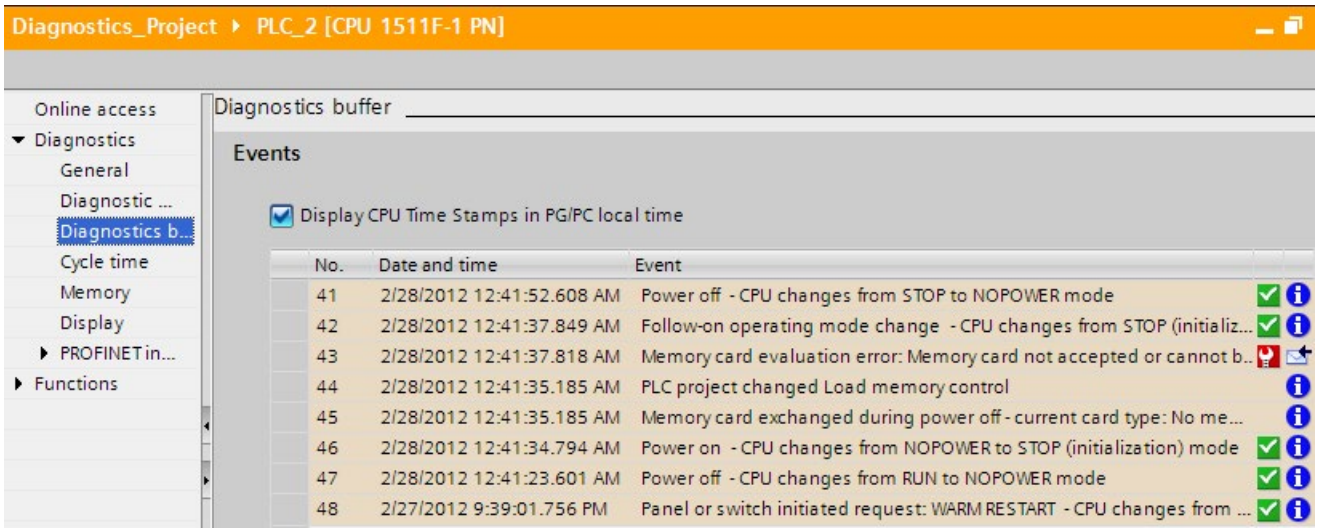


Figure 4-15 Diagnostics buffer in STEP 7

Note

Filtering events

You can filter the entries in the diagnostics buffer in the settings of the "Diagnostics buffer" area to only display specific types of events. This means that specific events, such as "CPU and configuration-internal events" or "Connection diagnostics events", can be displayed separately.

Security events

The following security events (event types) result in an entry in the diagnostics buffer.

- Going online with the correct or incorrect password
- Manipulated communications data detected
- Manipulated data detected on memory card
- Manipulated firmware update file detected
- Changed protection level (access protection) downloaded to the CPU
- Password legitimization restricted or enabled (by instruction or CPU display)
- Online access denied due to the possible number of simultaneous access attempts being exceeded
- Timeout when an existing online connection is inactive
- Logging on to the Web server with the correct or incorrect password
- Creating a backup of the CPU
- Restoring the CPU configuration (Restore)

To prevent the diagnostics buffer being "swamped" by large numbers of identical security events, you can set parameters so that these events are entered in the diagnostics buffer as a group alarm. For every interval (monitoring time), the CPU then only generates one group alarm per event type.

Configuring a group alarm for security events

To configure group alarms for security events, follow these steps:

1. Click on the CPU icon in the network view.

   The properties of the CPU are displayed in the Inspector window.
2. Navigate to the "Protection" > "Security event" area.
3. Click "Security event".
4. Select the option "Summarize security events in case of high message volume" to enable group alarms for security events.
5. Set the duration of an interval (monitoring period); the default is 20 seconds.

4.2.2.7 "Online tools" task card

Online view in the "Online tools" task card

The following requirements must be met to display the online view of the "Online tools" task card in STEP 7:

- An online connection to the CPU is available.
- You have selected the CPU in the topology view, network view or device view.

The "Online tools" task card provides an overview of the CPU state, the cycle time and the memory usage.

- The "CPU operator panel" pane displays the current state of some LEDs and the mode selector of a CPU.
- The "Cycle time" pane displays the cycle time diagram and below it the measured cycle times as absolute values.
- The "Memory" pane contains the current memory usage of the associated CPU. The free memory is shown both as a bar graph and as a numerical value (percentage).
  The display for "Load memory" contains, in addition to the online project data (program code, data blocks, hardware configuration etc.), all other data that may be on the SIMATIC memory card, such as recipes, data logs, HMI backups or non-SIMATIC files that have been copied to the memory card via the Web server of the CPU or offline in Explorer (for example, PDF files).

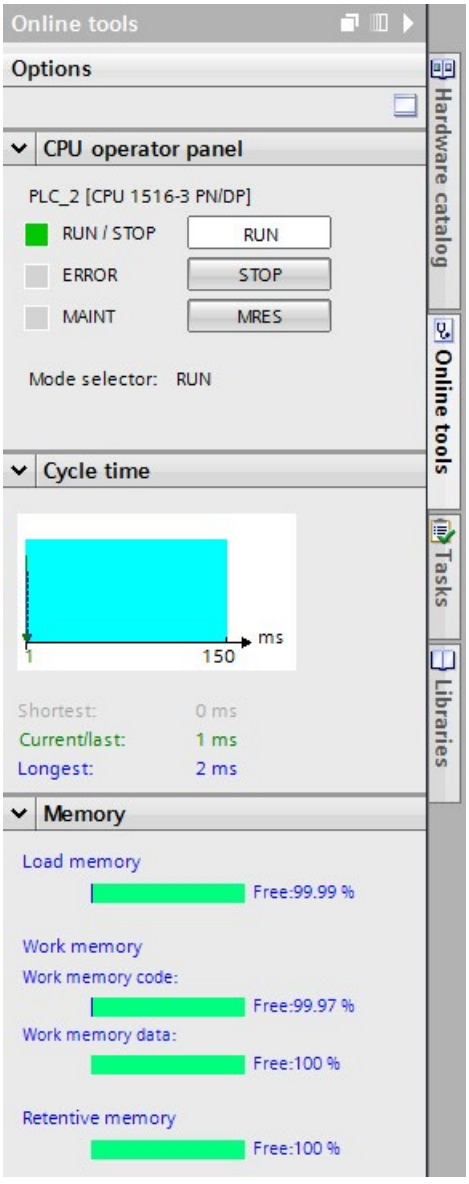


Figure 4-16 "Online tools" task card

4.2.2.8 Configuring the settings for I/O modules in STEP 7

You can also make settings for system diagnostics in STEP 7 for I/O modules. The parameters you have to configure depend on the I/O module.

The settings are optional.

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.
- A design with I/O modules has been configured.

Procedure

To make settings for system diagnostics of I/O modules in STEP 7, follow these steps:

1. Select the respective I/O module in the device view.
2. Open the "Properties" tab in the Inspector window.
3. Select the area "Inputs", for example.

   You have access to the settings for system diagnostics of the I/O module. If you select "Wire break", for example, a possible wire break for the channel is signaled during operation.

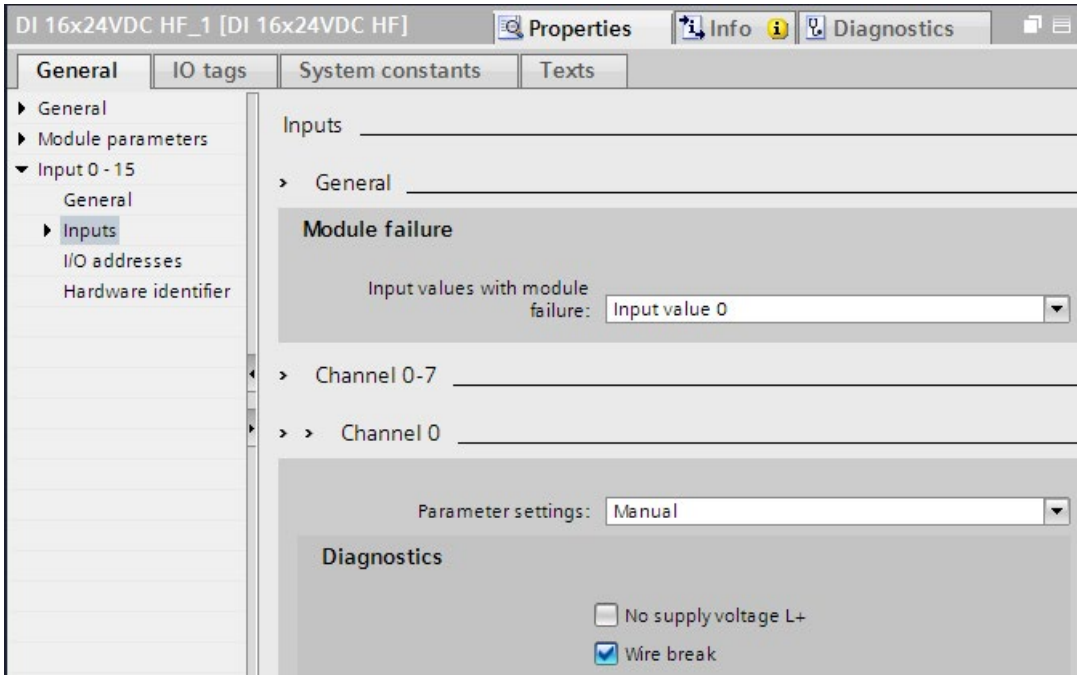


Figure 4-17 I/O setting with a digital input module

4. Save the hardware configuration.
5. Download the new hardware configuration to the CPU.

Additional information

The documentation for the respective module includes additional information on parameter assignment of I/O modules.

4.2.3 Diagnostics information using the web server

System diagnostics using the CPU Web server

The CPUs of the SIMATIC series have an integrated Web server and let you display the system diagnostics information by means of PROFINET. Any terminal devices, such as PCs or smartphones, can thus access module data, user program data and diagnostics data of a CPU by using an Internet browser. This means access to CPUs is possible without installed STEP 7.

In addition to normal websites, the Web server provides so-called basic websites with reduced content that are adapted to the requirements of small screens with low resolution.

Using CPU 1516-3 PN/DP as an example, the following figure shows the start page of the Web server:

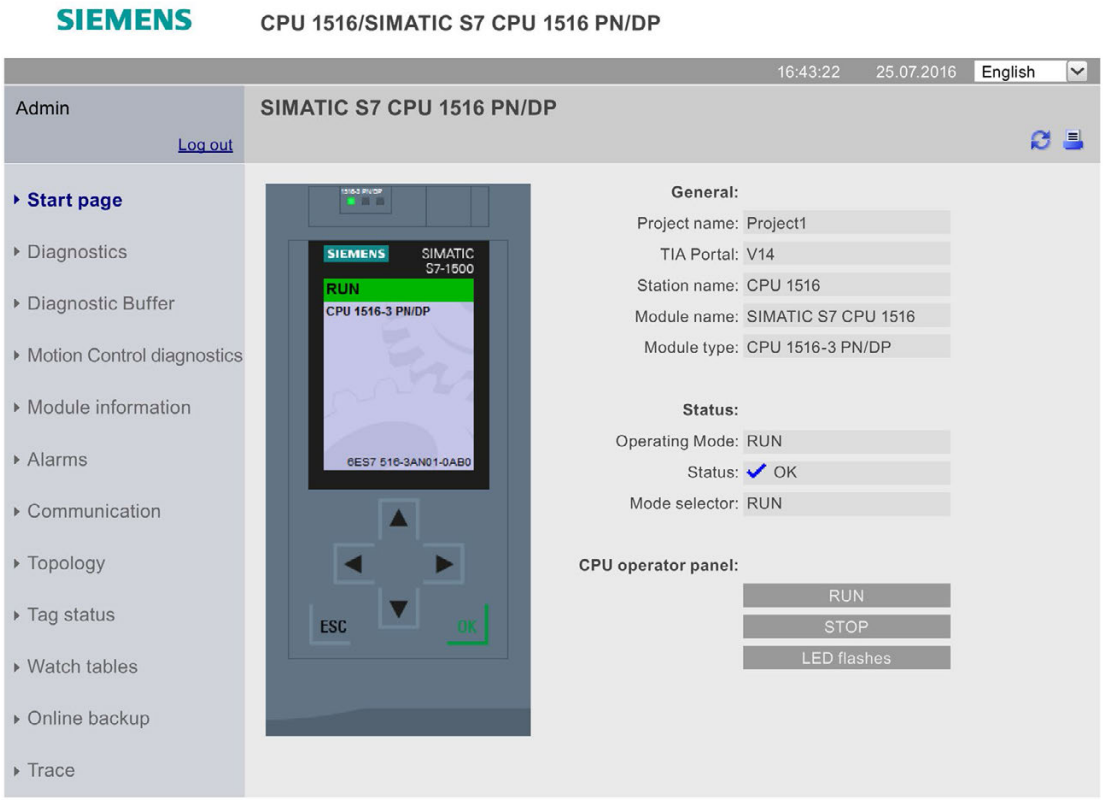


Figure 4-18 Web server, Start page

The following diagnostics options are available with the integrated Web server:

- Start page with general CPU information
- Information on diagnostics
- Contents of the diagnostics buffer
- Module information
- Alarms
- Information about communication
- PROFINET topology
- Motion Control diagnostics
- Trace

Configuring the Web server in STEP 7

Proceed as follows to activate the Web server:

Requirements

- You have opened STEP 7.
- You have added a CPU to the project.
- You have opened the project view.

Procedure

1. Open the network view.
2. Select the CPU.
3. Open the "Properties" tab in the Inspector window.
4. Select the entry "Web server" in the "General" area navigation.

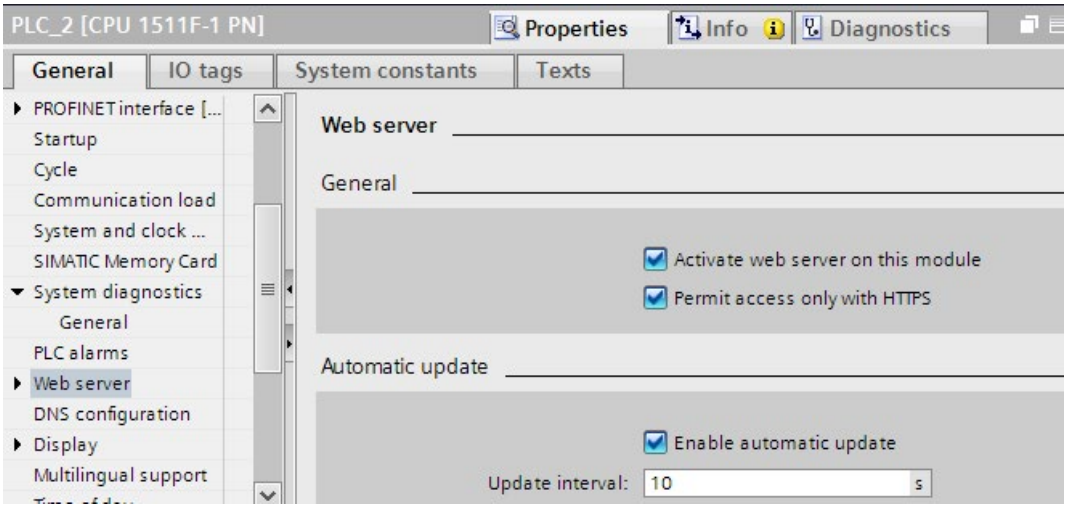


Figure 4-19 Activate the Web server

5. Select the "Activate web server on this module" check box.
6. If possible, always enable the option "Permit access only with HTTPS".
   Note the following: The activation of the Web server using the secure transmission protocol "HTTPS" requires a valid Web server certificate in the CPU.

NOTICE
Utilizing the full functionality of the Web server A valid CA-signed Web server certificate in the CPU is a requirement for: • User management with password-protected users • The use of safety-related functions (online backup and restore of the CPU configuration, saving and downloading diagnostic information in csv files) To use the full functionality of the Web server, we recommend that you create a CA-signed server certificate and assign it to the CPU. To create a CA-signed Web server certificate, you must enable the Certificate Manager in the global security settings of STEP 7 and assign a CA-signed server certificate to the Web server in the properties of the CPU. You can find additional information on handling Web server certificates in the "Configuring the Web server" section of the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560). Detailed information on Certification Authority (CA) certificates, device certificates (End Entity certificate), "Public Key Infrastructure" (PKI) and certificate management can be found in the Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925) and in the online help for STEP 7, keyword "Secure communication".

7. Automatic updating is activated in the default setting of a configured CPU.
8. Activate the Web server also for each interface via which you want to access the Web server.
   To do this, open the "Properties" tab in the Inspector window and select the "Web server" entry in the "General" area navigation. In the "Overview of interfaces" area, select the "Enabled web server access" check box for the corresponding interface.
9. Compile and load the configuration into the CPU.

Accessing the Web server

To access the Web server, proceed as follows:

1. Connect the display device (PG/PC, HMI, mobile terminal device) with the CPU or a communication module using a PROFINET interface.
   If you are working with WLAN, activate the WLAN on the display device and establish a connection to the access point (e.g. SCALANCE W788-1RR or SCALANCE W784-1), which is in turn connected to the CPU.
2. Open the web browser on the display device.
3. Enter the IP address of the interface of the CPU which is connected to the client in the "Address" field of the web browser in the following format: http://a.b.c.d or https://a.b.c.d (example input: http://192.168.3.141).
   The intro page of the CPU opens.
4. You need to perform the installation of the CA certificate again for each display device you want to use. A valid CA certificate is available for download from the "Intro" web page under "Download certificate". You can find instructions for installing the certificate in the help system of your Web browser and in the FAQ with the entry ID 103528224 at the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/103528224) website.
5. Click the NEXT link to go to the Web server pages.

Note

Managing access rights

In STEP 7, you can create users, define access rights and assign passwords under "Web server > User management". Users only have access to the options that are permanently linked to the access rights.

You can find additional information on managing access rights in the "Configuring the Web server" section of the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560).

"Diagnostics" option

The "Diagnostics" web page provides more information about the tabs:

- Identification

  This tab contains the characteristics of the CPU (serial number, article number, hardware and firmware version, etc.).

- Program protection

  This tab provides information on whether the PLC program contains know-how protection or copy protection.

- Memory

  This tab contains current values on the memory currently in use.

- Runtime information

  Current information on program/communication load and cycle time can be found in this tab.

- F-runtime groups (only with an F CPU)

  The safety program of an F-CPU consists of one or two F-runtime groups. You can find their cycle time (F-monitoring time) and runtime in this tab.

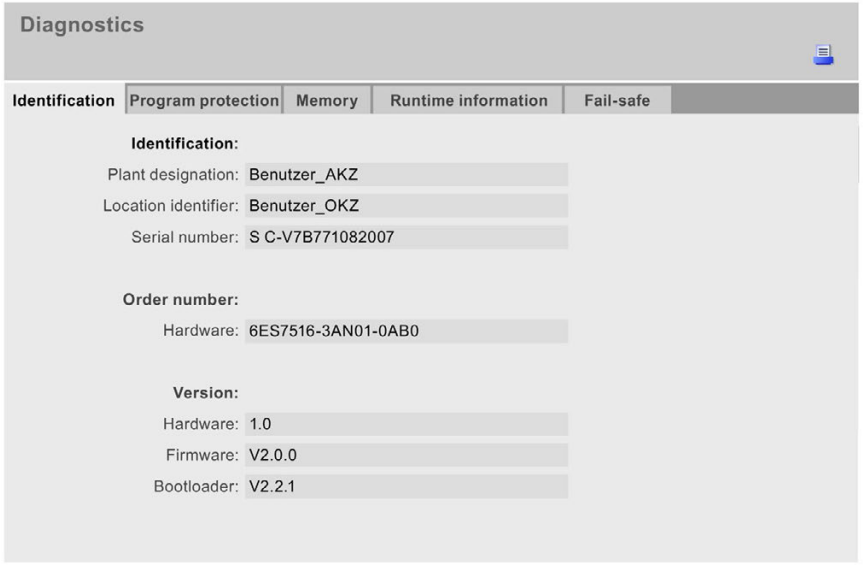


Figure 4-20 Web server, "Diagnostics" Web page

Diagnostics option "Diagnostics buffer"

The browser displays the content of the diagnostics buffer on the "Diagnostics buffer" Web page.

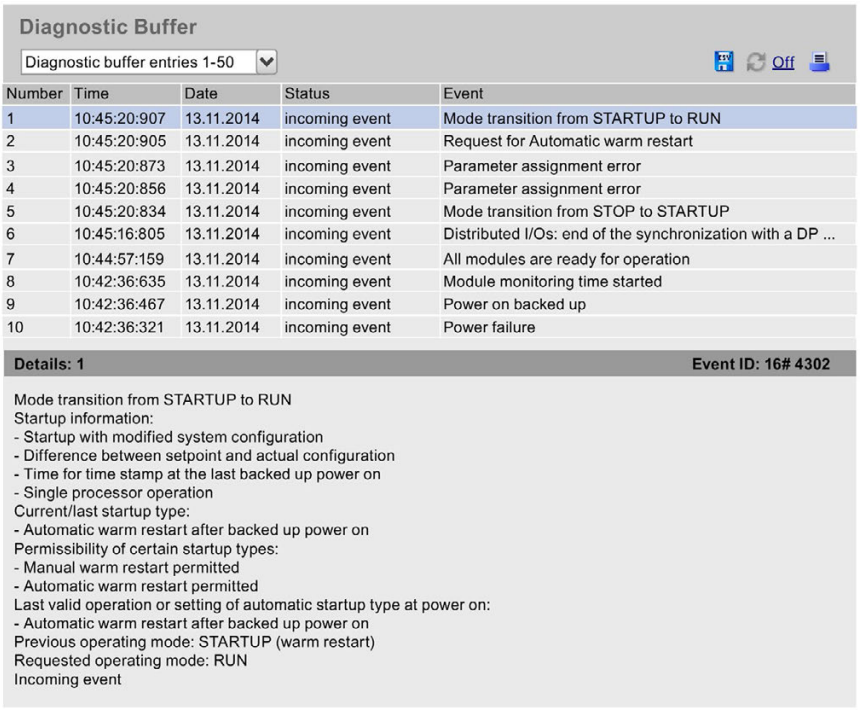


Figure 4-21 Web server, "Diagnostics buffer" Web page

Diagnostics option "Module information"

The status of a device is indicated by the Web browser with symbols and comments on the "Module information" Web page.

Modules are displayed on the "Module information" Web page in the "Name" column with a link. You can thus get to the faulty module in hierarchical order.

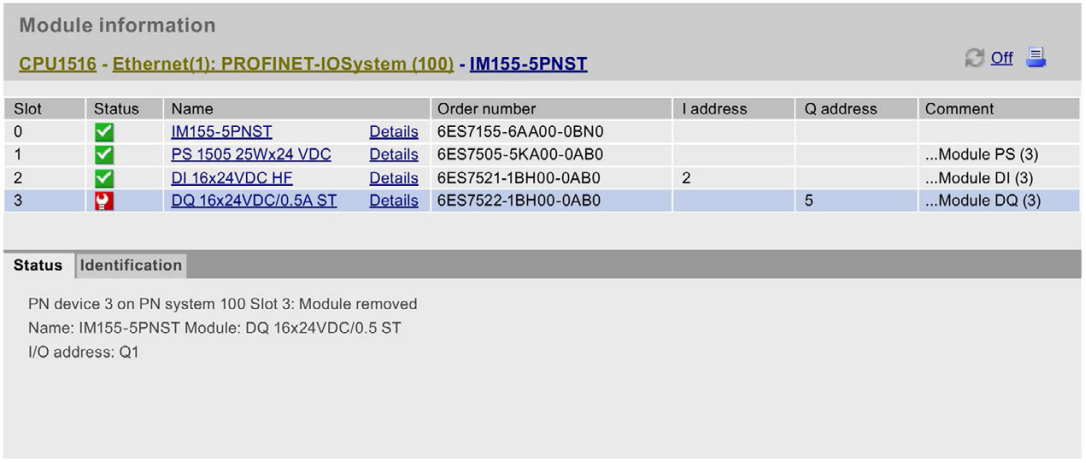


Figure 4-22 Web server, "Module information" Web page

Diagnostics option "Messages"

The Web browser displays the content of the message buffer on the "Messages" Web page. The messages can be acknowledged via the Web server if you have the appropriate user rights.

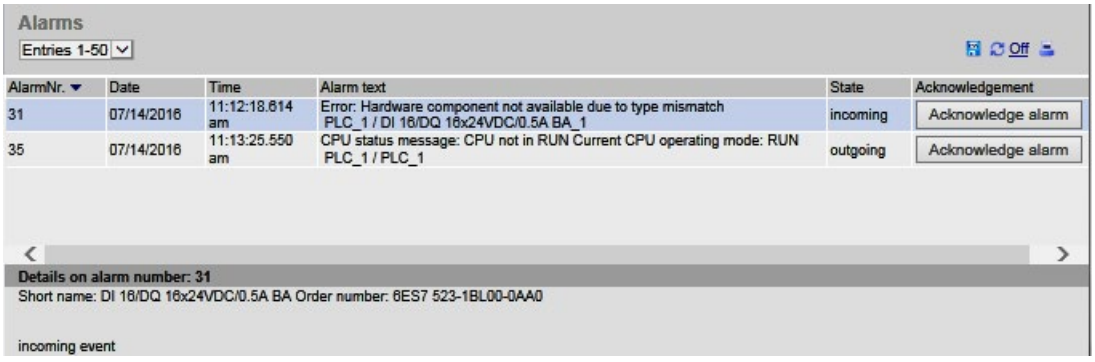
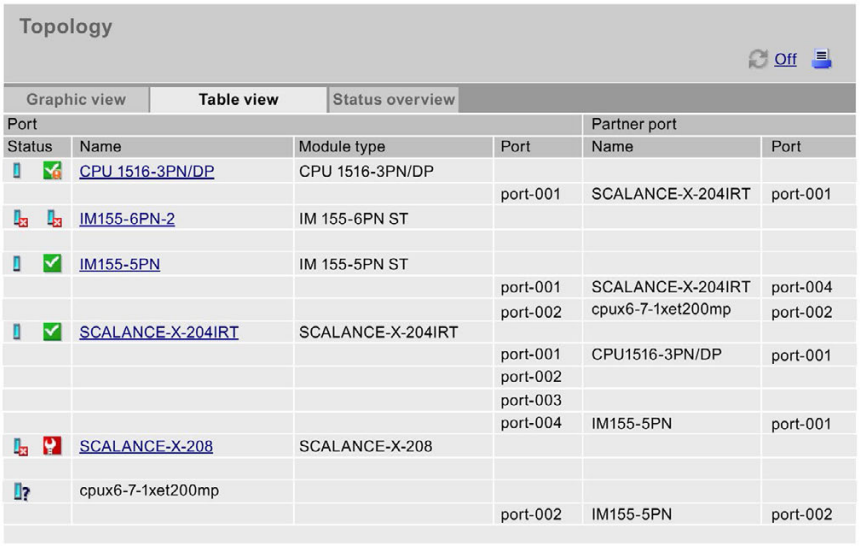


Figure 4-23 Web server, "Messages" Web page

"Topology" diagnostics option

The "Topology" Web page provides information on the topological configuration and status of the PROFINET devices in your PROFINET IO system.



Port				Partner port	
Status	Name	Module type	Port	Name	Port
	CPU 1516-3PN/DP	CPU 1516-3PN/DP			
			port-001	SCALANCE-X-204IRT	port-001
	IM155-6PN-2	IM 155-6PN ST			
	IM155-5PN	IM 155-5PN ST			
			port-001	SCALANCE-X-204IRT	port-004
			port-002	cpux6-7-1xet200mp	port-002
	SCALANCE-X-204IRT	SCALANCE-X-204IRT			
			port-001	CPU1516-3PN/DP	port-001
			port-002		
			port-003		
			port-004	IM155-5PN	port-001
	SCALANCE-X-208	SCALANCE-X-208			
	cpux6-7-1xet200mp				
			port-002	IM155-5PN	port-002

Figure 4-24 Web server, "Topology" Web page

"Motion Control Diagnostics" diagnostic option

The Web server displays statuses, errors, technology alarms and the current values of the configured technology objects (TOs).

The "Motion Control Diagnostics" web page provides detailed information on the configured technology objects in the following views:

- Diagnostics

  This view provides an overview list of configured technology objects, the status and error messages of a selected technology object, as well as values and limits of the movement status for a selected axis.

- Service overview

  This view contains diagnostic information for multiple technology objects and a filter option for selecting the displayed technology objects.

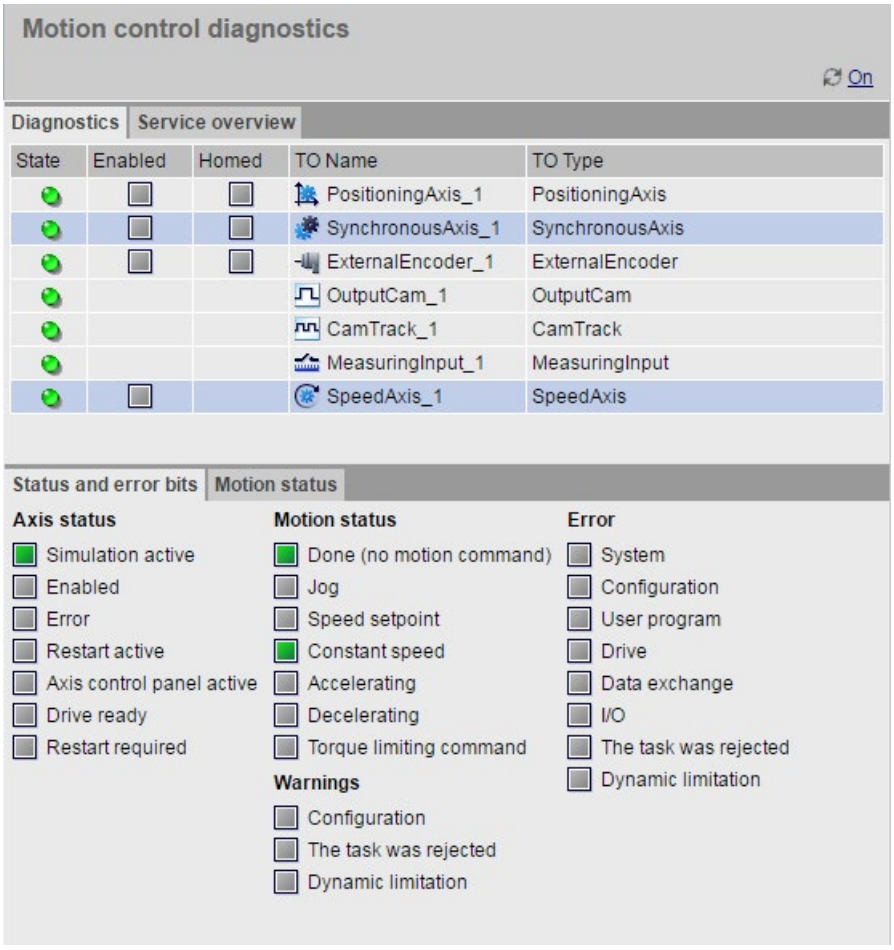


Figure 4-25 Web server, "Motion Control diagnostics" webpage

"Trace" diagnostic options

You can read, view and save the trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance.

The web page of the trace and logic analyzer function consists of several areas. The example in the figure below shows how the Web server user interface is divided when the "Trace" web page is first called.

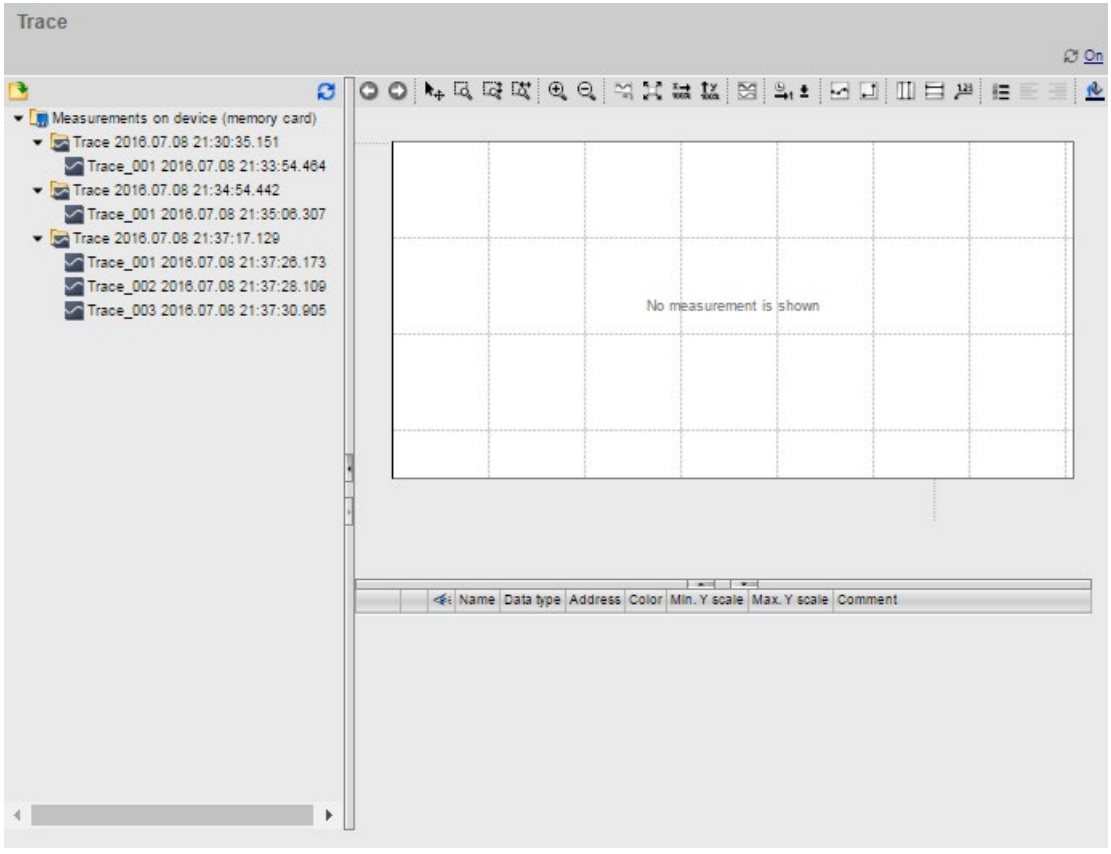


Figure 4-26 Web server, "Trace" home page (without measurement)

Additional information

Additional information on the topic is available in the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560).

You can find additional information on the trace function in the Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/ww/en/view/64897128) function manual.

4.2.4 Diagnostics information using the HMI diagnostics view

Objects for system diagnostics

The full functionality of the HIM diagnostics view is only available with Comfort Panels and WinCC RT Advanced . Basic Panels do not support the complete range of system diagnostics functions.

Two objects are available for system diagnostics on an HMI device.

System diagnostics view

The system diagnostics view reflects the current status of all accessible devices in your plant. You navigate directly to the cause of the error and the associated device. You have access to all diagnostics-capable devices that you have configured in the STEP 7 hardware and network editor.

System diagnostics window

The system diagnostics window is an operating element and display object.

The functions of the system diagnostics window are the same as for the system diagnostics view. Because the system diagnostics window is configured in the "Global screen", you can also specify, for example, if the object can be closed in WinCC Runtime.

Note

Compatibility with Basic Panels

Only the "System diagnostics view" object is available with Basic Panels.

Basic Panels do not support the "System diagnostics window" object or the graphic symbol "System diagnostics indicator".

4.2.4.1 Configuring system diagnostics

Introduction

You add a system diagnostics view or a system diagnostics window to your project to get an overview of all devices available in your plant.

The system diagnostics window behaves like the system diagnostics view but is only available in the global screen.

Requirements

- At least one CPU has been set up in the project.
- An HMI device (e.g., Comfort Panel) has been set up in the project.
- CPU and the HMI device are connected with each other by an HMI connection.
- You have created a screen (for the system diagnostics view).
- The global screen is open (for the system diagnostics window).
- The Inspector window is open.

Procedure

Proceed as follows to configure the system diagnostics:

1. Double-click the "System diagnostics view" object in the "Tools" task card. The object is added to the screen.

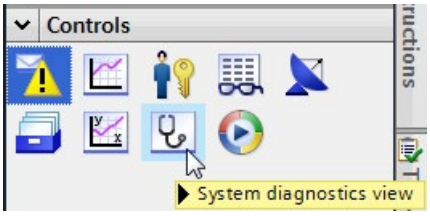


Figure 4-27 Adding a system diagnostics view

2. Select the "Properties" tab in the Inspector window.
3. Select the area "Columns".
4. Enable the columns that you require in the device view for WinCC Runtime, for example:
   - Status
   - Name
   - Operating mode
   - Slot
   - Address
5. Enable the columns that you require in the detail view for WinCC Runtime, for example:
   - Status
   - Name
   - Operating mode
   - Plant designation
   - Address
6. You can change the column headers in the "Columns" area, if necessary.
7. Select the "Display" area.
8. Enable "Column settings > Columns moveable" to move the columns in WinCC Runtime.
9. To close the system diagnostics window in WinCC Runtime, select "Properties > Window > Closable" in the "Properties" tab of the Inspector window.

Result

The system diagnostics view has been added to the screen. The diagnostics status of the entire plant is displayed in the system diagnostics view in WinCC Runtime.

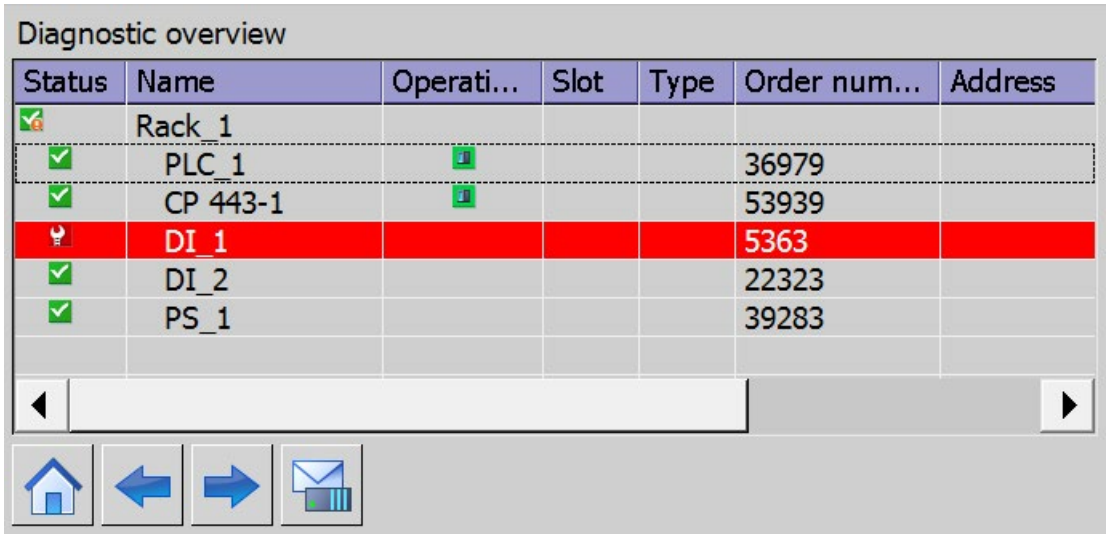


Figure 4-28 System diagnostics view in the screen

The system diagnostics window has been added to the global screen. If there is an error message in the plant, the system diagnostics window responds and displays the affected device.

4.2.4.2 Different views of the HMI diagnostics view

Introduction

There are three different views available in the system diagnostics view and the system diagnostics window.

- Device view
- Details view
- Matrix view (for master/IO systems only, PROFIBUS, PROFINET)

Device view

The device view shows all the available devices of a layer in a table. Double-clicking on a device opens either the lower-level devices or the detail view. Symbols in the first column provide information about the current state of the device.

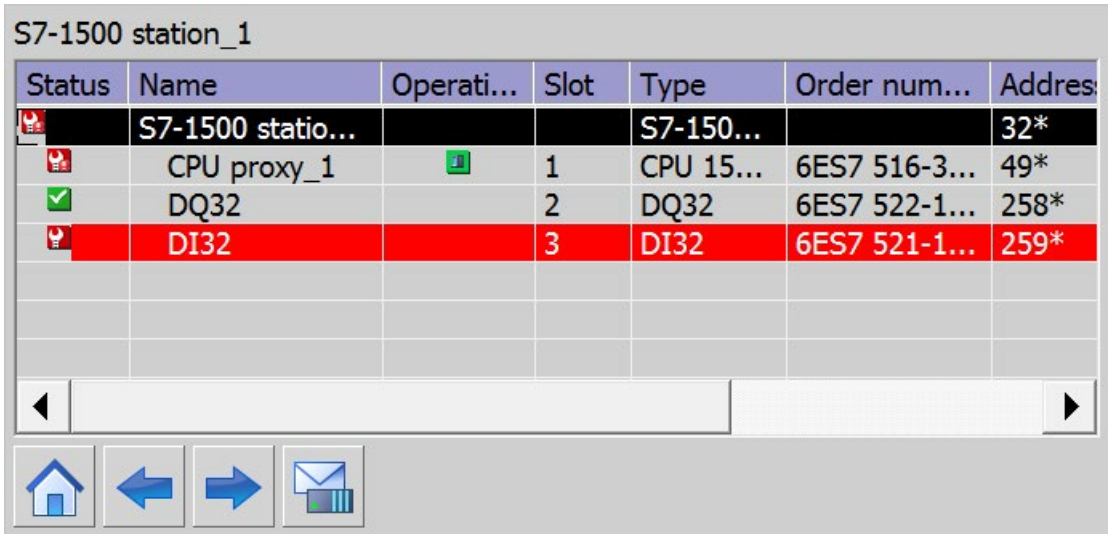


Figure 4-29 Device view

Details view

The detail view gives detailed information about the selected device and any pending errors. Check whether the data is correct in the detail view.

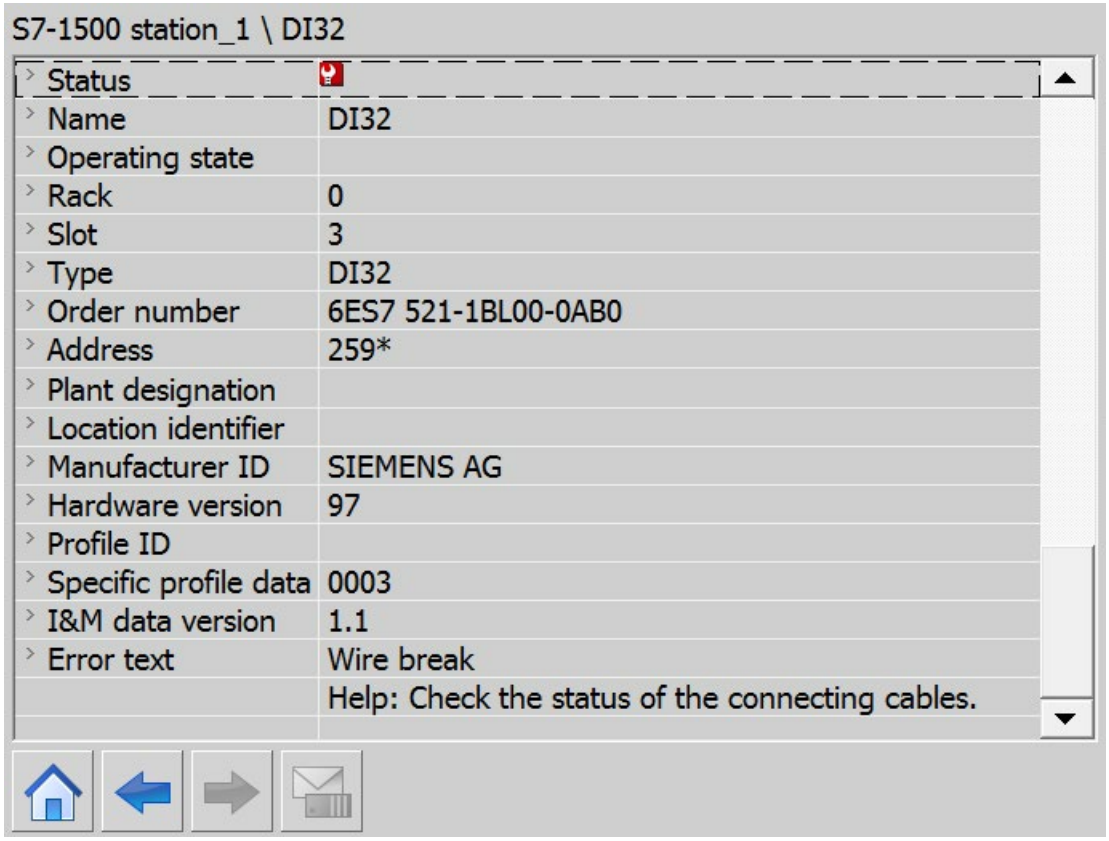


Figure 4-30 Details view

Matrix view

The matrix view is only available for distributed I/O systems. The matrix view shows the status of the devices of the PROFIBUS/PROFINET subnet.

- In PROFIBUS, the numbers assigned by PROFIBUS are used for identification (DP station number).
- In PROFINET, the IO devices are numbered consecutively from 1.

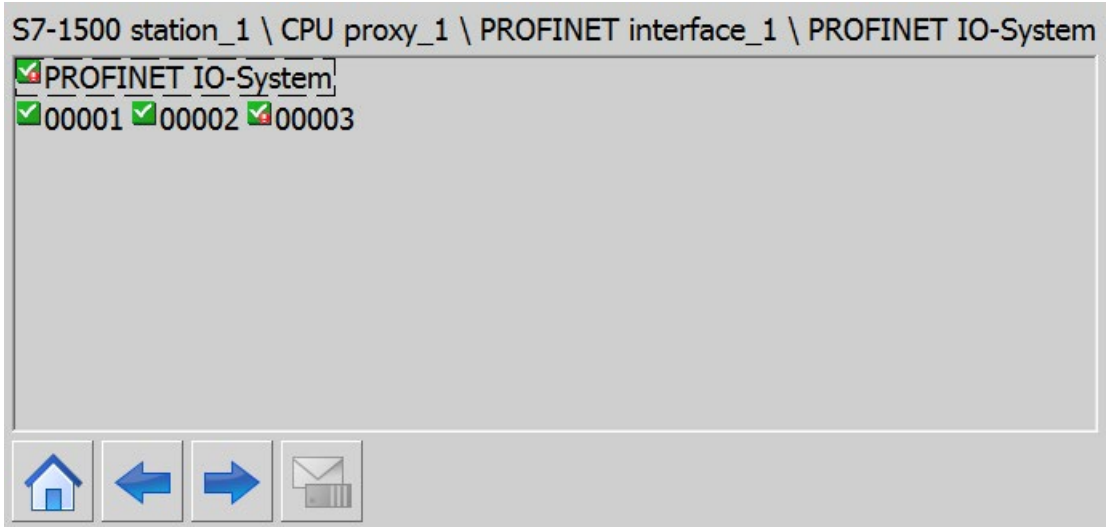


Figure 4-31 Matrix view

Navigation buttons

Button	Function
	Opens the lower-level devices or the detail view if there are no lower-level devices.
	Opens the higher-level device or the device view if there is no higher-level device.
	Opens the device view.

4.2.4.3 Inserting system diagnostics indicator

Introduction

The system diagnostics indicator is a predefined graphic symbol of the library which alerts you to errors in your plant.

The library object shows two different states:

- No error
- Error

Requirements

- An HMI device (e.g., Comfort Panel) has been set up in the project.
- The "Libraries" task card is opened.
- The global library "Buttons and Switches > DiagnosticsButtons" is open.
- A screen is open.
- The system diagnostics window has been set up in the global screen.

Procedure

1. Select the "DiagnosticsIndicator" object in the library.
2. Drag-and-drop the library object to the position in the work area where you want to insert the object.

   The library object is added.

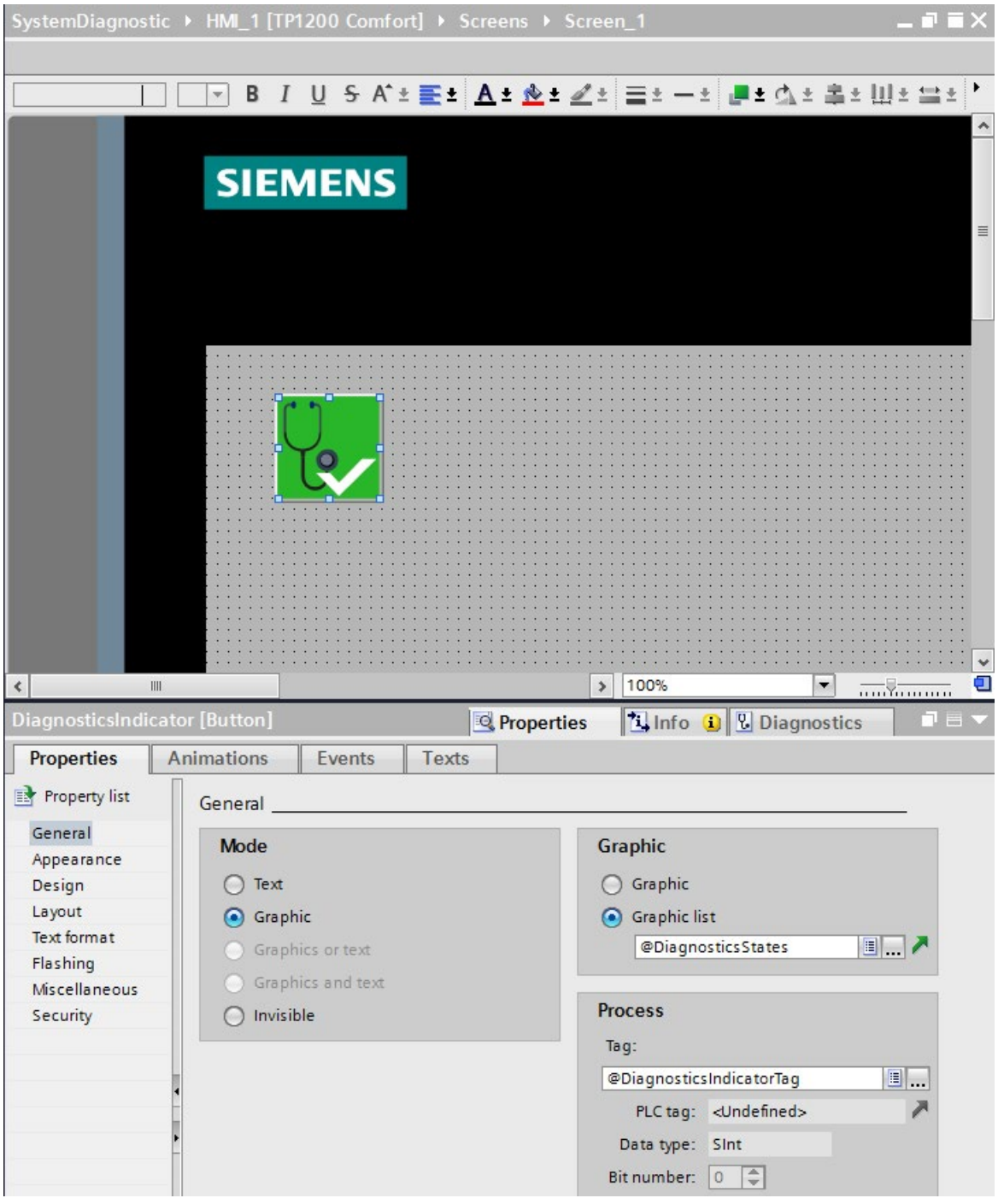


Figure 4-32 Inserting library object in the work area

3. Select the library object.
4. Open the "Events" tab in the Inspector window.

   The "ShowSystemDiagnosticsWindow" is preset for the event "Click".

Result

The system diagnostics indicator has been added to the project and connected with the system diagnostics window.

The system diagnostics indicator changes its appearance if an error message is output in WinCC Runtime. The system diagnostics window opens when you click on the system diagnostics indicator. The system diagnostics window shows the detail view of the affected device.

Configuring access protection for the system diagnostics window

Configure access protection for the system diagnostics indicator to prevent unauthorized access to the system diagnostics windows.

1. Select the "DiagnosticsIndicator" object in the screen.
2. Open the "Properties" tab in the Inspector window.
3. Select an authorization in the "Security in Runtime" area.

A logon dialog opens when you click on the system diagnostics indicator in WinCC Runtime. The system diagnostics window does not open unless you have the required authorization.

4.2.4.4 Configuring button as system diagnostics indicator

Introduction

Instead of using the object "DiagnosticsIndicator" from the library, you can, for example, configure a button in "Graphic" mode to indicate errors in your plant.

Requirements

- At least one CPU has been created.
- An HMI device (e.g., Comfort Panel) has been set up in the project.
- The "Tools" task card is open.
- A bit graphics list has been created with two different graphics for the states.
- A screen is open.
- You have created a system diagnostics view.

Procedure

Follow these steps to configure a button as system diagnostics indicator:

1. Double-click the "Button" object in the "Tools" task card. A button is added to the screen.
2. Enable the "Properties" tab in the Inspector window and the "Graphic" mode in the "General" area.
3. Select the bit graphics list as graphics list.
4. Select the "Properties" tab in the Inspector window and select the tag @DiagnosticsIndicatorTag under "Tag" in the "General" area.
5. To assign a function to the button, select the "Events" tab in the Inspector window.
6. Select the "Click" event.
7. Click on "Add function" in the table.
8. Select "EnableSystemDiagnosticsView".
9. Select the system diagnostics view.

Result

You have configured an interface that reacts to error events from the CPU. The button changes when an error event occurs in Runtime.

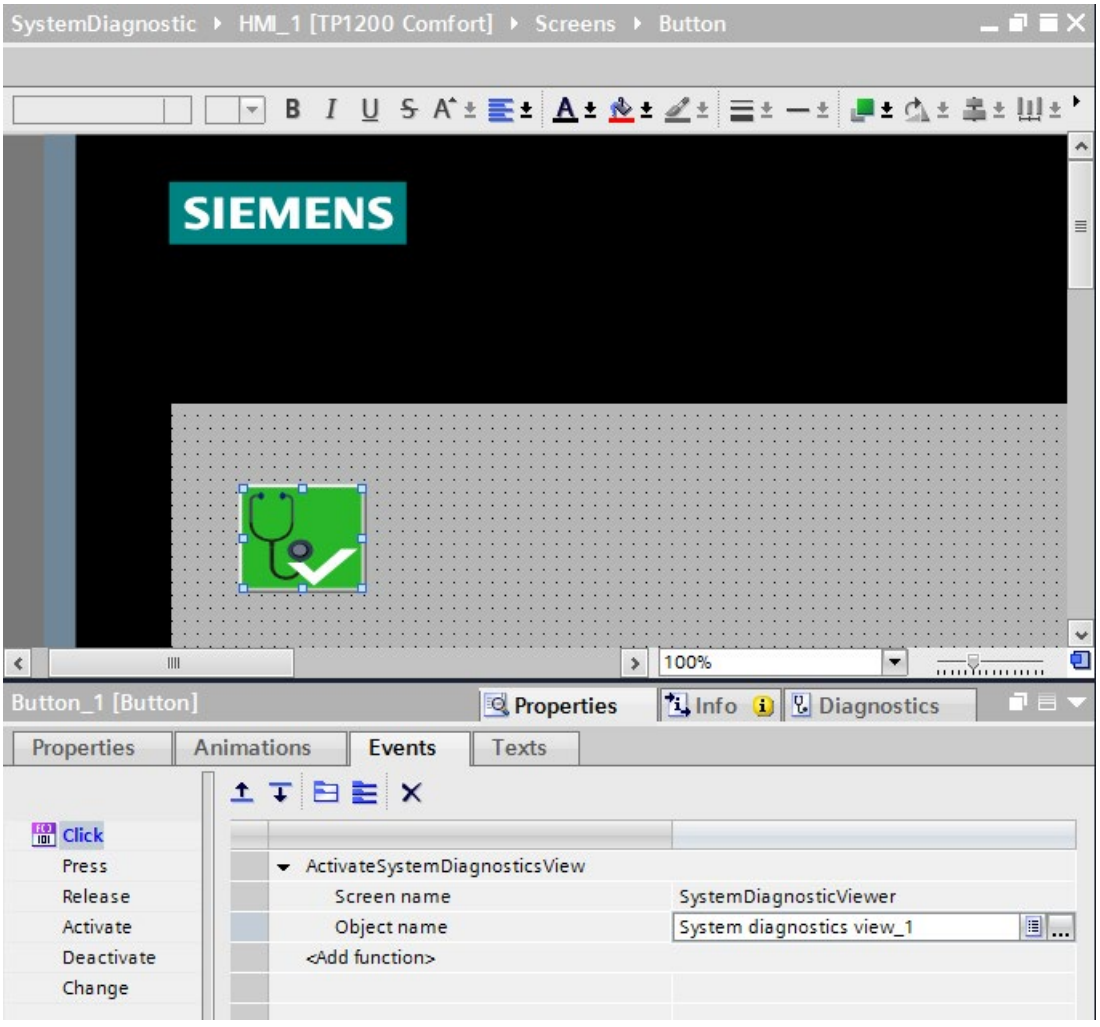


Figure 4-33 Configured button

The button has two states.

- Error

  The system diagnostics view opens when you click on the button. The system diagnostics view shows the detail view of the affected device.

- No error

  The system diagnostics view opens when you click on the button. The system diagnostics view shows the device view.

System diagnostics by means of the user program 5

5.1 Options of system diagnostics in the user program

Introduction

You can configure responses to diagnostics alarms in the user program. You can, for example, specify that your plant is stopped in case of specific diagnostics alarms.

Instructions

A vendor-independent structure of data records with diagnostics information applies. The following instructions are available for determining the system diagnostics of a device:

Table 5- 1 Instructions for determining the system diagnostics

Instruction	Description
RDREC	• Reads data records of a component (module or submodule) of a DP slave/IO device that may contain error information • Works asynchronously, which means processing takes place across several calls
RALRM	• Reads the start information of the OB when calling the diagnostics interrupt OB (OB 82) • Provides information on cause and location of error
DPNRM_DG	• Reads the current diagnostics data of a DP slave (DP standard diagnostics)
GEN_DIAG	• Generates diagnostics information • To generate diagnostics information, the module or submodule is identified with its logical address
Gen_UsrMsg	• Generates an alarm that is entered in the diagnostics buffer
GET_DIAG	• Provides diagnostics information • To provide diagnostics information, the module or submodule is selected
GET_NAME	• Reads the name of an IO device
T_DIAG	• Provides diagnostics and status information on a connection • Works asynchronously, which means processing takes place across several calls
RD_SINFO	• Reads the start information of the OB called last that has not been processed completely and the startup OB started last • Provides general error information
LED	• Reads the status of the module LED
Get_IM_Data	• Reads the Information&Maintenance data of the CPU • Works asynchronously, which means processing takes place across several calls
Transfer_IM_Data	• Transmits the Information&Maintenance data of the CPU
DeviceStates	• Outputs the state of all devices of an IO system
ModuleStates	• Outputs the state of all modules of a device

Additional information

Online help

In the online help for STEP 7, you can find:

- Additional information on instructions for system diagnostics
- Information about further options for evaluating diagnostic information in the user program (e.g. with the "RDREC", "RALRM", "GET_DIAG" instructions)
- Information on SIMATIC ProDiag. This functionality enables targeted and fast machine and plant diagnostics for SIMATIC S7-1500 and SIMATIC HMI:
  - Standardized diagnostics concept for different SIMATIC components
  - No additional configuration work for diagnostics functionality
  - Reduces the load on PLC memory and program run time

  You can find details in the online help under "Supervising machinery and plants with ProDiag".

Manuals

You can find additional information about evaluating diagnostic information in the user program in the following manuals:

- PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- From PROFIBUS DP to PROFINET IO (https://support.industry.siemens.com/cs/ww/en/view/19289930) programming manual
- Manual for the respective module

Application examples

You can find detailed application examples with further documentation and example projects on the Service&Support Website:

- Diagnostics in the user program with S7-1500 (https://support.industry.siemens.com/cs/ww/en/view/98210758)
- System diagnostics with S7-1500 and TIA Portal (https://support.industry.siemens.com/cs/ww/en/view/68011497)

FAQ

For more information about how to realize channel diagnostics in the user program of the SIMATIC S7-1500, refer to the FAQ with entry ID 109480387 on the Service&Support Website (https://support.industry.siemens.com/cs/ww/en/view/109480387).

5.2 System diagnostics using process image inputs

Introduction

In addition to event-driven system diagnostics, the input and output modules of the SIMATIC series provide diagnostics information using the process image input.

The system diagnostics described in the preceding sections is made available asynchronously to the program processing. To ensure the correct processing of the input and output data in the case of faults while reading the input and output data, some modules offer the so-called value status (QI = Quality Information) for evaluation.

Requirement for evaluation of the value status

The diagnostics information about the process image input is transmitted synchronized with the user data. Select the "Value status" check box in the properties of the I/O module in STEP 7 if you want to evaluate the value status of the channel.

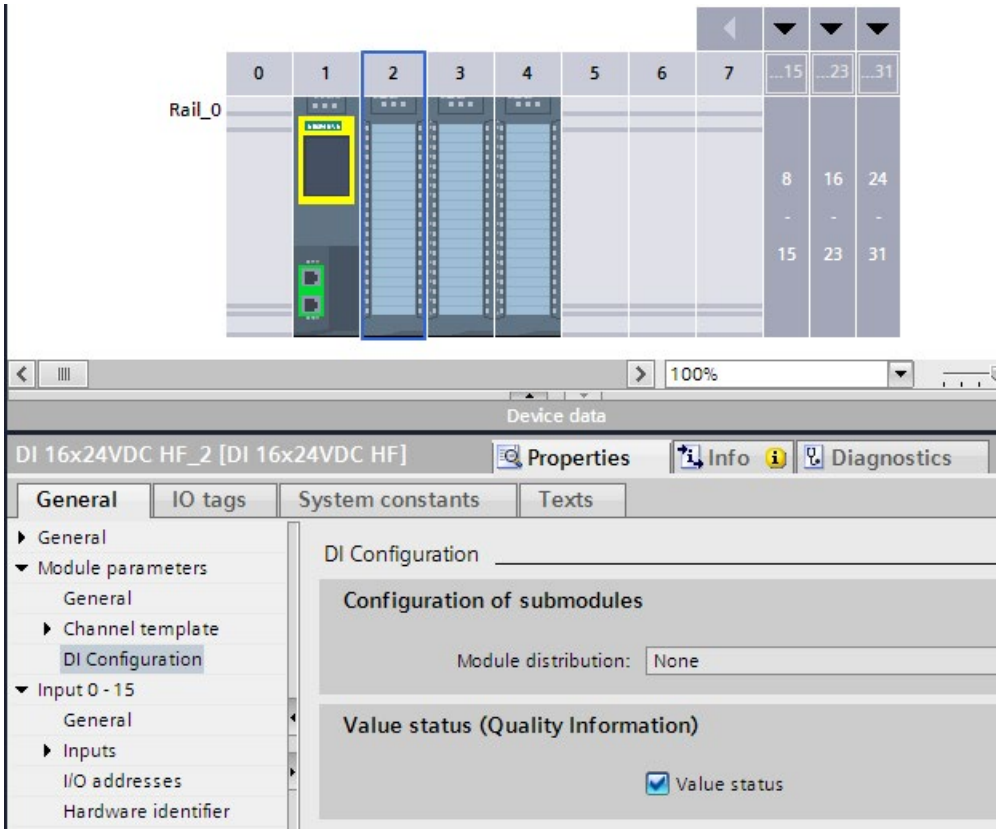


Figure 5-1 Enable value status

Evaluation of the value status

If you have enabled the value status for an I/O module, this module provides additional information on the value status in addition to the user data. This information is directly available in the process image input and can be called with simple binary operations.

Each channel is uniquely assigned one bit in the value status. The bit in the value status indicates the validity of the read-in value in the user data.

Table 5- 2 Example for evaluation of the user datum in case of a wire break for a digital input module

	Bit in user datum	Bit in value status	Value in user datum
Faulty channel	Logical 0	0	Invalid
Fault-free channel	Logical 0 (actual value)	1	Valid

Influence of the value status

The value status of an active channel is "Invalid" when any **one** of the following factors is given:

- Channel diagnostics pending (regardless of whether diagnostics, for example wire break, is configured for this channel)
- For output channels: "Reaction to CPU STOP" feature is active (due to CPU STOP, interrupted connection)
- For output channels of the digital on-board I/O of compact CPUs: If a channel is used for technology functions, it returns the value status 0 ("Invalid"). It does not matter in this context whether the output value is incorrect or not.
- PROFIenergy is active, i.e. hibernation is enabled (except in "Continue working mode")

When working with non-fail-safe modules, note that an invalid active channel also sets the value status of all other active channels to "Invalid". We therefore recommend that you disable all unconnected or unused channels.

Example - Evaluation of the value status for the input channel of an analog input module

The example below shows the basic evaluation of the value status for the input channel of an analog input module in the user program. The diameter of a cylinder is measured by means of a channel and its circumference is calculated.

- If the value status indicates the channel is error-free, the circumference is to be calculated.
- If the value status indicates the channel is defective, the value "0" is to be output as substitute value for the circumference.

The figure below shows the evaluation of the value status in the user program.

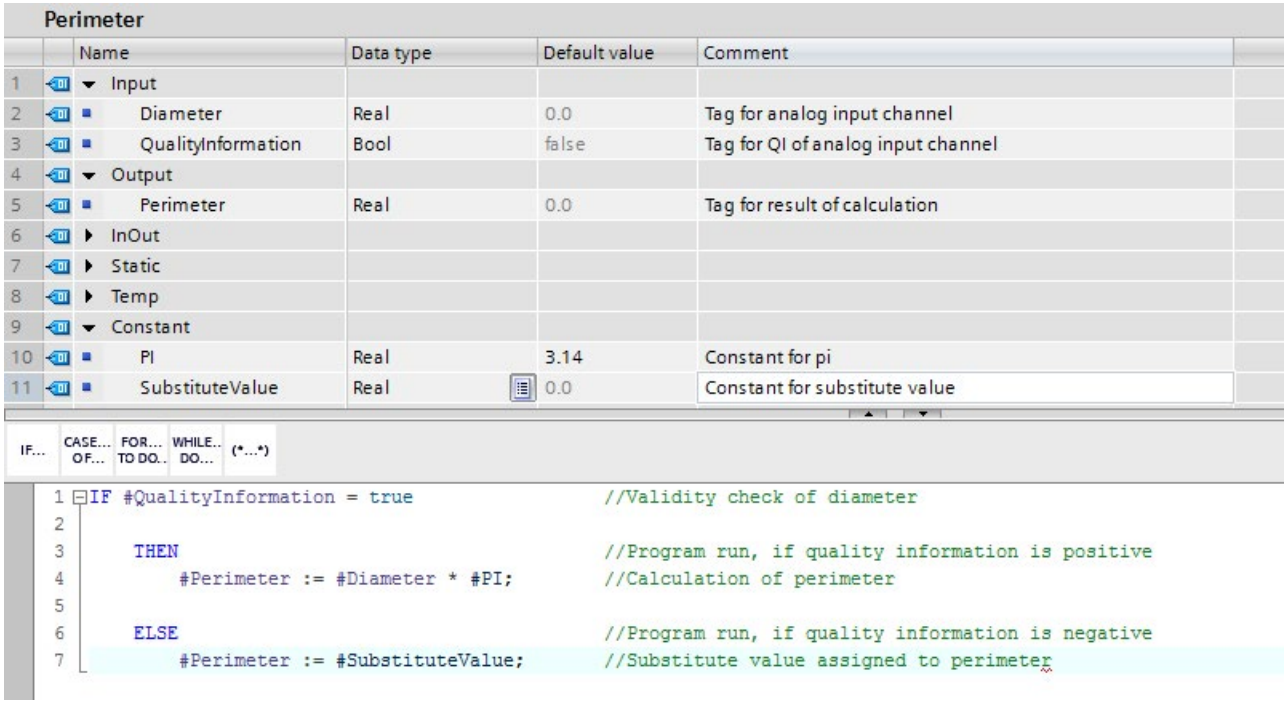


Figure 5-2 Example - Evaluation of the value status in the user program

Additional information

Depending on the I/O module, the value status reserves different addresses in the process image input. The manual for the module used includes specific information on the assignment and arrangement.

Alarms

6

Introduction

Alarms allow you to display events from processing in the automation system and to quickly detect errors, to precisely localize them and to remove them. Downtimes are significantly reduced in a plant.

Before alarms can be output, they need to be configured.

You can create, edit and compile event-dependent alarms along with their alarm texts and alarm attributes and display them on display devices.

In STEP 7, you create program alarms in the user program with the "Program_Alarm" instruction. You edit the attributes and alarm texts in the alarm editor in STEP 7.

You can output the alarm status with the "Get_AlarmState" instruction.

Advantages of program alarms

Compared to other alarm methods, such as HMI discrete alarms, program alarms offer the following advantages:

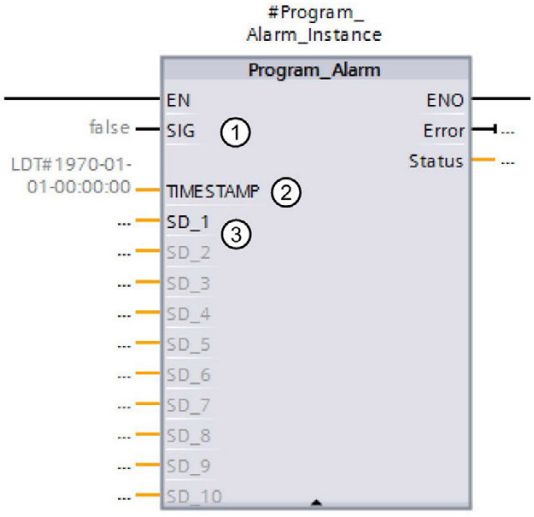
- Central engineering in STEP 7: You only configure a program alarm once for the CPU. The program alarm is automatically transferred from the CPU to all registered HMI devices.
- System-supported acknowledgment: The acknowledgment of a program alarm on an HMI device is automatically updated on other HMI devices by the CPU.
- Time stamping close to the event in the CPU
- Identical time stamps of the alarms on multiple HMI devices without time synchronization

6.1 Creating alarms with the "Program_Alarm" instruction

"Program_Alarm" instruction

You create a program alarm in STEP 7 with the "Program_Alarm" instruction.

The figure below shows the "Program_Alarm" instruction with the most important input tags.



① The "Program_Alarm" instruction monitors the signal at the SIG block input and generates a program alarm in case of a signal change at the SIG parameter. The instruction generates an incoming alarm when the signal changes from 0 to 1 and an outgoing program alarm if the signal changes from 1 to 0. The program alarm is triggered synchronously to program execution.

② The time stamp is automatically created when the alarm event occurs in the automation system and is passed along with the alarm.

③ You can append up to ten associated values to the program alarm at the parameters SD_i (1 ≤ i ≤10). The associated values are acquired at the time of the signal change at the SIG parameter and assigned to the program alarm.
Associated values are used to display dynamic contents in alarms.
Example: The temperature in the tank <associated value 1> is <associated value 2> °C.
You can find more information on associated values in the STEP 7 online help.

Figure 6-1 "Program_Alarm" instruction

Note

The "Program_Alarm" instruction can only be called in a function block.

A program alarm can be up to 256 bytes long in total (with associated values and texts from the text list).

The associated values can be a maximum of 512 bytes in length. Text lists are not affected by this.

The CPUs of the SIMATIC S7-1500 product series have the following memory for text lists:

- CPU 1510-x to CPU 1513-x: 2.25 MB
- CPU 1515-x to CPU 1516-x: 4.5 MB
- CPU 1517-x to CPU 1518-x: 6.75 MB

The number of configurable program alarms depends on the CPU used. With a CPU 1515-2 PN, for example, a maximum of 10,000 program alarms are possible. You can find this information in the device manual for the respective CPU under "Number of configurable alarms".

The number of simultaneously active "Program_Alarms" depends on the CPU used. With a 1515-2 PN CPU, for example, a maximum of 600 program alarms are possible. You can find this information in the device manual for the respective CPU under "Number of reserved user interrupts".

Sometimes, it is not possible for all program alarms that are active at the same time to be output within one cycle. Query the status of each "Program_Alarm" and activate the instruction again, if necessary. The cycle time is increased for a short time by simultaneously activating/sending multiple "Program_Alarms".

A maximum of 40,000 program alarms should be configured in a STEP 7 project on a 64-bit operating system.

Additional information

You can find more information on creating program alarms in the STEP 7 online help under "Creating and editing alarms".

6.2 Editing alarms in the alarm editor

Introduction

You can edit the created alarms in STEP 7 either in the program editor or in the alarm editor.

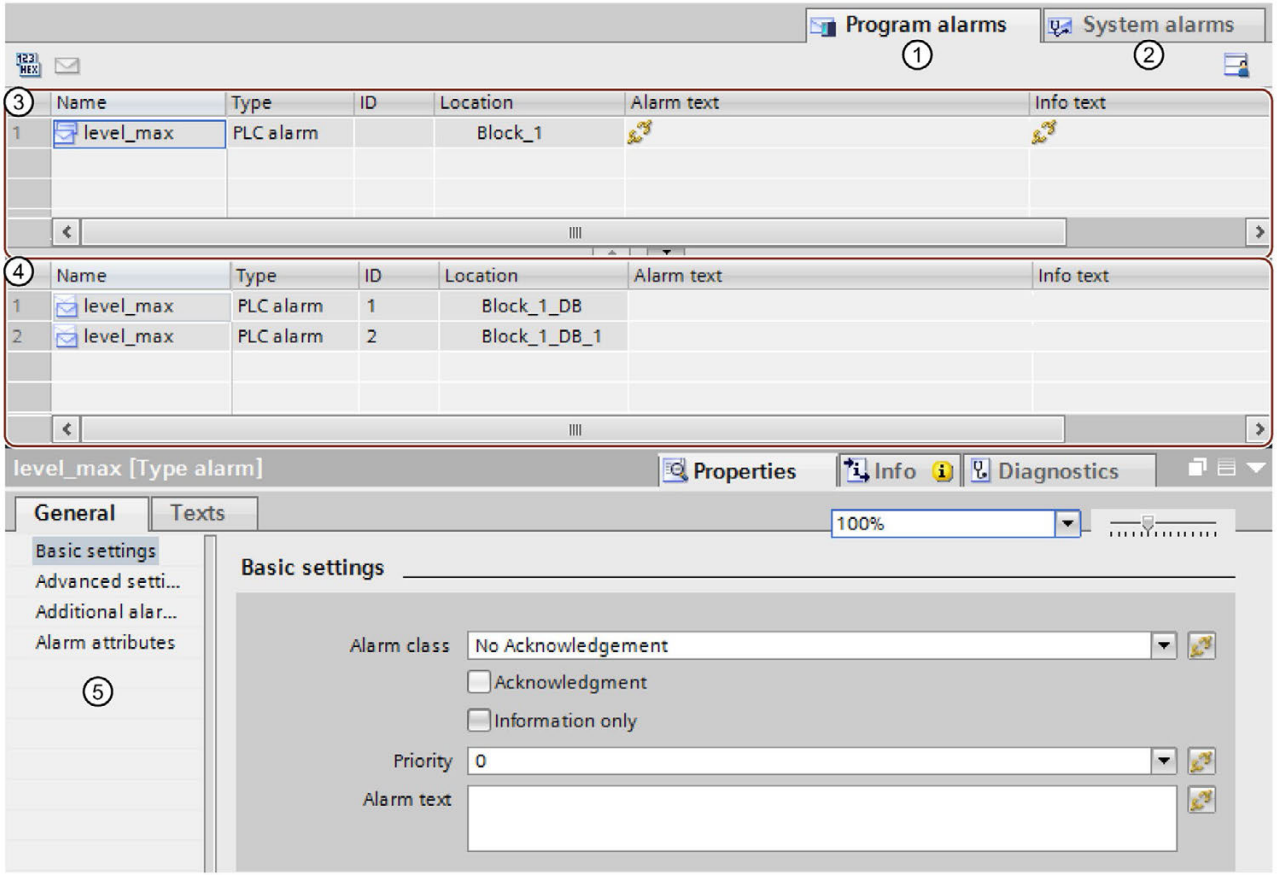
You can find additional information on editing alarms in the program editor in the STEP 7 online help under "Creating and editing alarms".

Editing alarms in the alarm editor

You can edit alarm texts in the alarm editor and specify attributes such as alarm class or priority for the alarms.

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Enter the required texts and attributes in the appropriate columns.

The figure below shows the layout of the alarm editor.



① "Program alarms" tab: You can edit program alarms here.

② "System alarms" tab: System alarms can only be viewed but not edited. To edit these alarms, you must navigate to the device view ("Go to device" menu command), where you can modify the system diagnostics alarms in the Inspector window.

③ "Type alarms" area:

This is where the type alarms created in a function block with the "Program_Alarm" instruction are displayed. Type alarms serves as templates for instance alarms (④).
All the inputs you make for the type alarm are automatically included in the instance alarms derived from it.

You can find more information on type alarms in the STEP 7 online help under "Alarm types and alarms".

④ "Instance alarms" area:

When you assign an instance DB to the message block (for example, call in an OB, FB, FC), instance alarms are automatically generated based on the template of the type alarm and alarm numbers are assigned.
You can modify the instance alarms for specific instances.

You can find more information on instance alarms in the STEP 7 online help under "Alarm types and alarms".

⑤ Properties of the selected type and instance alarm in the Inspector window

Figure 6-2 Layout of the alarm editor

You can enter or modify the necessary parameters, texts and attributes in the table or in the Inspector window.

Multilingual alarms

You can have program alarms displayed in multiple languages by assigning different project languages to the interface languages of the display devices.

Note

The project languages you want to assign must be activated and the corresponding texts (translations) must be available in the project. The project language selection can be found in the project tree under "Languages & Resources".

To create the texts of the program alarm as multilingual, follow these steps:

1. In the Inspector window of the alarm editor, open the "Properties" tab and the lower-level "Texts" tab.
2. Enter the text in the desired project language.
3. Open the "Properties" tab in the Inspector window of the CPU and select the "Display" command in the "General" area navigation. Under "Multilingual", assign one of the activated project languages to each interface language of the display devices. Overall, you can assign up to three different project languages to the user interface languages. All assigned project languages are loaded into the CPU.

Additional information

You can find additional information on texts and attributes in the STEP 7 online help under "Texts and attributes".

You can find more information on text lists in the STEP 7 online help under "Text lists for alarms".

6.3 Display of program alarms

Program alarms you create with the "Program_Alarm" instruction are automatically made available to the display devices.

You have the following options to display the alarms:

- STEP 7
- HMI
- Web server of the CPU
- Display of the CPU

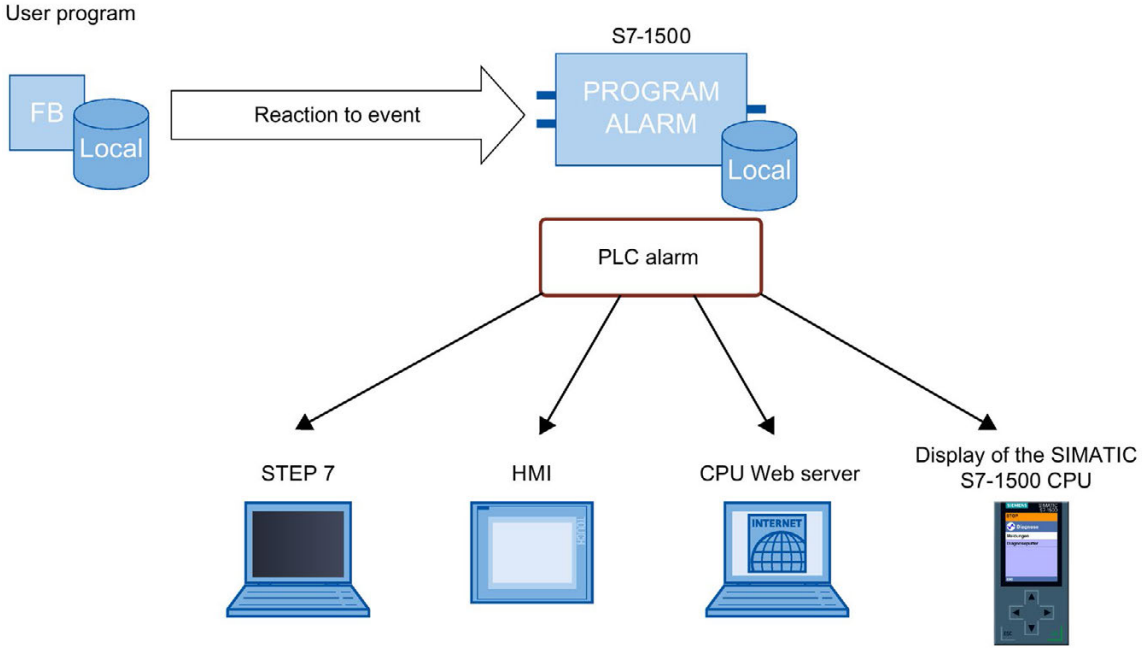


Figure 6-3 Display of program alarms

Multilingual alarms

You can have program alarms displayed in multiple languages by assigning different project languages to the interface languages. See section Editing alarms in the alarm editor (Page 78).

6.4 Output of the alarm state with the "Get_AlarmState" instruction

"Get_AlarmState" instruction

The "Get_AlarmState" instruction outputs the alarm state of a program alarm. The output of the alarm state always refers to a program alarm that was created using the "Program_Alarm" instruction.

The program alarm is selected with the "Alarm" input parameter. Specify the instance DB of the "Program_Alarm" instruction at the "Alarm" parameter.

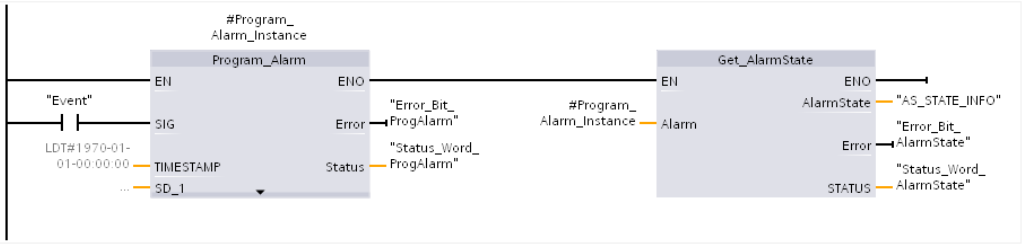


Figure 6-4 Call - Get_AlarmState

Additional information

You can find additional information on evaluation of the "Get_AlarmState" instruction in the STEP 7 online help.

6.5 Example program for program alarms

6.5.1 Task

Introduction

This section describes the basic configuration of program alarms with the "Program_Alarm" instruction based on two examples. The two examples solve the same problem but use a different approach. Example 1 does not use associated values. In example 2, an associated value is assigned to the program alarm to reference a text list.

Example - Minimum/maximum fill level of a tank

A tank is filled with a liquid. The fill level is monitored by two sensors.

If the liquid in the tank drops below a minimum fill level, an alarm is output for low fill level.

If the liquid in the tank exceeds a maximum fill level, an alarm is output for high fill level.

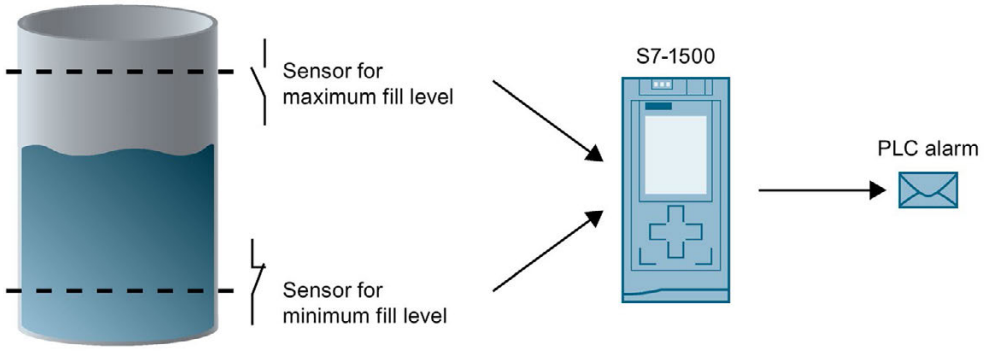


Figure 6-5 Example for fill level alarms

6.5.2 Example 1: Program alarm without associated values

Introduction

In this example, you create a program alarm for the maximum and the minimum fill level.

How the example works

When the maximum fill level is exceeded in the tank, a program alarm with the alarm text for the excessive fill level is output.

When the minimum fill level is undershot in the tank, a program alarm with the alarm text indicating that the fill level is too low is output.

Steps

The following steps are necessary for this example:

1. Define tags for signal acquisition
2. Create function block
3. Create program alarms
4. Call function block
5. Edit alarm text

Define tags for signal acquisition

The following table shows the tags that are used in this example. Define these tags in the standard tag table. The standard tag table is available in the project tree under "PLC tags".

Table 6- 1 Tags for fill level alarms

Name	Data type	Description
max	BOOL	Tag for maximum fill level If "max" = 1, the maximum fill level is exceeded.
min	BOOL	Tag for minimum fill level If "min" = 1, the minimum fill level is undershot.

The figure below shows the standard tag table with the defined tags "max" and "min".

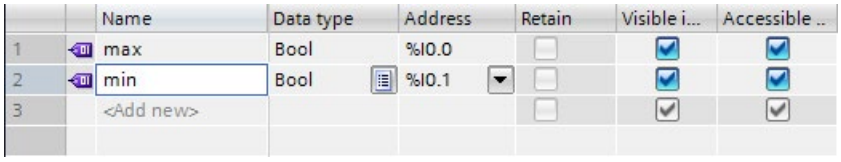


Figure 6-6 Define tags

Create function block

To create a function block, follow these steps:

1. Open the "Program blocks" folder in the project tree.
2. Double-click "Add new block".
   The "Add new block" dialog opens.
3. Select the button "Function block".

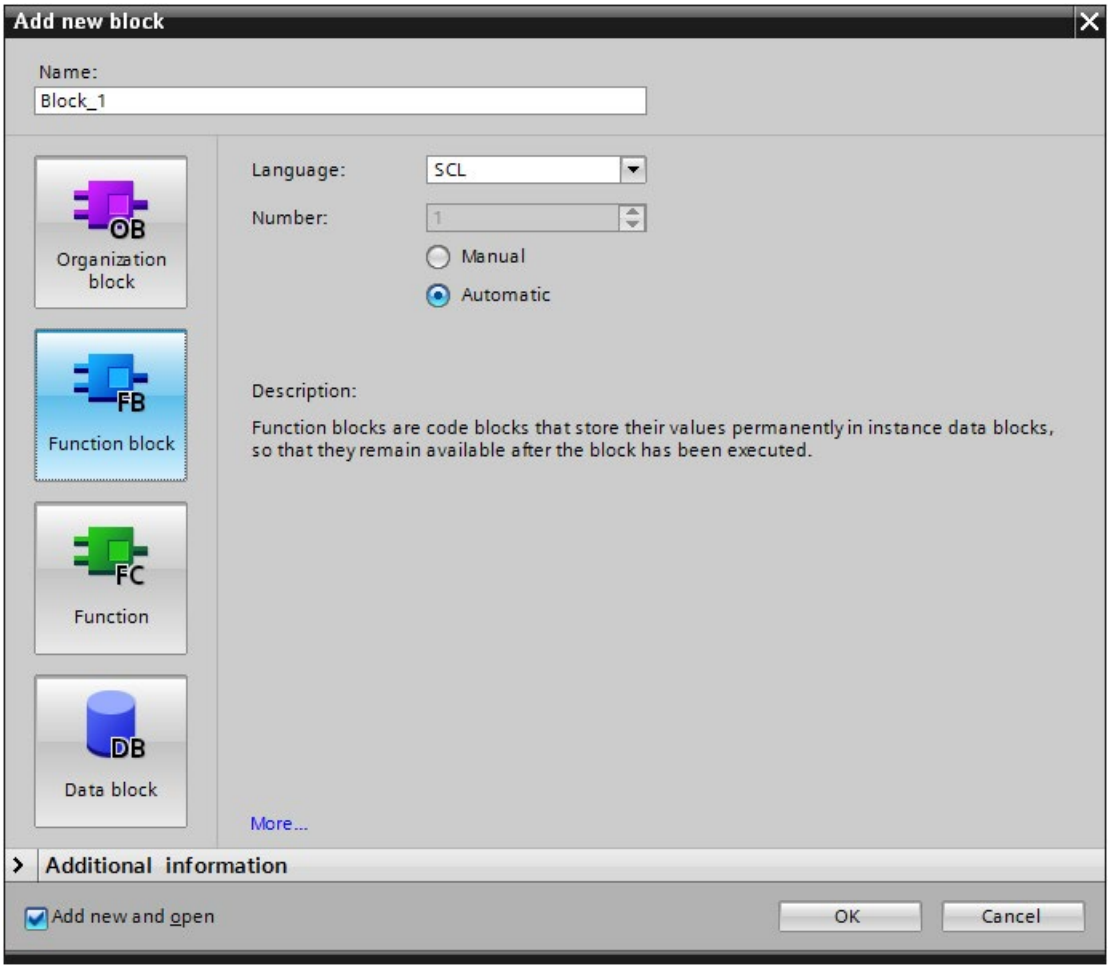


Figure 6-7 Create FB

4. Enter a name for the new block.
5. Select the language SCL.
6. Click on "OK" to confirm your input.

Result: You have created a function block.

Create program alarms

To create the program alarm for the example program, follow these steps:

1. Select the created function block (FB) in the "Program blocks" folder in the project tree and double-click the function block to open it.
2. Insert the call of the "Program_Alarm" instruction in the instruction part of the function block. The "Program_Alarm" instruction is available in the "Instructions" task card under "Extended instructions" > "Alarms".

   The "Call options" window opens.

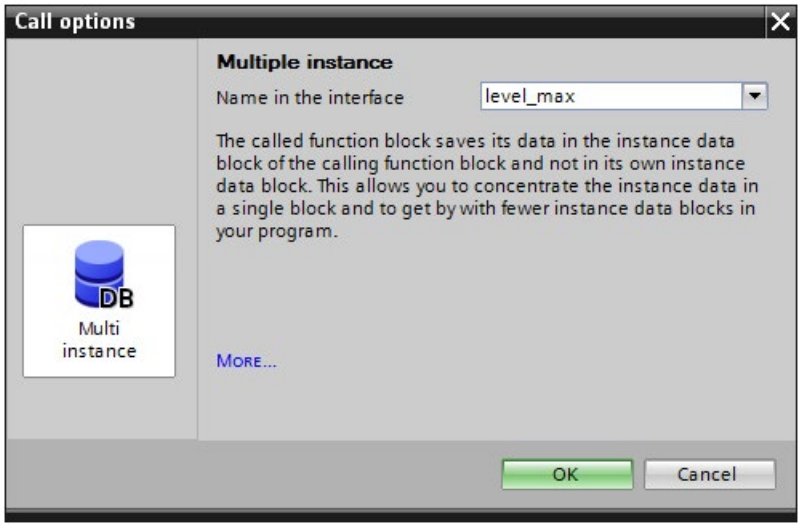


Figure 6-8 Call Program_Alarm

3. Enter "level_max" as the name and confirm the call options by clicking "OK".

   Result: The input tags of the "Program_Alarm" instruction are displayed in the instruction part.
4. Supply the SIG input tag of the "Program_Alarm" instruction with the tags for the maximum fill level.

   ```
   #level_max(SIG:="max");
   ```

   SIG: If a signal change occurs at the SIG input tag, the "Program_Alarm" instruction generates a program alarm.
5. Insert another call of the "Program_Alarm" instruction.
   The "Call options" window opens.
6. Enter "level_min" as the name and confirm the call options by clicking "OK".

   Result: The input tags of the "Program_Alarm" instruction are displayed in the instruction part.
7. Supply the SIG input tag of the "Program_Alarm" instruction with the tags for the minimum fill level.

   ```
   #level_min(SIG:="min");
   ```

Result: You have created two type alarms.

Call function block

To call the function block in the user program, follow these steps:

1. In the "Program blocks" folder, select the cycle OB (e.g., OB1) in which you want to call the function block and open the cycle OB with a double-click.
2. Select the function block you want to call in the "Program blocks" folder.
3. Drag the function block into the instruction part of the cycle OB.
   The "Call options" window opens.

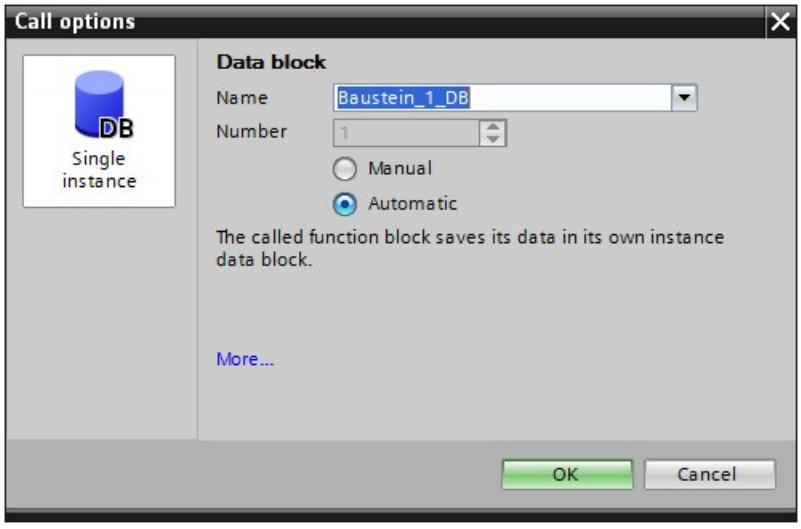


Figure 6-9 Call function block

4. Confirm the call options by clicking "OK".

Result: You have called the alarm block in the user program and created an instance alarm.

Edit alarm text

To edit the alarm text, follow these steps:

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Select the type alarm for the maximum fill level.
3. Enter the alarm text for the maximum fill level in the "Alarm text" column.
4. Select the type alarm for the minimum fill level.
5. Enter the alarm text for the minimum fill level in the "Alarm text" column.

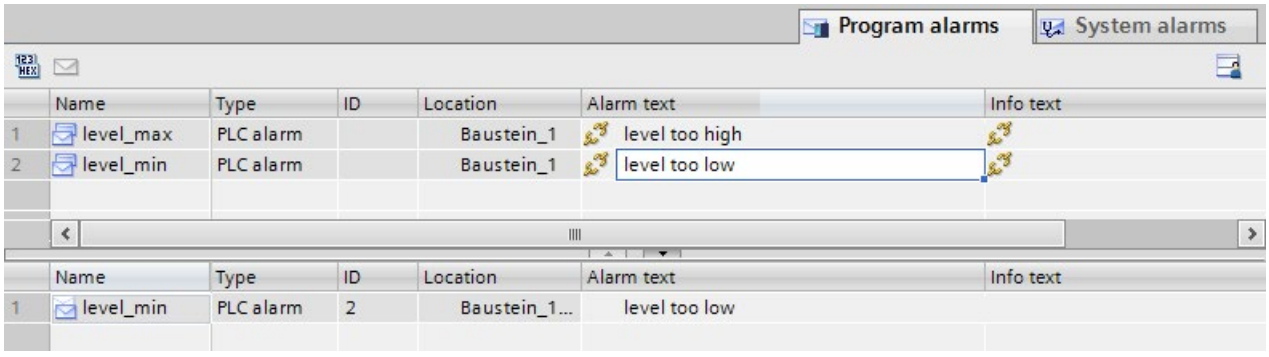


Figure 6-10 Edit alarm text

Result: You have created the alarm texts for both type alarms.

Additional information

You can learn how to create multilingual texts under "Multilingual alarms" in the section Editing alarms in the alarm editor (Page 78).

6.5.3 Example 2: Program alarm with associated value

Introduction

In this example, you create a shared program alarm for the maximum and the minimum fill level. The program alarm is given an associated value. The program alarm uses the associated value to access a text list entry and outputs a separate alarm text for the minimum and the maximum fill level.

How the example works

The program alarm is output if either the minimum fill level is undershot or the maximum fill level is exceeded.

The associated value 1 of the "Program_Alarm" instruction is assigned the tag for the maximum fill level. The associated value references a text list with the entries "0" and "1".

The following scenarios are possible for output of the alarm text:

- Associated value is "0": The entry "0" of the text list with the alarm text for the undershot fill level is output.
- Associated value is "1": The entry "1" of the text list with the alarm text for the excessive fill level is output.

Steps

The following steps are necessary for this example:

1. Define tags for signal acquisition
2. Create function block
3. Create program alarm
4. Call function block
5. Create a text list
6. Edit alarm text

Define tags for signal acquisition

The following table shows the tags that are used in this example. Define these tags in the standard tag table. The standard tag table is available in the project tree under "PLC tags".

Table 6- 2 Tags for fill level alarms

Name	Data type	Description
max	BOOL	Tag for maximum fill level If "max" = 1, the maximum fill level is exceeded.
min	BOOL	Tag for minimum fill level If "min" = 1, the minimum fill level is undershot.

The figure below shows the standard tag table with the defined tags "max" and "min".

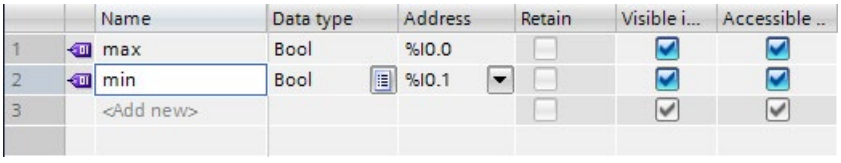


Figure 6-11 Define tags

Create function block

To create a function block, follow these steps:

1. Open the "Program blocks" folder in the project tree.
2. Double-click "Add new block".
   The "Add new block" dialog opens.

3. Select the button "Function block".

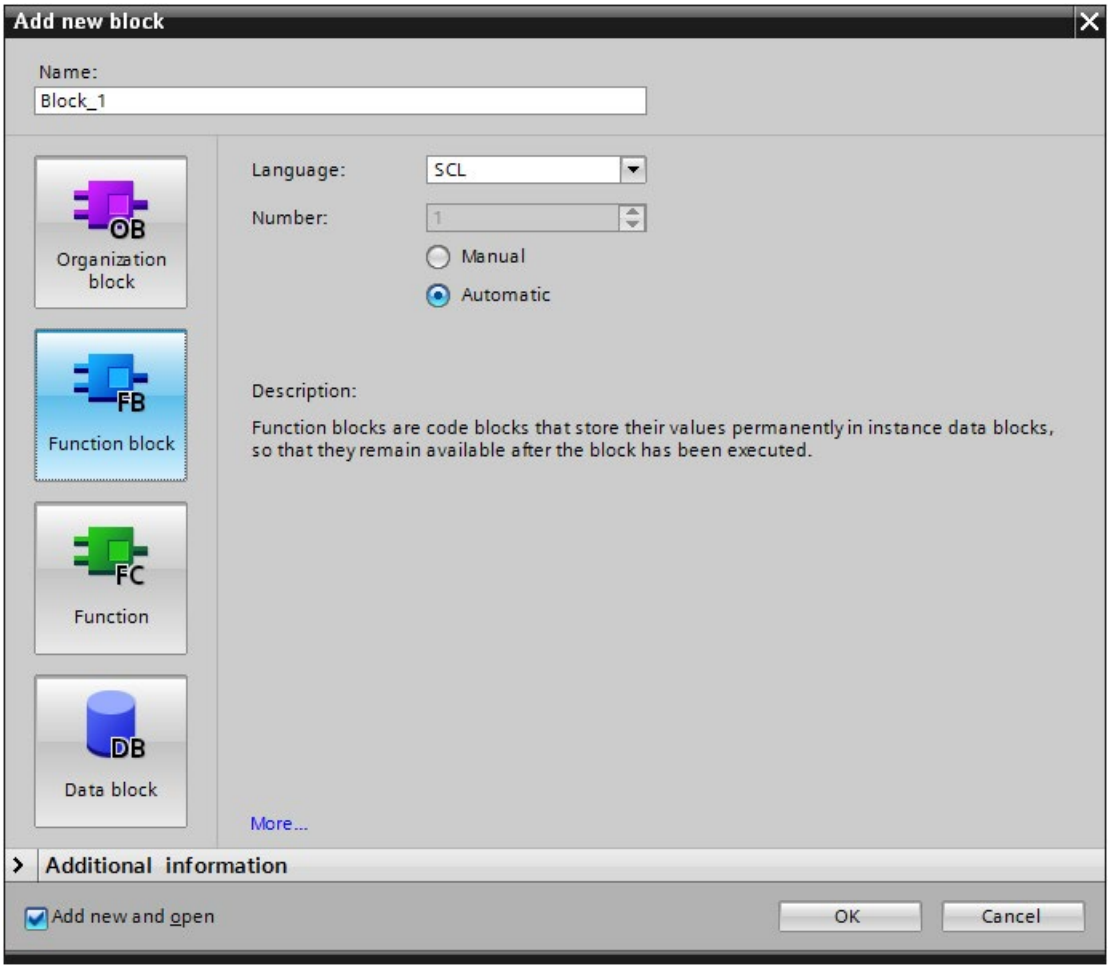


Figure 6-12 Create FB

4. Enter a name for the new block.
5. Select the language SCL.
6. Click on "OK" to confirm your input.

Result: You have created a function block.

Create program alarm

To create the program alarm for the example program, follow these steps:

1. Select the created function block (FB) in the "Program blocks" folder in the project tree.
2. Insert the call of the "Program_Alarm" instruction in the instruction part of the function block. The "Program_Alarm" instruction is available in the "Instructions" task card under "Extended instructions" > "Alarms".
   The "Call options" window opens.

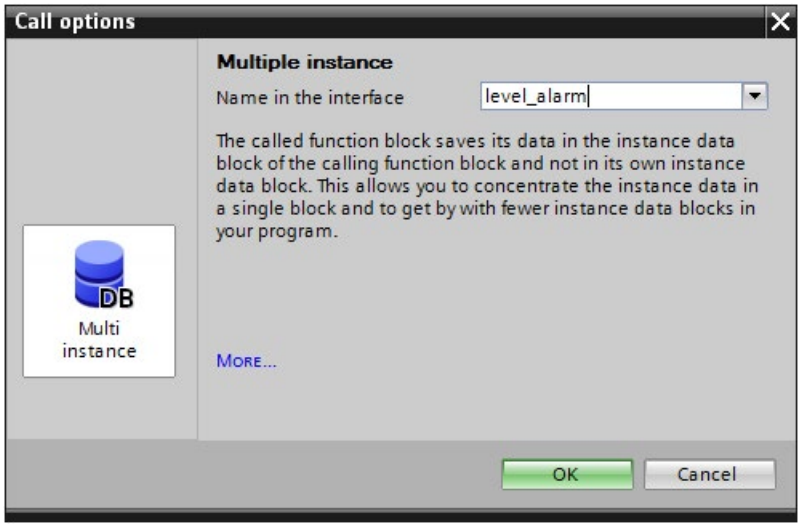


Figure 6-13 Call Program_Alarm

3. Enter "level_alarm" as the name and confirm the call options by clicking "OK".

   Result: The input tags of the "Program_Alarm" instruction are displayed in the instruction part.

4. Supply the SIG input tag of the "Program_Alarm" instruction with the XOR logic operation of the tags for minimum and maximum fill level and the input tag SD_1 with the tag for the maximum fill level.

   ```
   #level_alarm(SIG:="min"XOR"max",SD_1:="max");
   ```

   SIG: If a signal change occurs at the SIG input tag, the "Program_Alarm" instruction generates a program alarm.
   SD_1: The associated value is acquired at the time of the signal change at the input tag and assigned to the program alarm.

Result: You have created a type alarm.

Call function block

To call the function block in the user program, follow these steps:

1. In the "Program blocks" folder, select the cycle OB (e.g., OB1) in which you want to call the function block and open the cycle OB with a double-click.
2. Select the function block you want to call in the "Program blocks" folder.
3. Drag the function block into the instruction part of the cycle OB.
   The "Call options" window opens.

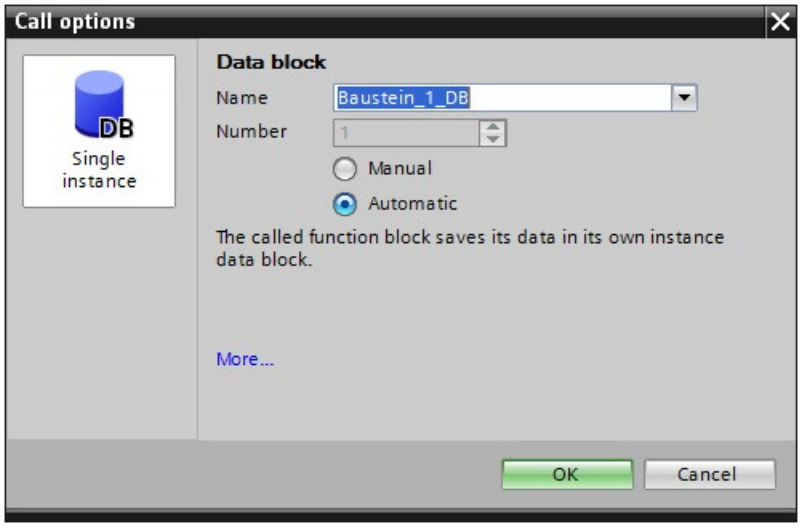


Figure 6-14 Call function block

4. Confirm the call options by clicking "OK".

Result: You have called the alarm block in the user program and created an instance alarm.

Creating a text list

To create the text list for the example program, follow these steps:

1. Double-click on the "Text lists" command in the program tree.
   The text list editor opens.
2. Double-click "<Add>" in the Text lists area.
   A new text list is added.
3. Name the text list "level_textlist".
4. Double-click "<Add>" in the Text list entries area of level_textlist.
   A new text list entry is added in the level_textlist text list.
5. Enter the alarm text for the maximum fill level in the "Entry" column.

6. Add another entry in the text list.
7. Enter the alarm text for the minimum fill level in the "Entry" column.

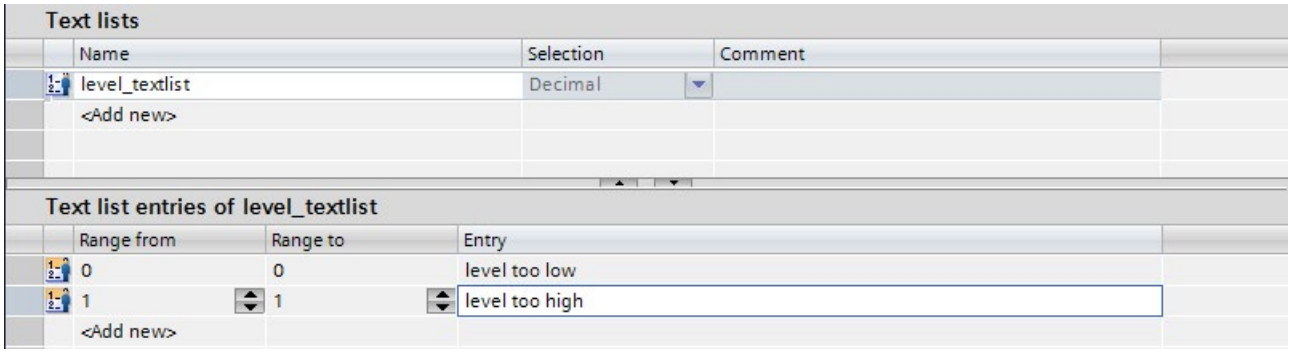


Figure 6-15 Creating a text list

Result: You have created the text list for the alarm text.

Edit alarm text

To edit the alarm text for the example program, follow these steps:

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Select the type alarm created for the example.
3. Click in the "Alarm text" column.
4. Open the shortcut menu and select the command "Insert a dynamic parameter (text list)".

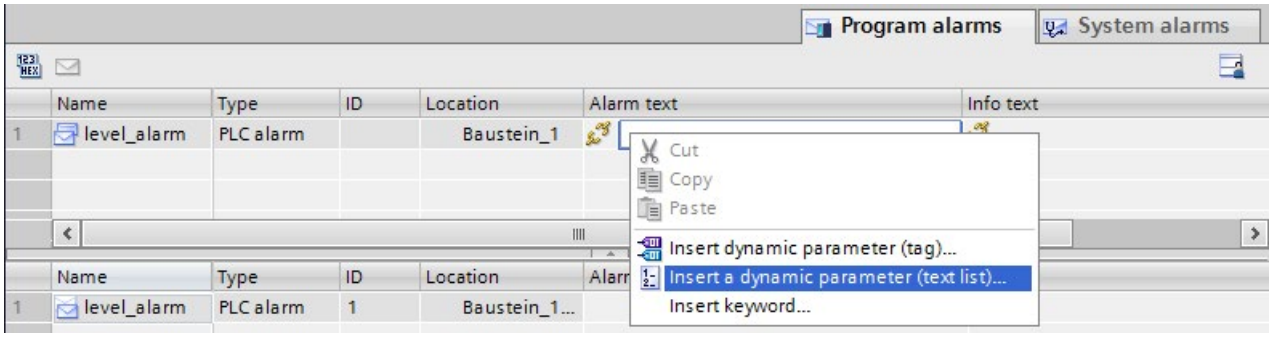


Figure 6-16 Edit alarm text

The window below opens.

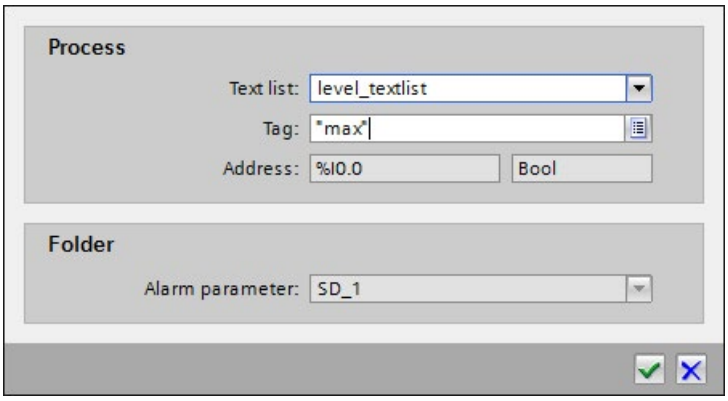


Figure 6-17 Insert a dynamic parameter (text list)

5. Select the text list "level_textlist" and the tag "max". Confirm your selection by clicking "OK".

Result: You have created the alarm text for the type alarms.
If the tag "max" (associated value 1) is 0, the alarm text "level too low" is output.
If the tag "max" (associated value 1) is 1, the alarm text "level too high" is output.

Additional information

You can learn how to create multilingual texts under "Multilingual alarms" in the section Editing alarms in the alarm editor (Page 78).

6.5.4 Displaying the alarm

Displaying the alarm in the Web server

The figure below shows the display of the alarm in the Web server for both examples.

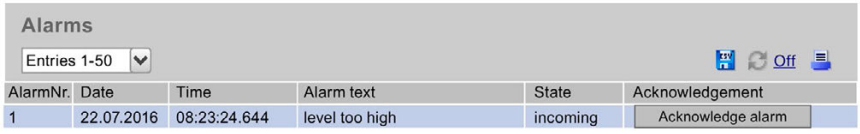


Figure 6-18 Displaying the alarm in the Web server

Displaying the alarm in STEP 7

Note

Displaying alarms in STEP 7

To display alarms in STEP 7, enable the option "Receive alarms" in the shortcut menu of the CPU.

The figure below shows the display of the alarm in STEP 7 for both examples.

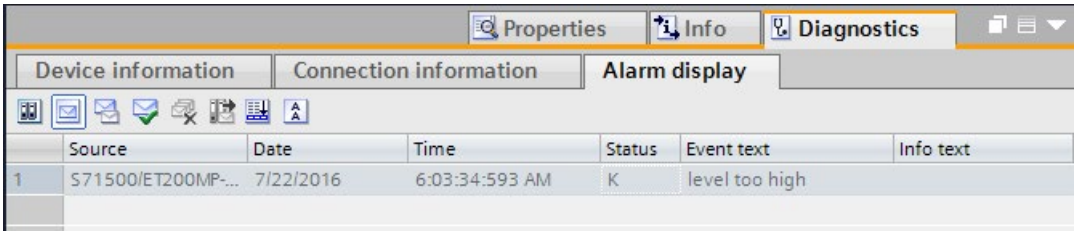


Figure 6-19 Display in STEP 7

Glossary

Alarm

An message sent to the operator due to events or states of the system.

Button (WinCC)

Object in WinCC that points out faults in the plant

Channel fault

Channel-related error of an individual channel - an I/O with inputs, for example, wire break or short circuit

Device

Modules with a network connection are referred to as device. Devices are installed on racks where they can be interconnected with other modules.

Diagnostics buffer

A buffered memory area in the CPU; it stores diagnostics events in the order of their occurrence

Firmware of the CPU

In SIMATIC, a distinction is made between the firmware of the CPU and user programs.

The firmware is a software embedded in electronic devices, which means it is permanently connected with the hardware functionally. It is usually saved in a flash memory, such as EPROM, EEPROM or ROM, and cannot be replaced by the user or only with special means or functions.

User program: see glossary entry "User program"

Global screen (WinCC)

A screen that is opened in the system diagnostics window is a global screen.

HMI device

Human Machine Interface, device for visualization and control of automation processes.

HMI diagnostics view (WinCC)

The HMI diagnostics view is an object in WinCC. The HMI diagnostics view can only be used with Comfort Panels and WinCC Advanced RT.

I/O module

Device of the distributed I/O that is used as interface between the controller and the process.

Industrial Ethernet

Guideline for setting up Ethernet in an industrial environment. The main difference to the standard Ethernet is the mechanical current carrying capacity and interference immunity of the individual components.

Memory reset

Procedure to set the memories of the CPU to a defined initial state.

PLC

Programmable **L**ogic **C**ontroller: Component of the CNC by which the machine manufacturer coordinates the interaction between the NC requirements (part program), the inputs of the machine operator and the current machine state.

PROFIBUS

Standard for fieldbus communication in automation technology.

PROFINET

Open component-based industrial communication system based on Ethernet for distributed automation systems. Communication technology promoted by the PROFIBUS Users Organization.

Subnet

Part of a network whose parameters must be synchronized with the devices (e.g., with PROFINET). It includes the bus components and all connected stations. Subnets can be linked by means of gateways, for example, to form a network.

System diagnostics

In the SIMATIC environment, the term "system diagnostics" refers to diagnostics of devices and modules. System diagnostics is used, for example, to monitor the states of the following components in the system: Power supply, device, I/O.

System diagnostics indicator (WinCC)

The system diagnostics indicator is a predefined graphic symbol of the library which alerts you to errors in your plant and displays two states: No error, error

Topology

Structure of a network. Common structures include:

- Linear bus topology
- Ring topology
- Star topology
- Tree topology

User program

In SIMATIC, a distinction is made between user programs and the firmware of the CPU.

The user program contains all instructions, declarations and data by which a plant or process can be controlled. It is assigned to a programmable module (for example, CPU, FM) and can be structured in smaller units.

Firmware: see glossary entry "Firmware of the CPU"

Value status

The value status describes a specific signal state. The value status is constantly updated and cyclically transmitted by the field device as quality statement together with the measured value.

Web server

Software/ communication service for data exchange using Ethernet. The web server provides the documents by means of standardized transmission protocols (HTTP, HTTPS) to a web browser. Documents can be static or dynamic upon request by the web browser composed from different sources by the web server.

WinCC

Windows **C**ontrol **C**enter: a PC-based process visualization system

WinCC Runtime

Component of the basic software WinCC

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SIMATIC/SINAMICS

Using the trace and logic analyzer function

Function manual

Edition 09/2016

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SIMATIC / SINAMICS

S7-1500, S7-1200 / S120, G120 Using the trace and logic analyzer function

Function Manual

09/2016
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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

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indicates that death or severe personal injury **may** result if proper precautions are not taken.

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indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

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Preface

Purpose of the documentation

The diagnostics options available with the trace and logic analyzer function are described in this documentation. Depending on the device used, the recording options can vary.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- Knowledge about the use of Windows-based computers
- S7-1200/1500 CPUs, ET 200SP, ET 200Pro
  - Knowledge of the SIMATIC industrial automation system
  - Knowledge of working with STEP 7
- SINAMICS G120
  - Knowledge of working with the drive
- SINAMICS S120
  - Knowledge of working with the drive

Validity of the documentation

This documentation applies to all products of the S7-1200, S7-1500, SINAMICS G120 and SINAMICS S120 product family as of TIA Portal V14.

Conventions

This documentation contains pictures of the devices described. The pictures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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- The online catalog and the online ordering system is available on the Internet (https://mall.industry.siemens.com).

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Description

1

1.1 Supported hardware

If a device supports the trace and logic analyzer function, "Traces" is offered for selection in the project tree below the device.

The following devices (Page 60) support the trace and logic analyzer function:

- SIMATIC S7-1200 CPUs (as of firmware version V4.0)
- SIMATIC S7-1500, ET 200SP and ET 200Pro CPUs
- SIMATIC S7-1500 software controller
- SINAMICS G120
- SINAMICS S120
- SIRIUS SIMOCODE pro (with Simocode ES)
- SIRIUS soft starter 3RW (with Soft Starter ES)

1.2 Recording of measured values with the trace function

Introduction

The trace and logic analyzer function can be called in the project navigator (Page 14) by double-clicking an entry in the "Traces" system folder. The measurements on the memory card can also be read and displayed via the diagnostic interface of the Web server.

You record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU. The number of installed traces is hardware-dependent.

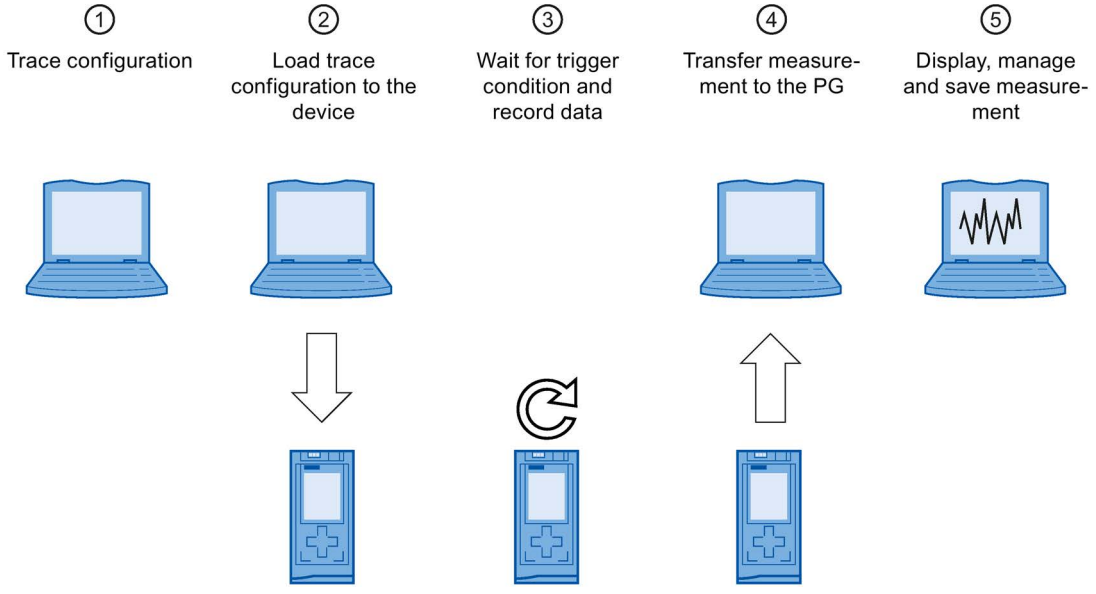
The recordings are saved on the device and, when required, can be read out with the engineering system (ES) and saved permanently. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes. The recorded values are overwritten when the recording is activated again.

Active recordings from the axis control panel are displayed in the "Traces" system folder as installed traces. Recordings can be added to the measurements in the curve diagram of the axis control panel or the PID via a shortcut menu command.

Depending on the device (Page 60) used, the recording options can vary.

A quick start (Page 36) for working with the trace and logic analyzer function can be found in the Operation section.

The following figure shows the method of operation of the "Traces":



① Trace configuration on the programming device (PG) in the TIA Portal

You can specify the signals to be recorded, the duration of the recording and the trigger condition in the trace configuration. The trace configuration depends on the device and is described at the respective device (Page 60).

② Transferring the trace configuration from the PG to the device

You can transfer the complete trace configuration (Page 44) to the device when an online connection is established.

③ Waiting for the recording

If the installed trace configuration is activated (Page 45), then the recording is performed independently of the PG. The recording is started as soon as the trigger condition is satisfied.

④ Transferring the measurement from the device to the PG

The saving of the measurement in the project (Page 48) stores the measurement in the opened project of the TIA Portal. The measurement can be saved at any time after completing the recording, irrespective of the time of the measurement.

⑤ Evaluating, managing and saving the measurement

Numerous options are available for the evaluation of the measurement in the curve diagram and in the signal table (Page 46). Various display types are possible, for example, a bit representation for binary signals.
Signal waves from different measurements can be put together as an overlay measurement and compared with each other.
Measurements can also be exported and imported as a file.
With the saving of the project (Page 48) in the TIA Portal, the measurements transferred to the project are also saved.

Supported TIA Portal features

The following TIA Portal features are supported as of V14:

- Saving of trace configurations and measurements in libraries
- Multiuser support for trace configurations and measurements (offline data)

1.3 Trace configuration, recording, installed trace and measurement

This section explains the meaning and relationships of the terms: trace configuration, recording, installed trace and measurement.

Trace configuration

Implement the following settings in the trace configuration:

- Signals to be recorded
- Recording conditions
  - Sampling
  - Trigger
  - Installed measurements (memory card)

Recording

A recording is performed in the device. There is only one recording for each installed trace configuration. When a new recording is started, the old recording is overwritten.

An installed recording is not retentive (it is lost when the device is switched off/on) but can be saved permanently in the project as a measurement.

Installed trace

An installed trace consists of a trace configuration and optionally a recording. The maximum number of installed traces depends on the device.

The trace configuration is stored retentively on the device. The retentivity of the trace configuration may also be configurable depending on the device, e.g. with the S120.

Measurement

A measurement consists of a trace configuration and a recording, provided that recorded data is present. Each installed trace can be saved as a measurement in the project.

The recording of a measurement can be viewed offline.

The configuration for a measurement can be transferred to the “Traces” folder using drag & drop.

Installed measurements (memory card)

The folder contains measurements that are saved on the device (e.g. on the memory card). These measurements are retentive and can only be deleted by the user.

The installed measurements can be transferred to the Measurements folder using drag & drop and are then saved as measurements in the project.

Trace configuration with an installed trace of the same name

Usually, there is a trace configuration in the project with the same name for an installed trace. When there is an online connection, this trace is displayed with the icon in the project tree.

See also User interface - “Traces” project tree folder (Page 16).

Overlay measurement

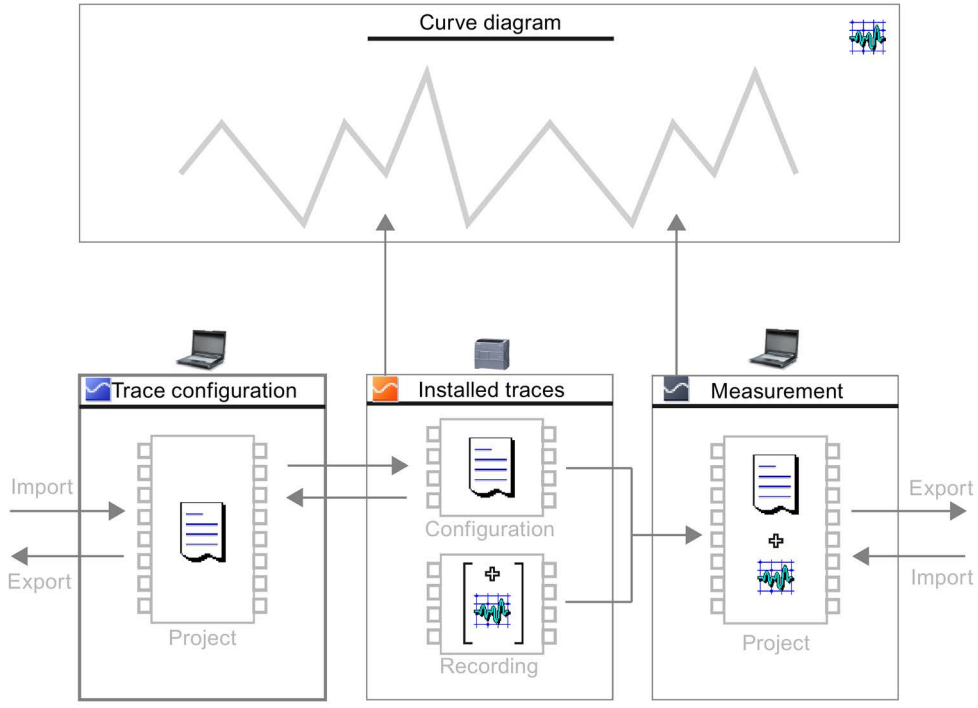
The overlay measurement allows a comparison and analysis of signals from different measurements with each other.

The measurements can be synchronized with each other and displayed as overlay measurements.

1.4 Data storage

The trace toolbar and the curve diagram also enable the transfer of the trace configuration and the viewing of the recording.

The following figure is a schematic diagram of the data storage:



Note

Saving the trace configuration and measurement

You save the trace configuration and measurement with the project in the TIA Portal.

If you close the project without saving, the trace configurations and the measurements transferred to the project are discarded. The trace editor can be closed and reopened without loss of data until the project is closed.

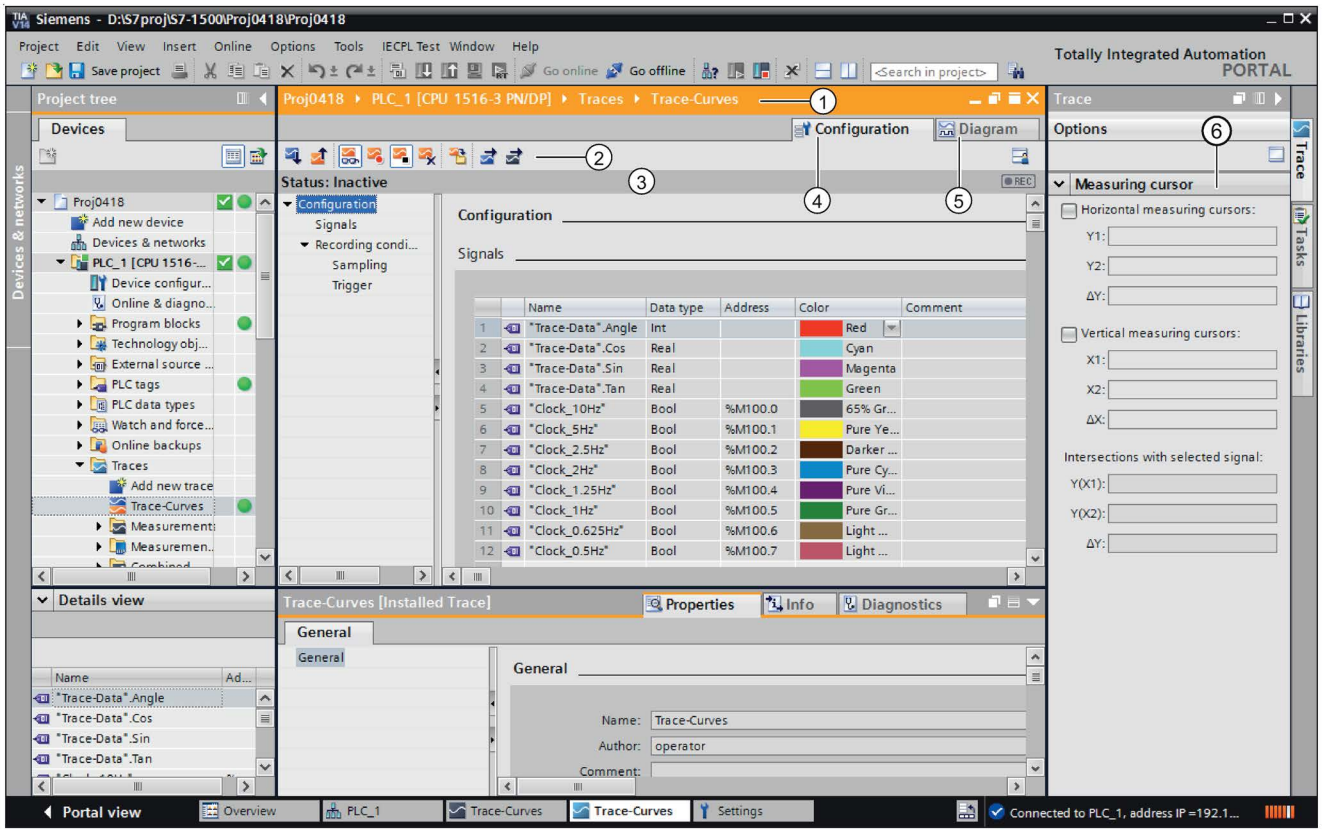
Software user interface

2

Display areas

The user interface of the trace and logic analyzer function consists of several areas.

The example in the figure below shows the division of the user interface in the TIA Portal:



Project navigator	
Management and creation of the trace and measurements directly in the project tree and via context menu commands.	
Working area	
	① Title bar of the working area Shows the device to which the current display belongs.
	② Trace toolbar Buttons for managing the trace in the project and device: • Activation/deactivation of installed traces • Deletion of installed traces • Transfer of trace configurations and measurements between the device and the project • Export of trace configurations and measurements • Switchover between offline and online display
	③ Status display of the trace Display of the current status of the recording.
	④ Configuration tab Device-specific configuration of the recording duration, trigger condition and signal selection. See Device-specific descriptions (Page 60).
	⑤ Diagram tab Display of the recorded values as a curve diagram and the signals from the displayed measurement.
	Signal selection tab Display of all signals that are contained in the overlay measurements.
"Trace" task card	
Display of the measurement cursor data ⑥ and snapshots.	
Inspector window	
Display of general information about the trace configuration	

2.1 Project navigator

2.1.1 User interface - “Traces” project tree folder

Trace configurations and installed traces are displayed in the "Traces" folder.

More information about the “Traces” sub-folder is provided in the following sections.

Double-click a trace to open the corresponding "Diagram" or "Configuration" tab in the working area.

Icons in the "Traces" folder

The following table explains the icons in the "Traces" folder:

Icon	Description
	Add trace configuration Double-click the icon to add a new trace configuration.
	Trace configuration (offline) Double-click the icon to open the "Configuration" tab.
	Installed trace (online) The icon is only displayed when there is no offline trace configuration of the same name for the installed trace. Double-click the icon to open the "Diagram" tab.
	Trace configuration with an installed trace of the same name If the button is deactivated, the trace configuration from the project is displayed. The trace corresponds to a trace configuration. If the button is activated, the trace configuration from the device is displayed. The trace corresponds to an installed trace. Double-click the icon to open the "Diagram" tab.

Status

When there is an online connection, the status is displayed in the right-hand column of the project tree. The status is also displayed as tooltip above the respective icon.

The following table shows the meaning of the icons:

Icon	Description
	Online and offline configuration are identical
	Online and offline configuration are different
	Configuration only exists online

Shortcut menu commands

The following table shows the shortcut menu commands for the "Traces" system folder:

Shortcut menu command	Description
“Add new group”	Inserts a new folder.
“Add new trace”	Inserts a new trace configuration and opens the configuration tab.
"Import trace configuration"	Imports a trace configuration from a file.

The following table shows the shortcut menu commands for trace configurations and installed traces / :

Shortcut menu command	Trace configuration	Installed trace	Description
"Copy"	x	-	Copies the trace configuration of the selected objects to the clipboard.
"Paste"	x	-	Inserts a trace configuration or measurement from the clipboard.
"Delete"	x	x	Deletes the selected objects from the project tree or from the device.
"Rename"	x	-	Switches the selected object to the editing mode.
"Export trace configuration"	x	-	Exports a trace configuration as a file with the extension "*.ttcfgx". For compatibility reasons, the "*.ttcfgx" file extension will be supported in V12, but does not contain any information about the device family.

The trace configuration can also be copied device-wide.

Several objects can be selected.

2.1.2 User interface - “Measurements” project tree folder

The “Measurements" folder shows the saved measurements.

Icons in the “Measurements" folder

The following table explains the icons in the “Measurements" folder:

Icon	Description
	Measurement (offline) Double-click the icon to open the "Diagram" tab. The configuration for a measurement can be transferred to the “Traces” folder using drag & drop.

Shortcut menu commands

The following table shows the shortcut menu commands for the "Measurements" system folder:

Shortcut menu command	Description
“Add new group”	Inserts a new folder.
"Import measurement"	Imports a measurement from a file with the "*.ttrecx" file extension. For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.

The following table shows the shortcut menu commands for measurements :

Shortcut menu command	Description
"Copy"	Copies the trace configuration of the selected objects to the clipboard.
"Paste"	Inserts a measurement from the clipboard.
"Delete"	Deletes the selected objects from the project tree or from the device.
"Rename"	Switches the selected object to the editing mode.
“Generate new overlay measurement”	Generates a new overlay measurement with the selected measurements.
"Export measurement"	Exports a measurement with the last saved standard view The measurement is saved with the extension "*.ttrecx" or "*.csv". For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.

The measurements can also be copied device-wide.

Several objects can be selected.

2.1.3 User interface - “Installed measurements (memory card)” project tree folder

The folder shows all measurements present on the memory card. The folder is only displayed when there is an online connection to the device.

Drag folders or measurements contained here to the “Measurements” system folder using drag & drop. This transfers the measurements to the project.

Icons in the "Traces" folder

The following table explains the icons in the system folder :

Icon	Description
	Folders generated automatically with information on the recording start time The name of the folder cannot be changed.
	Installed measurement Double-click the icon to open the "Diagram" tab. The time stamp in the name shows the occurrence of the trigger event.

Shortcut menu commands

The following table shows the shortcut menu commands for the folder :

Shortcut menu command	Description
"Copy"	Copies the selected objects to the clipboard.
"Delete"	Deletes the selected objects from the project tree and from the device.

The following table shows the shortcut menu commands for measurements :

Shortcut menu command	Description
“Open”	Opens the measurement in the “Diagram” tab.
"Copy"	Copies the selected objects to the clipboard.
"Delete"	Deletes the selected objects from the project tree and from the device.
"Export measure-ment"	Exports a measurement as a file with the extension "*.ttrecx" or "*.csv". For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.
“Properties”	Displays the general properties of the measurement (Page 35).

Several objects can be selected.

2.1.4 User interface - “Overlay measurements” project tree folder

The system folder “Overlay measurements" shows the configured overlay measurements.

Icons in the “Overlay measurements" folder

The following table explains the icons in the system folder “Overlay measurements”:

Icon	Description
	Add new overlay measurements Double-click the icon to add a new overlay measurement and open the “Diagram” tab.
	Overlay measurement Double-click the icon to open the "Diagram" tab.

Shortcut menu commands

The following table shows the shortcut menu commands for the system folder “Overlay measurements" or for a group folder contained within this:

Shortcut menu command	Description
“Add new group”	Inserts a new folder.
“Add new overlay measurement”	Inserts a new overlay measurement and opens the “Diagram” tab.

The following table shows the shortcut menu commands for overlay measurements:

Shortcut menu command	Description
“Open”	Opens the selected overlay measurements in the working area.
"Import measurement"	Imports a measurement from a file with the "*.ttrecx" file extension. For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.
"Copy"	Copies the selected objects to the clipboard.
"Paste"	Inserts measurements, measurements from installed traces or overlay measurements from the clipboard. Multiple objects can be inserted from the clipboard if they are all of the same type.
"Delete"	Deletes the selected objects from the project tree or from the device.
"Rename"	Switches the selected object to the editing mode.
“Properties”	Displays the general properties for the overlay measurements.

The overlay measurements can also be copied device-wide.

Several objects can be selected.

2.2 Working area

2.2.1 User interface - trace toolbar

Tools are available for handling the trace via buttons.

The following table shows the functions of the buttons:

Icon	Description
	Transfer the selected trace configuration to the device The selected trace configuration is transferred to the device.
	Transfer the selected trace configuration from the device The selected trace configuration is transferred from the device to the project.
	Observe on/off Change of the display between online and offline. **Note** Once monitor and automatic scaling are activated at the same time, no more actions can be undone using the “Undo” button. **Note** When an installed trace is first started the display in the curve diagram is set to automatic scaling by default. Make sure when the recording is restarted that any changes to the scaling settings are retained. Reactivate automatic scaling manually if necessary in order to monitor the recording.
	Activate recording If the recording of an installed trace is repeated, then the settings relevant for the display (curve diagram and signal table) are also retained for the new recording. **Note** When a recording is restarted, the previously recorded values are lost. To save the recorded values, save the measurement in the project (Page 48) before you activate the recording again.
	Deactivate recording
	Delete installed trace Deletes the selected trace from the device.
	Transfer the selected measurement from the device to the project The measurement is added to the "Measurements" system folder. **Note** In order to be able to save the installed trace data as a measurement, it must first have been displayed once in the curve diagram. The recording data is loaded from the device when displayed. If necessary wait until the display is updated, as only the displayed data is transferred to the project in all cases.
	Export trace configuration Exports a trace configuration as a file with the extension "*.ttcfgx". For compatibility reasons, the "*.ttcfgx" file extension will be supported in V12, but does not contain any information about the device family.

Icon	Description
	Generate a trace configuration Generates a new trace configuration from the measurement.
	Export measurement with the settings from the current view Exports a measurement as a file with the extension "*.ttrecx" or "*.csv". For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.
	Import measurement (only with overlay measurements) Imports a measurement from a file with the "*.ttrecx" file extension. For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.
	Select a measurement (only with overlay measurements) The drop down list box contains the imported measurements. Select the desired measurement to display the configuration.

2.2.2 User interface - Configuration tab

2.2.2.1 User interface - Configuration

The trace configuration depends on the device and is described at the respective device (Page 60).

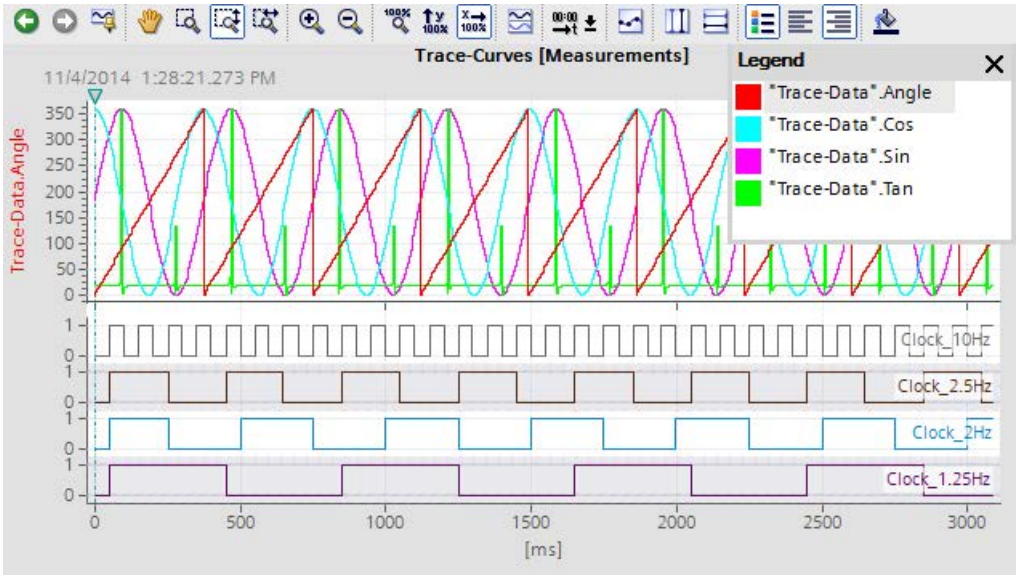
2.2.3 User interface - Diagram tab

2.2.3.1 User interface - curve diagram

The curve diagram displays the selected signals of a recording. Bits are shown in the lower diagram as a bit track. You can adjust the display of the signals in the signal table (Page 27) and with the toolbar of the curve diagram.

Setting options and displays in the curve diagram

The following figure shows an example of the display in the TIA Portal:



The scale in the diagram applies to the selected (highlighted in gray) signal in the legend. The legend can be moved and its size can be adjusted with the mouse.

The ▽ icon shows the device trigger time with a vertical line.

Functions using the mouse wheel

The following table shows which functions are possible in the curve diagram using the mouse wheel:

Function of the mouse wheel	Description
Move the curve diagram vertically	Turning the mouse wheel moves the display in the upper curve diagram up or down. If the signals are arranged in traces the display for the group is shifted that is located below the cursor. The cursor must be positioned above the upper curve diagram.
Move the curve diagram horizontally	Turning the mouse wheel with the <Shift> button pressed down moves the display in the curve diagram to the left or the right. The cursor must be positioned above the curve diagram.
Zoom in and zoom out	Turning the mouse wheel with the <Ctrl> button pressed down zooms in or out of the display in the curve diagram. The cursor position is the starting point for zooming in or out. The value axis of the lower curve diagram (bit tracks) is not affected. The cursor must be positioned above the curve diagram.

Shortcut menu commands

The following table shows the shortcut menu commands in the curve diagram:

Shortcut menu command	Description
"Save diagram as image"	Exports the current display in graphic format, e.g. as a bitmap.
"Copy image to clipboard"	Copies the current display to the clipboard.
"Center measurement cursors"	Positions the activated measurement cursors at a central point in the current display.
"Add to measurements" (only axis control panel and PID)	Adds the displayed recording to the "Measurements" system folder.
“Automatic bit track height"	Automatically adjusts the height of the bit tracks and thereby determines the size of the lower curve diagram. The setting is automatically deactivated once you change the space allocation between the curve diagrams manually. **Note** You can change the vertical space allocation between the upper and lower curve diagram. To do this drag the time axis of the upper curve diagram up or down with the mouse.

Toolbar of the curve diagram

Tools are available for adapting the display via buttons.

The following table shows the functions of the buttons:

Icon	Function	Description
	Undo zoom	Undoes the zoom function executed last. If several zoom functions have been executed, they can be undone step-by-step.
	Redo zoom	Redoes the last undone zoom function. If several zoom functions have been undone, they can be re-done step-by-step.
	Standard view	Uses the current view as standard for this recording. If the trace recording is shown again later, the standard view is restored.
	Move view	Moves the display with the mouse button pressed.
	Zoom selection	Selection of an arbitrary range with the mouse button pressed. The display is scaled to the range selection.
	Vertical zoom selection	Selection of a vertical range with the mouse button pressed. The display is scaled to the range selection.
	Horizontal zoom selection	Selection of a horizontal range with the mouse button pressed. The display is scaled to the range selection.
	Zoom in	Enlargement of the display. The ranges of the time axis and value axis are reduced every time the button is clicked. The curves are displayed larger.
	Zoom out	Reduction of the display. The ranges of the time axis and value axis are increased every time the button is clicked. The curves are displayed smaller.
	Display all	Scales the display of the available data so that the entire time range and all values are displayed.
	Automatic scaling of the value axis	Scaling of the display so that all values are displayed for the currently displayed time range. The relative scaling ratio between the signals may change. **Note** The automatic scaling of the value axis is stopped when the zoom function is activated for the value axis. This button reactivates the automatic adjustments to the minimum/maximum values.
	Show the overall time range	Scaling of the display so that the values in the value range currently displayed are displayed for the overall time range. The value range displayed only then changes if “Display all values” is activated. **Note** The automatic scaling of the time axis is stopped when a zoom function is activated for the time axis. This button reactivates the automatic adjustments for the time range.

Icon	Function	Description
	Arrange in tracks	Activate or deactivate the trace arrangement. When the trace arrangement is activated the signals are arranged among themselves with the relevant value axes. Signal groups are displayed in the same trace. This setting does not affect the display for the bit tracks.
	Unit changeover of the time axis	Switching the unit of the time axis The following units are adjustable: • Measurement points • Time (relative time related to the trigger time) • Absolute time
	Display samples	The samples are displayed as small circles on the curves.
	Display vertical measurement cursors	Display of the vertical measurement cursors. The vertical position of the two measurement cursors can be moved with the mouse. The associated measured values and the difference of the measurement cursors corresponding to the position are shown in the signal table. Display the “Measurement cursor” pane (Page 32) in the Trace task card in order to display further information.
	Display horizontal measurement cursors	Display of the horizontal measurement cursors. The horizontal position of the two measurement cursors can be moved with the mouse. Display the “Measurement cursor” pane (Page 32) in the Trace task card in order to display the values or to reposition the measurement cursor through entering the position.
	Display chart legend	Showing or hiding of the legend in the curve diagram and the bit track labels.
	Align the chart legend to the left	Display of the legend and the bit track labels on the left side of the curve diagram.
	Align the chart legend to the right	Display of the legend and the bit track labels on the right side of the curve diagram.
	Change background color	Changeover between various background colors.

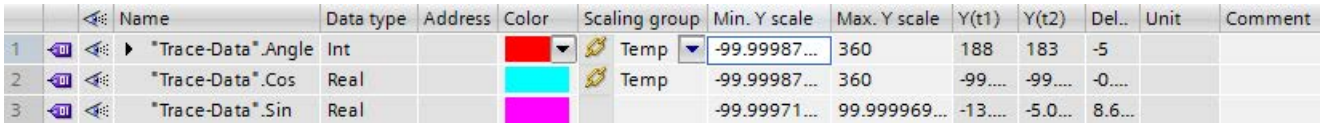
2.2.3.2 User interface - signal table

The signal table lists the signals of the selected measurement and provides setting options for some properties. If recording data of installed traces is displayed and the settings are changed in the signal table, these settings are retained until there is a change to the offline mode. If the installed trace is added to the measurements, the current settings of the signal table are saved in the measurement.

The signals can be sorted using drag-and-drop. The bits of a signal can be resorted within a signal.

Setting options and displays in the signal table

The following figure shows an example of the display in the TIA Portal:



		Name	Data type	Address	Color	Scaling group	Min. Y scale	Max. Y scale	Y(t1)	Y(t2)	Del..	Unit	Comment
1		"Trace-Data".Angle	Int			Temp	-99.99987...	360	188	183	-5		
2		"Trace-Data".Cos	Real			Temp	-99.99987...	360	-99....	-99....	-0....		
3		"Trace-Data".Sin	Real				-99.99971...	99.999969...	-13....	-5.0...	8.6...		

The following table shows the settings and displays of the recorded signals:

Column	Description
	Static display of the signal icon
	Selection for the display in the curve diagram The point indicates that at least one bit has been selected for display as bit track for the signal in the bit selection.
"Name"	Display of the signal name A click on the name of a displayed signal updates the scale in the curve diagram.
“Measurement”	Display of the measurement (in the “Diagram” tab only with overlay measurements) Shows the name of the measurement to which the signal belongs.
	Open bit selection Individual bits can also be selected for the following data types for display as a bit track in the lower curve diagram. • Byte, Word, DWord, LWord • SInt, USInt, Int, UInt, DInt, UDInt, LInt, ULInt Example of an opened bit selection for the DWORD data type: Select or deselect the relevant bit for display by clicking the icon.
"Data type"	Display of the data type
"Address"	Display of the address of the signal The field remains empty with optimized / type correct tags.
"Color"	Display and setting option for the color of the signal

1	"Tag_1"	Byte	%MB10
2	"Tag_4"	DWord	%MD20
3		Bool	%M23.0
4		Bool	%M23.1
5		Bool	%M23.2

Column		Description
"Signal group"		Display or input of the signal group name for one signal group The Y-scales are scaled identically for all signals of one signal group. Enter an identical signal group name for those signals that are to be scaled identically. Signals can be removed from the signal group by deleting the signal group name. The signal groups can be saved via the function "Use current view as standard" (button). **Note** Binary signals cannot be grouped.
	Gray field for chain icon	Move the cursor over the gray field or the chain icon (or) to add the signal to a signal group or delete the signal from the signal group. Clicking the chain icon adds the signal to a signal group or creates a new signal group. Clicking the chain icon removes the signal from the signal group. For a selected signal with signal group, the chain icon displays all signals of the same signal group.
	Input field	The input field displays the signal group name. As an alternative to the chain icon, you can assign or delete a group name via text input in this field.
"Min. Y-scale"		Display or input of the minimum value for the scaling of the signal
"Max. Y-scale"		Display or input of the maximum value for the scaling of the signal
"Y(t1)"		Display of the value at the position of the first measurement cursor
"Y(t2)"		Display of the value at the position of the second measurement cursor
"ΔY"		Display of the value difference between the first and the second measurement cursor
"Unit"		Display of the unit (e.g. for used-based values from technology objects)
"Comment"		Display and input option for a comment about the signal

Shortcut menu commands

The following table shows the shortcut menu commands of the signal table:

Shortcut menu command	Description
"Cut"	Cannot be selected.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Cannot be selected.
"Delete"	Cannot be selected.
"Rename"	Cannot be selected
“Display signal(s)”	Displays the selected signals in the curve diagram.
“Hide signal(s)”	Hides the selected signals in the curve diagram.

See also

Use of the signal table (Page 55)

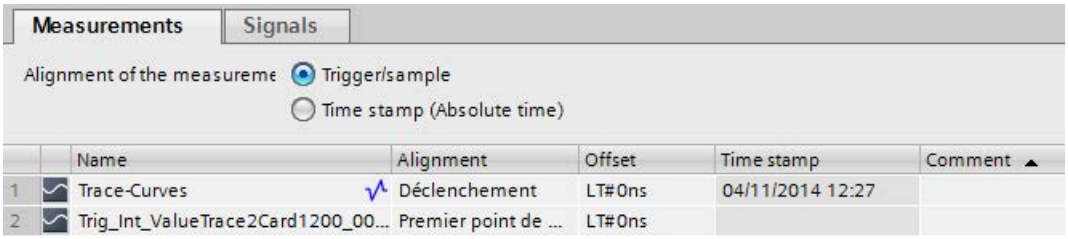
Using the signal group in the signal table (Page 56)

2.2.3.3 User interface - Measurements (overlay measurements)

The Measurements tab displays the individual measurements and among other things provides the setting options for synchronization.

Setting options and displays in the Measurements tab

The following figure shows an example of the display in the TIA Portal:



The following table shows the settings and displays for the measurements:

Column		Description
Alignment of the measurements		
	"Trig-ger/measure ment point"	Alignment of the measurements in accordance with the trigger or measurement point The individual zero point for the measurement is predefined in the table under the "Alignment" column.
	"Time stamp (absolute time)"	Alignment of the measurements in accordance with their time stamp The signals are aligned in accordance with the time from the absolute time stamp.
Table columns		
		Static display of the measurement icon
	"Name"	Display and change options for the measurement name The name must be a unique one and can be changed.
	"Alignment"	Alignment of the measurement (only adjustable with the "Trigger/measurement point" check box activated) Determines the individual zero point for a measurement. All signals for the measurement are displayed in relation to this zero point. The following settings are possible: • Trigger • First measurement point following the trigger event • First measurement point • Last measurement point
	"Offset"	Offset related to the time axis Moves the measurement left or right by the offset stated on the time axis. The offset can also be transferred via the clipboard to the cell from the ΔX value of the measurement cursor. See Align measurements precisely (overlay measurements) (Page 59).
	"Time stamp"	Display of the trigger time
	"Comment"	Display and input option for a comment about the signal

Shortcut menu commands

The following table shows the shortcut menu commands of the signal table:

Shortcut menu command	Description
"Cut"	Cannot be selected.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Cannot be selected.
"Delete"	Cannot be selected.
"Rename"	Switches the selected cell to the editing mode.
"Import measurement"	Imports a measurement from a file, e.g. with the "*.ttrecx" file extension. For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.
"Export measurement"	Exports a measurement as a file with the extension "*.ttrecx" or "*.csv". For compatibility reasons, the "*.ttrec" file extension will be supported in V12, but does not contain any information about the device family.

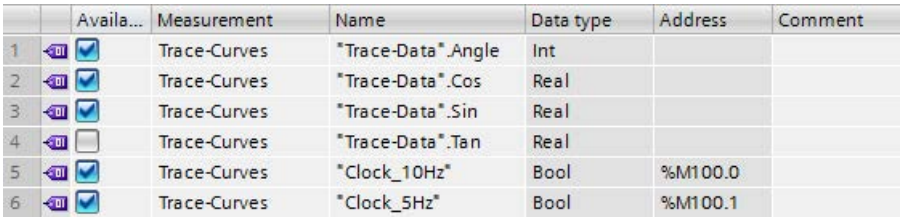
2.2.4 User interface - Signal selection tab (overlay measurements)

2.2.4.1 User interface - Signal selection (overlay measurements)

The Signal selection tab shows the signals for all measurements and allows signals that are presented in the signal table of the diagram to be preselected.

Setting options and displays in the Signal selection tab.

The following figure shows an example of the display in the TIA Portal:



		Availa...	Measurement	Name	Data type	Address	Comment
1		☑	Trace-Curves	"Trace-Data".Angle	Int		
2		☑	Trace-Curves	"Trace-Data".Cos	Real		
3		☑	Trace-Curves	"Trace-Data".Sin	Real		
4		☐	Trace-Curves	"Trace-Data".Tan	Real		
5		☑	Trace-Curves	"Clock_10Hz"	Bool	%M100.0	
6		☑	Trace-Curves	"Clock_5Hz"	Bool	%M100.1	

The following table shows the settings and displays for the table:

Column	Description
	Static display of the signal icon
"Available in the diagram"	Selection for the display in the curve diagram When the selection is activated the signal is transferred to the signal table for the curve diagram.
“Measurement”	Display of the measurement to which the signal belongs
“Name”	Display of the signal name
“Data type “	Display of the data type
"Address"	Display of the address (not for symbolic tags)
"Comment"	Display of a comment on the signal

You will find further information on the specific settings in User interface - signal table (Page 27).

Shortcut menu commands

The following table shows the shortcut menu commands for the signal selection:

Shortcut menu command	Description
"Copy"	Copies the content of the selected lines to the clipboard.
“Display selection in the signal table”	The selected signals are displayed in the signal table and are available in the diagram.
“Remove selection from the signal table”	The removed signals are not available in the diagram.

Several objects can be selected.

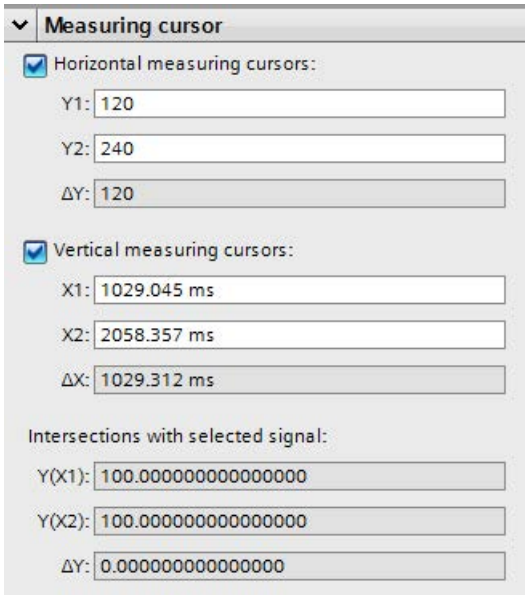
2.3 Trace task card

2.3.1 User interface - Measurement cursor pane

The “Measurement cursor” pane shows the position of the measurement cursor in the curve diagram and the values at the intersection points.

Setting options and displays of the "Measurement cursor” pane

The figure below shows the "Measurement cursor” pane:



The following table describes the settings and displays:

Setting/display		Description
Horizontal measurement cursor		
	Y1	Position of first measurement cursor The value states the position in relation to the scale of the signal currently selected. You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.
	Y2	Position of the second measurement cursor The value states the position in relation to the scale of the signal currently selected. You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.
	ΔY	Display of the position difference between the first and the second measurement cursor

Setting/display		Description
Vertical measurement cursor		
	X1	Position of first measurement cursor You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.
	X2	Position of the second measurement cursor You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.
	ΔX	Display of the position difference between the first and the second measurement cursor
Intersection points with selected signal		
	Y(X1)	Display of the value at the position of the first measurement cursor
	Y(X2)	Display of the value at the position of the second measurement cursor
	ΔY	Display of the value difference between the first and the second measurement cursor

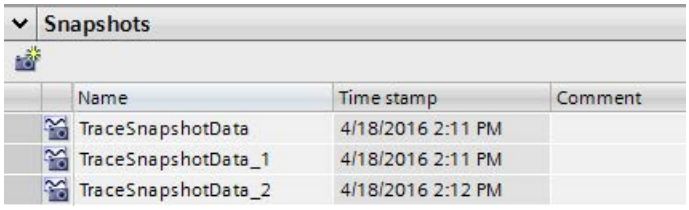
2.3.2 User interface - Snapshots pane

The “Snapshots” pane allows the user to save and restore different views for a measurement.

A snapshot is taken of the current view in the “Diagram” tab. The snapshots are saved in the measurement with the project.

Setting options and displays of the “Snapshots” pane

The figure below shows the “Snapshots” pane:



The following table shows the functions of the buttons:

Icon	Description
	Generate snapshot of the current view Saves the current view as a snapshot in the “Diagram” tab.

The following table shows the settings and displays:

Column	Description
	Static display of the snapshot icon
“Name”	Display and change options for the name
“Time stamp"	Display of the snapshot generation time
"Comment"	Display and input option for a comment

Several rows can be selected and deleted.

Double-clicking on a row opens the measurement with the saved view in the “Diagram” tab.

Shortcut menu commands

The following table shows the shortcut menu commands of the table:

Shortcut menu command	Description
“Restore snapshot”	Shows the measurement with the saved view in the “Diagram” tab.
"Delete"	Deletes the snapshot
"Rename"	Switches the cell to the editing mode

Several rows can be selected and deleted.

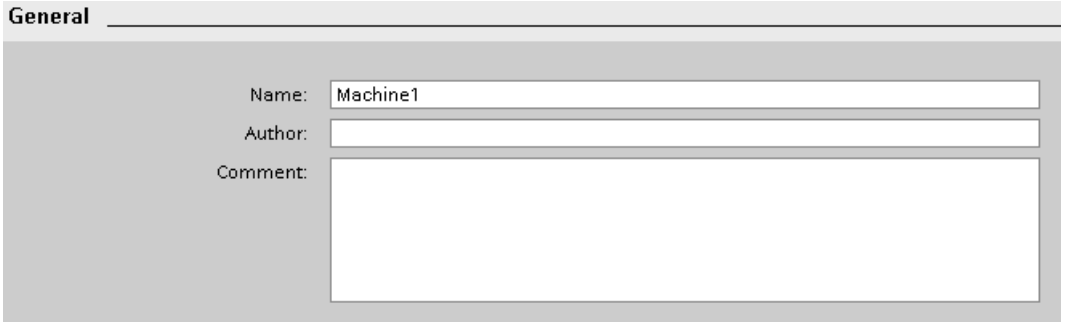
2.4 Inspector window

2.4.1 User interface - General

The "General" area shows the name of the trace configuration and input fields for the author and a comment.

Input options and displays in General

The following figure shows an example of the display in the TIA Portal:



The following table shows the input fields and displays:

Column	Icon	Description
"Name"	-	Name of the trace configuration.
"Author"	-	Author of the trace configuration
"Comment"	-	Input field for a comment. You can enter a line break with <Shift+Return>.

Operation 3

3.1 Quick start

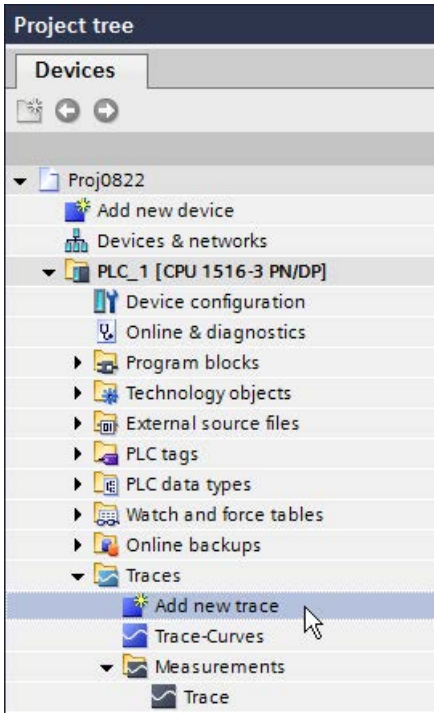
This description shows the steps for a recording of the S7-1500 CPU as an example. The displayed settings can differ depending on the device.

Requirement

A device is configured that supports the trace and logic analyzer function.

Creating a trace

The following figure shows the project tree with the "Traces" system folder below the device:



Procedure:

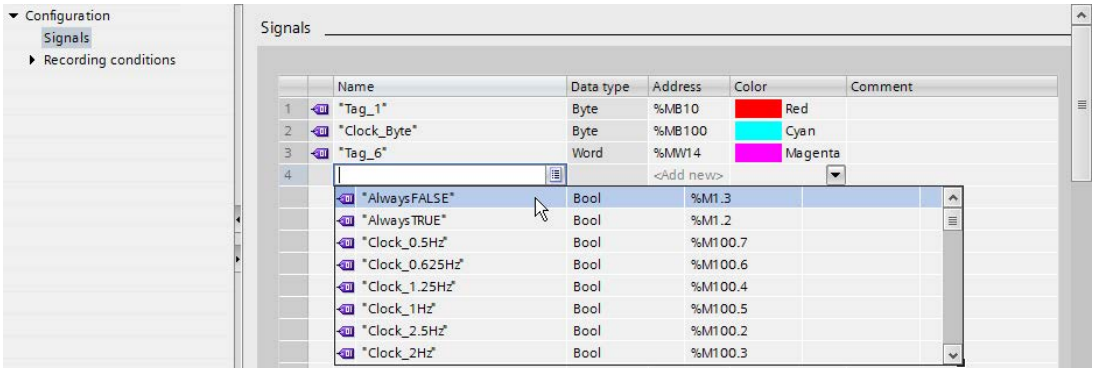
1. Double-click the "Add new trace" entry.

   A new trace configuration is created and the “Configuration" tab opens in the working area.

2. Adapt the name of the trace configuration by clicking the text.

Selecting signals

The following figure shows the configuration of the signals:



Procedure:

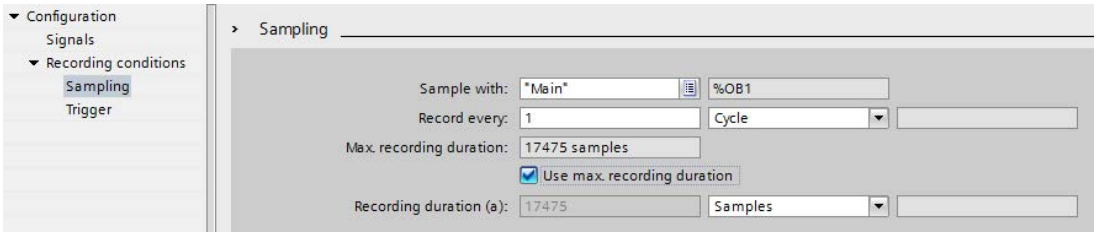
1. Select the signals to be recorded in the "Signals" area.

   Or:

2. Drag one or more signals, e.g. from a tag table, and drop them in the signal table.

Configuring the recording cycle

The following figure shows the configuration of the sampling:

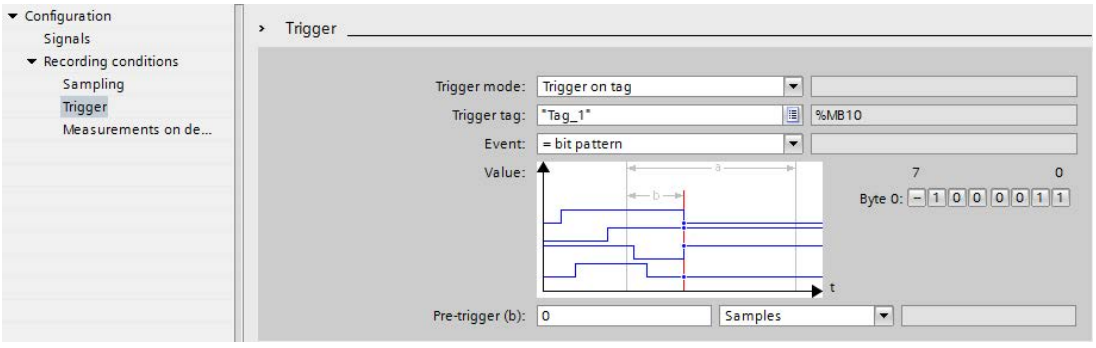


Procedure:

1. Configure the sampling.

Configuring the trigger

The following figure shows the configuration of the trigger:



Procedure:

1. Configure the trigger mode and the condition for the selected trigger.

Transferring the trace configuration to the device

Procedure:

1. Transfer the trace configuration to the device with the button.

   The following functions are executed:

   – An online connection is established to the device.
   – The trace configuration is transferred to the device.
   – The monitoring is activated.
   – The display switches to the "Diagram" tab.

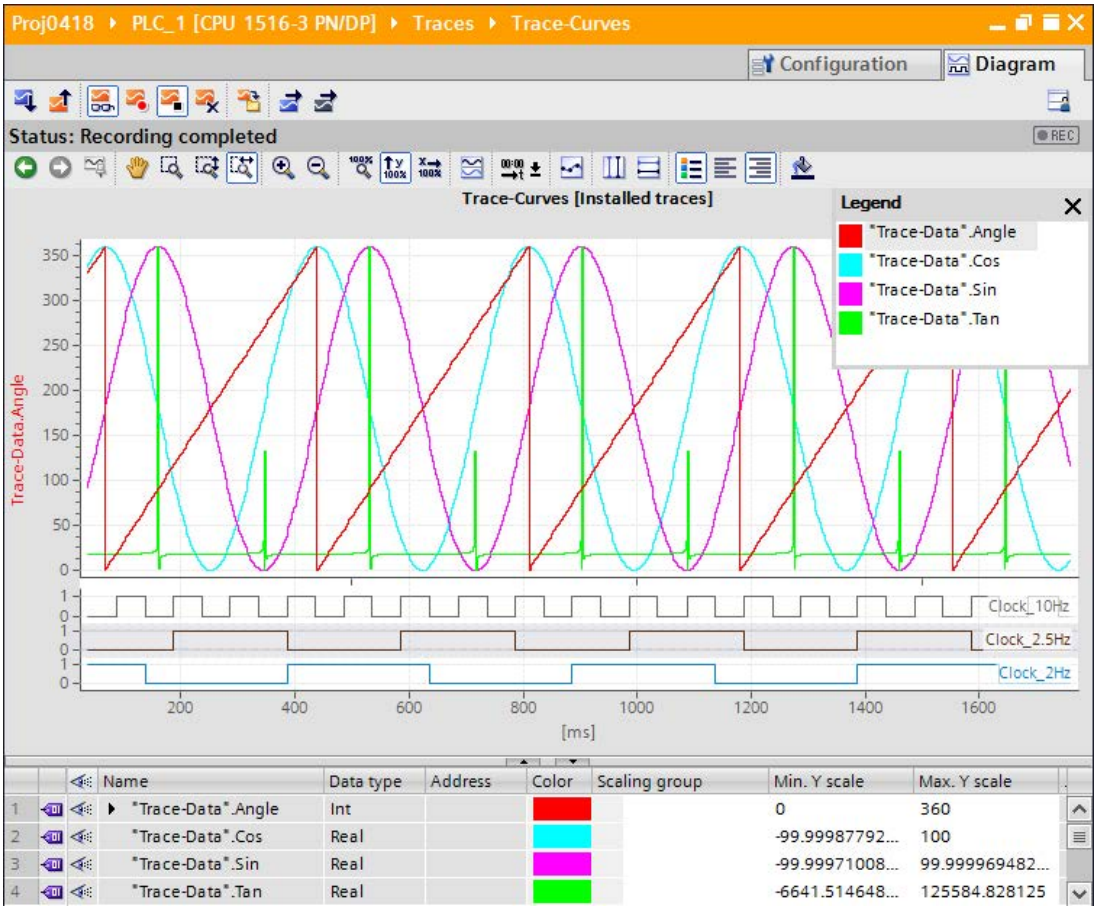
Activating a recording

Procedure:

1. Click the button.

Displaying the recording

The following figure shows the curve diagram with a recording:



Procedure:

1. Wait until the "Recording" or "Recording completed" status is displayed in the status display of the trace.
2. Switch to the "Diagram" tab.
3. Click the ▸ icon of a signal in the signal table.

   The individual bits of the signal are offered for display as a bit track.
4. In the signal table, select or deselect the individual signals and bits for display with the icon.

Saving the measurement in the project

Procedure:

1. Transfer the measurement to the project with the button.

   The measurement is displayed in the project tree under the "Measurements" system folder.

See also

User interface - trace toolbar (Page 21)

3.2 Using the trace function - overview

Requirement

A device is configured in the TIA Portal that supports the trace and logic analyzer function and to which an online connection has been established.

Procedure

The following table shows a procedural overview with typical steps when working with the trace and logic analyzer function.

Step	Description
1	Creating a trace (Page 41)
2	Configuring the trace (Page 52)
3	Transferring the trace configuration to the device (Page 44)
4	Activating/deactivating an installed trace (Page 45)
5	Monitoring the recording (Page 46)
6	Saving measurements in the project (Page 48)
7	Displaying the recording (Page 46)
8	Analyze an ongoing recording (Page 47)
9	Compare records (overlay measurements) (Page 57)

See also

Displaying a configuration (Page 41)

3.3 Project tree

3.3.1 Creating a trace

Traces can be created in the form of trace configurations in the project navigator.

The following instructions describe how you can create a trace configuration under the "Traces" system folder

Procedure

To create a trace configuration, proceed as follows:

1. Double-click the "Add new trace" entry.

A new trace configuration is created.

3.3.2 Displaying a configuration

Requirement

A trace configuration, an installed trace, a measurement or an overlay measurement is available in the "Traces" system folder.

Procedure

To display a trace configuration, proceed as follows:

1. Double-click the appropriate icon of a trace configuration, an installed trace, a measurement or an overlay measurement in the project tree.

   The "Configuration" or "Diagram" tab opens in the working area.

2. If required, click the "Configuration" tab for the display.

Note

Write protection

The configuration data of an installed trace and in all measurements is displayed with write protection.

See also

User interface - “Traces” project tree folder (Page 16)

3.3.3 Displaying a diagram

Requirement

An installed trace, a measurement or an overlay measurement is available in the "Traces" system folder.

Procedure

To display a diagram, proceed as follows:

1. Double-click the appropriate icon of an installed trace, a measurement or an overlay measurement in the project tree.

   The "Configuration" or "Diagram" tab opens in the working area.

2. If required, click the "Diagram" tab for the display.

See also

User interface - “Traces” project tree folder (Page 16)

3.3.4 Apply overlay measurement

Overlay measurements can be applied in the project tree with a comparison function for different measurements.

The following instructions describe how you can create an overlay measurement under the “Overlay measurements" system folder

Requirement

A device is configured that supports the trace and logic analyzer function.

Procedure

To apply an overlay measurement, proceed as follows:

1. Select one or more measurements in the “Measurements" system folder.
2. Drag the measurements to the “Overlay measurements” system folder.

A new overlay measurement is created.

3.3.5 Configuring objects in groups

You can set up groups in system folders in the project navigator. Use this option to configure the view for multiple objects.

The following instructions use measurements as an example in order to describe how to consolidate the measurements into groups. The same functionality is also available for the Traces and Overlay measurements system folders.

Requirement

Measurements are available in the “Measurements" system folder.

Procedure

Proceed as follows to configure measurements into groups:

1. Select the shortcut menu command “Add new group” by right-clicking on the “Measurements" system folder.

   A new group folder is created.

2. Assign a meaningful name to the new group.
3. Repeat step 1 until all required groups have been created.

   (Sub-groups (groups within groups) can also be created.)

4. Drag & drop the corresponding measurements to the group folder that has been created.

3.4 Working area - general

3.4.1 Transferring the trace configuration to the device

Requirement

- A valid trace configuration is in the "Traces" system folder.
- The maximum number of installed traces has not been reached yet.

Procedure

To transfer a trace configuration to the device, proceed as follows:

1. Open a valid trace configuration in the working area.
2. Click the button.

Result

The trace configuration is transferred to the device.

3.4.2 Activating/deactivating an installed trace

Requirement

- There is an online connection to the device.
- There is a trace in the device.
- The installed trace is displayed in the working area.
- The button is activated for viewing the displayed trace.

Activating an installed trace

To activate the recording for an installed trace, proceed as follows:

1. Click the button.

   The installed trace is activated and starts the recording according to the configured trigger condition. The trigger condition is device-specific and described in Section "Configuration" below the respective device (Page 60).

   The current status of the recording is displayed in the status display of the trace.

Note

When a recording is restarted, the previously recorded values are lost.

To save the recorded values, save the measurement in the project (Page 48) before you activate the recording again.

Deactivating an installed trace

To deactivate an activated installed trace, proceed as follows:

1. Click the button.

   The installed trace is deactivated.

   The status display of the trace changes to "Inactive".

3.4.3 Displaying the recording

Requirement

- There is an online connection to the device.
- There is a trace with recording in the device.

Or:

- A measurement is in the "Measurements" system folder.

Procedure

To display the recording, proceed as follows:

1. Select an installed trace.
2. Double-click the selected trace.
3. If required, activate the button for viewing.

Or:

1. Select a measurement in the "Measurements" system folder.
2. Double-click the selected measurement.

Result

The recording is displayed in the "Diagram" tab.

See also

User interface - “Traces” project tree folder (Page 16)

3.4.4 Analyze an ongoing recording

Requirements

- An ongoing recording is displayed in the "Diagram" tab.

Save the data currently recorded as a measurement

To analyze a certain time range for an ongoing recording, follow these steps:

1. Click the button.

   The data recorded up to now is added to the measurements.
   The current recording is not affected by this and continues running uninterrupted.

Analyze the measurement

To display the saved measurement, follow these steps:

1. In the “Measurements" system folder double-click the measurement that has just been saved in order to open it

   The “Diagram” tab for the measurement opens in the working area.

See also

Displaying the recording (Page 46)

Working area - Diagram tab (Page 53)

3.4.5 Saving measurements in the project

Requirement

- There is an online connection to the device.
- There is a trace with recording in the device.
- The installed trace data must have been displayed at least once in the curve diagram. The recording data is loaded from the device for the display.

Procedure

To save a recording in the project, proceed as follows:

1. Open the installed trace with the recorded data.
2. If required, make sure that the current data is loaded from the device by activating the button.
3. After activating the button wait until all data has been loaded and displayed.
4. Click the button.

   The measurement is added to the "Measurements" system folder.
5. Save the project in the TIA Portal.

Note

Generate measurements

A measurement of an installed trace can be generated at any time.

Use this functionality e.g. to save the data recorded up until this point in a recording and to analyze it as a static measurement.

3.4.6 Exporting and importing measurements

Requirement

At least one measurement is in the "Measurements" system folder for export.

Exporting measurements

To export a measurement, proceed as follows:

1. Right-click a measurement in the "Measurements" system folder and select the shortcut menu command “Export measurement".
2. Select a folder, a file name and a data type to save the measurement.
3. Click the "Save" button.

Importing measurements

To import a measurement, proceed as follows:

1. Right-click in the "Measurements" system folder and select the shortcut menu command "Import measurement".
2. Select the file e.g. of the "*.ttrecx" file type with the measurement to be imported.
3. Click the "Open" button.

   The imported measurement is displayed with the file name in the "Measurements" system folder.

Note

Export and import trace configurations

The same functionality is available for exporting and importing trace configurations.

3.4.7 Transferring the trace configuration from the device to the project

Requirement

- There is an online connection to the device.
- There is a trace in the device.

Procedure

To transfer a trace configuration to the project, proceed as follows:

1. Open an installed trace.
2. If required, activate the button for viewing.
3. Click the button to transfer the trace configuration from the device.

Result

The configuration is taken over as new trace configuration in the "Traces" system folder.

A trace configuration of the same name is overwritten in the system folder.

3.4.8 Deleting installed traces

Requirement

- There is an online connection to the device.
- There is a trace in the device.

Procedure

To delete an installed trace, proceed as follows:

1. Open an installed trace.
2. If required, activate the button for viewing.
3. Click the button.

   A confirmation prompt opens.
4. Confirm the prompt for deletion.

Or

1. Select one or more installed traces / in the project tree.
2. Press <Del> to delete the installed traces.

   A confirmation prompt opens.
3. If required, select an option for deletion and confirm the prompt.

3.5 Working area - Configuration tab

3.5.1 Configuring the trace

Requirement

The "Configuration" tab is open in the working area.

Configuring the trace

In the configuration, you specify the recording and trigger conditions and select the signals to be recorded.

See Section "Configuration" below the respective device (Page 60).

Note

Saving the trace configuration

You save the trace configuration with the project in the TIA Portal.

If you close the project without saving, the configuration is discarded.

See also

Displaying a configuration (Page 41)

3.6 Working area - Diagram tab

3.6.1 Use of the curve diagram

The curve diagram shows the signals of a recording selected in the signal table.

The display area can be zoomed as required. Measurement cursors can be used to select individual values for display in the signal table.

The following operating instructions describe the use of the curve diagram and of the measurement cursors as examples.

Requirements

- An installed trace or a measurement has been selected for display.
- The button is activated to monitor an installed trace.
- The "Diagram" tab is open in the working area.

Monitor an ongoing recording.

To display all of the data in an ongoing recording, proceed as follows:

1. Activate “Display all" via the button.

The entire time range and all values for the ongoing recording are displayed.

To display a consistent time window in an ongoing recording, proceed as follows:

1. Activate “Display all" via the button.
2. Select the desired time range via the button.

The trend view is updated while the scaling of the time range remains the same.

Evaluation of a certain instant of a recording

To display the values for a specific sample, proceed as follows:

1. Display the vertical measurement cursors via the button.
2. Move a measurement cursor with the mouse to the required position in the recording.

   The values of the signals are displayed in the signal table and in the “Measurement cursor” pane of the “Trace” task card.

Evaluation of the difference between two samples

To display the difference, proceed as follows:

1. Display the vertical measurement cursors via the button.
2. Move both measurement cursors with the mouse to the required samples in the recording.

   The values of the signals and the difference are displayed in the signal table and in the “Measurement cursor” pane of the “Trace” task card.

Using horizontal measurement cursors

To check whether a certain value has been reached, proceed as follows:

1. Display the horizontal measurement cursors via the button.
2. Move a measurement cursor with the mouse to the required value of the recording.

   The values of the measurement cursors for the selected signal are displayed in the “Measurement cursor” pane of the “Trace” task card.

Moving the time range displayed

Proceed as follows to move the time range displayed:

1. Select a time range via the button.
2. Move the curve to the desired time range by turning the mouse wheel with the <Shift> key pressed down.

Bringing a signal into the foreground

1. Display the legend via the button.
2. Click a signal in the legend.

Or:

1. Click a signal in the curve diagram.

The signal is displayed in the foreground and is highlighted/selected in the signal table. The value axis is updated for the selected signal.

See also

Displaying a diagram (Page 42)

User interface - curve diagram (Page 23)

User interface - signal table (Page 27)

3.6.2 Use of the signal table

The signal table shows the signals of an installed trace or a measurement. The preselected signals in the signal selection are displayed with an overlay measurement. You can show or hide individual signals for the display in the table and adapt the properties for the display. Individual bits can be selected for some data types and displayed as a bit track.

The following operating instructions describe the operation of the signal table.

Requirements

- An installed trace or a measurement has been opened in the "Diagram" tab.
- The button is activated to monitor an installed trace.
- For the display of individual bits as a bit track:
  at least one recorded signal supports the display as a bit track.

Display or hide individual signals and change the color

To adapt the display to suit your requirements, proceed as follows:

1. Click the icon of the respective signal in the column to select or deselect it for the display.
2. Click in the "Color" column for the respective signal and select a color.

   The default color for the signal changes.

Bringing a signal into the foreground

1. In the signal table, select the line of the signal.

   The Y-scale of the signal is displayed.

   The signal curve is brought into the foreground in the curve diagram.

Selecting individual bits for display as a bit track

To display individual bits as a bit track in the lower curve diagram, proceed as follows:

1. Click the icon of a signal in the signal table.
2. Click the icon in the open bit selection of the signal.

   The bits are selected or deselected for display.

See also

Displaying the recording (Page 46)

3.6.3 Using the signal group in the signal table

Individual signals can be scaled identically in a signal group, which makes it easier to compare the curve characteristics.

Binary signals cannot be grouped.

The following operating instructions describe how to work with the signal group.

Note

Saving signal groups

The signal groups can be saved individually for each measurement via the "Use current view as standard" function (button).

If the signal groups and the project are not saved then the signal groups created will be lost when the "Diagram" tab is closed.

Requirements

- An installed trace or a measurement is displayed.
- The button is activated to monitor an installed trace.
- The "Diagram" tab is open in the working area.
- There are at least two signals in the signal table that are not of the BOOL type.

Assigning signals to a signal group

To apply a signal group and assign signals to this group, proceed as follows:

1. In the signal table, select the line or cell of the required signal.
2. Click the gray field in the "Signal group" column.

   The sequence icon is displayed in the gray field and the name of the signal group is pre-assigned: Group
3. Click the gray fields of further signals that are to be assigned to this signal group.

Or:

1. Click in the text field of the "Signal group" column for a signal to be grouped.
2. Enter a name for the group.
3. Enter the same group name in the respective text fields for further signals or select the group name via the drop-down list.

The Y-scales of the grouped signals are scaled with the values of the signal that was selected first. Changes to a scale value always affect the entire group.

Removing signals from a signal group

To delete the assignment of a signal to a signal group, proceed as follows:

1. Click the sequence icon for the required signal in the "Signal group" column.

Or:

1. Click the text field for the required signal in the "Signal group" column.
2. Press the <Del> key.

Or:

1. Select the respective text field in the "Signal group" column for several signals using the <Shift> and <Ctrl> keys.
2. Press the <Del> key.

The signals are removed from the signal group or the signal group is deleted.

3.6.4 Compare records (overlay measurements)

Requirement

- An overlay measurement is created or is created implicitly by dragging the measurements to the system folder “Overlay measurements”.

  See also Apply overlay measurement.

Adding measurements for comparison

To compare measurements, insert the measurements to be compared to the overlay measurements. Proceed as follows for this:

1. In the project tree drag one or more measurements from the system folder “Measurements" to the icon for the overlay measurement.

Or:

1. Import saved measurements via the “Import measurement” shortcut menu command.

A copy of the measurements is added to the overlay measurement.

Note

Changes to the settings for measurements within the overlay measurement have no impact on the original measurements. The original measurements remain unchanged.

Select signals of the measurements for the signal table

Proceed as follows to select the signals for the signal table in the “Diagram” tab:

1. Double-click on the icon for the overlay measurement in the project tree.

   The tabs for the overlay measurement will be displayed in the working area.

2. Click the “Signal selection" tab in the working area.

   The signals for all measurements are displayed in the table.

3. Activate or deactivate the signal check box for those signals that should be visible or should not be visible in the signal table.

The activated signals are displayed in the signal table of the “Diagram” tab.

Use of the signal table

Proceed as follows to open and use the signal tables:

1. Click the “Diagram" tab in the working area.
2. Click on the “Signals” tab within the “Diagram” tab.
3. Use the signal tables as described under Use of the signal table.

Align measurements

Proceed as follows to align the time axis for the measurements for the comparison:

1. Click on the “Measurements” tab within the “Diagram” tab.
2. Select the alignment for the measurements via the check box.
3. Adjust the alignment and if necessary set an offset for the alignment of the individual measurements.

The measurements are aligned with each other accordingly on the time axis.

(The precise alignment of two measurements is described in the next section.)

Use of the curve diagram

Proceed as follows to open and use the curve diagram:

1. Click the “Diagram" tab in the working area.
2. Use the curve diagram as described under Use of the curve diagram.

3.6.5 Align measurements precisely (overlay measurements)

Requirement

- An overlay measurement is applied.
- Measurements for comparison are added to the overlay measurement.
- Signals of the measurements for the signal table are selected.
- The “Diagram” tab for the overlay measurement opens in the working area.

Align measurements precisely with position difference ΔX

Proceed as follows to align the time axis for two measurements precisely:

1. Display the vertical measurement cursors via the button.
2. Zoom into the time range, e.g. with the button until you are able to position the first measurement cursor precisely on the desired reference point for the first measurement.
3. Move the first measurement cursor with the mouse to the required position.
4. Search for the reference point for the second measurement, e.g. by switching to “Display all” with the button.
5. Zoom into the time range, e.g. with the button until you are able to position the second measurement cursor precisely on the desired reference point for the second measurement.
6. Move the second measurement cursor with the mouse to the required position.
7. Open the “Trace" task card.
8. In the “Measurement cursor” pane select the position difference value ΔX.
9. Copy the value to the clipboard.
10. Insert the value from the clipboard into the Offset cell of the first or second measurement.

Both measurements are precisely aligned with each other at the desired measurement points.

Note

When inserting the position difference as the offset make sure that you also adjust the leading character as necessary.

3.6.6 Printing a recording

The curve diagram supports the saving of the display as a graphic and the copying of the display to the clipboard. Also use these functions (Page 23) for printing.

Devices

4

4.1 S7-1200/1500 CPUs

4.1.1 Recordable variables

Device-dependent recording of tags

The following list shows the operand areas from which tags can be recorded:

- Process image input
- Process image output
- Bit memory
- Data blocks

Data types

Elementary data types can be recorded. The availability of the individual data types depends on the device used:

The following table lists the elementary data types:

Data types	Note
Binary numbers	
BOOL	-
Bit strings	
BYTE	-
WORD	-
DWORD	-
LWORD [1)]	Symbolic name required
Integers	
SINT	-
USINT	-
INT	-
UINT	-
DINT	-
UDINT	-
LINT [1)]	Symbolic name required
ULINT [1)]	Symbolic name required
Floating-point numbers	
REAL	-
LREAL	Symbolic name required

1) Not supported by S7-1200.

4.1.2 Lifetime of the installed trace configuration and recorded values

Installed trace configurations are retained after POWER OFF. The recording is activated again after the restart of the CPU.

Recorded values are lost during the restart.

Note

Downloading a configuration to the device in the "STOP" operating state

Note that after downloading a configuration in the "STOP" operating state, you must check the installed traces and, if required, reactivate them or transfer them again.

Note

If trigger tags that affect the address are changed, the trace configuration must also be transferred to the device again.

This is the case for example, when a data block is shortened or extended or the data type is changed.

4.1.3 Recording levels

The following list shows the execution levels that can be selected for the recording cycle:

- Program cycle - OB 1
- Time-of-day interrupt - OB 1x
- Time-delay interrupt - OB 2x
- Watchdog interrupt - OB 3x
- Synchronized processing cycles - OB 6x, not OB 60
- MC-PreServo - OB 67
- MC-Servo - OB 91
- MC-Interpolator - OB 92
- MC-PostServo - OB 95

Note

The measured values are recorded at the end of the OB after the processing of the user program.

4.1.4 Quantity structure

The following table shows the maximum quantity structure that can be recorded with the trace and logic analyzer function:

Device	Maximum number of installed traces	Maximum number of signals per trace configuration
S7-1200 (as of firmware version V4.0)	2	16
S7-1500	At least 4 (depending on the CPU type)	16

Example of CPU 1516-4 PN/DP

- Maximum of 3854 samples for 16 signals from PLC tags of the DWORD data type
- Maximum of 21844 samples for 16 signals from PLC tags of the BOOL data type
- Maximum of 58250 samples for 1 signal from a PLC tag of the BOOL data type

Further information can also be found in the form of FAQs under the ID 102781176 (http://support.automation.siemens.com/WW/view/en/102781176).

4.1.5 CPU load through trace recording

A trace recording increases the runtime of the respective recording level that can result in an execution level overflow with high utilization of the CPU.

Remedy for execution level overflow:

- **Change the trace configuration**

  1) Configure fewer tags and signals.

  2) Then increase the number of tags and signals up to the maximum number of signals step-by-step without an execution level overflow.

- **Select a slower recording level**

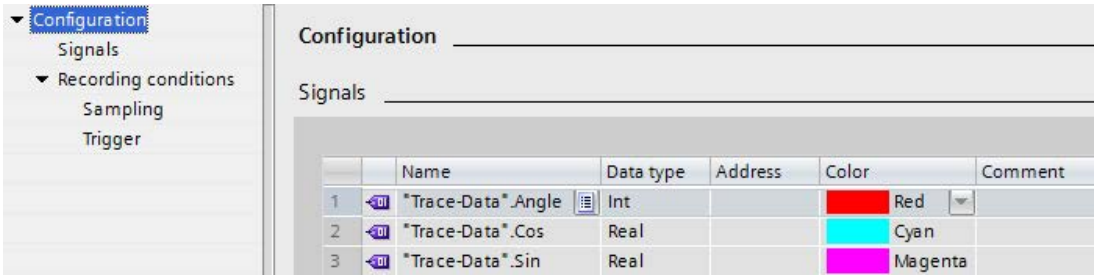
4.1.6 Software user interface of the configuration

4.1.6.1 Structure of the user interface

Display areas in the "Configuration" tab of the working area

The settings options differ depending on the configured device.

The following figure shows an example of the display in the TIA Portal:



The area navigation provides the following entries for selection:

- Configuration
  - Signals (Page 64)
  - Recording conditions (Page 66)

Displaying and changing properties of a trace configuration

A trace is selected in the project tree and displayed in the "Configuration" tab.

The trace configuration can only be changed offline and is displayed online with the write protection.

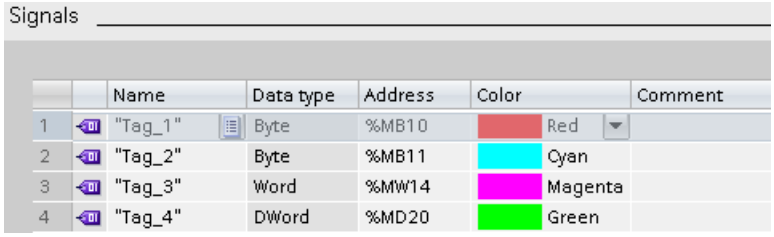
4.1.6.2 User interface - Signals

The "Signals" area shows a table in which the signals to be recorded are configured for the selected trace configuration.

Signals can also be inserted in the table using drag-and-drop.
The signals can be sorted using drag-and-drop.

Setting options and displays in "Signals"

The following figure shows an example of the display in the TIA Portal:



The following table shows the settings and displays:

Column	Icon	Description
		Display of the signal icon for a selected signal.
"Name"	-	Input field for the name or address of the signal. **Examples:** • “Data_block_1”.pressure • M0.0 • DB1.DBW3
-		Button to open the signal selection table. The button is displayed when the table line is selected. Clicking the icon opens a table which offers possible signals for selection. The selected signal is displayed in the input field.
"Data type"	-	Text field with display of the data type for the signal.
"Address"	-	Input field for the address of the signal. The field remains empty with optimized / type correct tags.
"Color"	-	Text field for display and selection of the color. Click the signal color to open the color selection dialog.
"Comment"		Input field for a comment on the signal.

Shortcut menu commands

The following table shows the shortcut menu commands of the table:

Shortcut menu command	Description
"Cut"	Cannot be selected.
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Pastes the contents of the clipboard to the selected line. The existing contents are overwritten.
"Delete"	Deletes the selected lines from the table or deletes the content of the selected cell.
"Rename"	Switches the selected cell to the editing mode.

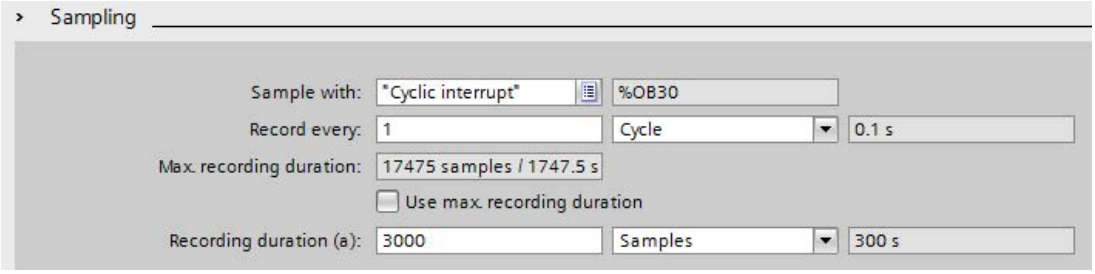
4.1.6.3 Recording conditions

User interface - Recording conditions

The "Recording conditions" area shows the trigger condition for the selected trace configuration and in which cycle, how fast and how long the recording is made. Configuration is possible when the trace configuration is displayed in offline mode or online mode with deactivated viewing .

Setting options and displays in "Recording conditions"

The following figure shows an example of the settings for the sampling in the TIA Portal:

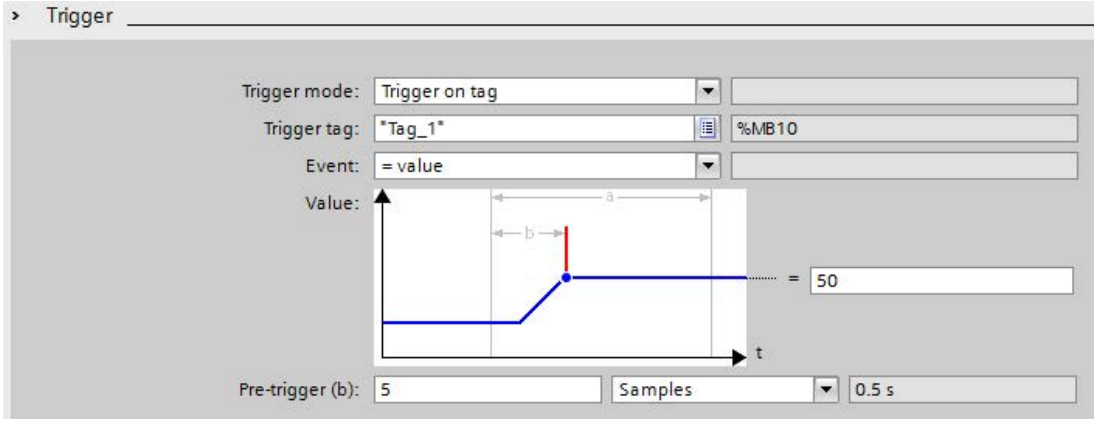


The following table explains the settings and displays:

Setting/display		Description
"Recording time"		
	Recording level entry field	Selection of the recording time. See Recording levels (Page 61)
	Address of the OB text field	Detailed information on the selected recording time.
"Record every"		
	Reduction entry field	Input of the reduction in relation to the reduction ratio and the unit.
	Reduction ratio drop-down list	Selection of the reduction ratio unit The following settings are possible: • "Cycle" • "s" (setting option depends on the recording level selected under “recording time”)
	Sampling time text field	Display of the sampling time, taking into account the configured reduction and the selected unit (only for constant bus cycle time OBs).
"Max. recording duration"		
	Max. recording duration text field	Displays the calculated maximum recording duration. The "Max. recording duration" depends on how many signals are recorded and the data type of these signals.

Setting/display		Description
	"Use max. recording duration"	Set the recording duration to the maximum value. When the checkbox is activated, the recording duration is set to the maximum possible recording duration. The set reduction in the "Record every" input field is taken into account. The recording duration is also adapted when additional signals are added. Further information can also be found in the form of FAQs under the ID 102781176 (http://support.automation.siemens.com/WW/view/en/102781176).
"Recording duration"		
	Recording duration entry field	Input of the recording duration in relation to the selected unit. If the "Recording duration = max. recording duration" checkbox is activated, entries are overwritten by the value displayed in "Max. recording duration".
	Unit drop-down list	Selection of the unit for the recording duration. The following settings are possible: • "Samples" The maximum number of samples recorded is the number for which parameters are assigned under recording duration. • "s" (setting option depends on the recording level selected under “recording time”)
	Calculated recording duration text field	Display of the calculated recording duration (only for constant bus cycle time OBs)

The following figure shows an example of the settings for the trigger in the TIA Portal:

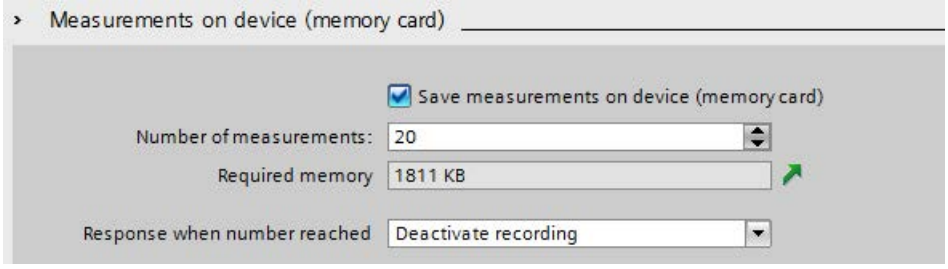


The following table explains the settings and displays:

Setting/display			Description
"Trigger mode"			Selection of the trigger mode.
	Trigger mode drop-down list		The following settings are possible: • "Record immediately" The recording is made immediately after the device is activated. • "Trigger on tag" The recording is made as soon as the installed trace is activated and the configured trigger condition is fulfilled.
	Text field		-
"Trigger tag"			The "Trigger tag" specifies a signal that triggers the recording.
	Trigger tag entry field		Enter a signal. **Examples:** • "DataBlock_1".Temperature • M0.0 • DB1.DBW3 See also Data types for trigger tags (Page 71).
			Opens the signal selection table. Clicking the icon opens a table which offers possible signals for selection as trigger tag. The selected signal is displayed in the input field.
	Trigger tag address text field		Display of the trigger tag address. With purely symbolic signals the field remains empty.
"Event"			The events that can be used on this trigger tag are offered for selection according to the data type of the trigger tag. The event can only be configured when a valid signal has been entered as trigger tag.
	Trigger events drop-down list		Event selection for which the trigger tag is checked. The entries in the drop-down list are described in Section Trigger event (Page 71).
	Text field		-
"Value"			Configuration of the selected event. The configuration options differ depending on the format of the trigger tag and the selected event. SeeTrigger event (Page 71).

Setting/display		Description
"Pre-trigger"		"Pre-trigger" defines the number of samples that are already recorded before the actual trigger condition is fulfilled. If the trigger event occurs immediately or shortly after the activation of the recording, this may result in a shorter recording duration. Examples of "Recording duration (a)" = 20 samples and "Pre-trigger (b)" = 5 samples: • Case 1: Trigger event occurs 50 samples after activation of the recording Actual recording duration (a) = 20 samples • Case 2: Trigger event occurs 2 samples after activation of the recording Actual recording duration (a) = 17 samples
	Duration entry field	Input of the duration in relation to the selection in the drop-down list.
	Unit drop-down list	Selection of the unit The following settings are possible: • "Samples" • "s" (setting option depends on the recording level selected under “recording time”)
	Resulting pre-trigger duration text field	Display of the calculated "Pre-trigger" duration (only for recording in constant bus cycle time OBs)

The following figure shows an example of the settings for the saving of installed measurements:



Note

Available memory in the device (memory card)

The memory in the device (memory card) is partly used by system-relevant functions or reserved for that purpose.

Thus it is not possible for the entire memory to be used for saving measurements.

For further information please refer to the Function Manual Structure and Use of the CPU Memory (https://support.industry.siemens.com/cs/us/en/view/59193101).

Note

Memory requirements upon restart

Following a device reboot the maximum number of measurements saved in the device is the number configured under “Number of measurements”.

With repeated restarts note that the measurements already saved are not overwritten and the “Number of measurements” configured in the device is saved once again.

The following table explains the settings and displays:

Setting/display	Description
“Saving of installed measurements (memory card)”	Repeat measurement automatically and store in the device retentively This setting is only possible with “Trigger on tag” trigger mode. The measurements are stored on the “primary” memory card. **Note** Only completed measurements are saved on the device. Any recording deactivated by the user is not saved on the device. **This function is available with the following firmware versions:** • S7-1200 as of V4.2 • S7-1500 as of V2.0
“Number of measurements”	Input of the number of measurements to be saved on the card.
“Memory requirements”	Display of the expected memory requirement for all measurements
	Displaying memory usage Shows the tab with the memory usage
“Behavior if number reached”	Selection for the behavior once “Number of measurements” is reached The following settings are possible: • “Deactivating a recording” The measurements are repeated until the “Number of measurements on the card” is reached. • “Overwrite oldest recording” The measurements are saved in a ring buffer and repeated until the user deactivates the recording. Once the number of measurements exceeds the “Number of measurements on the card” the oldest measurement on the card is overwritten in each case. **Note** Note that write processes that are repeated frequently may damage the card.

Data types for trigger tags

The following table shows the supported data types for the trigger tag:

Memory requirement and format of the number	Data type
1 byte	BOOL
8-bit integers	SINT, USINT, BYTE
16-bit integers	INT, UINT, WORD
32-bit integers	DINT, UDINT, DWORD
64-bit integers	LINT, ULINT, LWORD (not S7-1200)
32-bit floating-point numbers	REAL
64-bit floating-point numbers	LREAL

Trigger event

Depending on the selection in the drop-down list, the further settings differ for the "event".

The individual events are described below.

"=TRUE"

Supported data types: Bit (Page 71)

The recording starts when the state of the trigger is TRUE.

"=FALSE"

Supported data types: Bit (Page 71)

The recording starts when the state of the trigger is FALSE.

"Rising edge"

Supported data types: Bit (Page 71)

The recording is started when the trigger state changes from FALSE to TRUE.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Rising signal"

Supported data types: Integers and floating-point numbers (Page 71)

The recording is started when the rising value of the trigger reaches or exceeds the value configured for this event.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Falling edge"

Supported data types: Bit (Page 71)

The recording is started when the trigger state changes from TRUE to FALSE.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Falling signal"

Supported data types: Integers and floating-point numbers (Page 71)

The recording is started when the falling value of the trigger reaches or falls below the value configured for this event.
After activation of the installed trace, at least two cycles are required to identify the edge.

"In the range"

Supported data types: Integers and floating-point numbers (Page 71)

The recording starts as soon as the value of the trigger is in the value range configured for this event.

"Outside of the range"

Supported data types: Integers and floating-point numbers (Page 71)

The recording starts as soon as the value of the trigger is outside the value range configured for this event.

"Value change"

All data types are supported.

The value is checked for change when the recording is activated. The recording starts when the value of the trigger changes.

This trigger event is supported as of V13 SP1. Older versions of the TIA Portal cannot interpret the trigger. Note that no explicit information is output in this case. This can occur, for example, when the trace is transferred from a CPU to a TIA Portal less than V13 SP1 or a trace configuration is imported.

"= value"

Supported data types: Integers (Page 71)

The recording starts when the value of the trigger is equal to the value configured for this event.

"<> "<> value"

Supported data types: Integers (Page 71)

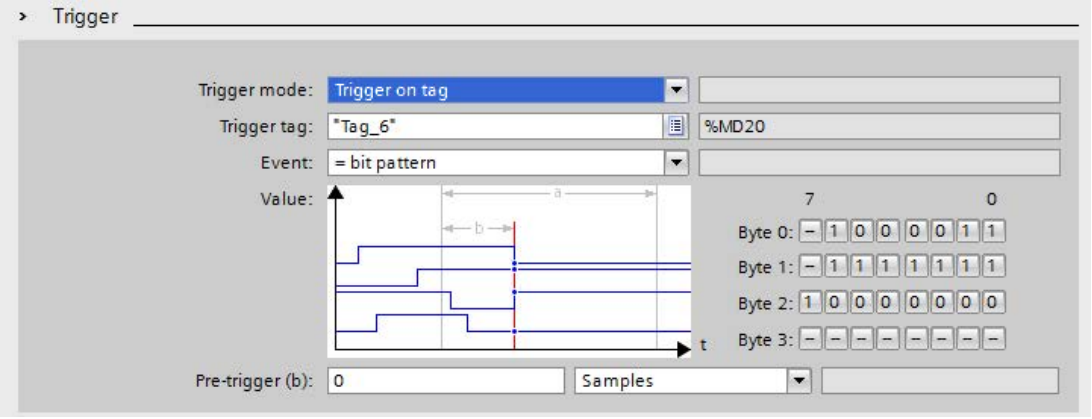
The recording starts when the value of the trigger is not equal to the value configured for this event.

"= bit pattern"

Supported data types: Integers (Page 71)

The recording starts when the value of the trigger matches the bit pattern configured for this event.

The following figure shows the setting options for a "bit pattern":



It is possible to switch between the icons by clicking the respective button.

The following table shows the icons:

Icon	Description
–	Bit is not evaluated
0	Bit is checked for FALSE
1	Bit is checked for TRUE

"<> bit pattern"

Supported data types: Integers (Page 71)

The recording starts when the value of the trigger does not match the bit pattern configured for this event.

See also

Configuring the trigger conditions (Page 76)

4.1.7 Configuration

4.1.7.1 Trace configuration - overview

The configuration of the recording conditions and the signals to be recorded is device-specific.

Requirement

A trace configuration has been created and opened in the working area of the "Configuration" tab.

Procedure

The following table shows the procedure for configuring.

Step	Description
1	Documentation of the configuration (optional) Enter a comment and an author for the configuration in the Inspector window.
2	Selecting signals (Page 75) Select the signals to be recorded in the "Signals" area.
3	Configuring the recording cycle and duration Select a recording time, a cycle and the duration in the "Recording conditions" area.
4	Configuring the trigger conditions (Page 76) In the "Recording conditions" area, select whether the recording is to be performed immediately or depending on a trigger condition.
5	Configure installed measurements (memory card) (Page 77) In the "Recording conditions" area, select whether the recording is to be saved on the device (memory card).

4.1.7.2 Selecting signals

Requirement

- A trace configuration has been created and opened.
- The "Signals" area is open in the "Configuration" tab.

Procedure

To configure the signals to be recorded, proceed as follows:

1. Select a signal. The following options are available:
   - In the "Name" column, click the button and select a tag.
   - Enter the symbolic tag name in the cell in the "Name" column.
   - Enter the address directly in the "Address" column.
   - Drag a signal to the table using drag-and-drop.
2. Click in the "Color" column and select a color for the display of the signal.
3. Click in the "Comment" column and enter a comment for the signal.
4. Repeat the procedure from step 1 until all the signals to be recorded have been entered in the table.

4.1.7.3 Configuring the recording cycle and duration

Requirement

- A trace configuration has been created and opened.
- The "Recording conditions" area is open in the "Configuration" tab.

Procedure

To configure the cycle and the duration of a recording, proceed as follows:

1. Click the button for the recording time.
2. Select an OB for the recording time (Page 61).
3. Select a unit for the reduction factor in the drop-down list for "Record every".
4. Enter the factor for the reduction in the input field for "Record every".
5. Select a unit in the drop-down list for "Recording duration".
6. Specify the recording duration.
   The following options are available:
   - Enter a value for the duration in the input field for "Recording duration".
   - Activate the "Use max. recording duration" checkbox.

4.1.7.4 Configuring the trigger conditions

Requirement

- A trace configuration has been created and opened.
- The "Recording conditions" area is open in the "Configuration" tab.

"Record immediately" trigger condition

To start the recording immediately, proceed as follows:

1. Select the "Record immediately" entry in the drop-down list for "Trigger mode".

   The input fields for the trigger tag are hidden.

"Trigger on tag" trigger condition

To start the recording depending on a condition, proceed as follows:

1. Select the "Trigger on tag" entry in the drop-down list for "Trigger mode".
2. Select a trigger tag. The following options are available:
   - Click the button for the trigger tag and select a tag.
   - Enter the address or the symbolic name of the tag directly in the input field for the trigger tag.

   A drop-down list with events and input fields is displayed. The display depends on the data type of the tag.
3. Configure the event.
4. Select a unit for the pre-trigger in the drop-down list for "Pre-trigger".
5. In order to record a period before the trigger event, enter a value greater than 0 in the input field for the pre-trigger.

Note

Cyclic test of the trigger condition

The trigger condition is checked in every cycle irrespective of the setting in "Record every". To reliably identify the trigger, the trigger signal must be present for at least one full cycle.

Note

No evaluation of the trigger during saving

No new trigger can be evaluated provided that the recording is saved.

4.1.7.5 Configure installed measurements (memory card)

Requirement

- A trace configuration has been created and opened.
- The "Recording conditions" area is open in the "Configuration" tab.
- The “Trigger on tag” trigger mode is set.
- The firmware on the device supports the recording of an installed measurement.

Procedure

Proceed as follows to save the installed measurement (on the memory card):

1. Select the "Save measurements on device (memory card)" check box.
2. Enter the number of measurements that ought to be saved on the card in the “Number of measurements” entry field.
3. Set the desired behavior once the “Number of measurements” has been reached in the “Behavior if number reached” drop-down list.

Glossary

Curve diagram

Displays the selected signals of a recording.

Installed trace

Consists of a trace configuration and optionally a recording.

Measurement

Consists of a trace configuration with an associated recording.

Overlay measurement

Permits a comparison and analysis of signals from different measurements.

Pre-trigger

Defines the interval in which the signals are already recorded before the actual trigger condition is fulfilled.

Recording

Is performed in the device. There is only one recording for each installed trace configuration.

Recording condition

Sampling and trigger for a trace configuration.

Recording duration

Factor in number of samples. The factor of 100 means, for example, that 100 samples are recorded.

Reduction

Factor in number of cycles. A factor of 2 means, for example, that a recording is made every second cycle.

Sampling

Setting, in which cycle, how fast and how long the recording is to be made.

Signal table

Lists the signals of the selected measurement and provides setting options for some properties.

Snapshot

Contains the settings for the view for a measurement.

Trace configuration

Contains all the information required to record values in a device.

Trigger

Specifies the trigger mode and the condition for the "Trigger on tag" mode.

Trigger mode

Specifies whether the recording should be started immediately or based on a trigger tag.

Trigger tag

Signal to trigger the recording.

Trigger time

The meaning of the measurement trigger time depends on the device.

e.g. SIMATIC S7-1200/1500 CPUs: Specifies the absolute time of the control system at the start of recording.

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Communcation

Function manual

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Function Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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Preface

Purpose of the documentation

This function manual provides you with an overview of the communication options, the CPUs, communication modules and processors and PC systems of the SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL and ET 200pro systems. This function manual describes the connection-oriented, asynchronous communication.

The documentation covers the following:

- Overview of the communication services
- Properties of the communication services
- Overview of the user activities for setting up the communication services

Basic knowledge required

The following knowledge is required in order to understand the Function manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about how to use STEP 7 (TIA Portal)

Scope of the documentation

This documentation is the basic documentation for all products of the SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL and ET 200pro systems. The product documentation is based on this documentation.

What's new compared to the previous version of the function manual (12/2014 edition)

What's new?		What are the customer benefits?	Where can I find the information?
New contents	OPC UA server	OPC UA is a uniform standard for data communication and is independent of any particular operating system platforms. OPC UA uses integrated safety mechanisms on various automation systems, for example with data exchange, at application level, for the legitimation of the user. The OPC UA server provides a large amount of data: • Values of PLC tags that clients can access • Data types of these PLC tags • Information about the OPC UA server itself and the CPU In this way, clients can gain an overview of the tag management and can read and write values.	Section OPC UA server (Page 119)
	Secure Open User Communication	Secure data exchange with other devices.	Section Secure Open User Communication (Page 66)
	Certificate handling in STEP 7	You can manage certificates for the following applications in STEP 7: • OPC UA server • Secure Open User Communication • Web server of the CPU	Section Managing certificates with STEP 7 (Page 75)
	Deactivating SNMP for the CPU	You can deactivate SNMP for the CPU. This can make sense under certain conditions, for example if the security guidelines in your network do not permit SNMP.	Section Disabling SNMP (Page 34)

Conventions

STEP 7: We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)".

"S7-1500 CPUs" also refers to the CPU variants S7-1500F, S7-1500T, S7-1500C as well as S7-1500pro CPUs, ET200SP CPUs as well as the SIMATIC S7-1500 SW controller.

This documentation contains pictures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

Note

A note contains important information on the product, on handling of the product and on the section of the documentation to which you should pay particular attention.

See also

PRODIS (http://www.siemens.com/simatic-tech-doku-portal)

Catalog (http://mall.industry.siemens.com)

Security information

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Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

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  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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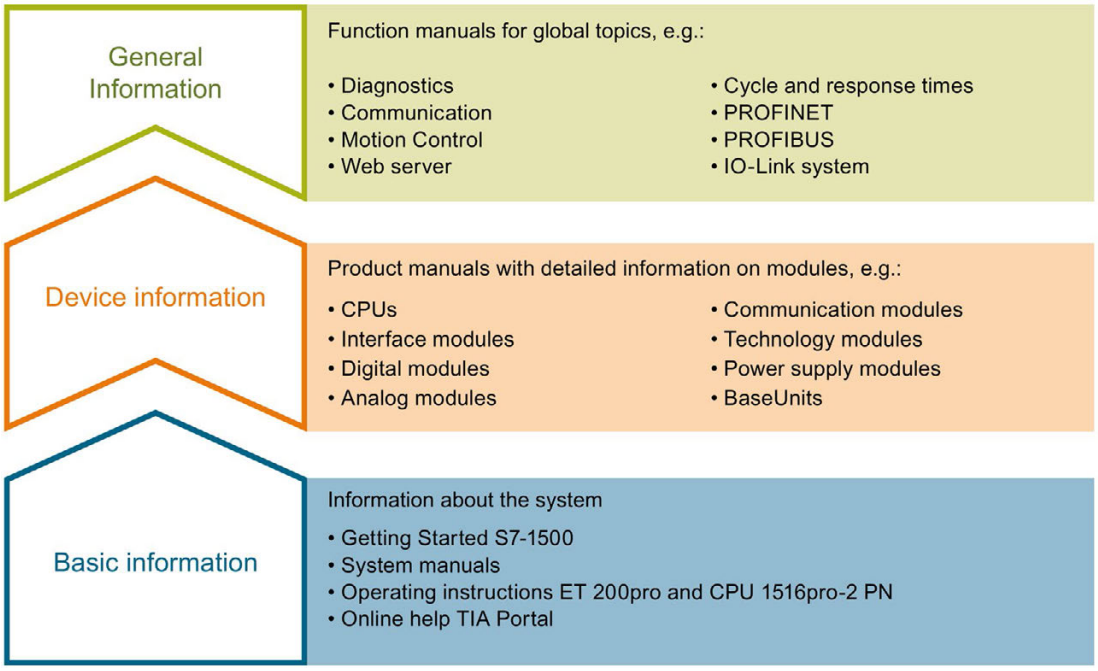
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

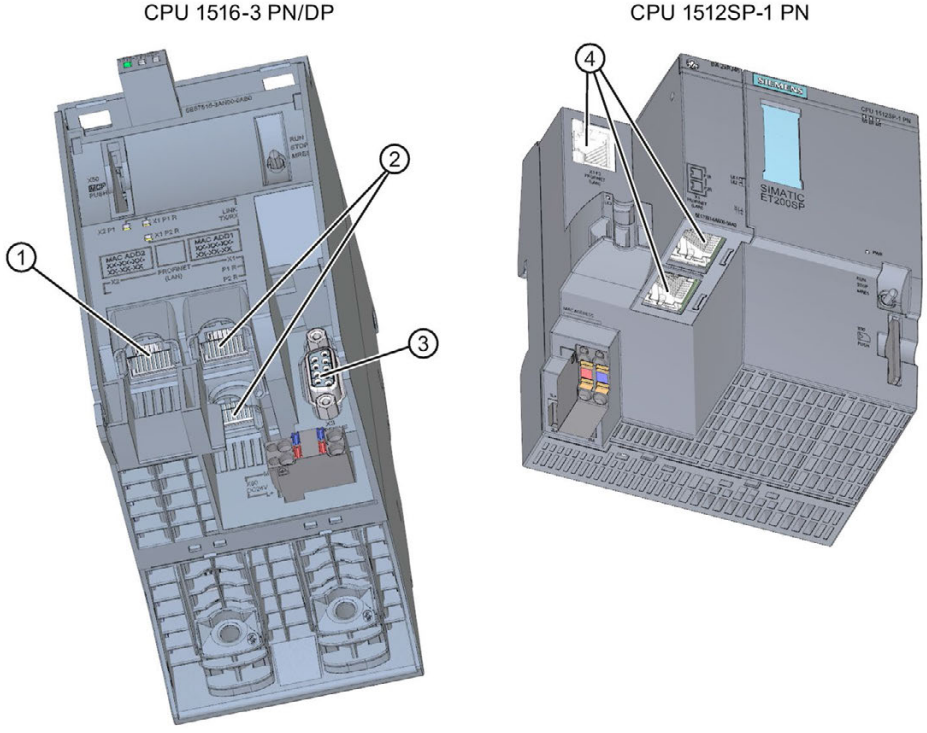
Product overview

2

CPUs, communications modules and processors, and PC systems of the S7-1500, , ET 200MPET 200SPET 200pro and ET 200AL systems provide you with interfaces for communication via PROFINET, PROFIBUS and point-to-point connections.

CPUs, communications modules and communications processors

PROFINET and PROFIBUS DP interfaces are integrated in the S7-1500 CPUs. The CPU 1516-3 PN/DP for example has two PROFINET interfaces and one PROFIBUS DP interface. Other PROFINET and PROFIBUS DP interfaces are available by using communications modules (CM) and communications processors (CP).

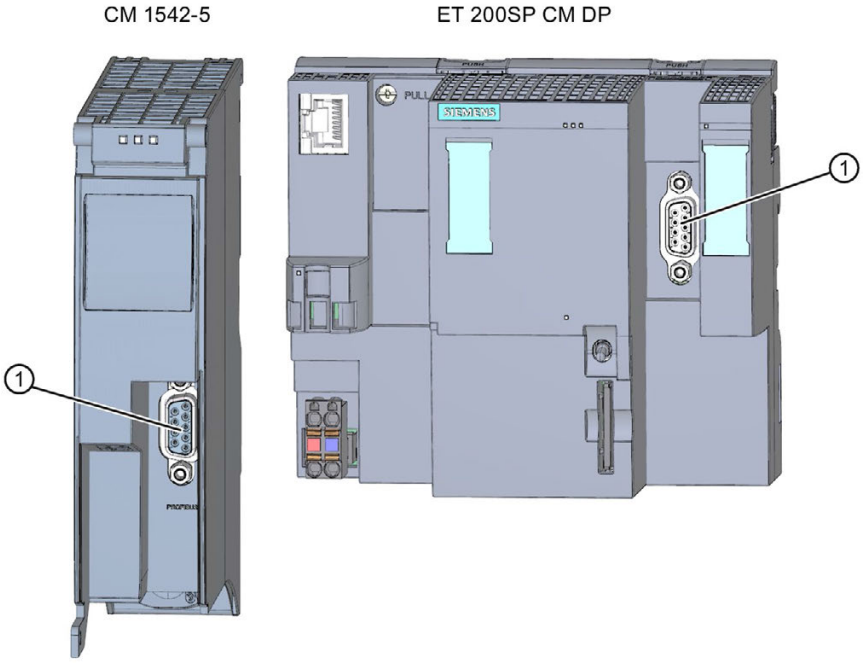


① PROFINET interface (X1) with 1 port
② PROFINET interface (X2) with 2-port switch
③ PROFIBUS DP interface (X3)
④ PROFINET interface (X1) with 3-port switch

Figure 2-1 Interfaces of the CPU 1516-3 PN/DP and CPU 1512SP-1 PN

Interfaces of communications modules

Interfaces of communications modules (CMs) extend the interfaces of CPUs (for example, the communication module CM 1542-5 adds a PROFIBUS interface to S7-1500 automation system).

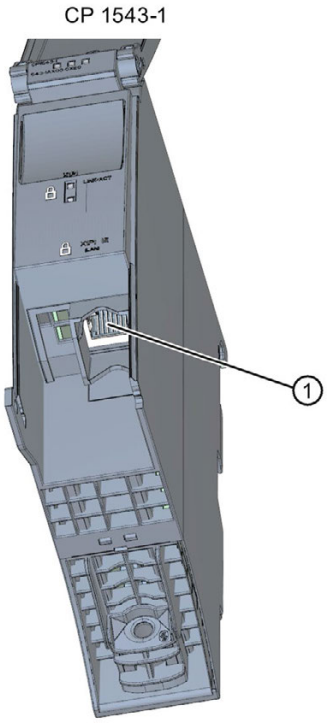


① PROFIBUS DP interface

Figure 2-2 PROFIBUS DP interface of the CM 1542-5 and CM DP

Interfaces of communications processors

Interfaces of communications processors (CPs) provide an additional functionality compared with the integrated interfaces of the CPUs. CPs allow special applications, for example the CP 1543-1 provides Industrial Ethernet security functions for protecting Industrial Ethernet networks via its Industrial Ethernet interface.

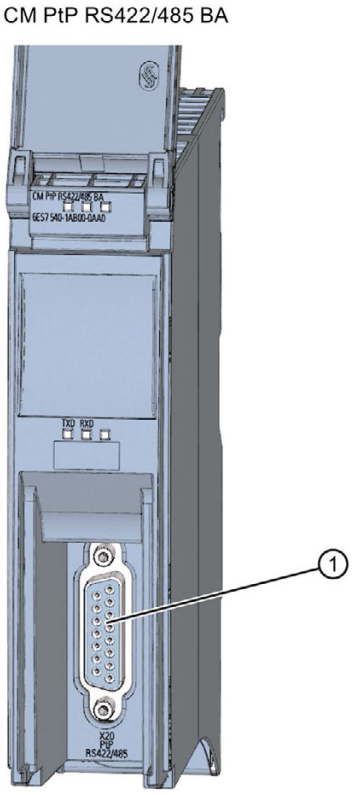


① Industrial Ethernet interface

Figure 2-3 Industrial Ethernet interface of the CP 1543-1

Interfaces of communications modules for point-to-point connections

The communication modules for point-to-point connections provide communication via their RS 232-, RS 422- and RS 485 interfaces, for example, Freeport or Modbus communication.

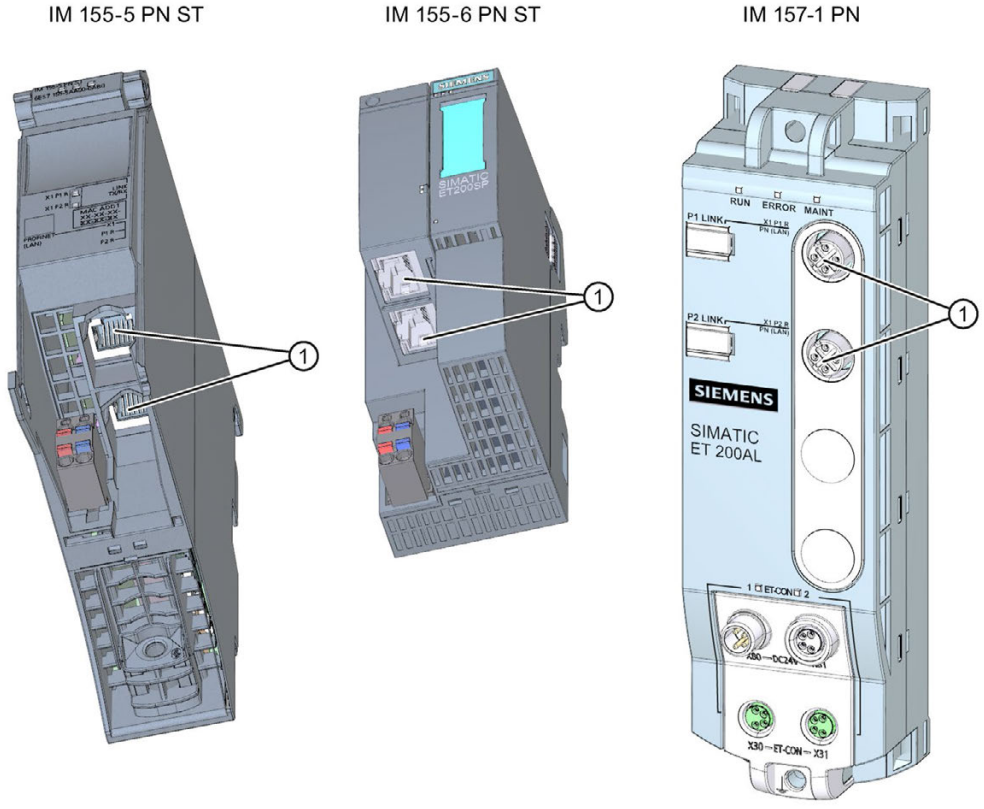


① Interface for point-to-point connections

Figure 2-4 Example of interface for point-to-point connection at the CM PtP RS422/485 BA

Interfaces of interface modules

PROFINET and PROFIBUS DP interfaces of the interface modules (IM) in ET 200MP, ET 200SP and ET 200AL are used to connect the distributed I/O ET 200MP, ET 200SP and ET 200AL to PROFINET or PROFIBUS of the higher-level IO controller or DP master.



① PROFINET interface with 2-port switch

Figure 2-5 PROFINET interfaces IM 155-5 PN ST (ET 200MP), IM 155-6 PN ST (ET 200SP), and IM 157-1 PN (ET 200AL)

Communications services

The communications services described below use the interfaces and communication mechanisms provided by the system via CPUs, communication modules and processors.

Communications services

3

3.1 Overview of communication options

Overview of communications options

The following communications options are available for your automation task.

Table 3- 1 Communications options

Communications options	Functionality	Via interface:		
		PN/IE[1]	DP	serial
PG communication	On commissioning, testing, diagnostics	X	X	-
HMI communication	On operator control and monitoring	X	X	-
Open communication using TCP/IP	Data exchange via PROFINET/Industrial Ethernet with TCP/IP Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TCON • T_DISCON	X	-	-
Open communication using ISO-on-TCP	Data exchange via PROFINET/Industrial Ethernet with ISO-on-TCP Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TUSEND/TURCV • TCON • T_DISCON	X	-	-
Open communication with UDP	Data exchange via PROFINET/Industrial Ethernet with UDP Instructions: • TSEND_C/TRCV_C • TUSEND/TURCV/TRCV • TCON • T_DISCON	X	-	-

Communications options	Functionality	Via interface:		
		PN/IE[1]	DP	serial
Open communication via ISO (only CPs with PROFINET/Industrial Ethernet interface)	Data exchange via PROFINET/Industrial Ethernet with the ISO protocol Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TCON • T_DISCON	X	-	-
Open communication with FDL (only CM 1542-5 as of firmware V2.0)	Data exchange via PROFIBUS with the FDL protocol Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TUSEND/TURCV • TCON • T_DISCON	-	X	-
OPC UA server (only via internal PROFINET interfaces of the CPU)	Data exchange with OPC UA clients	X	-	-
Communication via Modbus TCP	Data exchange via PROFINET with Modbus TCP protocol Instructions: • MB_CLIENT • MB_SERVER	X	-	-
E-mail	Sending process alarms via e-mail Instruction: • TMAIL_C	X	-	-
FTP (only CPs with PROFINET/Industrial Ethernet interface)	File management and file access via FTP (File Transfer Protocol); CP can be FTP client and FTP server Instruction: • FTP_CMD	X	-	-
Fetch/Write (only CPs with PROFINET/Industrial Ethernet interface)	Server services via TCP/IP, ISO-on-TCP and ISO Via special instructions for Fetch/Write	X	-	-
S7 communication	Data exchange client/server or client/client Instructions: • PUT/GET • BSEND/BRCV • USEND/URCV	X	X	-
Serial point-to-point connection	Data exchange via point-to-point with Freeport, 3964(R), USS or Modbus protocol Via special instructions for PtP, USS or Modbus RTU	-	-	X

Communications options	Functionality	Via interface:		
		PN/IE[1]	DP	serial
Web server	Data exchange via HTTP(S), for example for diagnostics	X	-	-
SNMP (Simple Network Management Protocol)	For monitoring and error recognition of IP networks, possibly parameterization of the IP network components via standard SNMP protocol	X	-	-
Time-of-day synchronization	Via PN/IE interface: CPU is NTP client (Network Time Protocol)	X	-	-
	Via DP interface: CPU/CM/CP is time-of-day master or time slave	-	X	-

* IE - Industrial Ethernet

Additional information

- Application example: CPU-CPU communication with SIMATIC controllers (compendium) You can find the application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/20982954).
- This FAQ (https://support.industry.siemens.com/cs/ww/en/view/102420020) describes how to configure fetch/write communication via CP1543-1 with S7-1500.
- Additional information about the Fetch/Write services is available in the STEP 7 online help.
- You can find additional information on the PtP link in the function manual CM PtP - Configurations for Point-to-Point Connections (http://support.automation.siemens.com/WW/view/en/59057093).
- You will find the description of the web server functionality in the function manual Web server (http://support.automation.siemens.com/WW/view/en/59193560).
- You will find information about the standard protocol SNMP on the Service & Support pages on the Internet (http://support.automation.siemens.com/WW/view/en/15166742).
- You will find information about time-of-day synchronization in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/86535497).

3.2 Overview of connection resources

Connection resources

Some communications services require connections. Connections allocate resources on the CPUs, CPs and CMs involved (for example memory areas in the CPU operating system). In most cases one resource per CPU/CP/CM is allocated for a connection. In HMI communication, up to 3 connection resources are required per HMI connection.

The connection resources available depend on the CPU being used, the CPs and CMs and must not exceed a defined high limit for the automation system.

Available connection resources in a station

The maximum number of resources of a station is determined by the CPU.

Each CPU has reserved connection resources for PG, HMI and web server communication. There are also resources available that can be used for SNMP, e-mail connections, HMI, S7 communication as well as for open communication.

When are connection resources allocated?

The time for allocation of connection resources depends on how the connection is set up, automatic, programmed or configured (see section Setting up a connection (Page 24)).

Additional information

You will find more detailed information on the allocation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 181).

3.3 Setting up a connection

Automatic connection

STEP 7 sets up a connection automatically (for example PG or HMI connection) if you have connected the PG/PC interface to an interface of the CPU physically and have made the interface assignment in STEP 7 in the "Go online" dialog.

Setting up a programmed connection

You set up the programmed connection in the program editor of STEP 7 in the context of a CPU by assigning instructions for communication, for example TSEND_C.

When specifying the connection parameters (in the Inspector window, in the properties of the instruction), you are supported by the easy-to-use user interface.

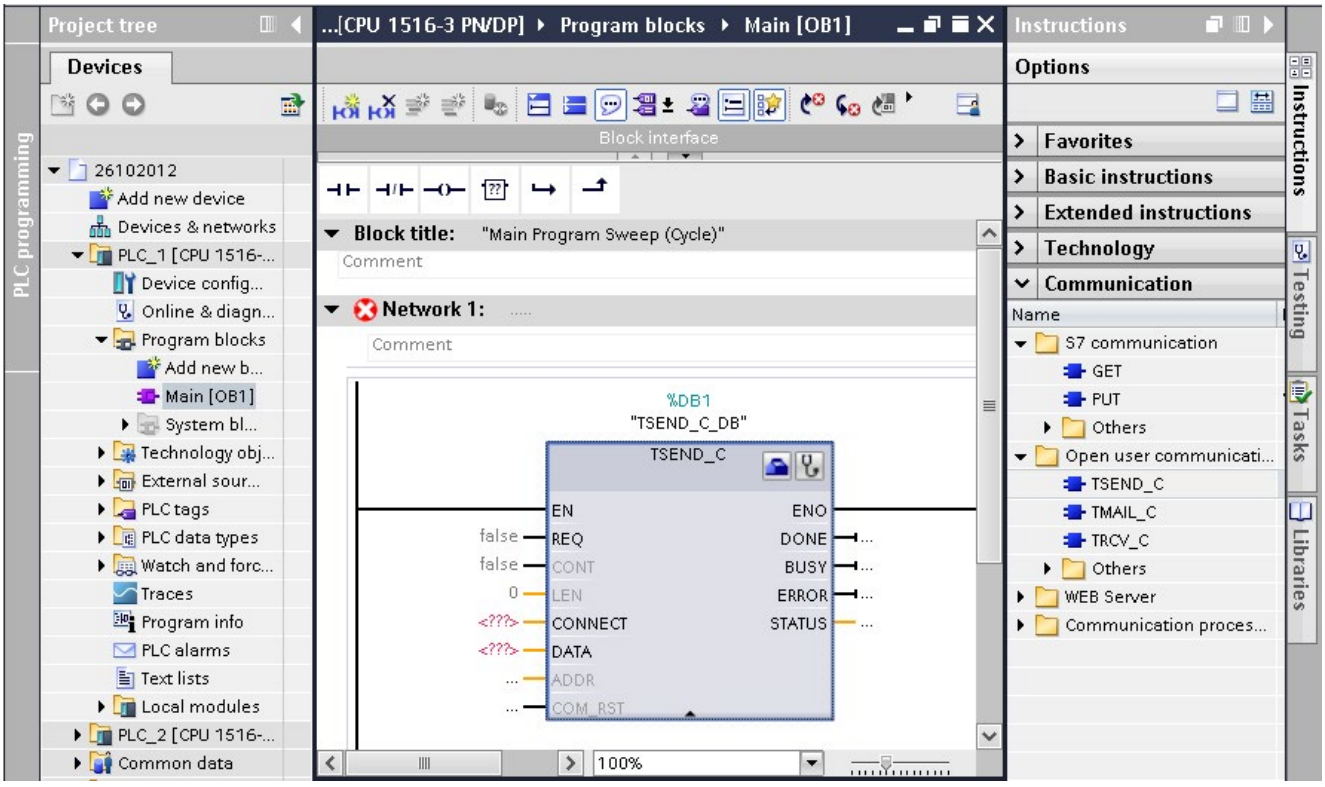


Figure 3-1 Programmed setup

Setting up a configured connection

You set up the configured connection in the network view of the Devices & networks editor of STEP 7 in the context of a CPU or a software controller.

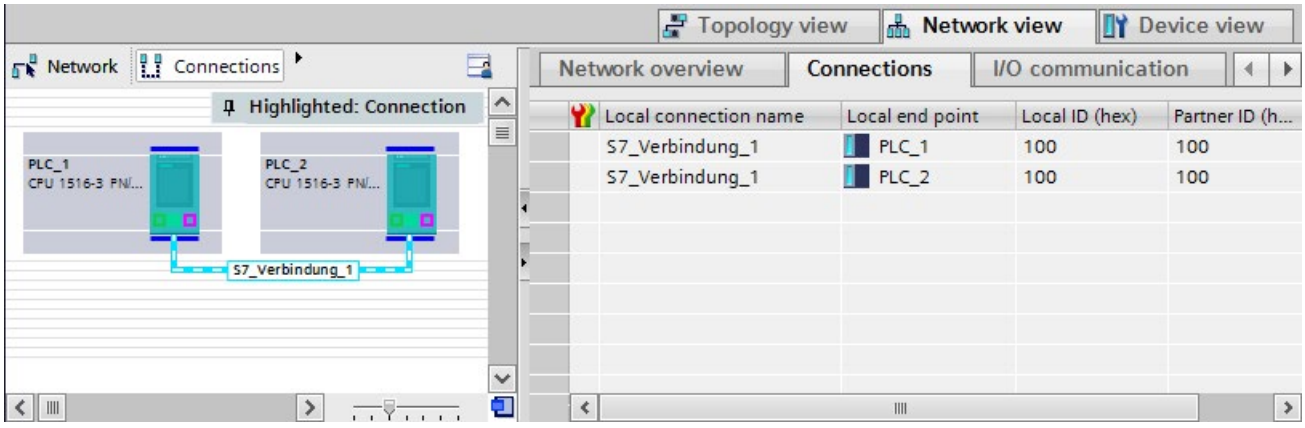


Figure 3-2 Configured setup

Effects on the connection resources of the CPU

You can often choose between a configured or a programmed connection. Programmed connection setup allows connection resources to be released following data transfer. Like routed connections, programmed connections are not guaranteed, meaning that they are only established when resources are available. With configured connection setup, the resource is available after download of the configuration until the configuration changes again. Corresponding resources are therefore reserved for connection establishment via configured connections. The "Connection resources" table in the Inspector window of the CPU displays an overview of connection resources already used and those still available.

How do I set up a connection?

Table 3- 2 Setting up the connection

Connection	Automatically	Programmed setup	Configured setup
Programming device connection	X	-	-
HMI connection	X	-	X
Open communication via TCP/IP connection	-	X	X
Open communication via ISO-on-TCP connection	-	X	X
Open communication via UDP connection	-	X	X
Open communication via ISO connection	-	X	X
Open communication via FDL connection	-	X	X
Communication via Modbus TCP connection	-	X	-
E-mail connection	-	X	-
FTP connection	-	X	-
S7 connection	-	-	X

Additional information

You will find further information on the allocation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 181).

3.4 Data consistency

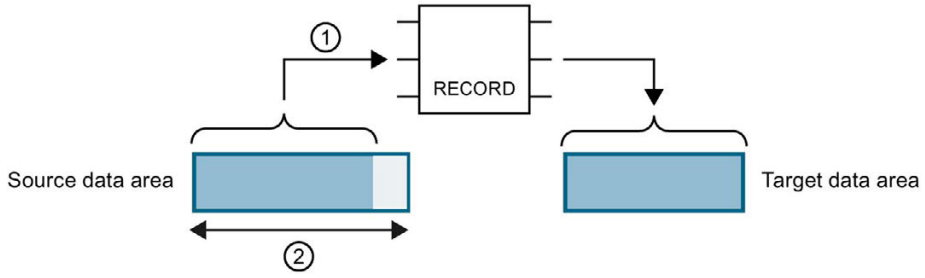
Definition

Data consistency is important for data transfer and you need to take this into account when configuring the communication task. Otherwise, malfunctions may occur.

A data area which cannot be modified by concurrent processes is called a consistent data area. This means that a data area which belongs together and which is larger than the maximum size of the consistent data area can consist in part of new and of old data at the same time.

An inconsistency can occur when an instruction for communication is interrupted, for example by a hardware interrupt OB with higher priority. This interrupts the transfer of the data area. If the user program in this OB now changes the data that has not yet been processed by the communication instruction, the transferred data originates from different times:

The following figure shows a data area that is smaller than the maximum size of the consistent data area. In this case, when transferring the data area, it is ensured that there is no interruption by the user program during data access so that the data is not changed.

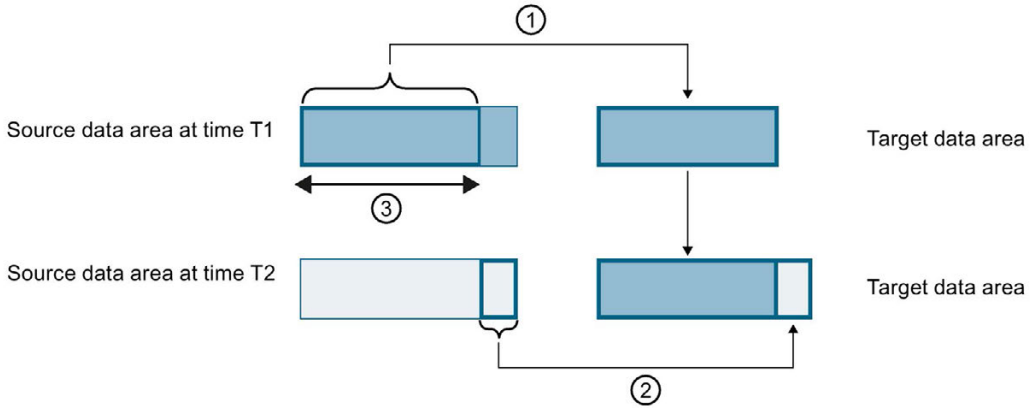


① The source data area is smaller than the maximum size of the consistent data area (②). The instruction transfers the data together to the destination data area.

② Maximum size of the consistent data area

Figure 3-3 Consistent transfer of data

The following figure shows a data area that is larger than the maximum size of the consistent data area. In this case, the data can be changed during an interruption of the data transfer. An interruption also occurs if, for example, the data area needs to be transferred in several parts. If the data is changed during the interruption, the transferred data originates from different times.



① The source data area is larger than the maximum size of the consistent data area (③). At time T1, the instruction only transfers as much data from the source data area into the destination data area as fits in the consistent data area.

② At time T2, the instruction transfers the rest of the source data area to the destination data area. After the transfer, data from different points in time exist in the destination data area. If the data in the source data area has changed in the meantime, an inconsistency may result.

③ Maximum size of the consistent data area

Figure 3-4 Transfer of data larger than the maximum consistency area

Example of an inconsistency

The figure below shows an example of changing data during the transfer. The destination data area contains data from different points in time.

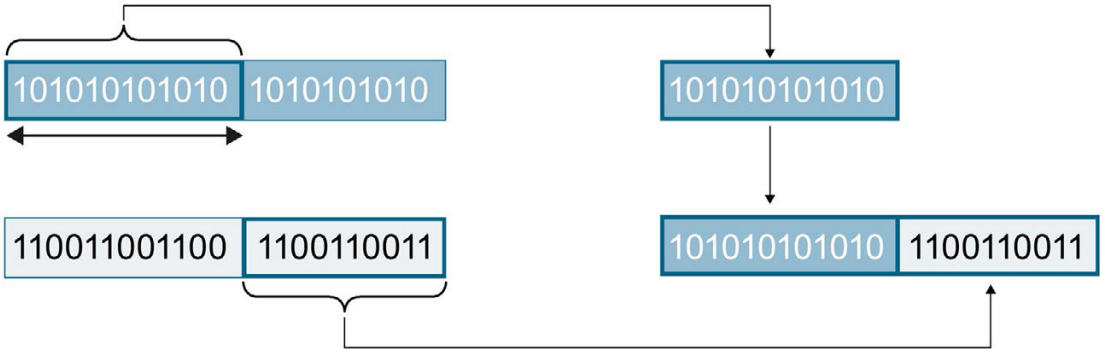


Figure 3-5 Example: Changing data during the transfer

System-specific maximum data consistency for S7-1500:

No inconsistency occurs if the system-specific maximum size of the consistent data is kept to. With an S7-1500, communication data is copied consistently into or out of the user memory in blocks of up to 512 bytes during the program cycle. Data consistency is not ensured for larger data areas. Where defined data consistency is required, the length of communication data in the user program of the CPU must not exceed 512 bytes. You can then access these data areas consistently, for example from an HMI device by reading/writing tags.

If more data than the system-specific maximum size needs to be transferred consistently, you yourself must ensure the data consistency with suitable measures in the user program.

Ensuring data consistency

Use of instructions for access to common data:

If the user program contains instructions for communication that access common data, for example TSEND/TRCV, you can coordinate access to this data area yourself, for example using the "DONE" parameter. The data consistency of the data areas that are transferred with an instruction for communication can therefore be ensured in the user program.

Note

Measures in the user program

To achieve data consistency, you can copy transferred data to a separate data area (for example, global data block). While the user program continues to work with the original data, you can transfer the data saved in the separate data area consistently with the communication instruction.

For the copying, use uninterruptible instructions such as UMOVE_BLK or UFILL_BLK. These instructions ensure data consistency up to 16 KB.

Use of PUT/GET instructions or Write/Read via HMI communication:

In S7 communication with the PUT/GET instructions or Write/Read via HMI communication, you need to take into account the size of the consistent data areas during programming or configuration. In the user program of an S7-1500 as server, there is no instruction available that can coordinate the data transfer in the user program. The data exchanged using PUT/GET instructions updates the S7-1500 while the user program is running. There is no point in time within the processing of the cyclic user program at which the data is exchanged consistently. The length of the data area to be transferred should be smaller than 512 bytes.

Additional information

- You will also find the maximum amount of consistent data in the device manuals of the communications modules in the Technical Specifications.
- You will find further information on data consistency in the description of the instructions in the STEP 7 online help.

3.5 Communications protocols and port numbers used for Ethernet communication

This section provides an overview of the protocols and port numbers supported for communication via PN/IE interfaces. For each protocol the address parameters, the respective communications layer as well as the communications role and the communications direction are specified.

This information makes it possible to match the security measures for protection of the automation system to the used protocols (for example firewall). Because security measures are limited to Ethernet or PROFINET networks, the tables do not include PROFIBUS protocols.

The tables below show the different layers and protocols that are being used.

The following table shows the protocols supported by the S7-1500 CPUs, ET 200SP CPUs and the CPU 1516pro-2 PN. The S7-1500 software controllers also support the protocols listed in the following table for the Ethernet interfaces that are assigned to the software controller.

Table 3- 3 Layers and protocols of the S7-1500 CPUs and software controllers (via PROFINET interface of the CPU)

Protocol	Port number	(2) Link layer (4) Transport layer	Function	Description
PROFINET protocols				
DCP Discovery and configuration protocol	Not relevant	(2) Ethertype 0x8892 (PROFINET)	Accessible devices PROFINET Discovery and configuration	DCP is used by PROFINET to discover PROFINET devices and provide basic settings.
LLDP Link Layer Discovery protocol	Not relevant	(2) Ethertype 0x88CC (LLDP)	PROFINET Link Layer Discovery protocol	LLDP is used by PROFINET to discover and manage neighbor relationships between PROFINET devices. LLDP uses the special multicast MAC address: 01-80-C2-00-00-0E
MRP Media Redundancy Protocol	Not relevant	(2) Ethertype 0x88E3 (IEC 62493-2-2010)	PROFINET medium redundancy	MRP provides control of redundant transmission paths by means of a ring topology. MRP uses multicast MAC addresses according to the standard
PTCP Precision Transparent Clock Protocol	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET send clock and time synchronization, based on IEEE 1588	PTC provides a time delay measurement between RJ45 ports and thus send clock synchronization and time synchronization. PTCP uses multicast MAC addresses according to the standard
PROFINET IO data	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Cyclic IO data transfer	The PROFINET IO frames are used to transmit IO data cyclically between PROFINET IO controller and IO devices via Ethernet.
PROFINET Context Manager	34964	(4) UDP	PROFINET connection less RPC	The PROFINET Context Manager provides an endpoint mapper in order to establish an application relation (PROFINET AR).

Protocol	Port number	(2) Link layer (4) Transport layer	Function	Description
Connection-oriented communications protocols				
SMTP Simple mail transfer protocol	25	(4) TCP	Simple mail transfer protocol	SMTP is used for sending e-mail and SMS (depending on provider).
HTTP Hypertext transfer protocol	80	(4) TCP	Hypertext transfer protocol	HTTP is used for communication with the CPU-internal web server.
ISO on TCP (according to RFC 1006)	102	(4) TCP	ISO-on-TCP protocol	ISO on TCP (according to RFC 1006) is used for message-oriented data exchange to remote CPU or software controller. S7 communication with ES, HMI, OPC server, etc.
NTP Network time protocol	123	(4) UDP	Network time protocol	NTP is used for synchronization of the CPU system time with the time of an NTP server.
SNMP Simple network management protocol	161 162 (trap)	(4) UDP	Simple network management protocol	SNMP is used for reading and setting of network management data (SNMP managed Objects) by the SNMP Manager.
HTTPS Secure Hypertext transfer protocol	443	(4) TCP	Secure Hypertext transfer protocol	HTTPS is used for communication with the CPU-internal web server via Secure Socket Layer (SSL).
Modbus TCP Modbus Transmission Control Protocol	502	(4) TCP	Modbus/TCP protocol	Modbus/TCP is used by MB_CLIENT/MB_SERVER instructions in the user program.
OPC UA Open Platform Communications Unified Architecture	4840	(4) TCP	Based on the TCP/IP protocol	Communication standard ranging from the enterprise level to the field level.

Protocol	Port number	(2) Link layer (4) Transport layer	Function	Description
OUC[1] Open User Communication and Secure OUC	1 ... 1999 can be used to limited extent[2]	(4) TCP (4) UDP	Open User Communication (TCP/UDP) Secure Open User Communication (TLS)	OUC instructions provide connection establishment, connection termination and data transfer based on the socket layer.
	2000 ... 5000 Recommended			
	5001 ... 49151 can be used to limited extent[2]			
IGMPv2 Internet Group Management Protocol	Not relevant	(3) Network layer	Internet Group Management Protocol	Network protocol for the organization of multicast groups.
Reserved	49152 ... 65535	(4) TCP (4) UDP	-	Dynamic port area used for active connection end point if the application does not determine the local port number.

1 Note: The open communication provides direct access to the UDP/TCP for the user. The user is responsible for observing the port restrictions/definitions of the IANA (Internet Assigned Numbers Authority).

2 Do not use ports for OUC, which are already used by other protocols.

The following table shows the protocols that are supported by the S7-1500 software controller via the Ethernet interfaces assigned to Windows.

Table 3- 4 Layers and protocols of the S7-1500 Software Controller (via Ethernet interface on the Windows side)

Protocol	Port number	(2) Link layer (4) Transport layer	Function	Description
PROFINET protocols				
DCP Discovery and configuration protocol	Not relevant	(2) Ethertype 0x8892 (PROFINET)	Accessible devices PROFINET Discovery and configuration	DCP is used by PROFINET to discover PROFINET devices and provide basic settings.
Connection-oriented communications protocols				
SMTP Simple mail transfer protocol	25	(4) TCP	Simple mail transfer protocol	SMTP is used for sending e-mail and SMS (depending on provider).
HTTP Hypertext transfer protocol	Adjustable [1]	(4) TCP	Hypertext transfer protocol	HTTP is used for communication with CPU-internal web server. You can change the port number to avoid conflict with other web servers on Windows. If you want to use web server access, you must activate the port in the Windows Firewall.
ISO on TCP (according to RFC 1006)	102	(4) TCP	ISO-on-TCP protocol	ISO on TCP (according to RFC 1006) for S7 communication with PG/PC or HMI.
OUC[2] Open User Communication and Secure OUC	1 ... 1999 can be used to limited extent[3, 4]	(4) TCP (4) UDP	Open User Communication (TCP/UDP) Secure Open User Communication (TLS)	OUC instructions provide connection establishment, connection termination and data transfer based on the socket layer. If you want to use OUC, you must activate the ports in the Windows Firewall.
	2000 ... 5000 recommended[4]			
	5001 ... 49151 can be used to limited extent[3, 4]			

Protocol	Port number	(2) Link layer (4) Transport layer	Function	Description
IGMPv2 Internet Group Management Protocol	Not relevant	(3) Network layer	Internet Group Management Protocol	Network protocol for the organization of multicast groups.
Reserved	49152 ... 65535	(4) TCP (4) UDP	-	Dynamic port range that is used for the active connection end point, if the application does not determine the local port number. If you wish to use this communication, you must activate the ports in the Windows Firewall.

1 Default setting for Windows assigned interfaces: 81

2 Note: The open user communication provides direct access to the UDP/TCP for the user. The user is responsible for observing the port restrictions/definitions of the IANA (Internet Assigned Numbers Authority).

3 Do not use ports for OUC, which are already used by other protocols.

4 Do not use ports for OUC, which are already used by other Windows applications.

The following table shows the protocols that are supported in addition to those listed in the tables for the S7-1500 communications modules (e.g. CP 1543-1).

Table 3- 5 Layers and protocols of S7-1500 communications modules

Protocol	Port number	(2) Link layer (4) Transport layer	Function	Description
PROFINET/Industrial Ethernet protocols				
Connection-oriented communications protocols				
FTP File transfer protocol	20 (data) 21 (control)	(4) TCP	File transfer protocol	FTP is used for the transmission of files (only in connection with CP 1543-1).
secureFTP File transfer protocol	20 (data) 21 (control)	(4) TCP	File transfer protocol	SecureFTP is used for the transmission of files by means of a TSL connection (only in connection with CP 1543-1).
DHCP Dynamic Host Configuration Protocol	68	(4) UDP	Dynamic Host Configuration Protocol	DHCP is used to retrieve the IP Address Suite from a DHCP server when starting up the IE interface.
Secure NTPv3 Network time protocol	123	(4) UDP	Network time protocol	Secure NTP is used to synchronize the CP 1543-1 internal system clock with an NTP server.
SNMP Simple network management protocol	161 162 (trap)	(4) UDP	Simple network management protocol	SNMPv3 permits the CP 1543-1 to read network management data (MIBs) from SNMPv3 agent with authentication.

3.6 SNMP

3.6.1 Disabling SNMP

The network management protocol SNMP (Simple Network Management Protocol) is a protocol that uses various services and tools for detection and diagnostics of the network topology.

SNMP uses the transport protocol UDP. SNMP recognizes two network components, the SNMP manager and the SNMP client. The SNMP manager monitors the network nodes: The SNMP clients collect the various network-specific information in the individual network nodes and store it in a structured form in the MIB (Management Information Base). Various services and tools can run detailed network diagnostics with the help of these data.

Under certain conditions, it is useful to disable SNMP. Examples:

- The security guidelines in your network do not allow the use of SNMP.
- You use your own SNMP solution, e.g. with your own communications instructions.

If you disable SNMP for a device, various options for diagnostics of the network topology (e.g. using the PRONETA tool or the Web server of the CPU) are no longer available to you.

Disabling SNMP

To disable SNMP for the integrated interfaces of a S7-1500 CPU, follow these steps:

1. In STEP 7, create a data block that contains the structure of data record $B071_H$.
   – The following table shows the structure of the data record $B071_H$.

Byte	Element	Code	Explanation
0-1	BlockID	$F003_H$	Header
2-3	BlockLength	8	The data record length is counted starting at byte 4 "Version".
4	Version	01 $_H$	
5	Subversion	00 $_H$	
6-7	Reserved	-	-
8-11	SNMP controller	Disable/enable SNMP	If you want to disable SNMP, enter the value 0. If you want to enable SNMP, enter the value 1.

2. Transfer the data record $B071_H$ in the startup OB (OB100) with the WRREC instruction (write data record) to the CPU.
   Use the hardware ID of an integrated interface of the CPU here.

3.6.2 Example: Disabling SNMP for a CPU 1516-3 PN/DP

Task

As the security guidelines in your network do not allow SNMP, you want to disable SNMP for a CPU 1516-3 PN/DP.

Requirements

- CPU 1516-3 PN/DP with firmware version V2.0
- STEP 7 V14

Solution

First, create a data block that contains the structure of data record B071H. The figure below shows the data block "Deactivate SNMP". The data block "Deactivate SNMP" contains the data record B071H as well as additional tags that you use to transfer the data record. The tag "snmp_deactivate" is used to trigger the job for WRREC. Place this tag in the retentive memory area so that the value is also available in the startup OB (OB100).

Deactivate SNMP

	Name	Data type	Start value	R...	A...	W..	V...	Comment
1	Static							
2	snmp_deactivate	Bool	TRUE	☑	☑	☐	☑	Tag for deactivation
3	snmp_record	Struct		☑	☑	☐	☑	Data record 16#B071
4	BlockID	UInt	16#F003	☑	☑	☐	☑	
5	BlockLenght	UInt	8	☑	☑	☐	☑	
6	Version	USInt	1	☑	☑	☐	☑	
7	Subversion	USInt	0	☑	☑	☐	☑	
8	Reserved	UInt	0	☑	☑	☐	☑	
9	SNMPControl	UDInt	0	☑	☑	☐	☑	
10	snmp_done	Bool	false	☐	☑	☐	☑	
11	snmp_error	Bool	false	☐	☑	☐	☑	
12	snmp_status	DWord	16#0	☐	☑	☐	☑	

Figure 3-6 Example: Data block for disabling SNMP

Transfer the data record B071H in the startup OB (OB100) to CPU 1516-3 PN/DP with the WRREC instruction (write data record).

In the following program code, the data record B071H is transferred with the WRREC instruction in a REPEAT UNTIL loop.

```
ORGANIZATION_BLOCK "Startup"
TITLE = "Complete Restart"
{ S7_Optimized_Access := 'TRUE' }
VERSION : 0.1
BEGIN
 REPEAT
 "WRREC_DB_1"
 (REQ := "Deactivate SNMP".snmp_deactivate,
  //Transfer data record
 INDEX:=16#B071,
  //Data record number for SNMP deactivation
 ID:="Local~PROFINET_interface_1",
  //any integrated PROFINET Interface
 DONE => "Deactivate SNMP".snmp_done,
 ERROR => "Deactivate SNMP".snmp_error,
 STATUS => "Deactivate SNMP".snmp_status,
 RECORD := "Deactivate SNMP".snmp_record)
  //Data record
 UNTIL "Deactivate SNMP".snmp_done OR "Deactivate SNMP".snmp_error
 END_REPEAT;
END_ORGANIZATION_BLOCK
```

Using program code

You will find the full program code here.

Follow these steps to apply the program code to your project:

1. Copy the entire program code to the clipboard with Ctrl+A, Ctrl+C.
2. Open a text editor (e.g. "Editor").
3. Paste the content of the clipboard to the text editor with Ctrl+V.
4. Save the document as an scl file, e.g. SNMP_DEACT.scl.
5. Open your project in STEP 7.
6. Import the scl file as an external source.
   You will find further information on importing external sources in the STEP 7 online help.
7. Generate the startup OB and the data blocks. (right-click on the scl file, shortcut menu: "Generate blocks from source")

Re-enabling SNMP

With small changes, you can use the program code used above to enable SNMP.

In the user program, assign the "Deactivate SNMP".snmp_record.SNMPControl tag the value "1":

```
"Deactivate SNMP".snmp_record.SNMPControl := 1;
```

SNMP will then be enabled again the next time the CPU is started.

PG communication

4

Properties

Using PG communication, the CPU or another module capable of communication exchanges data with an engineering station (for example PG, PC). The data exchange is possible via PROFIBUS and PROFINET subnets. The gateway between S7 subnets is also supported.

PG communication provides functions needed to load programs and configuration data, run tests, and evaluate diagnostic information. These functions are integrated in the operating system of the module capable of communication.

A PG/PC can be connected to a CPU online. The PG/PC can operate a maximum of 4 online connections at one time (for example to 4 CPUs).

Requirements

- The PG/PC is physically connected to the communication-capable module.
- If the communication-capable module is to be reached via S7 routing, the hardware configuration has to be loaded in the participating stations (S7 router and end point).

Procedure for connecting online

You must establish an online connection to the CPU for the programming device communication:

1. Select the CPU in the project tree in STEP 7.
2. Select the "Online > Go online" menu command.

3. In the "Go online" dialog, make the following settings for your online connection:
   - Select interface type (e.g. PN/IE) in the "Type of PG/PC interface" drop-down list.
   - In the "PG/PC interface" drop-down list, select the PG/PC interface (e.g. Ind. Ethernet card) you want to use to establish the online connection.
   - Select the interface or the S7 subnet with which the PG/PC is physically connected from the "Connection to interface/subnet" drop-down list.
   - If the communication-capable module can be reached via an S7 router (gateway), select the S7 router that connects the subnets in question from the "1st Gateway" drop-down .

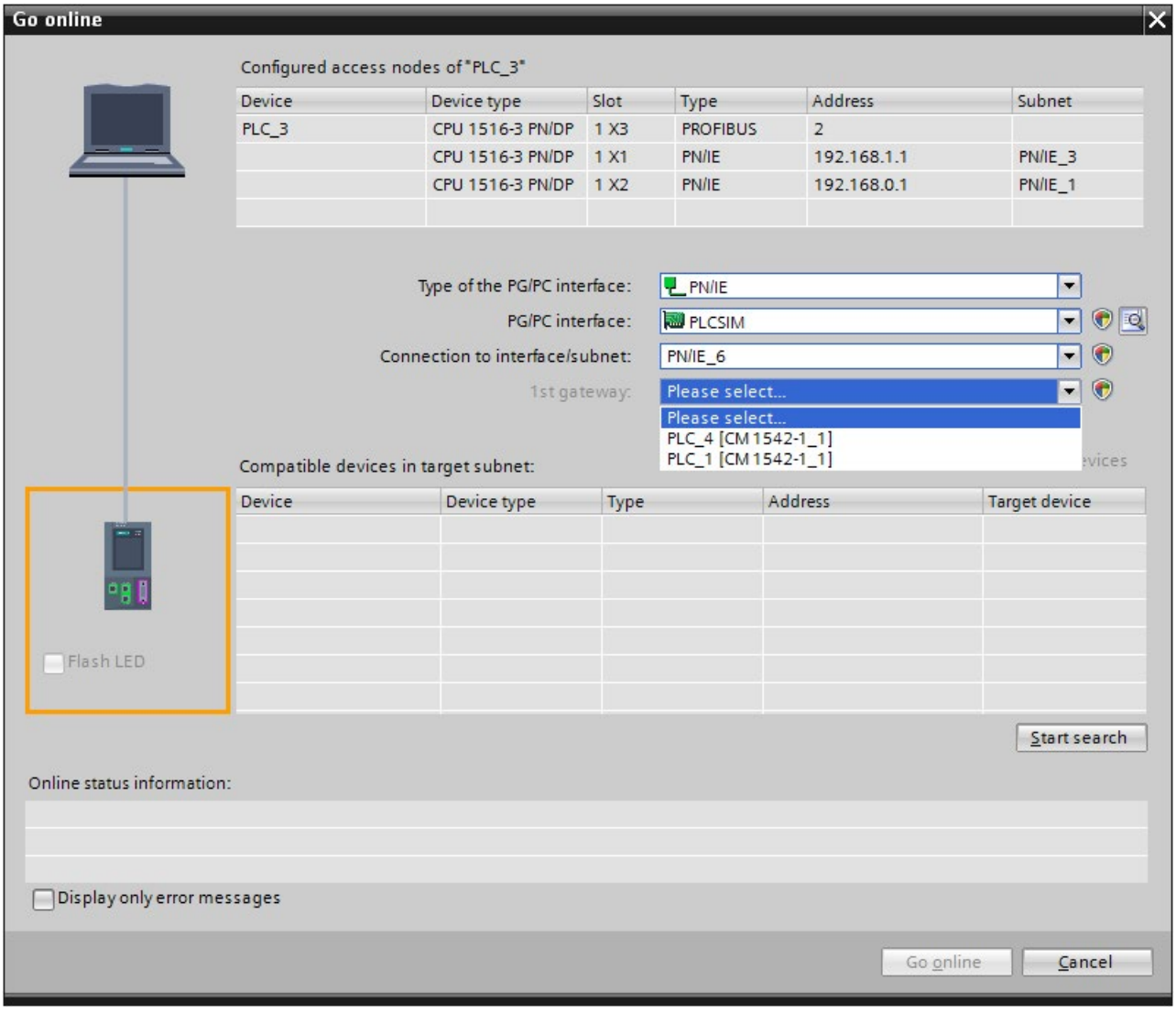


Figure 4-1 Setting up PG communication

4. In the "Compatible devices in target subnet" table, select the relevant CPU and confirm with "Go online".

Additional information

You can find more information on "Go online" in the STEP 7 online help.

HMI communication

5

Properties

Using HMI communication, one or more HMI devices (for example HMI Basic/Comfort/Mobile Panel) exchanges data with a CPU for operator control and monitoring with via the PROFINET or PROFIBUS DP interface. The data exchange is via HMI connections.

If you want to set up several HMI connections to a CPU, use for example:

- The PROFINET and PROFIBUS DP interfaces of the CPU
- CPs and CMs with the relevant interfaces

Procedure for setting up HMI communication

As soon as you drag-and-drop a tag, for example a tag from a global data block into an HMI screen or into the HMI tag table, STEP 7 automatically sets up an HMI connection. Alternatively, you can also set up the HMI connection yourself.

To set up an HMI connection, follow these steps.

1. Configure the HMI device in an existing configuration with a CPU in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and then "HMI connection" from the drop-down list.
3. Drag-and-drop a line between the end points of the connection (HMI device and CPU). The end points are highlighted in color. If the required S7 subnet does not yet exist, it is created automatically.

4. In the "Connections" tab, select the row of the HMI connection.

   In the "General" area of the "Properties" tab, you see the properties of the HMI connection, some of which you can change.

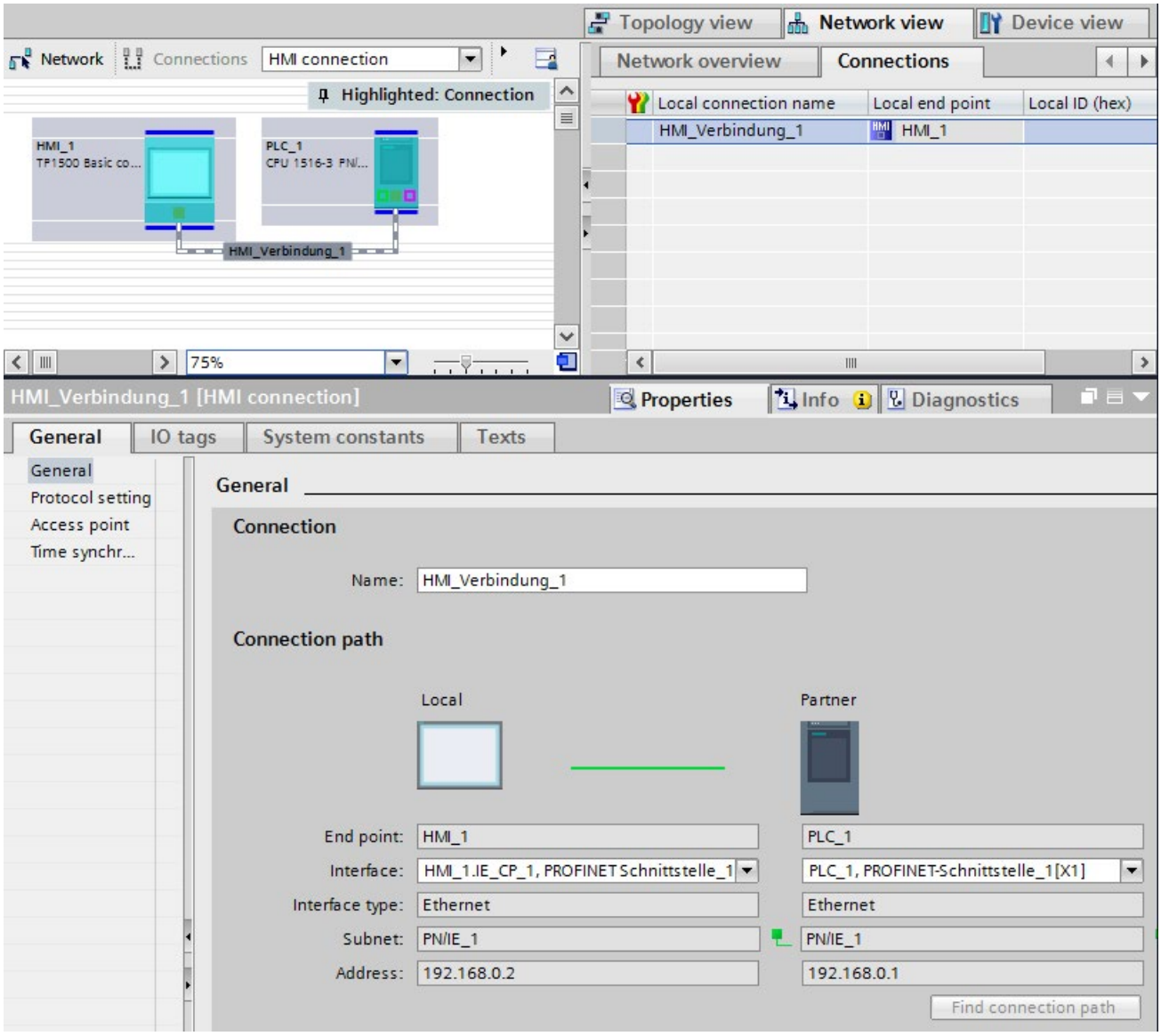


Figure 5-1 Setting up HMI communication

5. Download the hardware configuration to the CPU.
6. Download the hardware configuration to the HMI device.

Additional information

You can find information on S7 routing for HMI connections in the section S7 Routing (Page 175).

You can find more information on setting up HMI connections in the STEP 7 online help.

Open User Communication 6

6.1 Overview of Open User Communication

Features of Open User Communication

Through Open User Communication, also called "open communication", the CPU exchanges data with another device capable of communication. Open User Communication has the following features and characteristics:

- Open standard (communication partners can be two SIMATIC CPUs or a SIMATIC CPU and a suitable third-party device).
- Communication via various protocols (in STEP 7 known as "Connection types")
- High degree of flexibility in terms of the data structures transferred; this allows open data exchange with any communications devices as long as these support the connection types available.
- Open User Communication is possible in various automation systems, see technical specifications of the respective manuals.
  Examples:
  - Integrated PROFINET / Ind. Ethernet interfaces of CPUs (S7-1500, ET 200SP CPU, S7-1500 Software Controller, CPU 1516pro-2 PN)
  - PROFINET / Ind. Ethernet interfaces of communications modules (for example CP 1543-1, CM 1542-1)

Information about the Secure Open User Communication is available in the section Secure Open User Communication (Page 66).

6.2 Protocols for Open User Communication

Protocols for Open User Communication

The following protocols are available for open communication:

Table 6- 1 Transport protocols for open communication

Transport protocol	Via interface
TCP according to RFC 793	PROFINET/Industrial Ethernet
ISO-on-TCP according to RFC 1006 (Class 4)	PROFINET/Industrial Ethernet
ISO according to ISO/IEC 8073	Industrial Ethernet (only CP 1543-1)
UDP according to RFC 768	PROFINET/Industrial Ethernet
FDL	PROFIBUS

Table 6- 2 Application protocols for open communication

Application protocol	Used transport protocol
Modbus TCP	**TCP** according to RFC 793
E-mail	**TCP** according to RFC 793
FTP	**TCP** according to RFC 793

TCP, ISO-on-TCP, ISO, UDP

Prior to data transfer, these protocols (except UDP) establish a transport connection to the communications partner. Connection-oriented protocols are used when potential loss of data needs to be avoided.

The following is possible with UDP:

- Unicast to one device or broadcast to all devices on PROFINET via the PROFINET interface of the CPU or the Industrial Ethernet interface of the CP 1543-1
- Multicast to all recipients of a multicast group via the PROFINET interface of the CPU* or the PROFINET / Industrial Ethernet interface of the CP 1543-1

* As of firmware version V2.0, the PROFINET interface of the CPU supports a maximum of 5 multicast groups

Protocol for communication via PROFIBUS: FDL

Data transfer via an FDL connection (Fieldbus Data Link) is suitable for the transfer of related blocks of data to a communications partner on PROFIBUS that supports the sending and receiving of data according to the FDL service SDA (Send Data with Acknowledge) according to EN 50170, Vol 2. Both partners have the same rights; in other words, each partner can initiate sending and receiving event-driven.

In keeping with the FDL service SDN (Send Data with No Acknowledge) according to EN 50170, Vol 2, the following is possible with FDL:

- Broadcast to all devices on PROFIBUS via the PROFIBUS interface of the CM 1542-5
- Multicast to all recipients of a multicast group via the PROFIBUS interface of the CM 1542-5

Modbus TCP

The Modbus protocol is a communication protocol with linear topology based on a master/slave architecture. In the Modbus TCP (Transmission Control Protocol), the data is transmitted as TCP/IP packets.

Communication is controlled solely by suitable instructions in the user program.

E-mail and FTP

You can use email to send for example, data block contents (e.g. process data) as an attachment.

You can use the FTP connection (FTP = File Transfer Protocol) to transmit files to and from S7 devices.

The communication is controlled by instructions in the user program at the client end.

6.3 Instructions for Open User Communication

Introduction

You set up Open User Communication via the corresponding connection (for example, TCP connection) as follows:

- By programming in the user programs of the communications partners or
- By configuring the connection in STEP 7 in the hardware and network editor

Regardless of whether you set up the connection by programming or configuring, instructions are always required in the user programs of both communications partners for sending and receiving the data.

Setting up the connection via the user program

If the connection is set up by programming, the connection establishment and termination is implemented using instructions in the user program.

In certain areas of application it is an advantage not to set up the communications connections statically by configuring in the hardware configuration, but to have them set up by the user program. You can set up the connections via a specific application program-controlled and therefore when necessary. Programmed connection setup also allows connection resources to be released following data transfer.

A data structure is necessary for each communications connection that contains the parameters for establishing the connection (for example system data type "TCON_IP_v4" for TCP).

The system data types (SDT) are provided by the system and have a predefined structure that cannot be changed.

The various protocols have their own data structures (see table below). The parameters are stored in a data block ("connection description DB") for example of the system data type TCON_IP_v4.

There are two ways in which you can specify the DB with the data structure:

- Create the data block manually, assign parameters to it and write it directly to the instruction (necessary for e-mail and FTP)
- Recommendation: Have the data block created automatically in the properties in the program editor during configuration of the connection for the TSEND_C, TRCV_C and TCON instructions.

You can modify the connection parameters in the "connection description DB".

This FAQ (https://support.industry.siemens.com/cs/ww/en/view/58875807) describes how to program the TCON instruction to set up a connection for Open User Communication between two S7-1500 CPUs.

Protocols, system data types and employable instructions for programmed setup

Table 6- 3 Instructions for programmed setup of the connection

Protocol	System data type	Instructions for the user program
TCP	• TCON_QDN • TCON_IP_v4	Establish connection and send/receive data via: • TSEND_C/TRCV_C or • TCON, TSEND/TRCV or • TCON, TUSEND/TURCV (connection can be terminated via TDISCON)
ISO-on-TCP	• TCON_IP_RFC	
ISO according to ISO/IEC 8073 (Class 4)	• TCON_ISOnative[1] • TCON_Configured	
UDP	• TCON_IP_v4 • TADDR_Param • TADDR_SEND_QDN • TADDR_RCV_IP	Establish connection and send/receive data via: • TSEND_C/TRCV_C • TUSEND/TURCV/TRCV (connection can be terminated via TDISCON)
FDL[1]	• TCON_FDL	Establish connection and send/receive data via: • TSEND_C/TRCV_C or • TCON, TSEND/TRCV or • TCON, TUSEND/TURCV (connection can be terminated via TDISCON)
Modbus TCP	• TCON_IP_v4	• MB_CLIENT • MB_SERVER
E-mail	• TMAIL_v4 • TMAIL_v6 • TMAIL_FQDN	• TMAIL_C
FTP[2]	• FTP_CONNECT_IPV4[3] • FTP_CONNECT_IPV6[3] • FTP_CONNECT_NAME[3]	• FTP_CMD

1 This protocol can only be used with the CM 1542-5

2 This protocol can only be used with the CP 1543-1

3 User-defined data type

Setting up the connection with connection configuration

When setting up through the configuration of the connection, the address parameters of the connection are specified in the hardware and network editor of STEP 7.

To send and receive the data, use the same instructions as when the connections are set up by programming:

Table 6- 4 Instructions for sending/receiving with configured connections

Protocol	Send/receive with configured connections
Supported instructions:	
TCP	Send/receive data via: • TSEND_C/TRCV_C or • TSEND/TRCV or • TUSEND/TURCV
ISO-on-TCP	
ISO according to ISO/IEC 8073 (Class 4)	
UDP	Send/receive data via: • TSEND_C/TRCV_C or • TUSEND/TURCV
FDL	Send/receive data via: • TSEND_C/TRCV_C or • TSEND/TRCV or • TUSEND/TURCV
Modbus TCP	Not supported
E-mail	Not supported
FTP	Not supported

Additional instructions for open communication

You can use the following instructions for connections set up in the user program as well for as configured connections:

- T_RESET: Terminating and establishing a connection
- T_DIAG: Check the connection

Instructions and system data types for Secure Open User Communication

Information about the instructions and system data types for Secure Open User Communication is available in the section Secure Open User Communication (Page 66).

Additional information

The STEP 7 online help describes:

- The user and system data types
- The instructions for open communication
- The connection parameters

You will find information about the allocation and release of connection resources in the section Allocation of connection resources (Page 184).

6.4 Open User Communication with addressing via domain names

As of firmware version V2.0, S7-1500 CPUs, ET 200SP CPUs and the CPU 1516pro-2 PN support Open User Communication with addressing via Domain Name System (DNS). A DNS client is integrated in the CPU. In the case of communication via DNS, you use domain names as an alias for IP addresses to address communication partners. Addressing of the communication partners via domain names is possible for open communication via TCP and UDP.

At least one DNS server must be located in your network as a requirement for communication via DNS.

The S7-1500 software controller supports communication via DNS for all interfaces that are assigned to the software controller.

Setting up communication via DNS

The DNS client of the CPU must know the IPv4 address of at least one DNS server so that a CPU can establish a connection to a communication partner via its domain name. The CPU supports up to 4 different DNS servers.

To set up communication via domain names for an S7-1500 CPU, follow these steps:

1. Select the CPU in the network view of STEP 7.
2. In the Inspector window go to "Properties" > "General" > "DNS configuration".
3. Enter the IPv4 address of a DNS server in the "DNS server addresses" column of the "Server list" table.
   You can enter up to 4 IPv4 addresses of DNS servers.

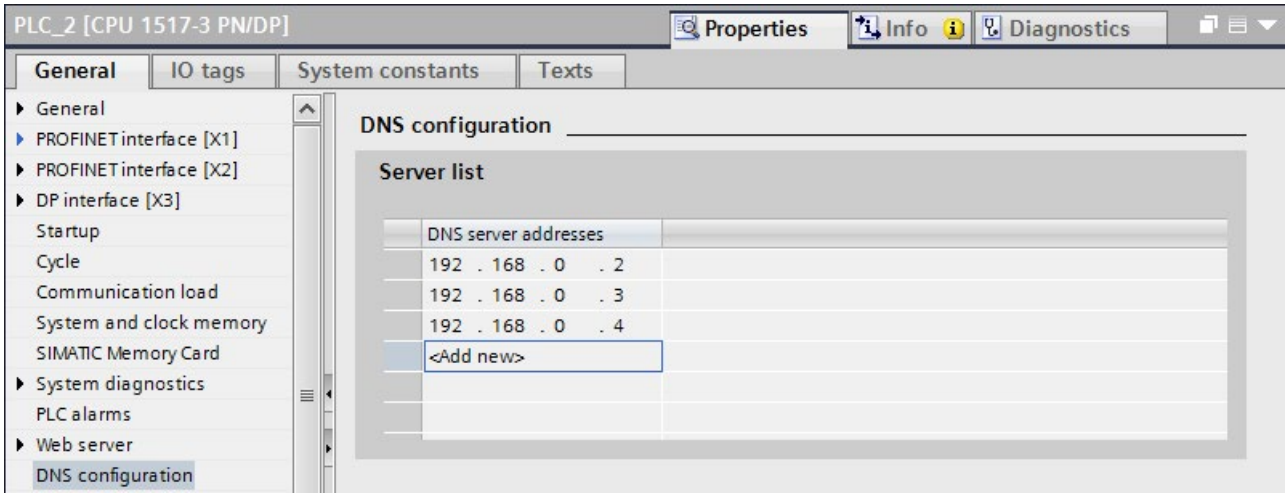


Figure 6-1 Entering DNS server addresses using a CPU 1516-3 PN/DP as an example

Setting up a TCP connection via the domain name of the communication partner

For TCP communication via the domain name you need to create a data block with the TCON_QDN system data type yourself, assign parameters and call it directly at the instruction. The TCON, TSEND_C and TRCV_C instructions support the system data type TCON_QDN:
To set up a TCP connection via the domain name of the communication partner, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_QDN in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "DNS Connection1" of data type TCON_QDN is defined.

Data_block_1

	Name	Datentyp	Startwert	Kommentar
1	Static			
2	DNS Connection1	TCON_QDN		
3	InterfaceId	HW_ANY	0	not relevant
4	ID	CONN_OUC	16#0	connection reference / identifier
5	ConnectionType	Byte	16#0B	type of connection: 16#0B=11=TCP/IP, 16#13=19=UDP
6	ActiveEstablished	Bool	false	active/passive connection establishment
7	RemoteQDN	String[254]	''	fully or partially qualified domain name of remote partner
8	RemotePort	UInt	0	remote UDP / TCP port number
9	LocalPort	UInt	0	local UDP / TCP port number

Figure 6-2 Data type TCON_QDN

3. Program the parameters of the TCP connection (for example the fully qualified domain name (FQDN)) in the tag of data type TCON_QDN.
4. Create a TCON instruction in the program editor.
5. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_QDN.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connection1" (data type TCON_QDN).

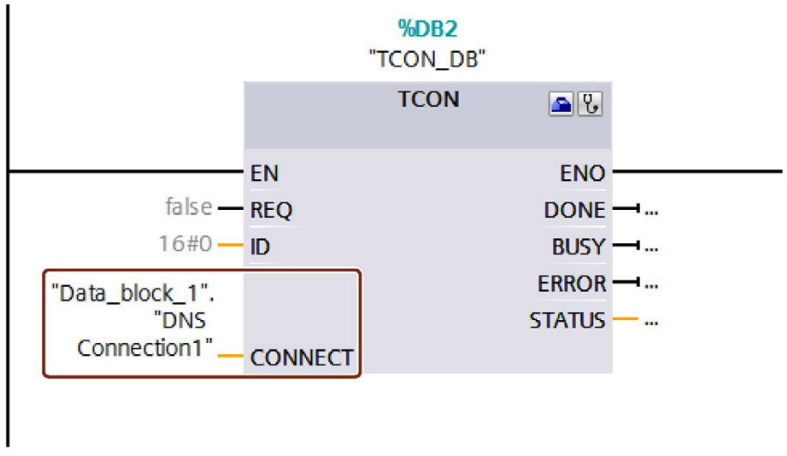


Figure 6-3 TCON instruction

Addressing a UDP connection via the domain name of the communication partner

For S7-1500 CPUs as of firmware version V2.0, you can address the recipient with its fully qualified domain name (FQDN) when sending data via UDP. With the instruction TUSEND at the parameter ADDR, you hereby reference a structure of the type TADDR_SEND_QDN.

The receiver can return an IPv4 or an IPv6 address. With the TURCV instruction at the ADDR parameter, you therefore reference a structure of the TADDR_RCV_IP type. Only this structure can include both IP address types.

Additional information

You can find more information about the system data types TCON_QDN, TADDR_SEND_QDN and TADDR_RCV_IP in the STEP 7 online help.

How to set up a secure TCP connection via the domain name of the communication partner is described in the section Secure Open User Communication (Page 66).

6.5 Setting up Open User Communication via TCP, ISO-on-TCP, UDP and ISO

Configuring a connection for the TSEND_C, TRCV_C or TCON instructions

Requirement: A TSEND_C, TRCV_C or TCON instruction is created in the programming editor.

1. Select a TCON, TSEND_C or TRCV_C block of Open User Communication in the program editor.
2. Open the "Properties > Configuration" tab in the inspector window.
3. Select the "Connection parameters" group. Until you select a connection partner, only the empty drop-down list for the partner end point is enabled. All other input options are disabled.

   The connection parameters already known are displayed:

   – Name of the local end point
   – Interface of the local end point
   – IPv4 address of the local end point

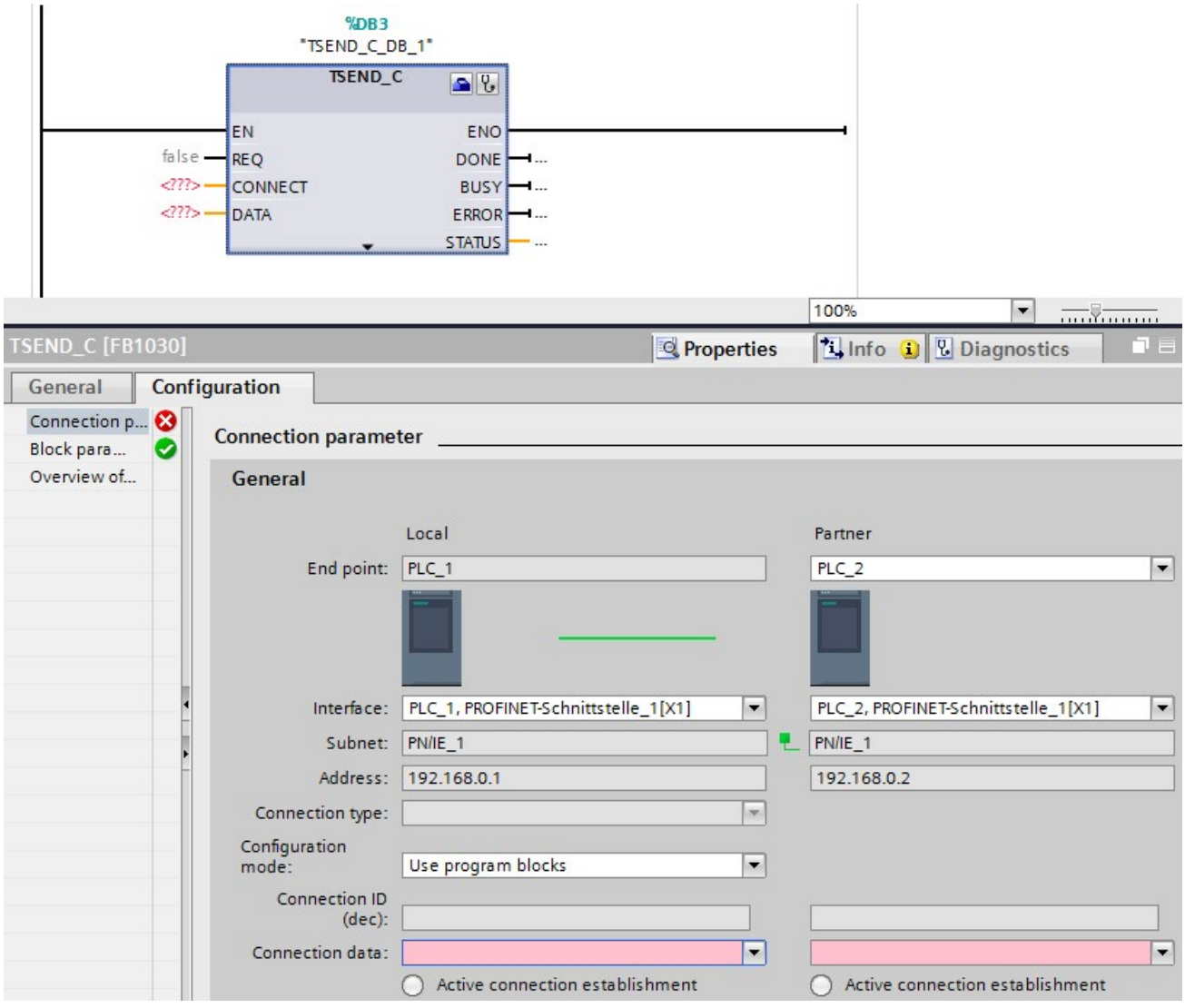


Figure 6-4 Connection parameters for TSEND_C

4. In the drop-down list box of the partner end point, select a connection partner. You can select an unspecified device or a CPU in the project as the communication partner. Certain connection parameters are then entered automatically.

   The following parameters are set:

   – Name of the partner end point
   – Interface of the partner end point
   – IPv4 address of the partner end point

   If the connection partners are networked, the name of the subnet is displayed.

5. In the "Configuration type" drop-down list, select between using program blocks or configured connections.

6. Select an existing connection description DB in the "Connection data" drop-down list or for configured connections select an existing connection under "Connection name". You can also create a new connection description DB or a new configured connection. Later, you can still select other connection description DBs or configured connections or change the names of the connection description DBs in order to create new data blocks:
   - You can also see the selected data block at the interconnection of the CONNECT input parameter of the selected TCON, TSEND_C or TRCV_C instruction.
   - If you have already specified a connection description DB for the connection partner using the CONNECT parameter of the TCON, TSEND_C or TRCV_C instruction, you can either use this DB or create a new DB.
   - If you edit the name of the displayed data block in the drop-down list, a new data block with the changed name but with the same structure and content is generated and used for the connection.
   - Changed names of a data block must be unique in the context of the communication partner.
   - A connection description DB must have the structure TCON_Param, TCON_IP_v4 or TCON_IP_RFC, depending on CPU type and connection.
   - A data block cannot be selected for an unspecified partner.

   Additional values are determined and entered after the selection or creation of the connection description DB or configured connection.

   The following is valid for specified connection partners:
   - ISO-on-TCP connection type
   - Connection ID with default of 1
   - Active connection establishment by local partner
   - TSAP ID
     for S7-1200/1500: E0.01.49.53.4F.6F.6E.54.43.50.2D.31

   The following is valid for unspecified connection partners:
   - TCP connection type
   - Partner port 2000

   The following applies for a configured connection with a specified connection partner:
   - TCP connection type
   - Connection ID with default of 257
   - Active connection establishment by local partner
   - Partner port 2000

   The following applies for a configured connection with an unspecified connection partner:
   - TCP connection type
   - Local port 2000

7. Enter a connection ID as needed for the connection partner. No connection ID can be assigned to an unspecified partner.

   Note

   You must enter a unique value for the connection ID at a known connection partner. The uniqueness of the connection ID is not be checked by the connection parameter settings and there is no default value entered for the connection ID when you create a new connection.

8. Select the desired connection type in the relevant drop-down list. Default values are set for the address details depending on the connection type. You can choose between the following:
   - TCP
   - ISO-on-TCP
   - UDP
   - ISO (only with Configuration mode "Use configured connection")

   You can edit the input boxes in the address details. Depending on the selected protocol, you can edit the ports (for TCP and UDP) or the TSAPs (for ISO-on-TCP and ISO).
9. Use the "Active connection establishment" check box to set the connection establishment characteristics for TCP, ISO and ISO-on-TCP. You can decide which communication partner establishes the connection actively.

Changed values are checked immediately for input errors by the connection configuration and entered in the data block for the connection description.

Note

Open User Communication between two communication partners can only work when the program section for the partner end point has been downloaded to the hardware. To achieve fully functional communication, make sure that you load not only the connection description of the local CPU on the device but also that of the partner CPU as well.

Configuring connections, e.g. for TSEND/TRCV

If you want to use the instructions for TSEND/TRCV for open communication, for example, you first need to configure a connection (e.g. TCP connection).

To configure a TCP connection, follow these steps:

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Click the "Connections" button and select the "TCP connection" connection type from the drop-down list.
3. Using drag-and-drop, connect the communication partner with each other (via an interface or local end point). If the required S7 subnet does not yet exist, it is created automatically.

   You can also set up a connection to unspecified partners.
4. Select the created connection in the network view.
5. Set the properties of the connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

   For connections to an unspecified partner, set the address of the partner.
   You can find the local ID (reference of the connection in the user program) in the "Local ID" area.
6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.
7. Select the required instruction from the "Instructions" task card, "Communication" area, "Open user communication", for example TSEND and drag it to a network of OB1.
8. At the ID parameter of the instruction, assign the local ID of the configured connection to be used for the transmission of data.
9. Interconnect the "DATA" parameter of the TSEND instruction with the user data, for example in a data block.
10. Download the hardware configuration and user program to the CPU.

Based on the procedure described above, set up the connection on the partner CPU with the instruction for receiving, TRCV, and download it to the CPU.

Point to note with ISO connections with CP 1543-1

If you use the "ISO connection" connection type, you will need to select the "Use ISO protocol" check box in the properties of the CP so that addressing using MAC addresses will work.

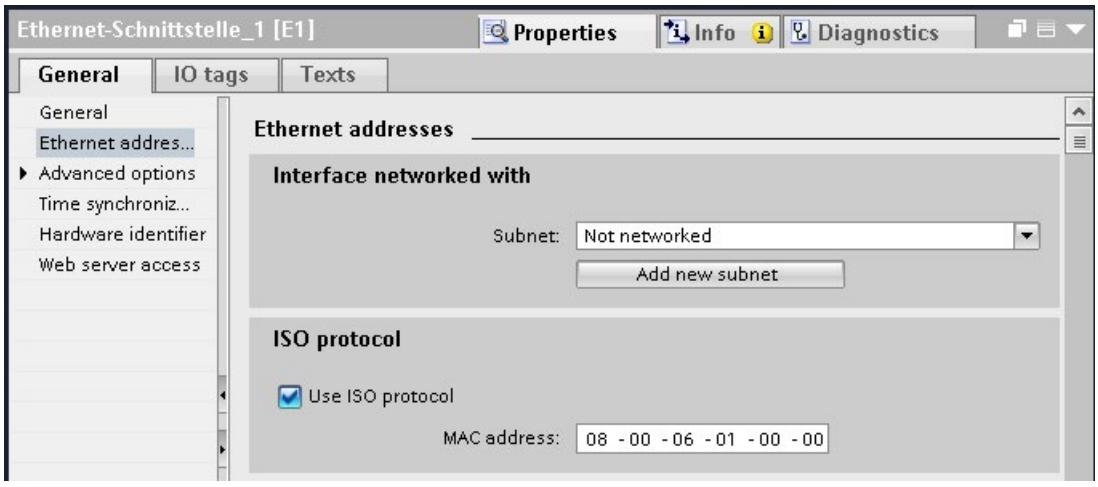


Figure 6-5 Select CP 1543-1 ISO protocol

Additional information

The STEP 7 online help describes:

- The instructions for open communication
- The connection parameters

This FAQ (https://support.industry.siemens.com/cs/ww/en/view/109479564) describes how the instructions TSEND_C and TRCV_C behave in the S7-1500.

6.6 Setting up communication over FDL

Requirements

- Configuration software: STEP 7 Professional V14
- End point of the connection: CPU S7-1500 firmware version V2.0 or higher with communication module CM 1542-5 with firmware version V2.0

Setting up a configured FDL connection

Proceed as follows to set up a configured FDL connection in STEP 7:

1. Create a TSEND_C instruction in the program editor.
2. Select the TSEND_C instruction and go to "Properties" > "General" > "Connection parameters" in the Inspector window.
3. Under End point, select the partner end point. Use one of the two partner end points below:
   - CPU S7-1500 with CM 1542-5
   - Unspecified
4. Under Configuration type, select "Use configured connection".
5. Under Connection type, select "FDL".
6. Under Interface, select the following interfaces:
   - Local: PROFIBUS interface of CM 1542-5
   - Specified partner: PROFIBUS interface of CM 1542-5
7. Under Connection data, select the setting <new>.

The figure below shows a fully configured FDL connection in STEP 7.

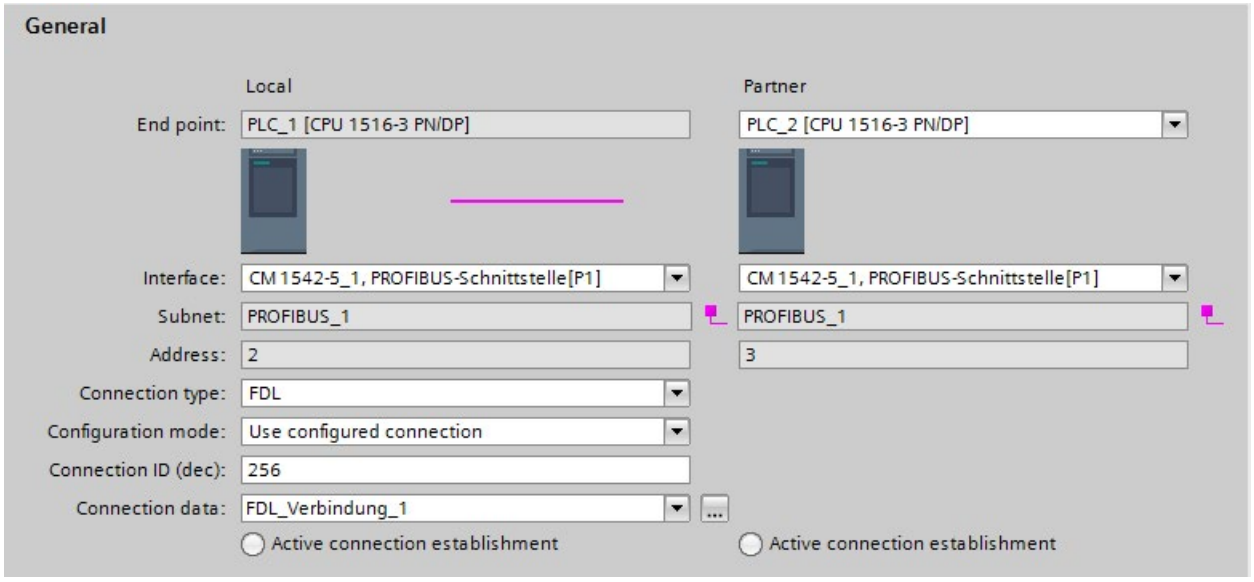


Figure 6-6 Configuring the FDL connection

Setting up an FDL connection in the user program

For communication via FDL, you need to create the data block of the TCON_FDL system data type yourself in each case, assign parameters and call it directly at the instruction. Follow these steps:

1. Create a global data block in the project tree.
2. In the global data block, define a tag of the data type TCON_FDL.

   The example below shows the global data block "FDL_connection" in which the tag "FDL_connection" of the data type TCON_FDL is defined.

FDL_connection

	Name	Data type	Start val..	R...	A...	...	V...	S...	Super...	Comment
1	Static									
2	FDL_connection	TCON_FDL								
3	InterfaceId	HW_ANY	0							HW identifier of PB interface submodule
4	ID	CONN_OUC	16#0							connection reference / identifier
5	ConnectionType	Byte	16#15							type of connection: 21= FDL connection
6	ActiveEstablished	Bool	false							active/passive connection establishment
7	ServiceId	Byte	16#0							service id: 0 – default, 1 – SDA, 2 – SDN
8	RemotePBAddress	Byte	16#0							remote ProfiBus partner address
9	LocalPBAddress	Byte	16#0							local ProfiBus partner address
10	RemoteLSAP	Byte	16#0							remote PB link-layer service access point
11	LocalLSAP	Byte	16#0							local PB link-layer service access point

Figure 6-7 Programming an FDL connection

3. Program the parameters of the FDL connection (e.g. the PROFIBUS addresses) in the tag of the data type TCON_FDL.

4. Create a TCON instruction in the program editor.
5. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_FDL.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "FDL_Connection" (data type TCON_FDL).

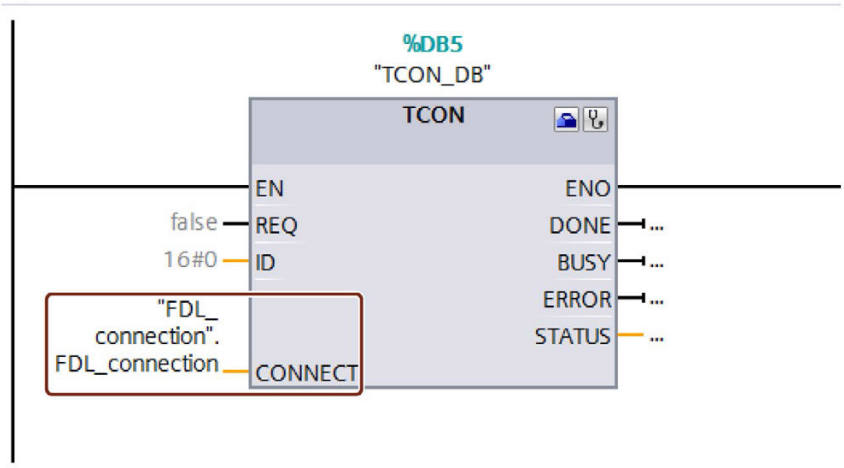


Figure 6-8 Example: TCON Instruction for FDL connection

6.7 Setting up communication with Modbus TCP

Setting up a connection for Modbus TCP via the user program

The parameter assignment takes place in the program editor at the instruction MB_CLIENT or MB_SERVER.

Procedure for setting up communication using Modbus TCP

The MB_CLIENT instruction communicates as a Modbus TCP client via the TCP connection. You establish a connection between the client and the server with the instruction, send Modbus requests to the server and receive the corresponding Modbus responses. You also control the setup of the TCP connection with this instruction.

The MB_SERVER instruction communicates as a Modbus TCP server via the TCP connection. The instruction processes connection requests of a Modbus client, receives and processes Modbus requests and sends responses. You also control the setup of the TCP connection.

Requirement: The client can reach the server via IP communication in the network.

1. Configure an S7-1500 automation system with CPU in the network view of the Devices & networks editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.

3. Select the required instruction, for example MB_CLIENT, from the "Instructions" task card, "Communication" area, "Other", "MODBUS TCP" and drag it to a network of OB1.
4. Assign the parameters of the MB_CLIENT or MB_SERVER instruction. Observe the following rules:

   An IPv4 server address must be specified for each MB_CLIENT connection.

   Each MB_CLIENT or MB_SERVER connection must use a unique instance DB with the data structure TCON_IP_v4.

   Each connection requires a unique connection ID. The connection ID and instance DB belong together in pairs and must be unique for each connection.

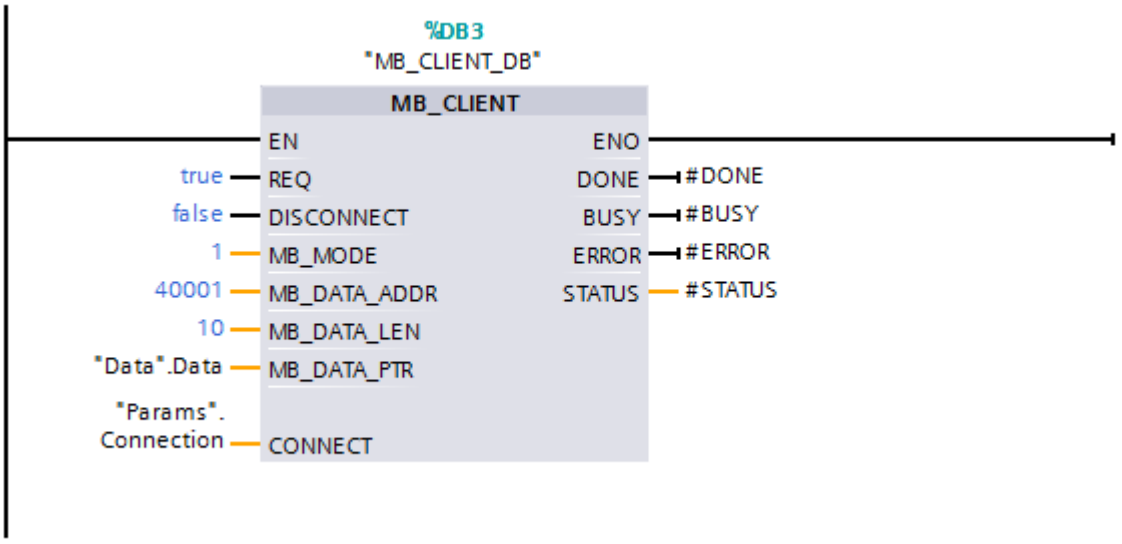


Figure 6-9 MB_CLIENT

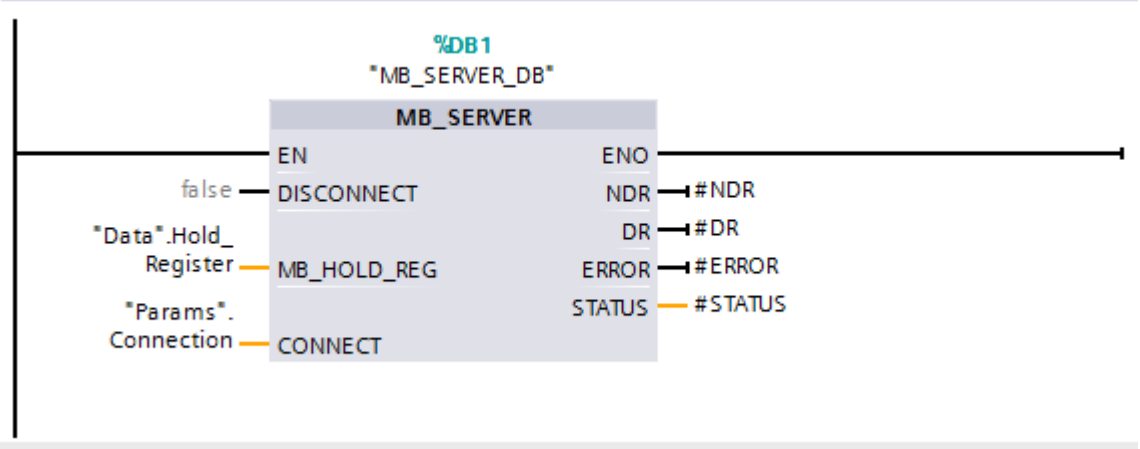


Figure 6-10 MB_SERVER

5. Download the hardware configuration and user program to the CPU.

Modbus TCP server as gateway to Modbus RTU

If you use a Modbus TCP server as a gateway to a Modbus RTU protocol, address the slave device in the serial network using the static parameter, MB_UNIT_ID. The MB_UNIT_ID parameter corresponds to the field of the slave address in the Modbus RTU protocol. The MB_UNIT_ID parameter in this case would forward the request to the correct Modbus RTU slave address.

You do not have to program the gateway function yourself.

You can find the MB_UNIT_ID parameter in the instance data block associated with MB_CLIENT instruction.

You can find more information on the MB_UNIT_ID parameter in the STEP 7 online help.

Modbus TCP communication between two S7-1500 CPUs

This FAQ (https://support.industry.siemens.com/cs/ww/en/view/94766380) describes how to program and parameterize the Modbus TCP communication between two S7-1500 CPUs.

6.8 Setting up communication via e-mail

Setting up a connection for e-mail via the user program

For communication using e-mail, you need to create the data block of the relevant system data type yourself, assign parameters and call the instruction directly. This procedure is introduced below.

Procedure for setting up communication using e-mail

A CPU can send e-mails. To send e-mails from the user program of the CPU, use the TMAIL_C instruction.

Requirement: The SMTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU in the network view of the Devices & networks editor of STEP 7.
2. Set the address parameters for the SMTP server in the TMAIL_C instruction. (Recommendation: Assign a name for the appendix.)
3. Create a global DB and within this global DB a tag of the type TMAIL_v4, TMAIL_v6 (only CP 1543-1) or TMAIL_FQDN (only CP 1543-1).
4. Interconnect the variable to the MAIL_ADDR_PARAM parameter of the TMAIL_C instruction.
5. Download the hardware configuration and user program to the CPU.

Additional information

The STEP 7 online help describes:

- The system data types
- The instructions for open communication
- The connection parameters

6.9 Setting up communication via FTP

Setting up a connection for FTP via the user program

For communication via FTP, you need to create the data block of the relevant system data type yourself, assign parameters and call the instruction directly. This procedure is introduced below.

FTP client and server functionality

Files can be sent by a CPU to an FTP server and can be received from the FTP server. Communication with FTP is only possible for the S7-1500 using the CP 1543-1. The CP can be an FTP server, FTP client or both. FTP clients can also be third-party systems/PCs.

For the FTP server functionality, configure the CP accordingly in STEP 7.

You can use the FTP client functionality to implement, for example, the establishment and termination of an FTP connection, the transfer and deletion of files on the server. For the FTP client functionality, use the FTP_CMD instruction.

Procedure for setting up FTP server functionality

Requirement: The FTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.

   At the same time, you need to select the check box "Permit access with PUT/GET communication from remote partner (PLC, HMI, OPC, ...)" in the HW configuration of the S7-1500 CPU under the "Protection" area navigation in the section "Connection mechanisms".

2. Make the following settings in the properties of the CP under "FTP configuration":
   - Select the "Use FTP server for S7 CPU data" check box.
   - Assign the CPU, a data block and a file name under which the DB for FTP will be stored.

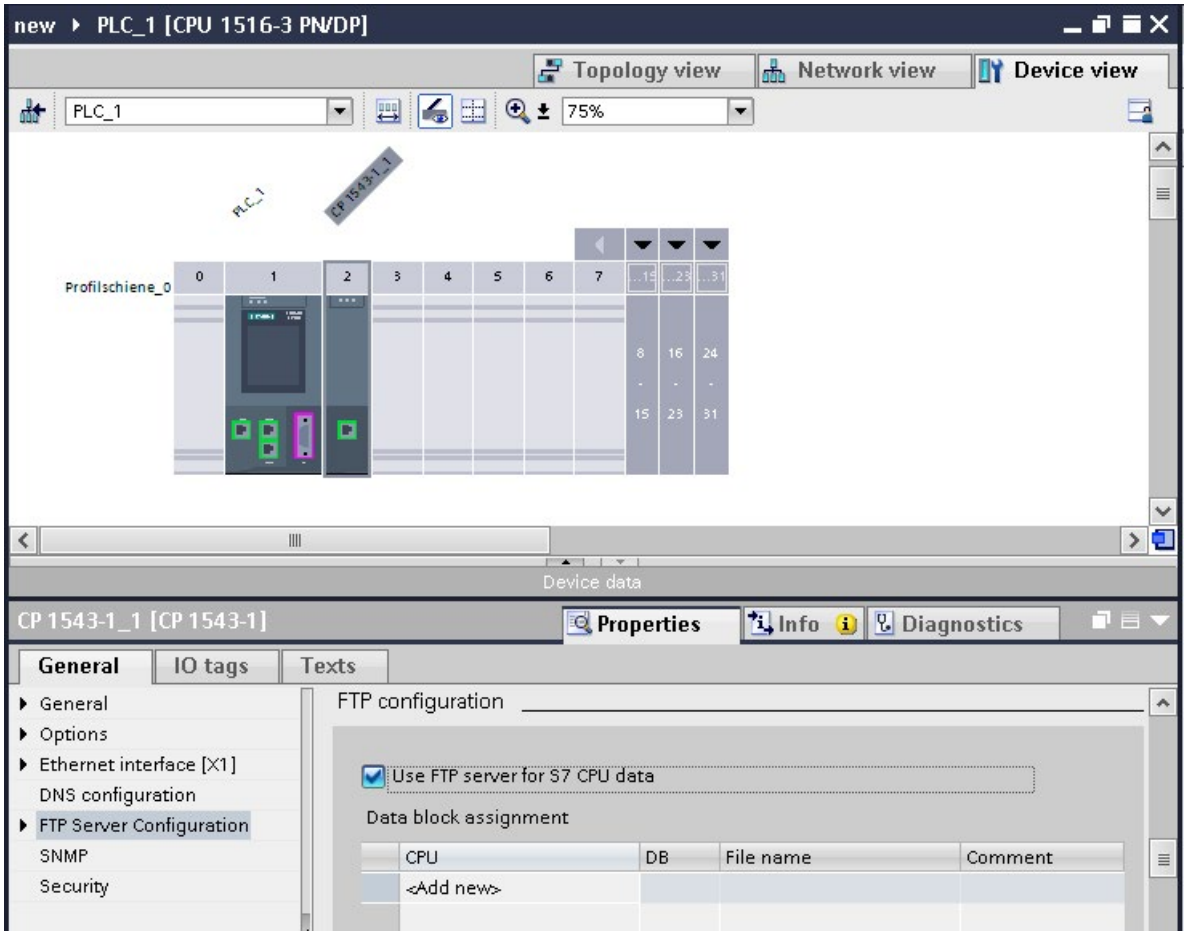


Figure 6-11 Setting up the FTP configuration

3. Download the hardware configuration to the CPU.

Procedure for setting up FTP client functionality

Requirement: The FTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.

   At the same time, you need to select the check box "Permit access with PUT/GET communication from remote partner (PLC, HMI, OPC, ...)" in the HW configuration of the S7-1500 CPU under the "Protection" area navigation in the section "Connection mechanisms".
2. Call the FTP_CMD instruction in the user program of the CPU.
3. Set the connection parameters for the FTP server in the FTP_CMD instruction.
4. Create a global DB and within this DB a tag of the type FTP_CONNECT_IPV4, FTP_CONNECT_IPV6 or FTP_CONNECT_NAME.
5. Interconnect the tag within the data block with the FTP_CMD instruction.
6. For the connection to the FTP server, specify the following in the DB:
   - The user name, the password and the IP address for the FTP access in the relevant data type (FTP_CONNECT_IPV4, FTP_CONNECT_IPV6 or FTP_CONNECT_NAME)
7. Download the hardware configuration and user program to the CPU.

Application examples

- Application example: FTP communication with S7-1500 and CP 1543-1
  You can find the application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/103550797).
- Application example: Evaluate FTP client communication with S7-1200/1500
  You can find the application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/81367009).

Additional information

The STEP 7 online help describes:

- The system data types
- The instructions for open communication
- The connection parameters

6.10 Establishment and termination of communications relations

Establishment and termination of communications

The table below shows the establishment and termination of communications as part of open communication.

Table 6- 5 Establishment and termination of communications

Setting up the connection	Establishing communication	Terminating communication
With the user program	After downloading the user program to the CPUs: The passive communications partner sets up the local connection access by calling TSEND_C/TRCV_C or TCON. Calling TSEND_C/TRCV_C or TCON on the active partner starts connection establishment. If the connection could be established, there is positive feedback to the instructions in the user program. After you have terminated a connection using the instruction T_RESET, the connection is reestablished. If the connection aborts, the active partner attempts to re-establish the connection. This applies only if the connection was successfully established beforehand with TCON.	• Using the TSEND_C/TRCV_C, TDISCON and T_RESET instructions • When the CPU changes from RUN to STOP mode • With POWER OFF/POWER ON on a CPU
By configuring a connection	After downloading the connection configuration and the user program to the CPUs.	By deleting the connection configuration in STEP 7 and downloading the changed configuration to the CPU.

6.11 Secure Open User Communication

6.11.1 Basics

6.11.1.1 Basics of Secure Communication

For STEP 7 (TIA Portal) as of V14 and for S7-1500 CPUs as of firmware V2.0, the options for secure communication have been broadened considerably.

"S7-1500 CPUs" also refers to the CPU variants S7-1500F, S7-1500T, S7-1500C as well as S7-1500pro CPUs, ET200SP CPUs as well as the SIMATIC S7-1500 SW controller.

Introduction

The attribute "secure" is used for the identification of communication mechanisms that are based on a Public Key Infrastructure (PKI) (for example RFC 5280 for Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List Profile). A Public Key Infrastructure (PKI) is a system that can issue, distribute and check digital certificates. The digital certificates issued are used in the PKI to secure computer-based communication. If a PKI uses asymmetric key cryptography, the messages in a network can be digitally signed and encrypted.

Components that you have configured in STEP 7 (TIA Portal) for secure communication use an asymmetric key encryption scheme with a public key (Public Key) and a private key (Private Key). TLS (Transport Layer Security) is used as the encryption protocol. TLS is the successor for the SSL (Secure Sockets Layer) protocol.

Objectives of secure communication

Secure communication is used to achieve the following objectives:

- Confidentiality
  i.e. the data are secret / cannot by read by eavesdroppers.
- Integrity
  i.e. the message that reaches the recipient is the same message, unchanged, that the sender sent. The message has not been altered on the way.
- End point authentication
  i.e. the end point communication partner is exactly who it claims to be and the party who is to be reached. The identity of the partner has been checked.

These objectives were in the past primarily relevant to IT and networked computers. Now, industrial machinery and control systems with sensitive data are at equally high risk, as they are also networked, and consequently pose strict security requirements for data exchange.

Protection of the automation cell by means of the cell protection concept through firewall, or via connection through VPN, for example with the security module, was common in the past and remains so.

However, it is becoming increasingly necessary to also transfer data to external computers in encrypted form via Intranet or public networks.

Common principles of secure communication

Independent of the context, secure communication is based on the concept of the Public Key Infrastructure (PKI) and contains the following components:

- An asymmetric encryption scheme that allows:
  - Encryption or decryption of messages using public or private keys.
  - The verification of signatures in messages and certificates.

    The messages/certificates are signed by the sender/certificate subject with their private key. The recipient/verifier checks the signature with the public key of the sender/certificate subject.
- Transport and storage of the public key using X.509 certificates:
  - X.509 certificates are digitally signed data that allow public key authentication in terms of the bound identity.
  - X.509 certificates can contain information that describes in more detail or restricts use of the public key. For example the date as of which a public key in a certificate is valid and when it expires.
  - X.509 certificates contain information about the issuer of the certificate in secure form.

The following paragraphs give an overview of these basic concepts, which are required for managing certificates in STEP 7 (TIA Portal), for example, and for programming communication instructions for secure Open User Communication (sOUC).

Secure communication with STEP 7

STEP 7 as of V14 provides the required PKI for the configuration and operation of secure communication.

Examples:

- The Hypertext Transfer Protokoll (HTTP) turns into Hypertext Transfer Protokoll Secure (HTTPS) with the help of the TLS (Transport Layer Security) protocol. Since HTTPS is a combination of HTTP and TLS, it is called "HTTP over TLS" in the corresponding RFC. You can see in the browser that HTTPS is being used; this is indicated by the URL "https://" instead of "http://" in the address bar of the browser. Most browsers highlight such secure connections.
- Open User Communication turns into secure Open User Communication. The underlying protocol is also TLS.
- E-mail providers also offer access over the "Secure SMTP over TLS" protocol to increase the security of e-mail communication.

The figure below shows the TLS protocol in the context of communication layers.

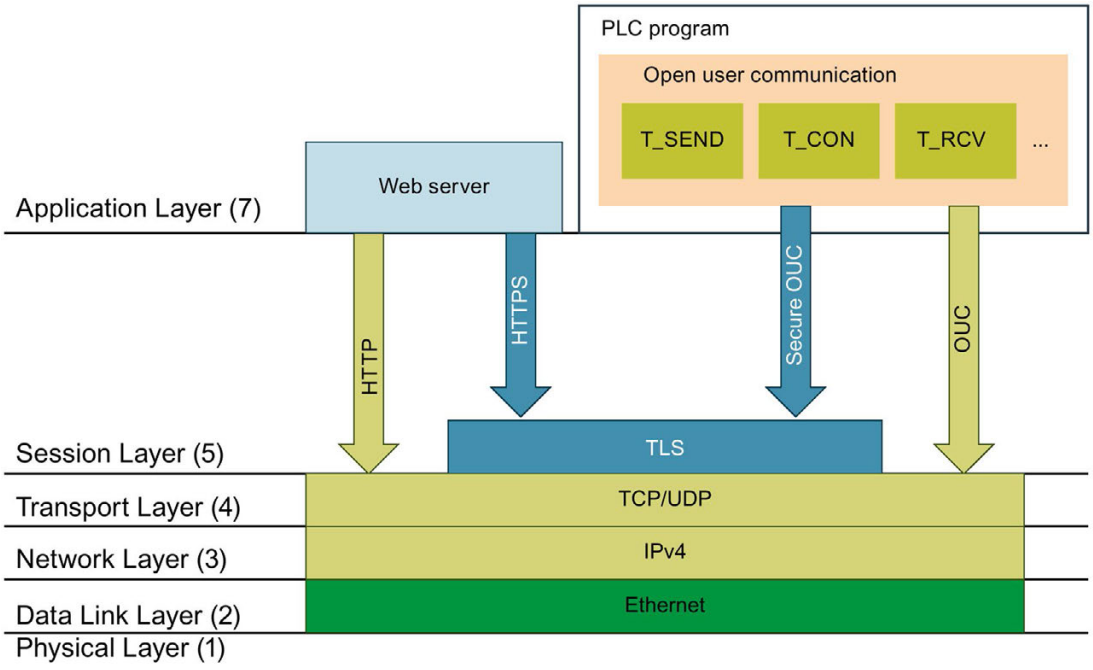


Figure 6-12 TLS protocol in the context of communication layers

Secure communication with OPC UA

An OPC UA server is implemented in S7-1500 CPUs as of firmware V2.0. OPC UA Security also covers authentication, encryption and data integrity with digital X.509 certificates and also uses a Public Key Infrastructure (PKI). Depending on the requirements placed by the application, you can select different security levels for the end point security. You will find the description of the OPC UA server functionality in the section OPC UA server (Page 119).

6.11.1.2 Confidentiality through encryption

Message encryption is an important element of data security. When encrypted messages are intercepted by third parties during communication, these potential eavesdroppers cannot access the information they contain.

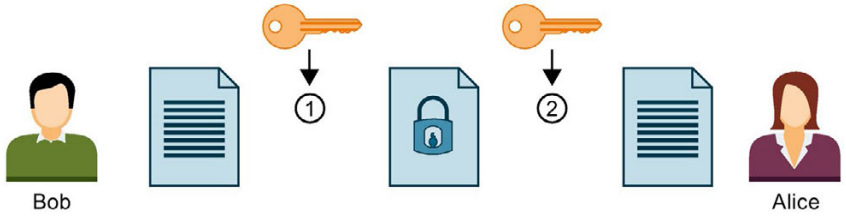
There is a wide range of mathematical processes (algorithms) for encrypting messages.

All algorithms process a "key" parameter to encrypt and decrypt messages.

- Algorithm + key + message => encrypted message
- Encrypted message + key + algorithm => (decrypted) message

Symmetric encryption

The central aspect of symmetric encryption is that both communication partners use the same key for message encryption and decryption, as shown in the figure below. Bob uses the same key for encryption as Alice uses for decryption. In general, we also say that the two sides share the secret key with which they encrypt or decrypt a message as a secret.



① Bob encrypts his message with the symmetric key
② Alice decrypts the encrypted message with the symmetric key

Figure 6-13 Symmetric encryption

The process can be compared to a briefcase to which the sender and recipient have the same key, which both locks and opens the case.

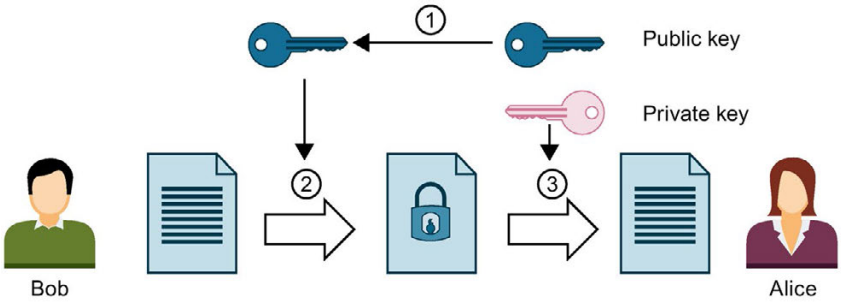
- Advantage: Symmetric encryption algorithms (such as AES, Advanced Encryption Algorithm) are fast.
- Disadvantages: How can the key be sent to a recipient without getting into the wrong hands? This is a key distribution problem. If enough messages are intercepted, the key can also be worked out and must therefore be changed regularly.

If there are a large number of communication partners, there is also a large number of keys to distribute.

Asymmetric encryption

Asymmetric encryption works with a pair of keys consisting of one public key and one private key. Used with a PKI, it is also known as Public Key cryptography or simply PKI cryptography. A communication partner, Alice in the figure below, has a private key and a public key. The public key is provided to the public, in other words any potential communication partner. Anyone with the public key can encrypt messages for Alice. In the figure below, this is Bob.

Alice's private key, which she must not disclose, is used by Alice to decrypt an encrypted message addressed to her.



① Alice provides Bob with her public key. No precautionary measures are required to this purpose: Anyone can use the public key for messages to Alice if they are sure that it is actually Alice's public key.

② Bob encrypts his message with Alice's public key.

③ Alice decrypts the encrypted message from Bob with her private key. As only Alice has the private key and never discloses it, only she can decrypt the message. With her private key, she can decrypt any message encrypted with her public key - not only messages from Bob.

Figure 6-14 Asymmetric encryption

The system can be compared to a mailbox into which anyone can put a message, but from which only the person with the key can remove messages.

- Advantages: A message encrypted with a public key can only be decrypted by the owner of the private key. As another (private) key is required for decryption, it is also much harder to work out the decryption key on the basis of large numbers of encrypted messages. This means that the public key does not have to be kept strictly confidential, unlike with symmetric keys.

  Another advantage is easier distribution of public keys. No specially secured channel is required in asymmetric cryptography to transfer the public key from the recipient to the sender encrypting the messages. Less work is thus required in managing the keys than would be the case in symmetric encryption procedures.

- Disadvantages: Complex algorithm (e.g. RSA, named after the three mathematicians Rivest, Shamir and Adleman), and therefore poorer performance than with symmetric encryption.

Encryption processes in practice

In practice, for example with a CPU Web server and Secure Open User Communication, the TLS protocol is used below the relevant application layer. Application layers are HTTP or SMTP, for example, as detailed above.

TLS (Transport Layer Security) uses a combination of asymmetric encryption and symmetric encryption (hybrid encryption) for secure data transfer, for example, over the Internet, and uses the following subprotocols:

- TLS Handshake Protocol, responsible for authentication of communication partners and negotiation of the algorithms and keys to be used for subsequent data transfer on the basis of asymmetric encryption.
- TLS Record Protocol, responsible for encryption of user data with symmetric encryption and data exchange.

Both asymmetric and symmetric encryption are considered secure encryption schemes - there is basically no difference in security between the two procedures. The degree of security depends on parameters such as the selected key length.

Abuse of encryption

You cannot tell what identity is assigned to a public key from the bit string. A fraud could provide their public key and claim to be someone else. If a third party then uses this key thinking that they are addressing their required communication partner, confidential information could end up with the fraud. The fraud then uses their private key to decrypt the message that was not intended for them, and sensitive information falls into the wrong hands.

To prevent this type of abuse, the communication partners must be confident that they are dealing with the right communication partner. This trust is established by using digital certificates in a PKI.

6.11.1.3 Authenticity and integrity through signatures

Attacks from programs that intercept communication between the server and client and act as if they themselves were client or server, are called man-in-the-middle attacks. If the false identity of these programs is not detected, they can obtain important information about the S7 program, for example, or set values in the CPU and attack a machine or plants. Digital certificates are used to avoid such attacks.

Secure communication uses digital certificates that meet the X.509 standard of the International Telecommunication Union (ITU). This allows the identity of a program, a computer or an organization to be checked (authenticated).

How certificates establish trust

The main role of X.509 certificates is to bind an identity with the data of a certificate subject (for example, e-mail address or computer name) to the public key of the identity. Identities can be people, computers or machines.

Certificates are issued by certificate authorities (Certificate Authority, CA) or by the subject of a certificate itself. PKI systems specify how users can trust the certificate authorities and the certificates that they issue.

The certificate process:

1. Anyone wishing to own a certificate submits a certificate application to a registration authority linked to the certificate authority.
2. The certificate authority assesses the application and applicant on the basis of set criteria.
3. If the identity of the applicant can be clearly established, the certificate authority confirms that identity by issuing a signed certificate. The applicant has now become the certificate subject.

The figure below is a simplified overview of the process. It does not show how Alice can check the digital signature.

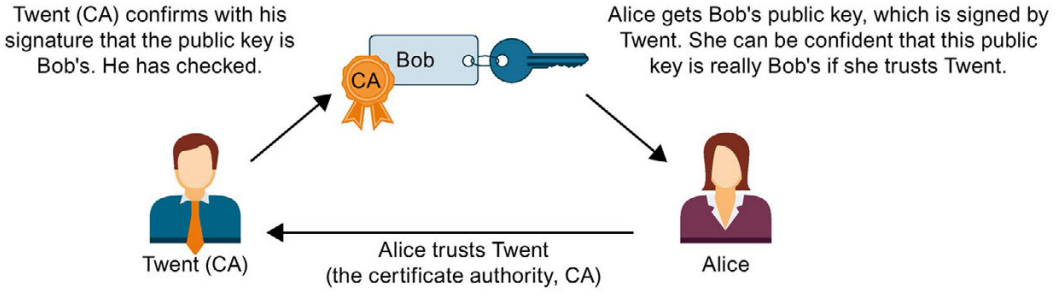


Figure 6-15 Signing of a certificate by a certificate authority

Self-signed certificates

Self-signed certificates are certificates whose signature comes from the certificate subject and not from an independent certificate authority.

Examples:

- You can create and sign a certificate yourself, for example, to encrypt messages to a communication partner. In the example above, Bob (instead of Twent) could himself sign his certificate with his private key. Using Bob's public key, Alice can check that the signature and public key from Bob match. This procedure is sufficient for simple internal plant communication that is to be encrypted.
- A root certificate is, for example, a self-signed certificate, signed by the certificate authority (CA), that contains the public key of the certificate authority.

Features of self-signed certificates

The "CN" (Common Name of Subject) for the certificate subject and "Issuer" attributes of self-signed certificates are identical: You have signed your certificate yourself. The field "CA" (Certificate Autority) must be set to "False"; the self-signed certificate should not be used to sign other certificates.

Self-signed certificates are not embedded in a PKI hierarchy.

Certificate content

A certificate to the X.509 V3 standard, the standard that is also used by STEP 7 and the S7-1500 CPUs, consists primarily of the following elements:

- Public key
- Details of the certificate subject (i.e. the holder of the key), for example, the Common Name (CN) of Subject .
- Attributes such as serial number and validity period
- Digital signature from the certificate authority (CA) confirming that the information is correct.

There are also extensions, for example:

- Specification of what the public key may be used for (Key Usage), for example, signing or key encryption.
  When you create a new certificate with STEP 7, for example in the context of Secure Open User Communication, select the correct entry from the list of possible usages, e.g. "TLS".
- Specification of a Subject Alternative Name (SAN), which is used in secure communication with Web servers (HTTP over TLS), for example, to ensure that the certificate in the address bar of the Web browser also belongs to the Web server specified in the URL.

How signatures are generated and verified

Asymmetric key usage ensures that certificates can be verified: The example of the "MyCert" certificate illustrates the "Sign" and "Verify signature" processes.

Generating a signature:

1. The issuer of the "MyCert" certificate generates a hash value from the certificate data using a specific hash function (for example SHA-1, Secure Hash Algorithm).

   The hash value is a bit string of a constant length. The advantage of the constant length of the hash value is that it always takes the same amount of time to sign.

2. Using the hash value generated in this way and the private key, the issuer of the certificate then generates a digital signature. The RSA signature scheme is often used.
3. The digital signature is saved in the certificate. The certificate is now signed.

Verifying a signature:

1. The authenticator of the "MyCert" certificate obtains the certificate of the issuer and thus the public key.
2. A new hash value is formed from the certificate data with the same hash algorithm that was used for signing (for example SHA-1).
3. This hash value is then compared with the hash value that is determined by means of the public key of the certificate issuer and the signature algorithm for checking the signature.
4. If the signature check produces a positive result, both the identity of the certificate subject as well as the integrity, meaning authenticity and genuineness, of the certificate content are proven. Anyone who has the public key, i.e. the certificate from the certificate authority, can check the signature and thus recognize that the certificate was actually signed by the certificate authority.

The figure below shows how Alice uses the public key in the certificate from Twent (who represents the certificate authority, CA) to verify the signature on Bob's public key. All that is required for verification is therefore the availability of the certificate from the certificate authority at the moment of checking. The validation itself is executed automatically in the TLS session.

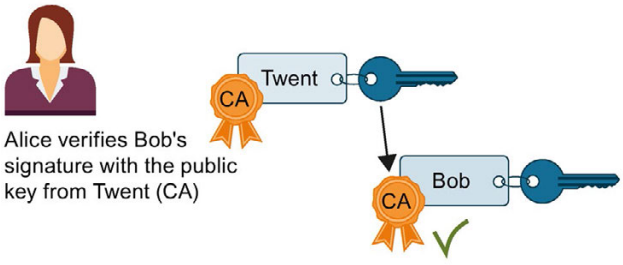


Figure 6-16 Verification of a certificate with the public key of the certificate of a certificate authority

Signing messages

The method described above for signing and verifying also uses the TLS session for signing and verifying messages.

If a hash value is generated by a message and this hash value is signed with the private key of the sender and attached to the original message, the recipient of the message is able to check the integrity of the message. The recipient decrypts the hash value with the public key of the sender, puts together the hash value from the message received and compares the two values. If the values are not the same, the message has been tampered with on the way.

Chain of certificates to root certificate

The certificates of a PKI are often organized hierarchically: The top of the hierarchy is formed by root certificates. Root certificates are certificates that are not signed by a higher-level certificate authority. The certificate subject and certificate issuer of root certificates are identical. Root certificates enjoy absolute trust. They form the "anchor" of trust and must therefore be known to the receiver as trusted certificates. They are stored in an area provided for trusted certificates.

Depending on the PKI, the function of root certificates is, for example, to sign certificates from lower-level certificate authorities, so-called intermediate certificates. This transfers the trust from the root certificate to the intermediate certificate. An intermediate certificate can sign a certificate just like a root certificate; both are therefore referred to as "CA certificates".

This hierarchy can be continued over multiple intermediate certificates until the end-entity certificate. The end-entity certificate is the certificate of the user who is to be identified.

The validation process runs through the hierarchy in the opposite direction: As described above, the certificate issuer is established and the signature checked with the issuer's public key, then the certificate of the higher-level certificate issuer is established along the entire chain of trust to the root certificate.

Conclusion: The chain of intermediate certificates to the root certificate, the certificate path, must be available in every device that is to validate an end-entity certificate of the communication partner, irrespective of the type of secure communication that you configure.

6.11.1.4 Managing certificates with STEP 7

STEP 7 as of version V14 together with the S7-1500-CPUs as of firmware version 2.0 support the Internet PKI (RFC 5280) in as far as an S7-1500-CPU is able to communicate with devices that also support the Internet PKI.

The usage of X.509 certificates for verifying certificates as described in the preceding sections, for example, is a result of this.

STEP 7 as of V14 uses a PKI similar to Internet PKI. Certificate Revocation Lists (CRLs), for example, are not supported.

Creating or assigning certificates

You create certificates for various applications in STEP 7 for devices with security properties, such as an S7-1500 CPU as of firmware V2.0.

The following areas in the Inspector window of the CPU allow the creation of new certificates or the selection of existing ones:

- "Protection & Security > Certificate manager" - for the generation and assignment of all types of certificates. TLS certificates for Secure Open User Communication are preset for the generation of certificates.
- "Web server > Server security" - for the generation and assignment of Web server certificates.
- "OPC UA > Server > Security" - for the generation and assignment OPC UA certificates.

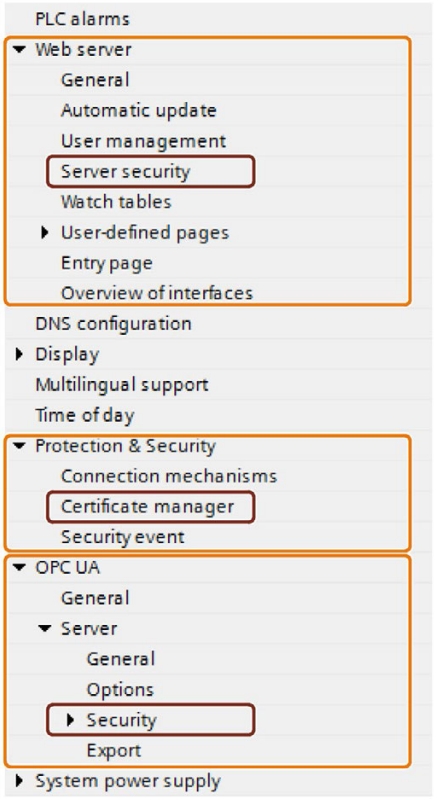


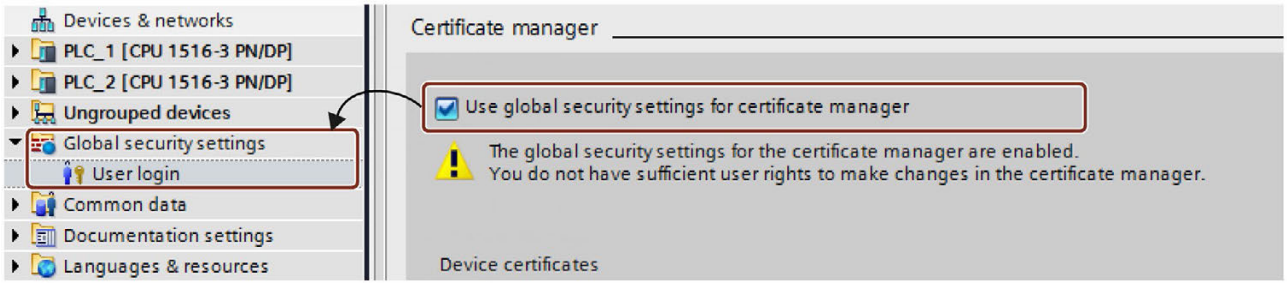
Figure 6-17 Security settings for an S7-1500 CPU in STEP 7

Special features of the section "Protection & Security > Certificate manager"

Only in this section of the Inspector window do you switch between the global, i.e. project-wide, and the local, i.e. device-specific, certificate manager (option "Use global security settings for the certificate manager"). The option decides whether you have access to all the certificates in the project or not.

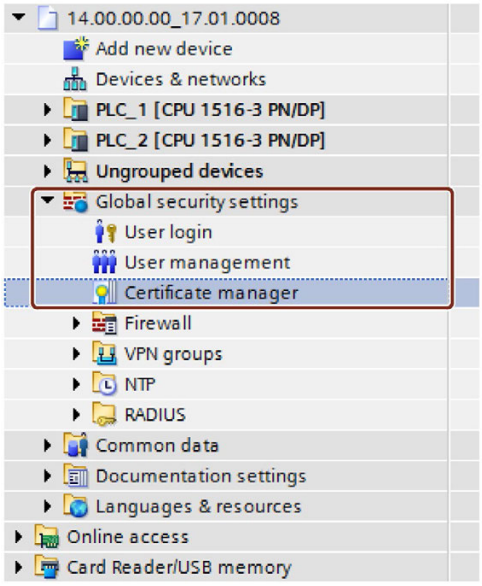
- If you do **not** use the certificate manager in the global security settings, you only have access to the local certificate memory of the CPU. You do not have access, for example, to imported certificates or root certificates. Without these certificates only a restricted functionality is available. You can, for example, only generate self-signed certificates.
- If you use the certificate manager in the global security settings and you are logged on as an administrator, you have access to the global, project-wide certificate memory. You can, for example, assign imported certificates to the CPU, or create certificates that are issued and signed by the project CA (certificate authority of the project).

The figure below shows how the "Global security settings" are shown in the project tree after the "Use global security settings for the certificate manager" option has been activated in the Inspector window of the CPU.



When you double-click "User login" in the project tree below the global security settings and log in, a line called "Certificate manager" is displayed, among other data.

When you double-click the "Certificate manager" line, you obtain access to all the certificates in the project, divided into the tabs "CA" (certificate authorities), "Device certificates" and "Trusted certificates and root certificate authorities".



Private keys

STEP 7 generates private keys while generating device certificates and server certificates (end-entity certificates). The location where the private key is stored encrypted depends on the use of the global security settings for the certificate manager:

- If you use global security settings, the private key is stored encrypted in the global (project-wide) certificate memory.
- If you do not use global security settings, the private key is stored encrypted in the local (CPU-specific) certificate memory.

The existence of the private key, which is required to decrypt data, for example, is displayed in the "Private key" column of the "Device certificates" tab of the certificate manager in the global security settings.

When the hardware configuration is loaded, the device certificate, the public key as well as the private key are loaded into the CPU.

NOTICE
The "Use global security settings for certificate manager" option influences the previously used private key: If you have already created certificates without using the certificate manager in the global security settings and then change the option for using the certificate manager, the private keys are lost and the certificate ID can change. A warning draws your attention to this fact. Therefore specify at the beginning of the project configuration which option is required for the certificate manager.

6.11.1.5 Examples for the management of certificates.

As explained in the preceding sections, certificates are required for every type of secure communication. The following section shows as an example how you handle the certificates with STEP 7 so that the requirements for Secure Open User Communication are fulfilled.

The devices which are involved at the respective communication partners are differentiated below. The respective steps for supplying the required certificates to the communications participants are described. An S7-1500 CPU or an S7-1500 software controller as of firmware version 2.0 is always required.

The general rule is:

While a secure connection is being established (handshake"), the communication partners as a rule only communicate their end-entity certificates (device certificates).

Therefore the CA certificates required to verify the transmitted device certificate must be located in the certificate memory of the respective communication partner.

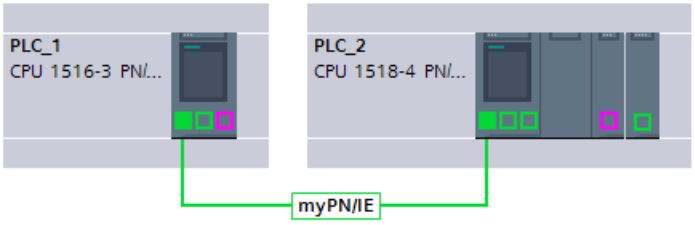
Secure Open User Communication between two S7-1500 CPUs

Two S7-1500-CPUs, PLC_1 and PLC_2, are to exchange data with each other via Secure Open User Communication.

You generate the required device certificates with STEP 7 and assign them to the CPUs as described below.

STEP 7 project certificate authorities (CA of the project) are used to sign the device certificates.

The certificates are to be referenced by their certificate ID in the user program (TCON communication instruction in combination with the associated system data type, for example TCON_IPV4_SEC). STEP 7 assigns the certificate ID automatically during the generation or creation of certificates.



Procedure

STEP 7 automatically loads the required CA certificates together with the hardware configuration to the participating CPUs so that the requirements for certificate verification exist for both CPUs. You therefore only have to generate the device certificates for the respective CPU; STEP 7 does the rest for you.

1. Mark PLC_1 and activate the "Use global security settings for certificate manager" option in the "Protection & Security" section.
2. Log in as a user in the project tree in the "Global security settings" section. For a new project, the "Administrator" role is planned for the first login.
3. Return to the PLC-1 in the "Protection & Security" section. Click in an empty line in the "Certificate subject" column in the "Device certificates" table to add a new certificate.
4. In the drop-down list for selecting a certificate click the "Add" button.

   The "Create Certificate" dialog opens.
5. Leave the default settings in this dialog. They are tailored to the usage of Secure Open User Communication (usage: TLS).

   Tip: Supplement the default name of the certificate subject, in this case the CPU name. In order to differentiate you better leave the default CPU name in case you have to manage a large number of device certificates.

   Example: PLC_1/TLS becomes PLC_1-SecOUC-Chassis17FactoryState.
6. Compile the configuration.

   The device certificate and the CA certificate are part of the configuration.
7. Repeat the steps described above for PLC_2.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

Using self-signed certificates instead of CA certificates

When creating device certificates you can select the "Self-signed" option. You can create self-signed certificates without being logged in for the global security settings. This procedure is not recommended because the resulting certificates do not exist in the global certificate memory and can therefore not be assigned directly to a partner CPU.

As described above you should select the name of the certificate subject with care so that the right certificate can be assigned to a device without any doubt.

Verification with the CA certificates of the STEP 7 project is not possible for self-signed certificates. To ensure that self-signed certificates can be verified you have to include the self-signed certificates of the communication partner into the list of trusted partner devices for each CPU. To this purpose you must have activated the "Use global security settings for certificate manager" option and be logged in as a user in the global security settings.

Proceed as follows to add the self-signed certificate of the communication partner of the CPU:

1. Mark PLC_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
2. Click in an empty line in the "Certificate subject" column in the "Device certificates" table to add a new certificate.
3. Select the self-signed certificate of the communication partner from the drop-down list and confirm the selection.

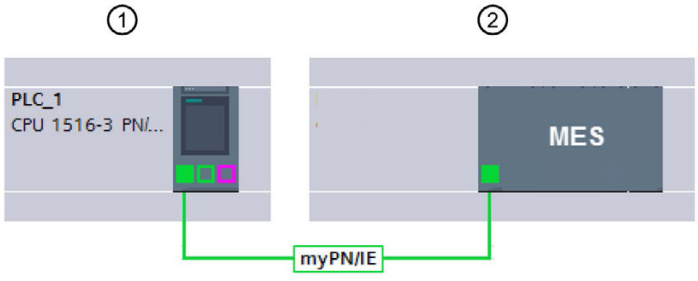
In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

Secure Open User Communication between S7-1500 CPU as a TLS client and an external device as a TLS server

Two devices are to exchange data with each other via TLS connection or TLS session, for example, exchanging recipes, production data or quality data:

- An S7-1500 CPU (PLC_1) as TLS client; the CPU uses Secure Open User Communication
- An external device, for example a Manufacturing Execution System (MES), as TLS server

The S7-1500 CPU establishes the TLS connection / session to the MES system as TLS client.



① TLS client
② TLS server

The S7-1500 CPU requires the CA certificates of the MES system to authenticate the TLS server: The root certificate and, if appropriate, the intermediate certificates for verifying the certificate path.

You have to import these certificates into the global certificate memory of the S7-1500 CPU.

Proceed as follows to import certificates of the communication partner:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the appropriate table (trusted certificates and root certificate authorities) for the certificate to be imported.
3. Right-click in the table to open the shortcut menu. Click "Import" and import the required certificate or the required CA certificates.

   Through the import the certificate has a certificate ID assigned to it and can be assigned to a module in the next step.
4. Mark PLC_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
5. Click in an empty line in the "Certificate subject" column to add the imported certificates.
6. Select the required CA certificates of the communication partner from the drop-down list and confirm the selection.

Optionally the MES system can also request a device certificate of the CPU to authenticate the CPU (i.e., the TLS client). In this case, the CA certificates of the CPU must be made available to the MES system. The prerequisite for importing the certificates into the MES system is a preceding export of the CA certificates from the STEP 7 project of the CPU. Follow these steps:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the matching table (CA certificate) for the certificate to be exported.
3. Right-click the selected certificate to open the shortcut menu.
4. Click "Export".
5. Select the export format of the certificate.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

Secure Open User Communication between an S7-1500 CPU as TLS server and an external device as TLS client

If the S7-1500 CPU acts as TLS server and the external device, for example an ERP system (Enterprise Resource Planning System) establishes the TLS connection / session, you require the following certificates:

- For the S7-1500 CPU, you generate a device certificate (server certificate) with a private key and download it with the hardware configuration into the S7-1500 CPU. You use the "Signed by certificate authority" option when generating the server certificate.

  The private key is required for the key exchange as explained in the figure for the example "HTTP over TLS".

- You have to export the CA certificate of the STEP 7 project for the ERP system and import / load it into the ERP system. With the CA certificate the ERP system verifies the server certificate of the S7-1500 that was transferred from the CPU to the ERP system during the establishment of the TLS connection / session.

① TLS server
② TLS client

Figure 6-18 Secure OUC between an S7-1500 CPU and ERP system

The required steps are described in the preceding sections.

Secure Open User Communication via S7-1543-1 CP as an e-mail client (SMTP over TLS)

An S7-1500 CPU can establish a secure connection to an e-mail server via the CP 1543-1 with the communication instruction TMAIL-C.

The system data types TMail_V4_SEC, TMail_V6_SEC and TMail_QDN_SEC allow you to determine the partner port of the e-mail server and thus to reach the e-mail server via "SMTP over TLS".

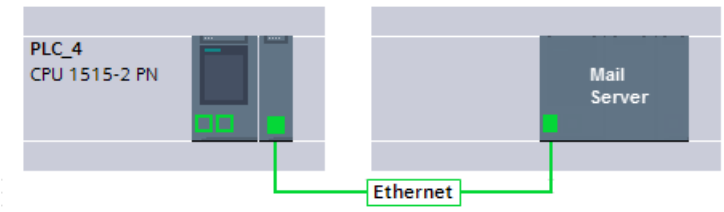


Figure 6-19 Secure OUC between a CP1543-1 and a mail server

Requirement for secure e-mail connection is the importing of the root certificate and the intermediate certificates of the e-mail server (provider) into the global certificate memory of the STEP 7 project. If these certificates have been assigned to the CP, the CP can verify by means of these certificates the server certificate of the e-mail server that is sent during the establishment of the TLS connection / session.

Follow these steps:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the appropriate table (trusted certificates of root certificate authorities) for the certificate to be imported.
3. Right-click in the table to open the shortcut menu. Click "Import" and import the required certificate or the required CA certificates.

   Through the import a certificate ID is assigned to the certificate and can be assigned to the CP in the next step.
4. Mark the CP 1543-1 and navigate to the "Certificates of partner devices" table in the "Security" section.
5. Click in an empty line in the "Certificate subject" column to add the imported certificates.
6. Select the required CA certificates of the e-mail server from the drop-down list and confirm the selection.

In the next step you have to create the user programs for the e-mail client function of the CPU and load the configurations together with the program.

6.11.1.6 Example: HTTP over TLS

The following paragraphs show how the mechanisms described are used to establish a secure communication between a Web browser and the Web server of an S7-1500 CPU.

Initially the changes for the "Permit access only with HTTPS" option in STEP 7 are described. As of STEP 7 V14 you have the possibility to influence the server certificate of the Web server of an S7-1500 CPU as of firmware V2.0: The server certificate is generated as of these versions with STEP 7.

In addition it illustrates the processes that are executed when a website of the CPU Web server is called with a Web browser of a PC through an encrypted HTTPS connection.

Using Web server certificates for S7-1500 CPUs, FW V2.0 or higher

For S7-1500 CPUs with a firmware version before V2.0, you were able to set "Permit access only with HTTPS" when setting the Web server properties, without specific requirements applying.

You did not have to handle certificates for these CPUs; the CPU automatically generates the certificates required for the Web server.

For S7-1500 CPUs as of firmware V2.0, STEP 7 generates the server certificate (end-entity certificate) for the CPU. You assign a server certificate to the Web server in the properties of the CPU (Web server > Server security).

Because a server certificate name is always preset, there is no change to the easy configuration of the Web server: You activate the Web server and activate the "Permit access only with HTTPS" option - STEP 7 generates a server certificate with the default name during compiling.

Irrespective of whether you use the certificate manager in the global security settings or not: STEP 7 has all the information required to generate the server certificate.

In addition you have the possibility to determine the properties of the server certificate, for example, the name or the validity period.

Loading the Web server certificate

The server certificate generated by STEP 7 is then automatically also loaded to the CPU when the hardware configuration is loaded.

- If you use the certificate manager in the global security settings, the certificate authority of the project (CA certificate) signs the server certificate of the Web server: During loading the CA certificate of the project is loaded as well automatically.
- If you do not use the certificate manager in the global security settings, STEP 7 generates the server certificate as a self-signed certificate.

When you address the Web server of the CPU over the IP address of the CPU, a new server certificate (end-entity certificate) must be generated and loaded with each change in the IP address of an Ethernet interface of the CPU. This is necessary because the identity of the CPU changes with the IP address – and the identity requires a signature in accordance with the PKI rules.

You can avoid this problem by addressing the CPU with a domain name instead of its IP address, for example "myconveyer-cpu.room13.myfactory.com". For this purpose, you have to manage the domain names of the CPU via a DNS server.

Supplying a Web browser with a CA certificate of the Web server

In the Web browser the user who accesses the websites of the CPU through HTTPS should install the CA certificate of the CPU. If no certificate is installed, a warning is output recommending that you do not use the page. To view this page, you must explicitly "Add an exception".

The user receives the valid root certificate (Certification Authority) for download from the "Intro" web page of the CPU Web server under "Download certificate".

STEP 7 offers a different possibility: Export the CA certificate of the project with the certificate manager into the global security settings in STEP 7. Subsequently import the CA certificate into the browser.

Course of the secure communication

The figure below shows, in simplified terms, how communication is established ("handshake") focusing on the negotiation of keys used for data exchange (here with HTTP over TLS).

However, the course can be applied to all communication options that are based on the usage of TLS, i.e. also for Secure Open User Communication (see Basics for secure communication).

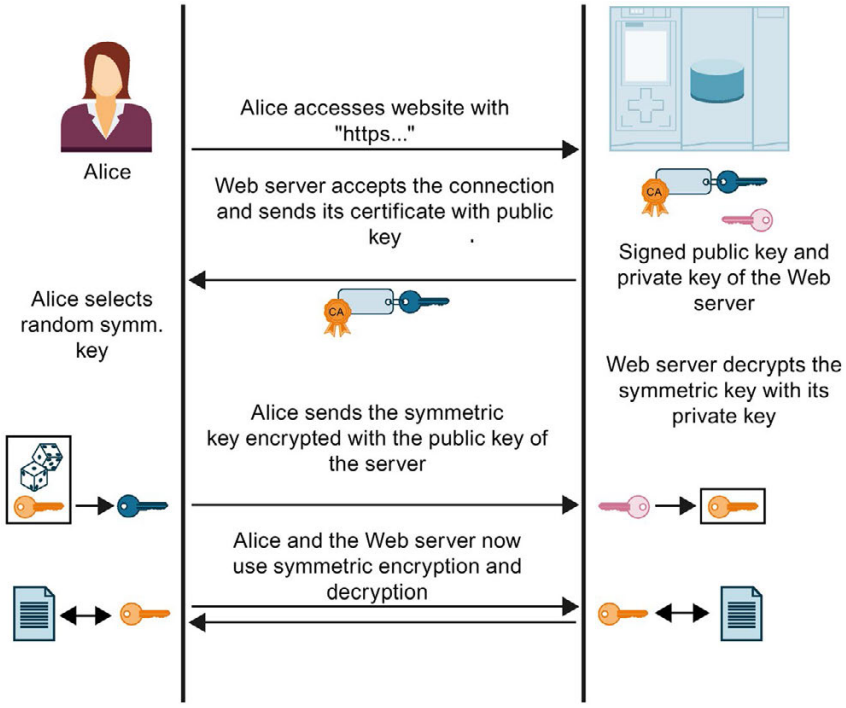


Figure 6-20 Handshake with https

The figure does not show the measures taken at Alice's end (browser) to verify the certificate sent by the Web server. Whether Alice can trust the Web server certificate received and therefore the identity of the Web server, and can accept the exchange of data, depends on positive verification.

The steps for verifying the authenticity of the Web server:

1. Alice must know the public keys of all relevant certificate authorities, which means she requires the complete certificate chain to verify the Web server certificate (i.e. the end-entity certificate of the Web server):

   Alice will generally have the required root certificate in her certificate storage. When a Web browser is installed, a whole range of trusted root certificates is also installed. If she does not have the root certificate, she has to download it from the certificate authority and install it in the certificate authority of the browser. The certificate authority can also be the device on which the Web server is located.

   You have the following options for obtaining the intermediate certificates:

   – The server itself sends the required intermediate certificates to Alice along with its end-entity certificate – in the form of a signed message so that Alice can verify the integrity of the certificate chain.

   – The certificates often contain the URLs of the certificate issuer. Alice can load the required intermediate certificates from these URLs.

   When you work with certificates in STEP 7 it is always assumed that you have imported the intermediate certificates and the root certificate into the project and assigned them to the module.

2. Alice validates the signatures in the certificate chain with the public keys of the certificates.

3. The symmetric key must be generated and transferred to the Web server.

4. If the Web server is addressed by its domain name, Alice also verifies the identity of the Web server in accordance with the Internet PKI rules defined in RFC 2818. She is able to do this because the URL of the Web server, in this case the "Fully Qualified Domain Name" (FQDN), is saved in the end-entity certificate of the Web server. If the certificate entry in the "Subject Alternative Name" field corresponds to the entry in the address bar of the browser, everything is fine.

The process continues with the exchange of data with the symmetric key, as shown in the figure above.

6.11.2 Secure OUC of an S7-1500 CPU as TLS client to an external PLC (TLS server)

The following section describes how you can set up Open User Communication via TCP from an S7-1500 CPU as TLS client to a TLS server.

Setting up a secure TCP connection from an S7-1500 CPU as TLS client to a TLS server

S7-1500 CPUs as of firmware version V2.0 support secure communication with addressing via a Domain Name System (DNS).

For secure TCP communication via the domain name you need to create a data block with the TCON_QDN_SEC system data type yourself, assign parameters and call it directly at the TCON instruction.

Requirements:

- Current date and time are set in the CPU.
- Your network includes at least one DNS server.
- You have configured at least one DNS server for the S7-1500 CPU.
- TLS client and TLS server have all the required certificates.

To set up a secure TCP connection to a TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_QDN_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "DNS ConnectionSEC" of the data type TCON_QDN_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	DNS Connection SEC	TCON_QDN_SEC		
3	ConnPara	TCON_QDN		parameter of the TCP connection
4	InterfaceId	HW_ANY	0	not relevant
5	ID	CONN_OUC	5	connection reference / identifier
6	ConnectionType	Byte	11	type of connection: 16#0B=11=TCP/IP, 16#13
7	ActiveEstablished	Bool	true	active/passive connection establishment
8	RemoteQDN	String[254]	'plc_1.factory127.'	fully or partially qualified domain name of rem
9	RemotePort	UInt	4000	remote UDP / TCP port number
10	LocalPort	UInt	0	local UDP / TCP port number
11	ActivateSecureConn	Bool	true	activate the security functionality of that conn
12	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a
13	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 a
14	TLSServerCertRef	UDInt	7	for Server side: Reference to own X.509 V3 se
15	TLSClientCertRef	UDInt	0	for Client side: add id of own X.509 V3 client c

Figure 6-21 Data type TCON_QDN_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the fully qualified domain name (FQDN) of the TLS server, for example, for "RemoteQDN".

4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "ExtTLSCapabilities": If you enter the value 1, the client validates the subjectAlternateName in the X.509-V3 certificate of the server to verify the identity of the server. This validation is executed in the context of TCON.
   - "TLSServerCertRef": ID of the X.509-V3 certificate (usually a CA certificate) that is used by the TLS client to validate the TLS server authentication. If this parameter is 0, the TLS client uses all (CA) certificates currently loaded in the client certificate store to validate the server authentication.

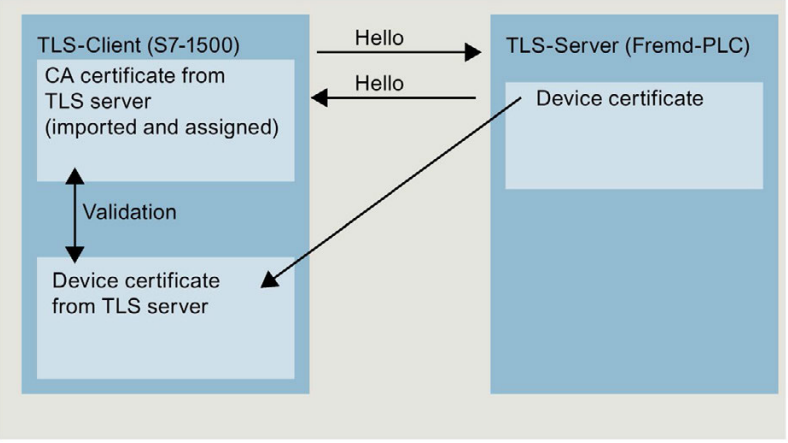


Figure 6-22 Certificate handling from the perspective of the S7-1500 as a TLS client

   - "TLSClientCertRef": ID of the own X.509-V3 certificate.
5. Create a TCON instruction in the program editor.

6. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_QDN_SEC.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connectionSEC" (data type TCON_QDN_SEC).

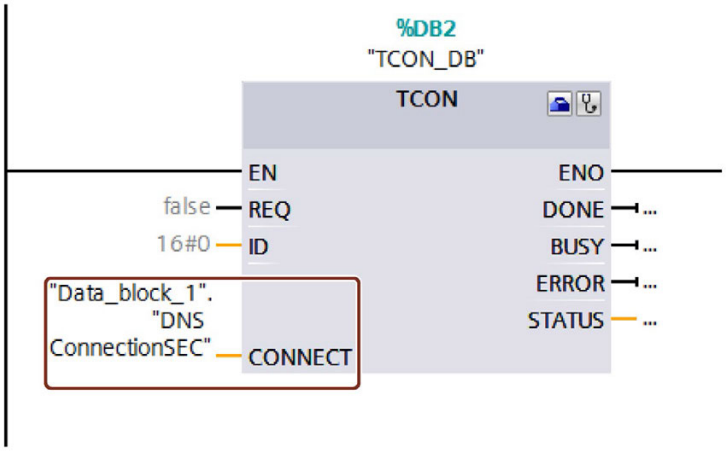


Figure 6-23 TCON instruction

Additional information

You can find more information on the TCON_QDN_SEC system data type in the STEP 7 online help.

For additional information on secure communication, refer to the section Basics (Page 66).

6.11.3 Secure OUC of an S7-1500 CPU as TLS server to an external PLC (TLS client)

The following section describes how you can set up Open User Communication via TCP from an S7-1500 CPU as TLS server to a TLS client.

Setting up a secure TCP connection via the domain name of the communication partner

S7-1500 CPUs as of firmware version V2.0 support secure communication with addressing via a Domain Name System (DNS).

For secure TCP communication via the domain name you need to create a data block with the TCON_QDN_SEC system data type yourself, assign parameters and call it directly at the TCON instruction.

Requirements:

- Current date and time are set in the CPU.
- Your network includes at least one DNS server.
- You have configured at least one DNS server for the S7-1500 CPU.
- TLS client and TLS server have all the required certificates.

To set up a secure TCP connection to a TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_QDN_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "DNS ConnectionSEC" of the data type TCON_FDL_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	DNS Connection SEC2	TCON_QDN_SEC		
3	ConnPara	TCON_QDN		parameter of the TCP connection
4	InterfaceId	HW_ANY	0	not relevant
5	ID	CONN_OUC	8	connection reference / identifier
6	ConnectionType	Byte	11	type of connection: 16#0B=11=TCP/IP, 16#13
7	ActiveEstablished	Bool	false	active/passive connection establishment
8	RemoteQDN	String[254]	''	fully or partially qualified domain name of rem
9	RemotePort	UInt	0	remote UDP / TCP port number
10	LocalPort	UInt	2010	local UDP / TCP port number
11	ActivateSecureConn	Bool	true	activate the security functionality of that conn
12	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a
13	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 a
14	TLSServerCertRef	UDInt	5	for Server side: Reference to own X.509 V3 se
15	TLSClientCertRef	UDInt	0	for Client side: add id of own X.509 V3 client c

Figure 6-24 TCON_QDN_SEC_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter, for example, the local ID of the TCP connection for "ID".

4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerReqClientCert": Request for an X.509-V3 certificate from the TLS client.
   - "TLSServerCertRef": ID of the own X.509-V3 certificate.

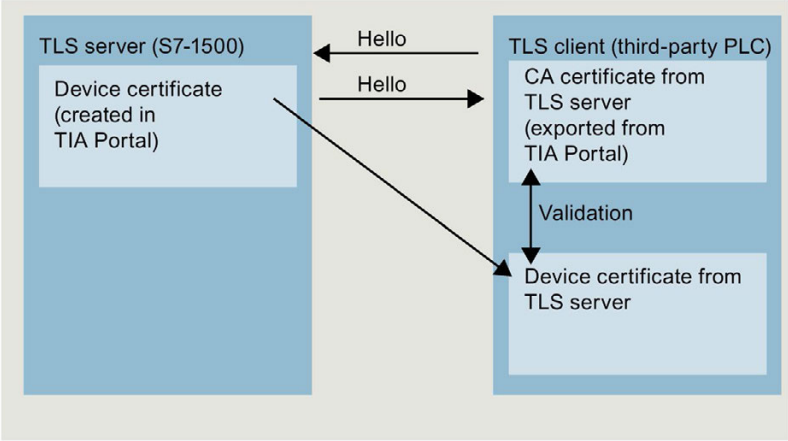


Figure 6-25 Certificate handling from the perspective of the S7-1500 as TLS server

   - "TLSClientCertRef": ID of the X.509-V3 certificate (or a group of X.509-V3 certificates) that is used by the TLS server to validate TLS client authentication. If this parameter is 0, the TLS server uses all (CA) certificates currently loaded in the server certificate store to validate the client authentication.
5. Create a TCON instruction in the program editor.
6. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_QDN_SEC.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connectionSEC" (data type TCON_QDN_SEC).

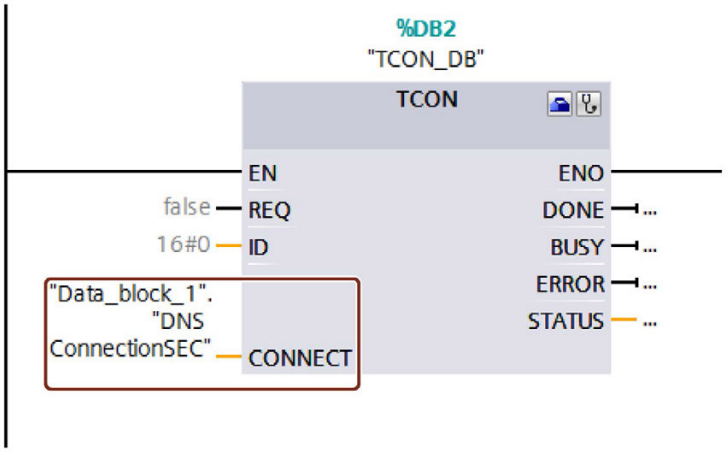


Figure 6-26 TCON instruction

Additional information

You can find more information about the system data types TCON_QDN_SEC in the STEP 7 online help.

For additional information on secure communication, refer to the section Basics (Page 66).

6.11.4 Secure OUC between two S7-1500 CPUs

The following section describes how you can set Secure Open User Communication via TCP between two S7-1500 CPUs. In the process one S7-1500 CPU acts as TLS client (active establishing of the connection) and the other S7-1500 CPU as TLS server (passive establishing of the connection).

Setting up a secure TCP connection between two S7-1500 CPUs

For secure TCP communication between two S7-1500 CPUs you need to create a data block with the TCON_IPv4_SEC system data type yourself in every CPU, assign parameters and call it directly at the TCON instruction.

Requirements:

- Current date and time are set in the CPU.
- Both S7-1500 CPUs have at least firmware version V2.0
- TLS client and TLS server have all the required certificates.

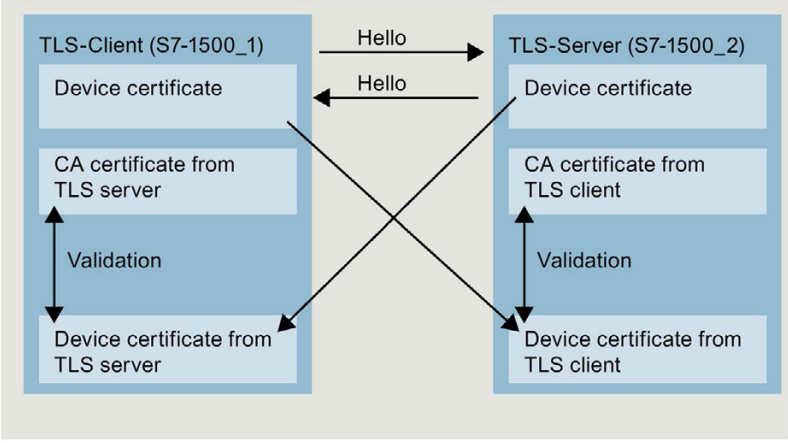


Figure 6-27 Certificate handling for Secure OUC between two S7-1500 CPUs

Settings at the TLS client

To set up a secure TCP connection in the TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_4_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Client" of the data type TCON_IP_V4_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Client	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	72	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	true	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	100	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against th
19	TLSServerCertRef	UDInt	1	for Server side: Reference to own X.509 V3 server certificate; fo
20	TLSClientCertRef	UDInt	5	for Client side: add id of own X.509 V3 client certificate; for Sen

Figure 6-28 IP_V4_SEC_Client

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the IPv4 address of the TLS server, for example, for the "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.
   - "TLSClientCertRef": ID of the own X.509-V3 certificate.
5. Create a TCON instruction in the program editor.
6. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_IP_4_SEC.

Settings at the TLS server

To set up a secure TCP connection in the TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_4_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Server" of the data type TCON_IP_V4_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Server	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	120	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	false	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	10	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	true	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against the
19	TLSServerCertRef	UDInt	6	for Server side: Reference to own X.509 V3 server certificate; fo
20	TLSClientCertRef	UDInt	1	for Client side: add id of own X.509 V3 client certificate; for Serv

Figure 6-29 IP_V4_SEC_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the IPv4 address of the TLS client, for example, for the "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerReqClientCert ": Request for an X.509-V3 certificate from the TLS client. Enter the value "true".
   - "TLSServerCertRef": ID of the own X.509-V3 certificate.
   - "TLSClientCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.

5. Create a TCON instruction in the program editor.
6. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_IP_4_SEC.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "SEC connection 1 TLS client" (data type TCON_IP_4_SEC).

Additional information

You can find more information about the system data types TCON_IP_4_SEC in the STEP 7 online help.

For additional information on secure communication, refer to the section Basics (Page 66).

6.11.5 Secure OUC via CP interface

The following sections describes the particular points to be taken into consideration in the case of Secure Open User Communication via a CP interface. At least one station is an S7-1500 station with the following modules:

- S7-1500 CPU as of firmware version V2.0 (with the exception of S7-1500 Software Controller)
- CP 1543-1 as of firmware version V2.0 or CP 1543SP-1 as firmware version V1.0

The CP acts in an S7-1500 station as a TLS client (active connection establishment) or a TLS server (passive connection establishment).

The fundamental procedure and the concept for using secure communication via a CP interface is similar to that of secure communication via the interfaces of the S7-1500 CPUs. Essentially, you have to assign the certificates to the CPU in the role of a TLS server or TLS client and not to the CPU. Other rules and procedures therefore apply. These are described below.

Handling certificates for CPs

The following applies in general: You have to be logged on at the certificate manager in the global security settings. The generation of self-signed certificates also requires logon for the global security settings. You have to have sufficient rights as a user (administrator or user with the "Standard" role with the right to "Configure security").

The starting point for the generation or assignment of certificates at the CP is the section "Security > Security properties". In this section, you log on for the global security settings.

Procedure:

1. In the network view of STEP 7, mark the CP and select the section "Security > Security properties" in the Inspector window.
2. Click on the "User logon" button.
3. Log on using your user name and password.

4. Enable the "Activate security functions" option.

   The security properties are initialized.

5. Click in the first line of the "Device certificates" table to generate a new certificate or select an existing device certificate.

6. If the communication partner is also an S7-1500 station, you also have to assign a device certificate to the communication partner with STEP 7 as described here or for the S7-1500 CPU.

Example: Setting up a secure TCP connection between two S7-1500 CPUs via CP interfaces

In order to establish secure TCP communication between two S7-1500 CPs, you have to create a data block with the system data type TCON_IPv4_SEC in each CPU, carry out the parameter assignment and call it directly at the instruction.

Requirements:

- Both S7 1500 CPUs have at least firmware version V2.0. If you use the CP 1543SP-1: Firmware version as of V1.0.
- Both CPs (for example CP 1543-1) must have at least firmware version V2.0
- TLS client and TLS server have all the required certificates.
  - A device certificate (end-entity certificate) for the CP must be generated and be located in the certificate memory of the CP. If a communication partner is an external device (for example an MES or ERP system), a device certificate also has to exist for this device.
  - The root certificate (CA certificate) with which the device certificate of the communication partner is signed must also be located in the certificate memory of the CP or in the certificate memory of the external device. If you use intermediate certificates, you have to ensure that the complete certificate path exists in the validating device. A device uses these certificates to validate the device certificate of the communication partner.
- The communication partner must always be addressed via its IPv4 address, not via its domain name.

The following figure shows the different certificates in the devices for the case that both communication partners communicate via a CP 1543-1. In addition, the figure shows the transfer of the device certificates during establishment of the connection ("Hello").

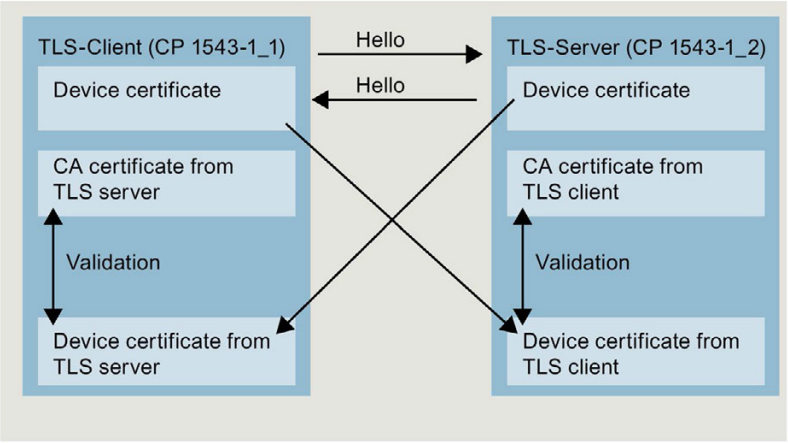


Figure 6-30 Certificate handling in secure OUC between two S7-1500 CPUs via CP interfaces.

Settings at the TLS client

To set up a secure TCP connection in the TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_4_SEC in the global data block. To do so, enter the string "TCON_IP_V4_SEC" in the "Data type" field.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Client" of the data type TCON_IP_V4_SEC is defined.

The Interface ID has the value of the HW identifier of the IE interface of the local CP (TLS client).

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Client	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	258	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	true	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	100	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against th
19	TLSServerCertRef	UDInt	1	for Server side: Reference to own X.509 V3 server certificate; fo
20	TLSClientCertRef	UDInt	5	for Client side: add id of own X.509 V3 client certificate; for Ser

Figure 6-31 IP_V4_SEC_Client

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS server for "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.
   - "TLSClientCertRef": ID of the own X.509-V3 certificate.
5. Create a TCON instruction in the program editor.
6. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_IP_4_SEC.

Settings at the TLS server

To set up a secure TCP connection in the TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_4_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Server" of the data type TCON_IP_V4_SEC is defined.

   The interface ID has the value of the HW identifier of the IE interface of the local CP (TLS server).

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Server	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	260	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	false	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	10	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	true	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against the
19	TLSServerCertRef	UDInt	6	for Server side: Reference to own X.509 V3 server certificate; fo
20	TLSClientCertRef	UDInt	1	for Client side: add id of own X.509 V3 client certificate; for Serv

Figure 6-32 IP_V4_SEC_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS client for "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerReqClientCert ": Request for an X.509-V3 certificate from the TLS client. Enter the value "true".
   - "TLSServerCertRef": ID of the own X.509-V3 certificate.
   - "TLSClientCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.

5. Create a TCON instruction in the program editor.
6. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_IP_4_SEC.

Upload device as new station

When you upload a configuration with certificates and configured secure Open User Communication as a new station into your STEP 7 project, the certificates of the CP are not uploaded, in contrast to the certificates of the CPU. After the device has been loaded as a new station, no more certificates are contained in the corresponding tables of the CPs for the device certificates.

You have to perform configuration of certificates again after the upload. Otherwise, renewed loading of the configuration results in the certificates that originally exist in the CP being deleted so that secure communication does not function.

Secure OUC connections via CPU and CP interfaces - similarities

- Connection resources:
  No differences between OUC and secure OUC. A programmed secure OUC connection uses a connection resource just like an OUC connection, irrespective of which IE/PROFINET interface communicates with the station.
- Connection diagnostics:
  No differences between OUC and secure OUC connection diagnostics.
- Loading of projects with secure OUC connections into the CPU:
  Only possible in STOP of the CPU, if certificates are loaded as well.
  Recommendation: Load to device > Hardware and software. Reason: Ensuring the consistency between the program with secure OUC, hardware configuration and certificates.
  Certificates are loaded with the hardware configuration - therefore loading requires a stop of the CPU. The reloading of blocks that utilize further secure OUC connections is only possible in RUN if the certificates required for this purpose are already located on the module.

6.11.6 Secure OUC via e-mail

The following section describes how to set up a secure connection (SNMP over TLS) to a mail server with the TMAIL_C communication instruction. You cannot set up the secure connection to a mail server through an integrated interface of the CPU. This is only possible through the interface of a CP.

Setting up a secure connection to a mail server

For secure communication to a mail server you need to create a data block with one of the system data types TMAIL_V4_SEC, TMAIL_V6_SEC or TMAIL_QDN_SEC yourself, assign parameters and call it directly at the TMAIL_C instruction.

Requirements:

- Current date and time are set in the CPU.
- S7-1500 CPU as of firmware version V2.0 with communication module CP 1543-1 as of firmware version V2.0
- ET 200SP CPU as of firmware version V2.0 with communication module CP 1542SP-1 (IRC) as of firmware version V1.0
- You have assigned all the CA certificates of the mail server (TLS server) to the CP (TLS client) and have loaded the configuration into the CPU.

To set up a secure connection via the IP4 address of the mail server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TMAIL_V4_SEC in the global data block.

   The example below shows the global data block "MailConnDB" in which the tag "MailConnectionSEC" of the data type TMAIL_V4_SEC is defined.

MailConnDB

Name	Datentyp	Startwert	Kommentar
Static			
MailConnectionSEC	TMail_V4_SEC		
InterfaceId	HW_ANY	"Local~CP_1543-1_1~Ethernet-Schnittstelle_1"	Use HW-identifier of the IE-interface to specify th
ID	CONN_OUC	100	connection reference / identifier
ConnectionType	Byte	16#20	type of connection 16#20=32=TMail_V4 or TMai
ActiveEstablished	Bool	true	active / passive connection establishment
WatchDogTime	Time	T#5000ms	watchdog time to monitor SMTP server associat
MailServerAddress	IP_V4		IPv4 address of mail server
ADDR	Array[1..4] of Byte		IPv4 address
ADDR[1]	Byte	144	IPv4 address
ADDR[2]	Byte	145	IPv4 address
ADDR[3]	Byte	2	IPv4 address
ADDR[4]	Byte	20	IPv4 address
UserName	String[254]	'myName'	user name which is necessary to login into the
PassWord	String[254]	'myPW'	user password which is necessary to login into
From	EMAIL_ADDR		source mail address
LocalPartPlusAt...	String[64]	'Mustermann@'	local part of e-mail address plus "@" sign
FullQualifiedD...	String[254]	'siemens.com'	full qualified domain name part of e-mail addre
RemotePort	UInt	587	remote TCP port number
ActivateSecureConn	Bool	TRUE	activate the security functionality of that conne
ExtTLSCapabilities	Byte	16#0	for further capability extensions of the TLS hand
TLSServerCertRef	UDInt	7	Reference to the X.509 V3 (CA-) certificate of the

Figure 6-33 Data type TMAIL_V4_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the IPv4 address of the mail server, for example, for the "MailServerAddress".
4. Set the parameters for secure communication in the "Start value" column. Enter the certificate ID of the CA certificate of the communication partner, for example, for "TLSServerCertRef".
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerCertRef": Reference to the X.509 V3 (CA) certificate of the mail server, which is used by the TLS client to validate the authentication of the mail server.

5. Create a TMAIL_C instruction in the program editor.
6. Interconnect the MAIL_ADDR_PARAM parameter of the TMAIL_C instruction with the tag of the data type TMAIL_V4_SEC.

   In the following example the MAIL_ADDR_PARAM parameter of the TMAIL_C instruction is interconnected with the tag "MailConnectionSEC" (data type TMAIL_V4_SEC).

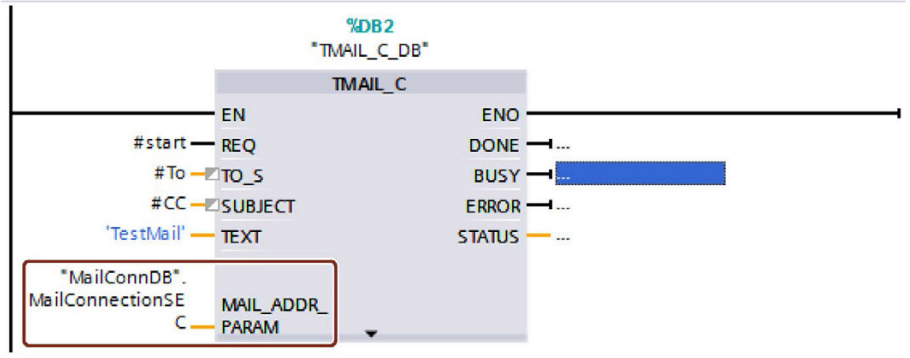


Figure 6-34 TMAIL_C instruction

Additional information

You can find more information on the TMail_V4_SEC system data type in the STEP 7 online help.

For additional information on secure communication, refer to the section Basics (Page 66).

S7 communication 7

Characteristics of S7 communication

S7 communication as homogeneous SIMATIC communication is characterized by vendor-specific communication between SIMATIC CPUs (not an open standard). S7 communication is used for migration and for connecting to existing systems (S7-300, S7-400).

For data transfer between two S7-1500 automation systems, we recommend that you use open communication (see section Open User Communication (Page 42)).

Properties of S7 communication

Using S7 communication, the CPU exchanges data with another CPU. Once the user has received the data at the receiver end, the reception data is automatically acknowledged to the sending CPU.

The data is exchanged via configured S7 connections. S7 connections can be configured at one end or at both ends.

S7 communication is possible via:

- Integrated PROFINET or PROFIBUS DP interface of a CPU
- Interface of a CP/CM

S7 connections configured at one end

For an S7 connection configured at one end, the configuration for this connection takes place in only one communication partner and is only downloaded to it.

A one-sided S7 connection can be configured to a CPU that is only a server of an S7 connection (e.g. CPU 315-2 DP). The CPU is configured and the address parameters and interfaces are thus known.

In addition, a one-sided S7 connection can be configured to a partner who is not in the project and whose address parameters and interface and therefore are not known. You need to enter the address; it is not checked by STEP 7. The partner is initially unspecified (no partner address is registered when you create the S7 connection). Once you enter the address, it is "unknown" (i.e. it is named, but the project is unknown).

This makes it possible to use S7 connections beyond the boundaries of a project. The communication partner is unknown to the local project (unspecified) and is configured in another STEP 7 or third-party project.

S7 connections configured at both ends

When an S7 connection is configured at both ends, the configuration and download of the configured S7 connection parameters takes place in both communication partners.

Instructions for S7 communication

For S7 communication with S7-1500, the following instructions can be used:

- PUT/GET

  You write data to a remote CPU with the PUT instruction. You can use the GET instruction to read data from a remote CPU. The PUT and GET instructions and are one-sided instructions, i.e. you need only an instruction in one communication partner. You can can easily set up the PUT and GET instructions via the connection configuration.

  Note

  Data blocks for PUT/GET instructions

  When using the PUT/GET instructions, you can only use data blocks with absolute addressing. Symbolic addressing of data blocks is not possible.

  You must also enable this service for protection in the CPU configuration in the "Protection" area.

  This FAQ (https://support.industry.siemens.com/cs/ww/en/view/82212115) provides information about how to configure and program an S7 instruction and the GET and PUT communication instructions for data exchange between two S7-1500 CPUs.

- BSEND/BRCV

  The BSEND instruction sends data to a remote partner instruction of the type BRCV. The BRCV instruction receives data from a remote partner instruction of the type BSEND. You use the S7 communication via the BSEND/BRCV instruction pair for secure transmission of data.

- USEND/URCV

  The USEND instruction sends data to a remote partner instruction of the type URCV. The URCV instruction receives data from a remote partner instruction of the type USEND. You use the S7 communication via the USEND/URCV instruction pair for fast, non-secure transmission of data regardless of the timing of the processing by the communications partner; for example for operating and maintenance messages.

S7 communication via PROFIBUS DP interface in slave mode

You can find the "Test, commissioning, routing" check box in STEP 7 in the properties of the PROFIBUS DP interface of communications modules (e.g. CM 1542-5). Using this check box, you decide whether the PROFIBUS DP interface of the DP slave is an active or passive device on PROFIBUS.

- Check box selected: The slave is an active device on PROFIBUS.
- Check box cleared: The DP slave is a passive device on PROFIBUS. You can only set up S7 connections configured at one end for this DP slave.

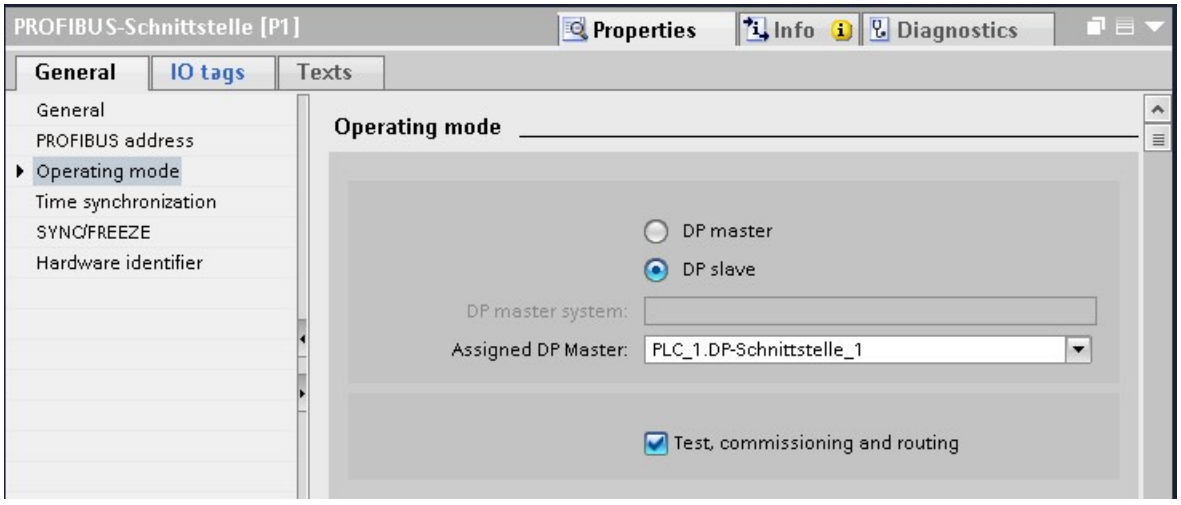


Figure 7-1 "Test, commissioning, routing" check box

Configuring S7 connections for PUT/GET instructions

You can create S7 connections and assign the parameters for these in the connection parameter assignment of the PUT/GET instructions. Changed values are checked immediately by the connection parameter assignment for input errors.

Requirement: A PUT or GET instruction is created in the programming editor.

To configure an S7 connection using PUT/GET instructions, follow these steps:

1. In the program editor, select the call of the PUT or GET instruction.
2. Open the "Properties > Configuration" tab in the inspector window.

3. Select the "Connection parameters" group. Until you select a connection partner, only the empty drop-down list for the partner end point is enabled. All other input options are disabled.

   The connection parameters already known are displayed:

   – Name of the local end point
   – Interface of the local end point
   – IPv4 address of the local end point

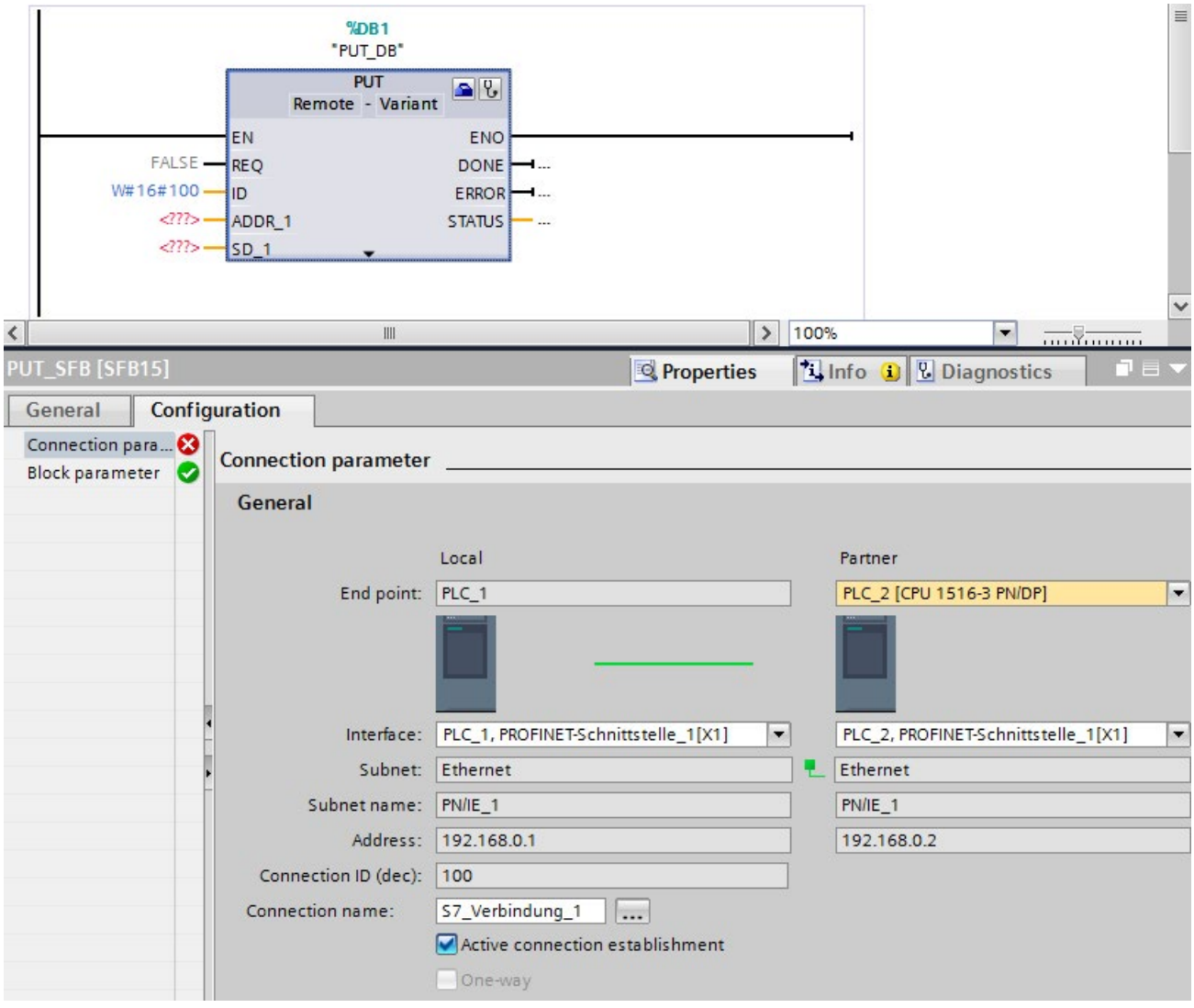


Figure 7-2 Connection configuration for PUT instruction

4. In the drop-down list box of the partner end point, select a connection partner. You can select an unspecified device or a CPU in the project as the communication partner.

   The following parameters are automatically entered as soon as you have selected the connection partner:

   – Name of the partner end point
   – Interface of the partner end point. If several interfaces are available, you can change the interface as required.
   – Interface type of the partner end point
   – Subnet name of both end points
   – IPv4 address of the partner end point
   – Name of the connection which is used for the communication.

5. If required, change the connection name in the "Connection name" input box. If you want to create a new connection or edit an existing connection, click on the "Select connection" button on the right side next to the input box for the connection name.

Note

The PUT and GET instructions between two communication partners can only run if both the hardware configuration and the program part for the partner end point have been loaded into the hardware. To achieve fully functional communication, make sure that you load not only the connection description of the local CPU on the device but also that of the partner CPU as well.

Configuring S7 connections for e.g. BSEND/BRCV

If you want to use the instructions for BSEND/BRCV for S7 communication, for example, you first need to configure an S7 connection.

To configure a S7 connection, follow these steps:

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and the "S7 connection" entry from the drop-down list.
3. Using drag-and-drop, connect the communication partner with each other (via an interface or local end point). If the required S7 subnet does not yet exist, it is created automatically.

   You can also set up a connection to unspecified partners.

4. In the "Connections" tab, select the row of the S7 connection.
5. Set the properties of the S7 connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

   For S7 connections to an unspecified partner, set the address of the partner.
   You can find the local ID (reference of the S7 connection in the user program) in the "Local ID" area.

6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.
7. In the program editor, call the relevant instructions for S7 communication in the user program of the communication partner (configured at one end) or in the user programs of the communication partners (configured at both ends). Select the BSEND and BRCV instructions from the "Communication" area of the "Instructions" task card, for example, and drag them to a network of OB1.
8. At the ID parameter of the instruction, assign the local ID of the configured connection to be used for the transmission of data.
9. Assign the parameters for the instructions indicating which data will be written to where and which data will be read from where.
10. Download the hardware configuration and user program to the CPU(s).

S7 communication via CP 1543-1

If you set up S7 communication via the Industrial Ethernet interface of the CP 1543-1, you can select the transport protocol for data transfer in the properties of the S7 connection under "General":

- "TCP/IP" check box selected (default): ISO-on-TCP (RFC1006): for S7 communication between S7-1500 CPUs
- "TCP/IP" check box cleared: ISO protocol (IEC8073): Addressing using MAC addresses

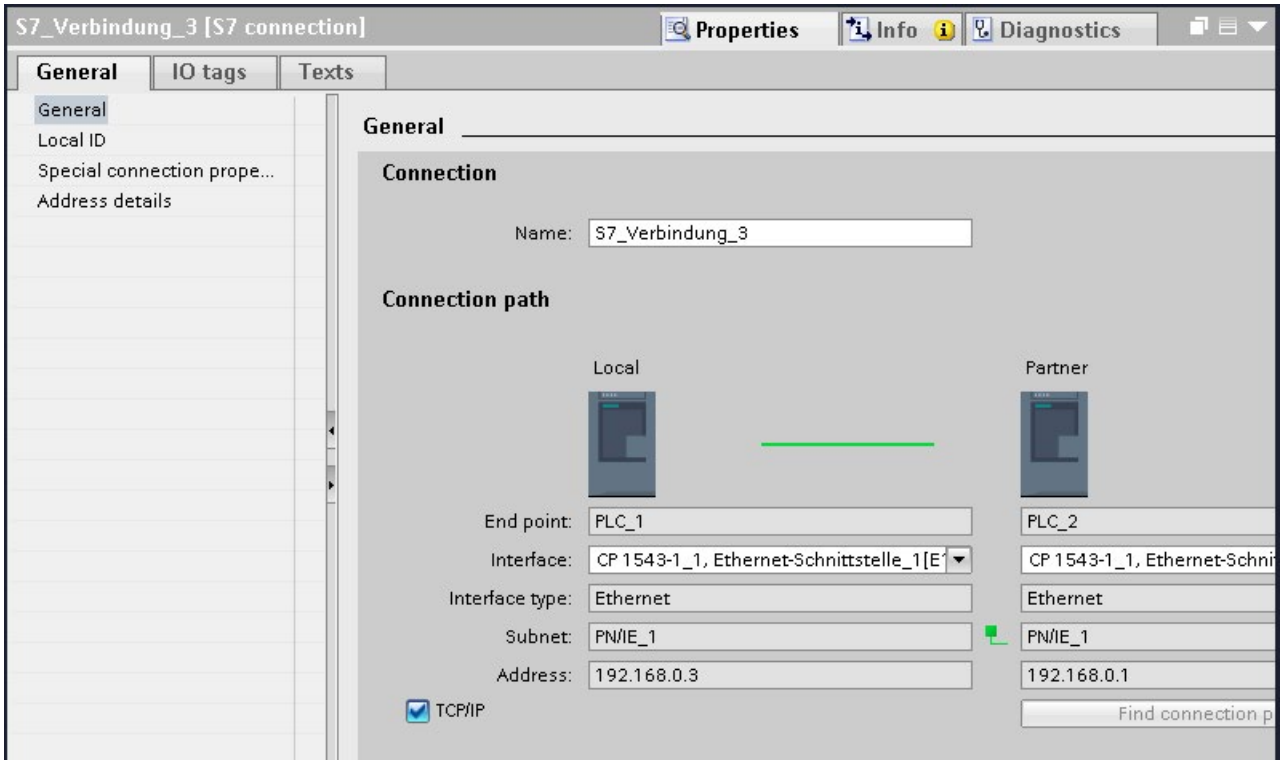


Figure 7-3 Selecting the CP 1543-1 transport protocol

Procedure for setting up an S7 connection via different S7 subnets

You have the option of using an S7 connection over multiple S7 subnets (PROFIBUS, PROFINET/Industrial Ethernet) (S7 routing (Page 175)).

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Network" button.
3. Connect the relevant interfaces with the S7 subnets (PROFIBUS, PROFINET/Industrial Ethernet) using drag-and-drop.
4. Select the "Connections" button and the "S7 connection" entry from the drop-down list.

5. Using drag-and-drop in our example, connect PLC_1 in the left S7 subnet (PROFIBUS) to PLC_3 in the right S7 subnet (PROFINET).

   The S7 connection between CPU 1 and CPU 3 is configured.

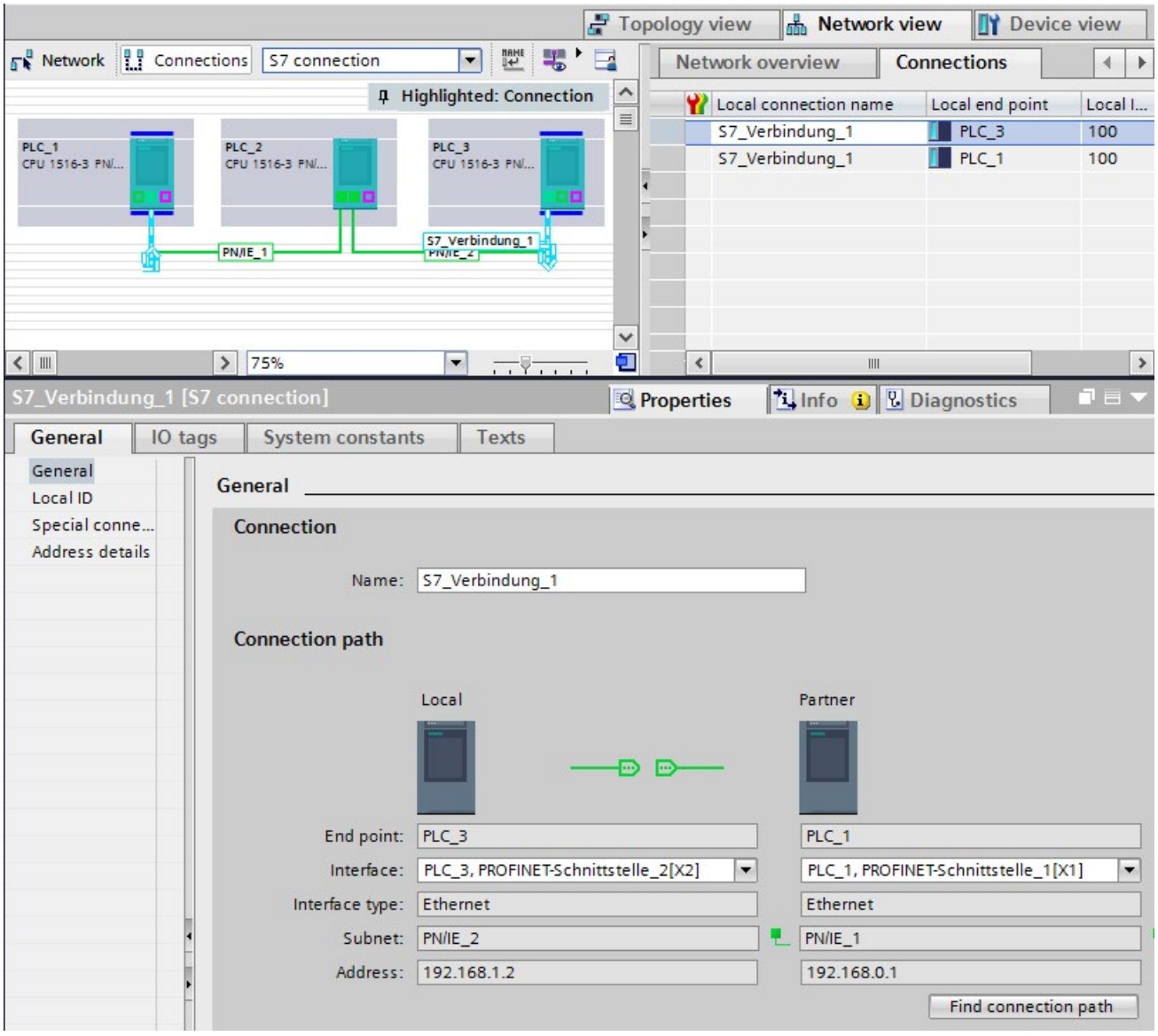


Figure 7-4 S7 connections via different subnets

ET 200SP Open Controller as router for S7 connections

If you assign the "PROFINET onboard [X2]" interface to the CPU 1515SP PC (F) of the SIMATIC PC station, the CPU 1515SP PC (F) can be used as a router for S7 connections. If you use the CP interface for "None, or a different Windows setting", you cannot use the Open Controller as a router for routed S7 connections.

An existing S7 connection routed by the CPU 1515SP PC (F) becomes invalid if the assignment of the interface of the CPU 1515SP PC (F) is changed from "SIMATIC PC station" to "None, or a different Windows setting". Since the PLC now no longer handles routing functions for this connection, when the CPU 1515SP PC (F) is compiled, no message relating to the invalid connection is displayed. The invalid routed S7 connection is displayed only when the end points of the connection are compiled.

The interfaces required for routed S7 connections must remain explicitly assigned on the CPU 1515SP PC (F) . You can edit the assignment of the interface of the CPU 1515SP PC (F) in the properties under "PROFINET onboard [X2] > Interface assignment".

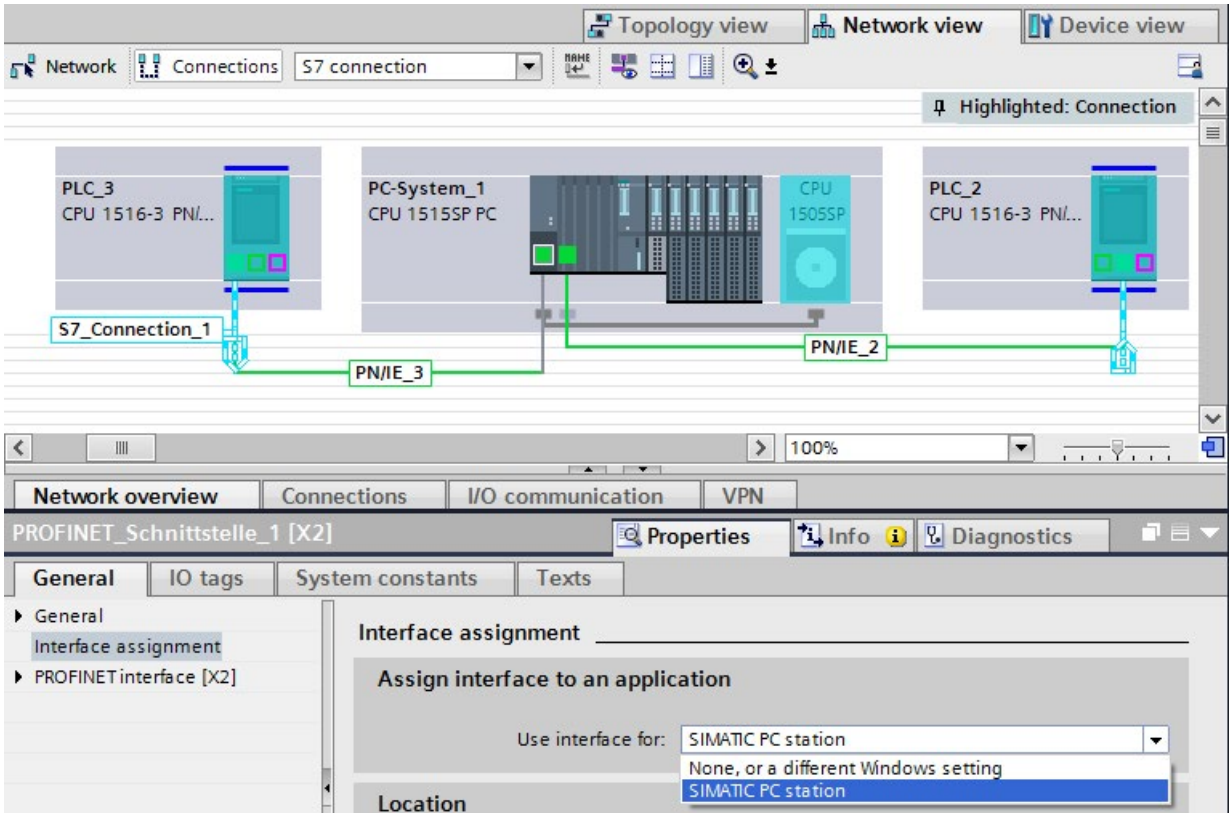


Figure 7-5 S7 routing PC station

Additional information

You can find detailed information on configuring S7 connections and how to use the instructions for S7 communication in the user program in the STEP 7 online help.

Point-to-point link

8

Functionality

A point-to-point connection for S7-1500, ET 200MP and ET 200SP is established via communications modules (CMs) with serial interfaces (RS232, RS422 or RS485):

- S7-1500/ET 200MP:
  - CM PtP RS232 BA
  - CM PtP RS422/485 BA
  - CM PtP RS232 HF
  - CM PtP RS422/485 HF
- ET 200SP:
  - CM PtP

The bidirectional data exchange via a point-to-point connection works between communications modules or third-party systems or devices capable of communication. At least 2 communication partners are required for communication ("point-to-point"). With RS422 and RS485, more than two communications partners are possible.

Protocols for communication via a point-to-point connection

- Freeport protocol (also called ASCII protocol)
- Procedure 3964(R)
- Modbus protocol in RTU format (RTU: Remote Terminal Unit)
- USS protocol (universal serial interface protocol)

The protocols use different layers according to the ISO/OSI reference model:

- Freeport: Uses layer 1 (physical layer)
- 3964 (R), USS and Modbus: Use layer 1 and 2 (physical layer and data link layer; therefore greater transmission reliability than with Freeport). USS and Modbus use additionally layer 4.

Properties of the Freeport protocol

- The recipient recognizes the end of the data transfer by means of a selectable end criterion (e.g. character delay time elapsed, receipt of end character, receipt of a fixed amount of data).
- The sender cannot recognize whether the sent data arrived free of errors at the recipient.

Properties of procedure 3964 (R)

- When the data is sent, control characters are added (start, end and block check characters). Make sure that these control characters are not included as data in the frame.
- Connection establishment and termination makes use of control characters.
- If transfer errors occur, data transfer is automatically repeated.

Data exchange using Freeport or 3964 (R) communication

The data to be sent is stored in the user program of the corresponding CPU in data blocks (send buffer). A receive buffer is available on the communications module for the received data. Check the properties of the receive buffer and adapt them if necessary. You must create a data block for receiving in the CPU.

In the user program of the CPU, the "Send_P2P" and "Receive_P2P" instructions handle the data transfer between the CPU and CM.

Procedure for setting up Freeport or 3964 (R) communication

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. Select the interface of the CM in the device view of STEP 7.
3. Assign the parameters of the interface (for example connection communication, configuration of message sending) in the Inspector window of STEP 7 under "Properties" > "General".
4. Select the "Send_P2P" or "Receive_P2P" instruction in the "Instructions" task card under "Communication" > "Communications processor" and drag-and-drop the instruction into the user program (for example into a FB).
5. Assign the parameters for the instructions according to your configuration.
6. Download the hardware configuration and user program to the CPU.

Otherwise: Dynamic parameter assignment of the communications module

In certain types of application it is an advantage to set up communication dynamically; in other words, program-controlled by a specific application.

Typical applications for this, could be, for example manufacturers of serial machines. To make the user interfaces as convenient as possible for their customers, these manufacturers adapt the communications services to the particular operator entries.

Instructions for Freeport communication

There are 3 instructions available for the dynamic configuration in the user program for Freeport communication. The following applies to all 3 instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "Send_Config" instruction is used for the dynamic configuration, for example of time intervals and breaks in transmission (serial transmission parameters) for the relevant port.
- The "Receive_Config" instruction is used for dynamic configuration, for example of conditions for the start and end of a message to be transferred (serial receive parameters) for the relevant port.

Instructions for 3964 (R) communication

There are 2 instructions available for dynamic configuration in the user program for 3964 (R) communication. The following applies to the instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "P3964_Config" instruction is used for the dynamic configuration of protocol parameters.

Properties of the USS protocol

- Simple, serial data transfer protocol with cyclic message frame traffic in half duplex mode that is tailored to the requirements of drive technology.
- Data transfer works according to the master-slave principle.
  - The master has access to the functions of the drive and can, among other things, control the drive, read status values and read and write the drive parameters.

Data exchange using USS communication

The communications module is the master. The master continuously sends frames (job frames) to the up to 16 drives and expects a response frame from each addressed drive.

A drive sends a response frame under the following conditions:

- When a frame is received without errors
- When the drive is addressed in this frame

A drive must not send if these conditions are not met or the drive was addressed in the broadcast.

The connection to the relevant drive exists for the master once it receives a response frame from the drive after a specified processing time (response delay time).

Procedure for setting up USS communication

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the instructions for USS communication according to your task in the "Communication" area, "Communications processor" folder of the "Instructions" task card and drag them to a network of OB1:
   - The "USS_Port_Scan" instruction allows you to communicate via the USS network.
   - The "USS_Drive_Control" instruction prepares send data for the drive and evaluates the response data of the drive.
   - The "USS_Read_Param" instruction is used to read out parameters from the drive.
   - The "USS_Write_Param" instruction is used to change parameters on the drive.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

Properties of the Modbus protocol (RTU)

- Communication takes the form of serial, asynchronous transfer with a transmission speed of up to 115.2 kbps, half duplex.
- Data transfer works according to the master-slave principle.
- The Modbus master can send jobs for reading and writing operands to the Modbus slave:
  - Reading inputs, timers, counters, outputs, memory bits, data blocks
  - Writing outputs, memory bits, data blocks
- Broadcast to all slaves is possible.

Data exchange using Modbus communication (RTU)

The communications module can be a Modbus master or Modbus slave. A Modbus master can communicate with one or more Modbus slaves (the number depends on the physical interface). Only the Modbus slave explicitly addressed by the Modbus master is permitted to return data to the Modbus master. The slave detects the end of the data transfer and acknowledges it. If an error occurs, it provides an error code to the master.

Procedure for setting up Modbus communication (RTU)

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the instructions for Modbus communication according to your task in the "Communication" area, "Communications processor" folder of the "Instructions" task card and drag them to a network of OB1:
   - The "Modbus_Comm_Load" instruction configures the port of the CM for Modbus communication.
   - The "Modbus_Master" instruction is used for Modbus master functionality.
   - The "Modbus_Slave" instruction is used for Modbus slave functionality.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

Additional information

- You can find more detailed information on communication via point-to-point connections and basics of serial data transmission in the function manual CM PtP communication module - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).
- You can find a description of how to use the instructions for point-to-point connections in the user program in the STEP 7 online help.
- You can find information about the communications modules with a serial interface in the manual of the particular communications module.

OPC UA server

9

9.1 What you need to know about OPC UA

9.1.1 OPC UA and Industry 4.0

Uniform standard for data exchange

Industry 4.0 stands for the intensive utilization, evaluation and analysis of data from the production in IT systems of the enterprise level.

PLC programs today already record a wide range of data at the production and process level (pressure values, temperatures and counter readings) and make them available to systems at the enterprise level, for example, to increase the product quality.

With Industry 4.0 the data exchange between the production and enterprise levels will increase much faster in the future.

However, prerequisite for the success of Industry 4.0 is a uniform standard for data exchange.

The OPC UA (Unified Architecture) standard is particularly suitable for data exchange across different levels thanks to its independence from specific operating systems, its secure transfer procedures and thanks to the semantic description of the data.

OPC UA not only makes data available, but also information about the data (e.g. data types). This enables machine-interpretable access to the data.

9.1.2 Structure of the description

Using this description

This description is provided for the users of the OPC UA server of an S7-1500 CPU.

With OPC UA one system (server) make data available, other systems (clients) use these data.

Therefore you must use an OPC UA client to access the data of the S7-1500.

To demonstrate the handling of OPC UA clients this description uses the following OPC UA clients:

- "UaExpert" from Unified Automation. An extensive test client that you can use free of charge.

  Unified Automation (https://www.unified-automation.com).

- "UA Sample Client" of the OPC Foundation. This client is available free of charge for users who are registered at the OPC Foundation.

  OPC Foundation (https://opcfoundation.org).

- Example program "UaClient" of SIEMENS.

  The application is available free of charge and shows, for example, how to establish connections between servers and clients, how to read and write PLC tags, see section "Programming the OPC UA client (Page 164)". The program is also used to explain the mode of operation/concepts of OPC UA clients/server in the following sections.

  The source code for the example program is available as appendix to this manual.

You have to configure the server of the S7-1500 before clients can access the data of an S7-1500. The procedure is described in the section "Configuring the OPC UA server of the S7-1500".

A lot of space is given to the topic of security in the description because security considerations are a decisive aspect of OPC UA.

The following section lists the key features of OPC UA in the form of key points.

Application example

Siemens Industry Online Support makes an application example with a client API available. With the functions of this interface, .NET programmers can access the OPC UA server of an S7-1500. The client API is based on the .NET OPC UA stack of the OPC Foundation. You can use the application example and the API free of change; download from here (http://support.automation.siemens.com/WW/view/en/109737901).

9.1.3 Features of OPC UA

The key features

The new standard has the following features:

- OPC UA does not depend on a specific operating system platform.

  OPC UA can, for example, be used with Windows, Linux, Apple OS X, a real-time operating system or a mobile operating system (such as Android).

- OPC UA is implemented in several programming languages.

  The OPC Foundation has implemented the OPC UA standard in several programming languages: Stacks are available for ANSI C, .NET and Java.

- The OPC Foundation provides the Java and .Net stack as well as example programs as open source software. See Github (https://github.com/opcfoundation).

- Several companies offer software development kits (SDKs) that contain stacks of the OPC Foundation and additional functions.

  This reduces the development work required for OPC UA applications.

- Scalability:

  OPC UA can be used in sensors, embedded systems, controllers, PC systems and smartphones, and in servers running MES and ERP applications.

- OPC UA operates on the client-server principle:

  An OPC UA server provides information within a network.

  An OPC UA client accesses this information.

- Integrated security mechanisms

  OPC UA uses security mechanisms at various different levels:

  – A secure connection can be established between an OPC UA server and an OPC UA client if the client and server can prove their identities with certificates (X.509 V3) and accept each other's certificates (security at the application level).

    Alternatively, an unsecured connection between server and client is possible ("None"), depending on the configuration.

  – A server can request user authentication for access to information from the user. Depending on the configuration, this can be by means of certificate (not configurable in Step 7), user name/password, or without requirement (guest access).

  The security mechanisms are optional and can be configured.

- OPC UA does not depend on a specific transport layer.

  The following transport mechanisms are currently supported by OPC UA:

  – The transfer of messages as a binary stream directly over TCP/IP

  – The transfer of messages with XML (over TCP/IP and HTTP; only slow transfer is possible and therefore rarely used; cannot be configured in STEP 7)

  Rapid data exchange directly over TCP/IP is supported by all OPC UA applications (required in the OPC UA specification).

- PLC tag mapping

  The information from the OPC UA server (for example the PLC tags) is modeled as nodes connected over references. This makes it possible to navigate from node to node with an OPC UA client and find out what content can be read, monitored or written.
- Metadata

  OPC UA servers can provide a lot of information, for example, on the CPU, the OPC UA server itself, the data and the data types. OPC UA is based on a type instance concept. Both instances and their type definitions are available in runtime.

9.1.4 From the classic OPC interface to OPC UA

Standard interface

Traditional OPC only runs on Windows operating systems.

To get around this restriction, the OPC Foundation developed the OPC UA standard.

The standard is non-platform-specific and uses widespread standard protocols (TCP/IP).

Different systems are therefore able to exchange data, for example:

- Controllers and MES and ERP systems
- Siemens controllers and controllers from other manufacturers
- Smartphones and controllers
- Embedded systems and controllers
- Smart sensors and controllers

9.1.5 The OPC UA server of CPU S7-1500

The OPC UA server of CPU 1500

The S7-1500 CPUs as of firmware 2.0 are equipped with an OPC UA server.

"S7-1500 CPUs" also refers to the CPU variants S7-1500F, S7-1500T, S7-1500C as well as S7-1500pro CPUs, ET 200SP CPUs as well as the SIMATIC S7-1500 SW controller.

Access to the OPC UA server of the CPU is possible over all integrated PROFINET interfaces of the CPU 1500. Exception: With SIMATIC S7-1500 SW controllers, access to the OPC UA server is only possible via interfaces that are used for the software PLC.

For firmware 2.0, access over CP or CM is not possible.

For access by clients, the server saves the enabled PLC tags and other information in the form of nodes (see Configuring access to PLC tags (Page 145)).

The nodes are connected and form a network.

OPC UA defines access points to this network (well-known nodes) that enable navigation to subordinate nodes.

You can read, monitor and write values of tags in the PLC program with an OPC UA client.

9.1.6 Address space of the OPC UA server

Different node classes

OPC UA servers provide information in the form of nodes.

A node can, for example, be an object, a tag or a method.

The example below shows the address space of the OPC UA server of an S7-1500 CPU (extract from the OPC UA client "UaExpert" from Unified Automation).

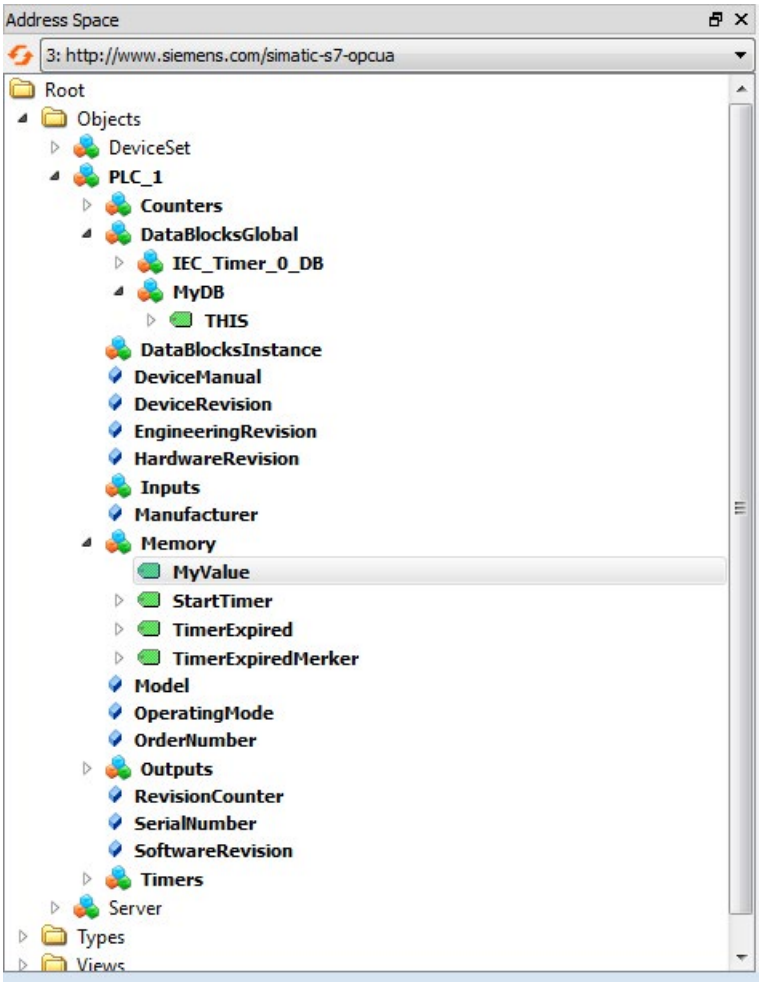


Figure 9-1 Address space of the OPC UA server of an S7-1500 CPU

The following nodes in the example above belong to the "Object" node class: "Objects", "DeviceSet", "PLC_1".

And the following nodes belong to the "Tag" node class: "THIS" below "MyDB", "MyValue", "StartTimer".

Nodes have numerous attributes, for example, "NodeId", "BrowseName", "Description".

Tags also have the attribute "Value", which contains the value of PLC tags.

Address space

The nodes are linked over references, for example, the reference "HasComponent", which represents a hierarchical relationship between a node and its subordinate nodes.

With their references, the nodes form a network that can but does not necessarily take the form of a tree.

A network of nodes is also referred to as the address space.

All the nodes in the address space of the OPC UA server of the S7-1500 CPU can be accessed starting from the root.

9.1.7 End points of the OPC UA servers

Various security policies

Before a secure connection is established, OPC UA clients query from the server the security policies with which connections can be established.

The server returns a list with all end points and the associated security policies that the server offers.

The example below shows the end points of a OPC UA server of an S7-1500 CPU (extract from the example program "UaClient" from Siemens; see section "Programming the OPC UA client (Page 164)"):

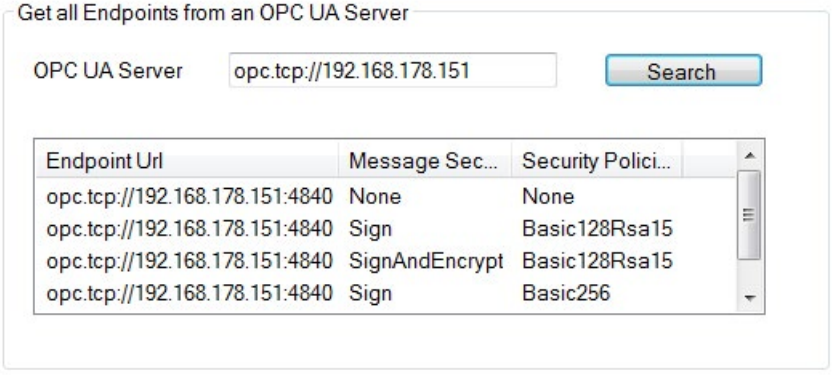


Figure 9-2 End points of the OPC UA server of an S7-1500 CPU in the example program "UaClient" of SIEMENS

For information on configuring the end points of an S7-1500, see the section "Handling of the server and client certificates (Page 156)".

Structure of end points

End points consist of the following components:

- Identifier for OPC: "opc.tcp"
- IP address: 192.168.178.151 (in our example)
- Port number for OPC UA: 4840 (default port)

  The port number can be configured, see section "Settings of the OPC UA server (Page 151)".
- Security settings for messages (Message Security Mode): None, Sign, SignAndEncrypt.
- Encryption and hash procedures (Security Policy): None, Basic128Rsa15, Basic256, Basic256Sha256 (in our example).

The following figure shows the program "UA Sample Client" of the OPC Foundation.

The client has established a secure connection to the OPC UA server of an S7-1500 CPU to the end point "opc.tcp://192.168.178.151:4840 - [SignAndEncrypt: Basic 128Rsa 15: Binary".

The security policies "SignAndEncrypt": Basic 128Rsa 15" are contained in the end point.

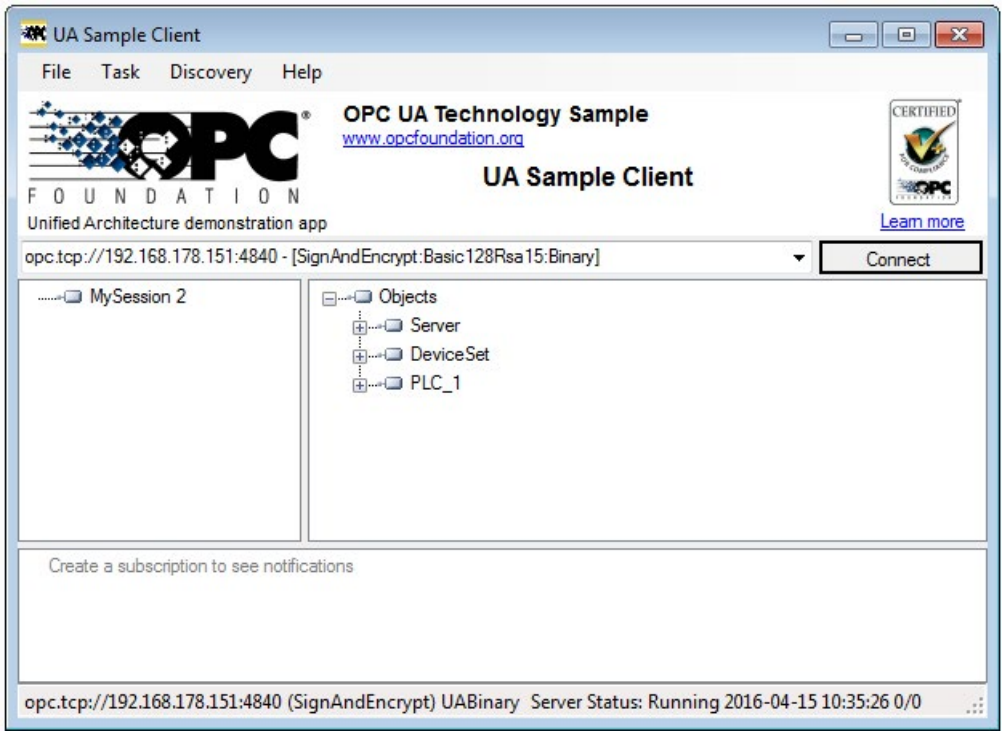


Figure 9-3 Extract from the example program "UA Sample Client"

A connection to a server end point is only established if the OPC UA client complies with the required security policies of this end point.

What information does an OPC UA server provide?

OPC UA servers provide a wide range of data:

- The values of PLC/DB tags which the clients can access.
- The data types of these PLC/DB tags.
- Information about the OPC UA server itself and about the CPU.

This gives clients an overview and allows them to read out specific information.

Previous knowledge of the PLC program and the CPU data is not required.

For example, you do not need to ask the developer of the PLC program when PLC tags are to be read. All necessary information is stored on the server itself (for example, the data types of the PLC tags).

How do you access this information?

You have the following options:

- Online: You have all the available information displayed during the OPC UA server runtime. To do so, navigate (browse) the address space of the server.
- Offline: You export an XML file from STEP 7 V14 that is based on the XML schemes of the OPC Foundation.
- Offline with the Openness API of STEP 7 V14: In your program, you use the API (Application Programming Interface) of the TIA Portal to access the function for exporting all PLC tags that can be read by OPC UA (.NET Framework 4.0 is required, see TIA Portal Openness).
- You already know the syntax and the PLC program. In this case, you can access the OPC UA server without first researching the information.

9.1.8 Addressing nodes

Namespace and NodeId

A NodeId uniquely identifies a node in the OPC UA address space.

The NodeId consists of an identifier and a namespace index.

Namespaces are used to avoid naming conflicts.

The OPC Foundation has defined a wide range of nodes that provide information about the given OPC UA server.

In addition, the OPC Foundation has defined basic data and tag types.

These nodes can be found in the namespace of the OPC Foundation and have the index 0.

Siemens namespace and identifier

The namespace "http://www.siemens.com/simatic-s7-opcua" is assigned to the SIMATIC S7-1500.

The SIEMENS namespace currently has the index 3.

This can, however, change if additional namespaces are inserted into the server or if existing ones are deleted.

Therefore it is necessary to query the current index of the namespace from the server before values are read or written.

The figure below shows the result of such a query: The "UaClient" program of SIEMENS is used as an example.

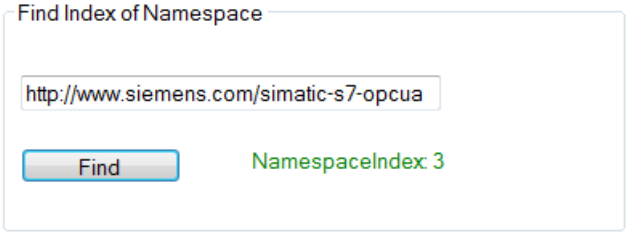


Figure 9-4 Query of namespace index in the example program "UaClient"

Identifier

The identifier corresponds to the name of the PLC tag in quotation marks.

The quotation mark is the only sign that is not permitted as part of a name in STEP 7. Quotation marks avoid naming conflicts.

The following example reads the value of the "StartTimer" tag:

Figure 9-5 Example: Reading out the Boolean tag "StartTimer"

The identifier can consist of several components. The individual components are then separated by a period.

The following example reads the content of the array data block "MyDB".

This data block contains an array with ten integer values.

All ten values are to be read at the same time. Therefore "0:9" ids entered at the array range.

Figure 9-6 Example: Reading out the array data block "MyDB"

The PLC tags in the address range of the OPC UA server

The figure below shows where the PLC tags of the example are located in the address space of the OPC UA server (extract from UaClient):

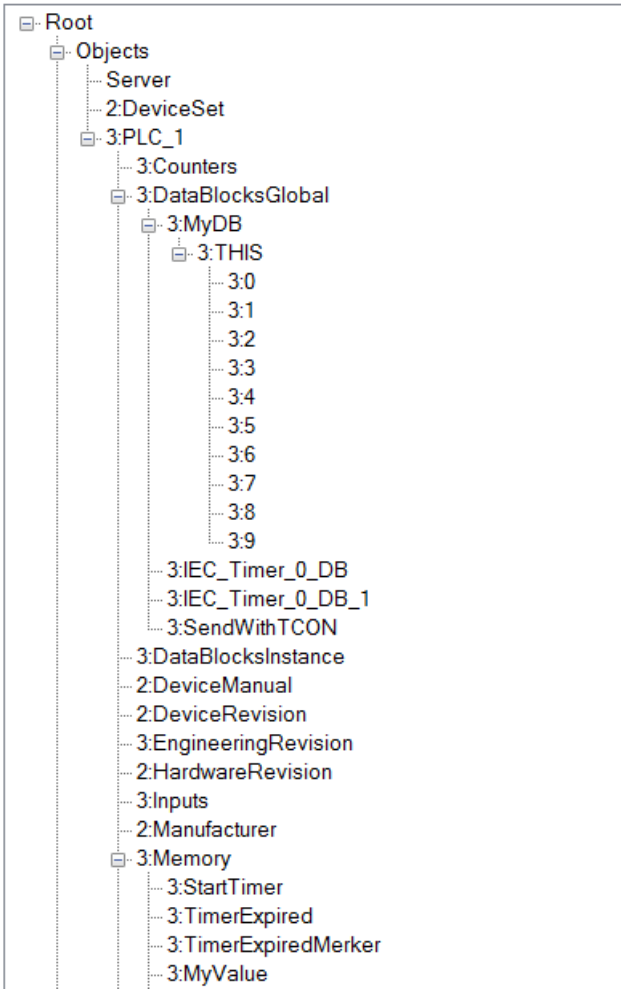


Figure 9-7 Example: PLC tags in the address space of the OPC UA server

The data block "MyDB" is a global data block. Therefore it is located below the "DataBlocksGlobal" node.

"StartTimer" is a memory tag and is therefore stored below the "Memory" node.

9.1.9 The OPC UA client

Reading data from the S7-1500

OPC UA clients are programs that read data from an OPC UA server of an S7-1500 and write data to the server.

The programs can, however, only read and write data that have been enabled for this purpose (see "Managing write and read rights (Page 145)").

To establish a connection to an OPC UA server you need the end points of the server (see section "End points of the OPC UA servers (Page 124)").

Which data exist on a server?

If a connection to the end point of the server exists, you can use the navigation function of the client: You browse starting from a defined starting point (from the "root" node) through the address space of the server.

This provides you with the following information, among other things:

- The enabled PLC tags, data blocks and data block tags
- The namespace index and the identifiers of these PLC tags, data blocks and data block tags
- The data types of the PLC tags and DB tags
- The number of components in arrays (required for reading and writing arrays)
- Information about the OPC UA server itself as well as information about the S7-1500 based on the OPC UA for Devices standard of the OPC Foundation (for example, serial number, firmware version)

Reading data from the server

You now know the namespace index, identifier and data type of PLC tags. This allows you to specifically read individual PLC tags and DB tags as well as complete array data blocks and structures.

Examples for the reading of Boolean tags and array data blocks from the OPC UA server of an S7-1500 CPU are available in the section "Addressing nodes (Page 126)".

Writing data to the server

With the information that you obtain while navigating through the address space of the server (index, identifier and data type) you can also transfer values to the S7-1500 with the OPC UA client.

The following example overwrites the first three values in the array data block "MyDB" (extract from UaClient):

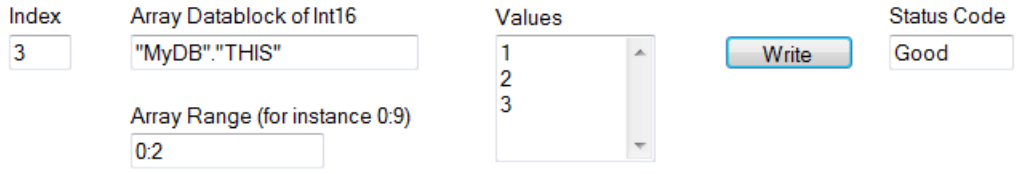


Figure 9-8 Example: Writing values to the array data block "MyDB"

You specify which components of the array you want to overwrite for "Array range".

The "Good" status code indicates that the values were transferred successfully.

However, you can only write the values to the S7-1500, not the time stamps of these values. The time stamps can only be read.

Faster access through registration

The examples up to now use strings as identifiers, for example, "MyBD2."THIS".

If an internal address is used as the identifier instead of a string, however, access is much faster.

If you access specific tags regularly, you should therefore use the functions "RegisteredRead" and "RegisteredWrite":

In the process your client first registers the PLC tags at the server. The server returns an identifier that the client uses for the actual access.

This identifier is only valid for the current session and has to be requested again when the session is disconnected / lost.

In the following example, the "StartTimer" tag of the server was first registered. Subsequently, the rapid function "RegisteredWrite" is used for setting the value.

Figure 9-9 Example: Registered writing for the Boolean tag "StartTimer"

The "RegisteredRead" function can be used according to the same scheme, which makes sense in particular at recurrent reading out of data. Take into account, however, that depending on the application it may be advisable to use a subscription instead.

Subscription

The term "Subscription" is used for a function in which only those tags for which an OPC UA client has registered at the OPC UA server are transferred. The OPC UA server only sends a message to the OPC UA client for these registered tags (subscriptions) when a value has changed. The monitoring of these tags makes constant sampling by the OPC UA client superfluous; the network load is thus reduced.

You must create a subscription to use this function.

To this purpose you specify the "Publishing Interval" (send interval) for the UaClient and click the "Create" button.

The "Publishing Interval" is the interval at which new values are sent to the client.

A subscription was created for the following example: Every 50 milliseconds, the client receives a message with the new values (Publishing Interval 50 ms) if the values have changed.

You can set the OPC UA server of the S7-1500 CPU by means of the "Minimum publishing interval" so that it does not serve extremely short send intervals requested by the client, see Settings of the OPC UA server (Page 151).

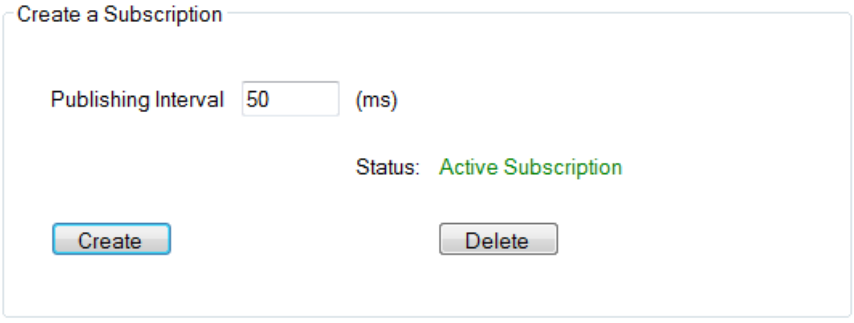


Figure 9-10 Creating a subscription

Which PLC tags are monitored?

When the subscription has been created, you specify for the server the tags it is to monitor.

In the following example the "Voltage" tag was added to the subscription.

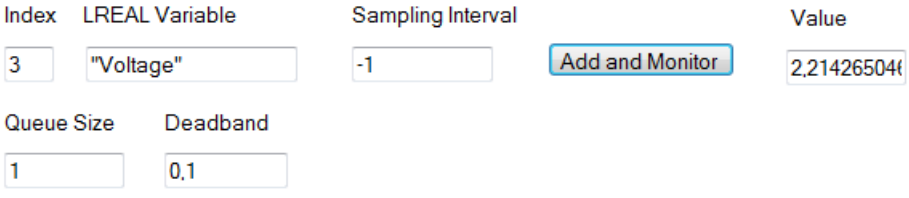


Figure 9-11 Example: "Voltage" tag has been added to the subscription

The "Voltage" tag contains the voltage variable that is detected by an S7-1500 CPU (via an analog input module AI 4xU/I 2-wire).

The sampling interval contains a negative value (-1). This specifies that the OPC UA server checks for changes to the values with the smallest possible interval.

In this example, the length of the queue is set to the value "1": Only one value is always read at an interval of 50 milliseconds from the CPU and subsequently sent to the OPC UA client if the value has changed.

The "Deadband" parameter amounts to "0.1" in the example: Value changes have to amount to at least 0.1 Volt; only then does the server send the new value to the client. Smaller value changes are not sent.

You can use this parameter, for example, to suppress signal noise: Minor changes in a process variable that do not have any real significance.

9.2 Security with OPC UA

9.2.1 Security

This section addresses the question of security with digital certificates and encrypted connections between an OPC UA server and clients.

What level of security is required in a given project?

What are digital certificates?

What is the role of certificates in the establishment of secure connections?

9.2.2 Do not disable security policies

Addressing risks

OPC UA allows the exchange of data between different systems, both within the process and production levels and to systems at the control and enterprise level.

This possibility also entails security risks. That is why OPC UA uses a range of security mechanisms:

- Verification of the identity of OPC UA server and clients.
- Verification of the identity of the user.
- Signed / encrypted data exchange between OPC UA server and clients.

These security policies should only be bypassed in specific cases where it is absolutely necessary:

- During commissioning
- In stand-alone projects with no external Ethernet connection.

If you have selected the end point "None" for "UA Sample Client" of the OPC Foundation, for example, the program issues a clear warning:

Figure 9-12 Security warning in the example program "UA Sample Client"

Connections to the end point "None" are not secure

The OPC UA server of the S7-1500 CPU sends it public certificate to the client also at "None". And some clients verify this certificate. But the client does not send a certificate to the server. The identity of the client remains unknown with "None".

The data traffic between the server and the client is not secure (neither signed nor encrypted). In the case of a connection of the end point "None" you can record the data traffic, for example, by using the network analysis tool Wireshark that allows the recording and analysis of the data traffic in a network.

Rules

- Only use the end point "None" as an exception.
- Only use the "guest authentication" of the user as an exception.
- Only allow access to PLC tags and DB tags via OPC UA if it is genuinely necessary.

9.2.3 Certificates pursuant to ITU X.509

Digital certificates

Security mechanisms are integrated in several layers in OPC UA. Digital certificates have an important role here.

An OPC UA client can only establish a secure connection to an OPC UA server if the server accepts the digital certificate of the client and classifies it as trustworthy. See section Configuring the OPC UA server of the S7-1500 (Page 148).

The client must also check and trust the certificate of the server.

The server and client must show their identities and that they are who they claim to be: They must prove their identity.

Mutual authentication of client and server prevents, for example, man-in-the-middle attacks.

Man-in-the-middle attacks

A "man-in-the-middle" could have positioned itself between server and client. A man-in-the-middle is a program that intercepts communication between server and client and claims to be client or server, and is thus able to obtain information about the S7 program or to set values in the CPU and attack a machine or plant.

OPC UA uses digital certificates that meet standard X.509 of the International Telecommunication Union (ITU).

This allows the identity of a program, a computer or an organization to be proven (authenticated).

X.509 certificates

An X.509 certificate includes the following information:

- Version number of the certificate
- Serial number of the certificate
- Information on the algorithm used by the certificate authority to sign the certificate.
- Name of the certificate authority
- Start and end of the validity period of the certificate
- Name of the program, person or organization for which/whom the certificate has been signed by the certificate authority.
- The public key of the program, person or organization.

An X509 certificate links an identity (name of a program, person or an organization) to the public key of the program, person or organization.

Signing certificates

To allow you to check whether a certificate has been manipulated, certificates are signed.

There are two possible procedures here:

- You contact a certificate authority (CA) and have your certificate signed.

  In this case, the certificate authority verifies your identity and signs your certificate with the private key of the certificate authority.

  You send a CSR (Certificate Signing Request) to the certificate authority to this purpose.

  The procedure for generating a CSR yourself with the OpenSSL tool is described here (Page 138).

- You create a certificate yourself and sign it.

  To this purpose you use the "Opc.Ua.CertificateGenerator" program of the OPC Foundation, for example. The procedure is described here (Page 137).

  Or you use OpenSSL: Instructions are available under Generating PKI key pairs and certificates yourself (Page 138).

Signing

It is not only certificates that you can sign and have signed, but also Word files, PDF files and source code, for example.

Signing starts with the sender creating a hash value from the plain text (plain text message).

The sender then encrypts the hash value with the private key of the sender and subsequently transfers the plain text together with the encrypted hash value to the recipient.

To verify the signature, the recipient needs the public key of the sender (this is contained in the X509 certificate of the sender).

The recipient uses the sender's public key to decrypt the hash value received.

The recipient then forms the hash value themselves from the plain text received (the hash process is contained in the sender's certificate).

The recipient compares the two hash values:

- If the two hash values are identical, the plain text message has reached the sender unchanged: The certificate, Word or PDF file transferred has not been manipulated.
- If the two hash values do not match, the plain text message has not reached the sender in an identical state: The certificate, Word or PDF file transferred has been manipulated or has been damaged during transfer.

The signature makes it possible to prove the integrity of a message.

Encryption

You can encrypt Word files, PDF files and source code, for example. This prevents unauthorized parties from reading the content.

X509 certificates are not encrypted: They are public and can be viewed by anyone.

Encryption involves the sender encrypting the plain text message with the public key of the recipient.

To do so, the sender requires the recipient's X509 certificate, as it contains the public key of the recipient.

The recipient decrypts the message with their private key. Only the recipient can decrypt the message: They alone hold the private key. The private key must therefore never be disclosed.

Secure channel

OPC UA uses the private and public key of client and server to establish a secure connection, the secure channel.

Once the secure connection has been established, the client and server generate an internal key known only to them which they use for signing and encrypting messages.

This symmetric process (a shared key) is much faster than asymmetric processes (private and public key).

9.2.4 Certificates with OPC UA

This section describes how OPC UA uses X509 certificates.

X509 certificates with OPC UA

OPC UA uses three types of X509 certificates for establishing connections from client to server:

- OPC UA application certificates

  Such X509 certificates identify the software instance, the installation of client or server software.

  For the "Organization name" attribute, you enter the name of the company that uses the software.

  Note:

  The OPC UA server of the S7-1500 also uses application certificates for the security setting "None".

  This ensures compatibility with OPC UA V1.1 and older.

- OPC UA software certificates

  This X509 certificate identifies a specific version of the client or server software.

  These certificates contain attributes that describe which tests this version of the software has passed during certification by the OPC Foundation (or recognized test laboratories).

  For the "Organization name" attribute, you enter the name of the company that has developed (or markets) the software.

  Note: Software certificates are not used with STEP 7 V14.

- OPC UA user certificates

  This X509 certificate identifies the specific user who, for example, accesses process data from the OPC UA server of an S7-1500.

  This certificate is not required if the user can authenticate themselves with a password, or if anonymous access is configured.

  Note: User certificates are not used with STEP 7 V14.

These certificates are end-entity certificates: They identify, for example, a person, an organization, a company, an instance (installation) of a software.

See also

Creating self-signed certificates (Page 137)

9.2.5 Creating self-signed certificates

This chapter is only relevant if an OPC UA client is to be used that cannot itself create a client certificate.

In this section you learn how you can generate a self-signed application certificate for your client with the "OPC.UA.CertificateGenerator" tool of the OPC Foundation.

In the section below you will learn how to use the "OPENSSL" tool to this purpose.

Certificate generator of the OPC Foundation

You can, for example, generate a self-signed certificate with the OPC.UA.CertificateGenerator.

To do this, follow these steps:

1. Download the tool from the website of the OPC Foundation.

   This program is available, for example, on the website of the OPC Foundation (https://opcfoundation.org/developer-tools/developer-kits-unified-architecture) under "Resources > Samples / Code > Unified Architecture" in "Sample Applications".

2. Install the example applications of the OPC Foundation on your computer.
3. Use the Windows Explorer to call the installation directory: It is located under "C:\Program Files (x86)\OPC Foundation\UA 1.02\Sample Applications".
4. Keep the [Shift] key pressed and right-click in the directory so that the shortcut menu is displayed.
5. Select "Open command prompt here".
6. Enter the following command after the prompt character in the command prompt:

   "Opc.Ua.CertificateGenerator -cmd issue -sp . -an MyClient"

7. Press the enter key.
8. The program generates for "MyClient.":
   - In the "certs" subfolder the "MyClient" certificate with the public key of the client
   - In the "private" subfolder the private key of the client.

   "MyClient" is only an example.

   Let us assume that your OPC UA client is called "SuperClient". Then enter the following string in the command prompt:

   "Opc.Ua.CertificateGenerator -cmd issue -sp . -an SuperClient"

   The figure below shows the entry in the command prompt:

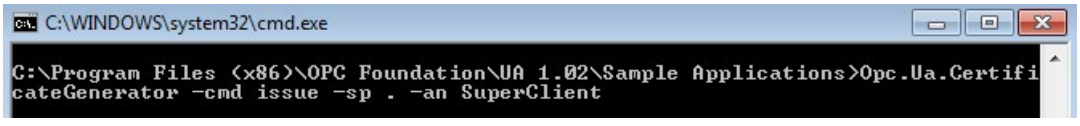


Figure 9-13 Generating a self-signed client certificate with the OPC.UA.CertificateGenerator

The description is based on the Opc.Ua.CertificateGenerator" of the OPC Foundation of June 25, 2015.

A different entry may be necessary for other versions of the generator.

To obtain information about the required entry, follow these steps:

1. Enter the following command in the command prompt: "Opc.Ua.CertificateGenerator -?"

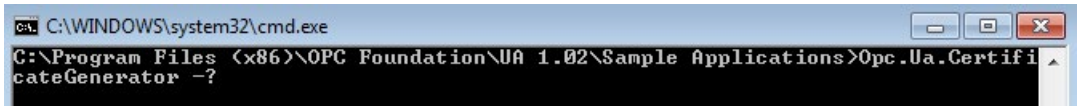


Figure 9-14 Calling the help function

   The help is displayed.

2. Use the options that are entered at "Create a self-signed Application Certificate".

9.2.6 Generating PKI key pairs and certificates yourself

This chapter is only relevant if an OPC UA client is to be used that cannot itself create a PKI key pair and a client certificate.

This section describes how you generate a private and public key with OpenSSL, generate an X509 certificate and sign the certificate yourself.

Using OpenSSL

To work with OpenSSL under Windows, follow these steps:

1. Install OpenSSL with Windows.

   If you are using a 64-bit version of the operating system, install OpenSSL in the "C:\OpenSSL-Win64" directory, for example.

   You can obtain OpenSSL-Win64 as a download from various providers for open source software.

2. Create a directory, for example "C:\demo".
3. Open the command line (cmd.exe).

   Click "Start" and enter "cmd" in the search field.

   Right-click "cmd.exe" in the results list. Execute the program as an administrator.

   Windows then opens the command line (DOS prompt)

4. Switch to the "C:\demo" directory.

   To do this, enter the following command: "cd C:\demo".

5. Set the following network variables:

   set RANDFILE=c:\demo\.rnd

   set OPENSSL_CONF=C:\OpenSSL-Win64\bin\openssl.cfg

   The figure below shows the command line with the following commands:

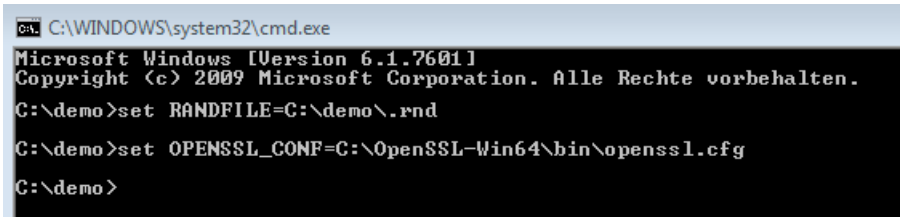


Figure 9-15 Generating PKI key pairs and certificates yourself (1)

6. Now start OpenSSL.

   If OpenSSL has been installed in the directory C:\OpenSSL-Win64, enter the following: C:\OpenSSL-Win64\bin\openssl.exe

   The figure below shows the command line with the following command:

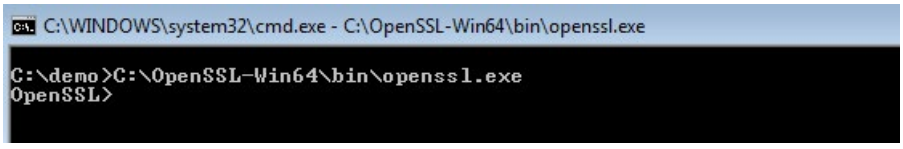


Figure 9-16 Generating PKI key pairs and certificates yourself (2)

7. Generate a private key (the private key also includes the corresponding public key).

   The key should be saved in the "myKey.key" file.

   The key is 1024 bits long

   Enter the following command: "genrsa -out myKey.key 1024"

   The figure below shows the command line with the command and OpenSSL:

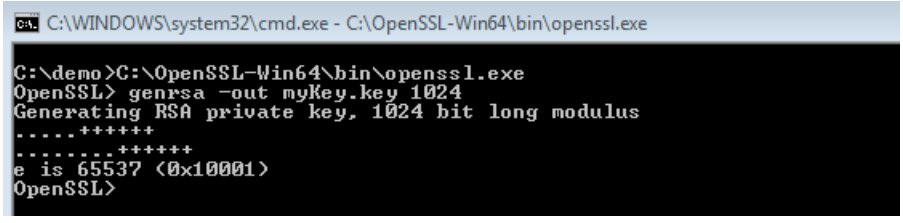


Figure 9-17 Generating PKI key pairs and certificates yourself (3)

8. Generate a CSR (Certificate Signing Request).

   To do this, enter the following command: "req -new -key myKey.key -out myRequest.csr".

   During execution of this command, OpenSSL queries information from your certificate:

   – Country name: for example "DE" for Germany, "FR" for France
   – State or province name: for example: "Bavaria".
   – Location Name: for example "Augsburg".
   – Organization Name: Enter the name of your company here.
   – Organizational Unit Name: for example "IT"
   – Common Name: for example "OPC UA client of machine A"
   – Email Address:

   The information you enter is added to the certificate.

   The figure below shows the command line with the command and OpenSSL:

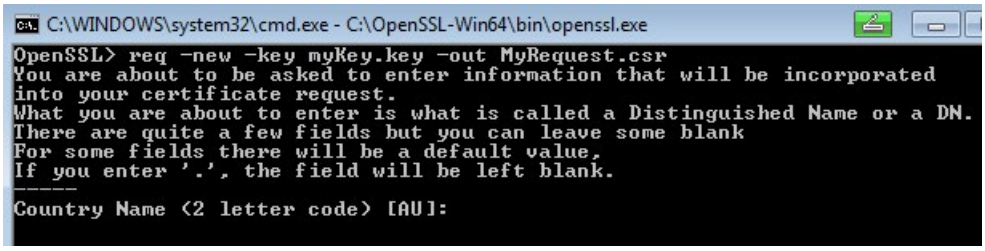


Figure 9-18 Generating PKI key pairs and certificates yourself (4)

The command creates a file in the C:\demo directory containing the certificate signing request (CSR); in the example, this is "myRequest.csr".

There are two ways to use a CSR:

– You send the CSR to a certificate authority (CA):

  Please note the instructions of the certificate authority in question.

  The certificate authority (CA) checks your information and identity (authentication) and signs the certificate with the private key of the certificate authority.

  You receive the signed X509 certificate and use that certificate for OPC UA, HTTPS or S OUC (secure open user communication), for example.

  Your communication partners use the public key of the certificate authority to check whether your certificate was really issued and signed by that CA (i.e. that the certificate authority has confirmed your information).

– You sign the CSR yourself

  Using your private key.

  This option is shown in the next step.

9. Generate and sign your certificate (self-signed certificate)

   To do this, enter the following command: "x509 -req -days 365 -in myRequest.csr -signkey myKey.key -out myCertificate.crt".

   The figure below shows the command line with the command and OpenSSL:

Figure 9-19 Generating PKI key pairs and certificates yourself (5)

The command generates an X509 certificate with the attributes that you transfer with the CSR ("myRequest.csr" in the example). The command also signs the certificate with your private key ("myKey.key" in the example).

Your communication partners can use your public key (contained in your certificate) to check whether your certificate is really from you. This rules out your certificate having been manipulated by an attacker.

With self-signed certificates, you yourself confirm that the information in your certificate is correct. There is no independent body that checks your information.

9.2.7 Secured transferring of messages

Establishing secure connections with OPC UA

OPC UA uses secure connections between client and server. OPC UA checks the identity of the communication partners.

OPC UA uses certificates in accordance with X509-V3 from the ITU for client and server authentication.

Exception: A secure connection is not established with the "None" security mode.

Message security mode

OPC UA uses the following modes to protect messages:

- None

  All messages are not secure.

  In order to use this security mode establish a connection to a None end point of a server.

- Sign

  All messages are signed. This allows the integrity of the messages received to be checked. Manipulations are detected.

  In order to use this security mode establish a connection to a Sign end point of a server.

- SignAndEncrypt

  All messages are signed and encrypted. This allows the integrity of the messages received to be checked. Manipulations are detected and no attacker can read the content of the message (confidentiality protected).

  In order to use this security mode establish a connection to a SignAndEncrypt end point of a server.

Layers required

The figure below shows the three layers that are always required for establishing a secure connection: the transport layer, the secure channel and the session.

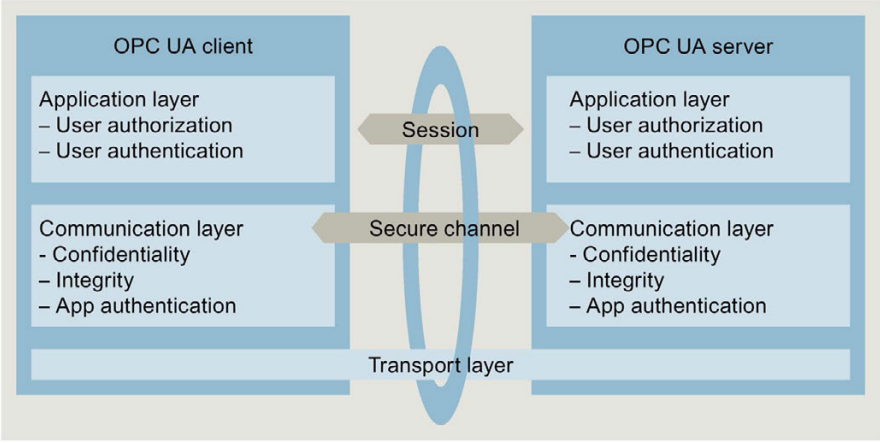


Figure 9-20 Layer model for a UPC UA connection

- Transport layer:

  This layer sends and receives messages. To this purpose OPC UA uses an extension of the standard Ethernet protocol TCP/IP (TCP UA).

  The transport layer is the basis for the subsequent secure channel.

- Secure channel

  The secure channel receives the data received from the transport layer, and forwards that data to the session.

  The secure channel forwards data of the session that are to be sent to the transport layer.

  In "Sign" security mode, the secure channel signs the data (messages) that are sent. When a message is received, the secure channel checks the signature in order to detect any manipulations.

  In "SignAndEncrypt" security mode, the secure channel signs and encrypts the send data. Data received are decrypted by the secure channel, which then checks the signature.

  In "None" security mode, the message packages pass through the secure channel unchanged (the messages are received and sent in plain text).

- Session

  The session forwards the messages from the secure channel to the application or receives from the application the messages that are to be sent. The application uses the process values or provides the values.

Establishing the secure channel

The server starts establishing the secure channel when it receives a request to this effect from the client.

This request is signed or signed and encrypted, or the message is sent in plain text (security mode of the selected server end point). With "Sign" and "SignAndEncrypt", the client sends a secret (random number) with the request.

The server validates the client certificate (contained in the request, unencrypted) and checks the identity of the client.

If the server trusts the client certificate, it decrypts the message and checks the signature ("SignAndEncrypt"), checks the signature only ("Sign") or leaves the message unchanged ("None").

The server then sends a response to the client (same level of security as the request). The server secret is contained in the response. The client and server calculate a symmetric key from the client and server secret.

The secure channel is now established.

The symmetric key (instead of the private and public key of client and server) is now used for signing and encrypting messages.

Establishing the session

The client starts establishing the session by sending a CreateSessionRequest to the server. This message contains a nonce, a random number that is only used once. The server needs to sign this nonce to prove that it is really the subject of the private key belonging to the certificate that the server used to establish the secure channel.

This message too (and all subsequent messages) is secured in line with the security policies for the selected server end point (security mode).

The server then responds with the CreateSession response. This message contains the software certificate of the server and the signed nonce.

The client checks the signed nonce.

If the server passes the test, the client sends a SessionActivate request to the server. This message contains the information that is required for user authentication:

- Either the user name and password

- Or the X509 certificate of the user (not used in STEP 7 V14)

- Or no data (if an anonymous access is configured).

If the user has the necessary rights, the server returns a message to the client (ActivateSession response). This activates the session.

The secure connection between the OPC UA client and server has now been established.

9.3 Configuring access to PLC tags

9.3.1 Managing write and read rights

Enabling PLC tags and DB tags for OPC UA

OPC UA clients can access PLC tags and DB tags reading and writing if the tags are enabled for OPC UA (default setting).

If the tags are enabled, the check box at "Can be accessed from HMI/OPC UA" is activated.

The following example shows an array data block:

MyDB

Name	Data type	Accessible from HMI/OPC UA	Writable from HMI/OPC UA	Visible in HMI engineering
MyDB	Array[0..9] o...	☑	☑	☑
MyDB[0]	Int	☑	☑	☑
MyDB[1]	Int	☑	☑	☑
MyDB[2]	Int	☑	☑	☑
MyDB[3]	Int	☑	☑	☑
MyDB[4]	Int	☑	☑	☑
MyDB[5]	Int	☑	☑	☑
MyDB[6]	Int	☑	☑	☑
MyDB[7]	Int	☑	☑	☑
MyDB[8]	Int	☑	☑	☑
MyDB[9]	Int	☑	☑	☑

Figure 9-21 Example: For array data block enabled for OPC UA

This data block can be read by OPC UA clients completely in one pass (see Addressing nodes (Page 126)).

The check box at "Accessible from HMI/OPC UA" is activated for all the components of the array.

In addition clients can assign new values to all the components of the array because the check box is selected for "Writable from HMI/OPC UA".

In our example OPC UA clients have read and write rights for all the components of the array.

Result: OPC UA clients can both read and write these components.

Removing write rights

If you want to write-protect a tag, deselect the "Writable from HMI/OPC UA" option for the tag. This removes the write right for the OPC UA clients.

Result: Only read access by OPC UA clients is possible. OPC UA clients cannot assign values to these tags and therefore cannot influence execution of the S7 program.

Removing write and read rights

To write-protect and read-protect a tag, disable the "Accessible from HMI/OPC UA" option for that tag (checkbox not selected). This makes the OPC UA server remove the tag from its address space. OPC UA clients can no longer see that CPU tag.

Result: OPC UA clients can neither read nor write the tag.

If you remove the read or write permission from a component of a structure, the structure can no longer be written or read as a whole.

Visible in HMI Engineering

The option "Visible in HMI Engineering" applies to Siemens engineering tools.

If you disable the option "Visible in HMI Engineering" (check mark not set), you can no longer configure the tag in the WinCC TIA Portal. The option has no effect on OPC UA.

Rules

- Only allow read access to PLC tags and tags of data blocks in STEP 7 if this is necessary for communication with other systems (controllers, embedded systems or MES).

  You should not enable other PLC tags.
- Only allow write access over OPC UA if it is genuinely necessary for specific PLC tags and tags of data blocks.

9.3.2 Faster access to arrays and structures

High performance

OPC UA is designed for the transfer of many data in a short time.

You can increase the performance notably if you do not access individual PLC tags, but rather read and write arrays and structures as a whole.

Access to arrays is fastest. Therefore, you should combine the data for OPC UA clients into arrays.

If this is not possible, you should place the data in a structure.

Procedure

To create a data block with an array (array data block), follow these steps:

1. Select the CPU with the OPC UA server in the project tree.
2. Double click "Program blocks".
3. Double-click "Add new block".
4. Click "Data block".
5. Select a unique name for the data block. Or accept a name that is already entered.
6. Select the "Array DB" entry from the "Type" drop-down list.
7. Select the data type for the individual components of the array from the "Array data type" drop-down list.
8. Enter the high limit of the array for "Array limit".
9. Click "OK".

9.3.3 Exporting the XML file with the enabled PLC tags

Generating an OPC UA export file

PLC tags and DB tags that are enabled for OPC UA in your configuration can be exported to an XML file for offline engineering of OPC UA clients. The XML file is based on the XML schemes of the OPC Foundation.

Follow these steps:

1. Select the CPU.

   To do so, click the CPU icon (for example in the network view).

2. In the properties of the CPU click "General > OPC UA > Server > Export".

3. Click the "Export OPC UA XML file" button:

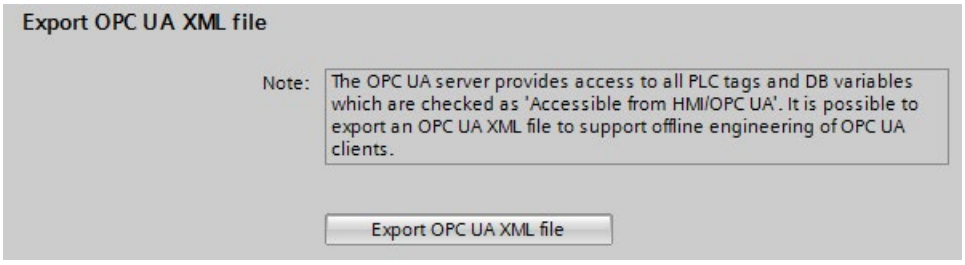


Figure 9-22 Exporting a OPC UA file in STEP 7

4. Select the directory in which you want to save the export file.

5. Select a new name for the file or keep the name that is already entered.

6. Click "Save".

Tip: The ZIP file supplied with this manual contains a converter with which you can extract the tags and Node IDs from the XML into a CSV file. You then obtain a list of the tags of the CPU that can be accessed by OPC UA.

9.4 Configuring the OPC UA server of the S7-1500

9.4.1 Enabling the OPC UA server

Requirements

- You have acquired a runtime license for the operation of the OPC UA server, see Licenses for the OPC UA server (Page 163).
- When using certificates for secure communication (for example, HTTPS, secure OUC, OPC UA), make sure that the corresponding modules have the current time of day and the current date. Otherwise, the modules evaluate the used certificates as invalid and the secure communication does not work.

Commissioning an OPC UA server

In the basic setting the OPC UA server of the CPU is not enabled for security reasons: OPC UA clients have neither write nor read access to the S7-1500.

Proceed as follows to enable the OPC UA server of the CPU.

1. Select the CPU.

   To do so, click the CPU icon (for example in the network view).
2. In the properties of the CPU click "OPC UA > Server".
3. Activate the OPC UA server of the CPU.
4. Confirm the security information.

Settings are retained
If you have already enabled the server and made settings, those settings are not lost if the server is then disabled. The settings continue to be saved and are available when you enable the server again.

Application name

The application name is the name of the OPC UA server of the CPU. It is displayed under "OPC UA > General":

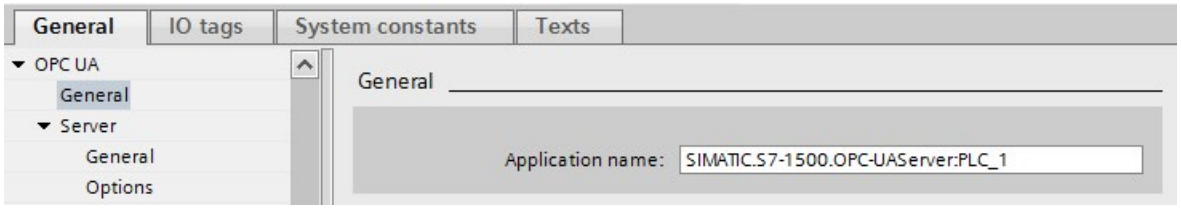


Figure 9-23 Application name of the OPC UA server in STEP 7

The default setting for the server name is: "SIMATIC.S7-1500.OPC-UAServer:PLC1".

The default setting consists of "SIMATIC.S7-1500.OPC-UAServer:" and the name of the CPU selected under "General > Product information > Name", in this case "PLC_1".

Clients can use the application name as a meaningful name for the server.

The example below comes from UaExpert:

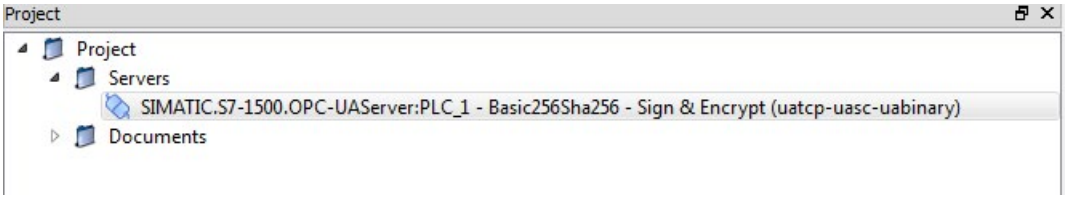


Figure 9-24 Display of the application name in UaExpert

If you have activated the server, you can also use a different name that is meaningful in your project.

Changing the application name

To change the name of the OPC UA server, follow these steps:

1. Select the CPU.

   To do so, click the CPU icon (for example in the network view).
2. In the properties of the CPU click "OPC UA > General".
3. Enter a meaningful name.

9.4.2 Access to the OPC UA server

The OPC UA server of the S7-1500 can always be accessed over all internal PROFINET interfaces of the CPU (however, not over the PROFINET interfaces of CP/CM).

In the example, connections to the OPC UA server of the CPU can be established over the following URLs (Uniform Resource Identifiers):

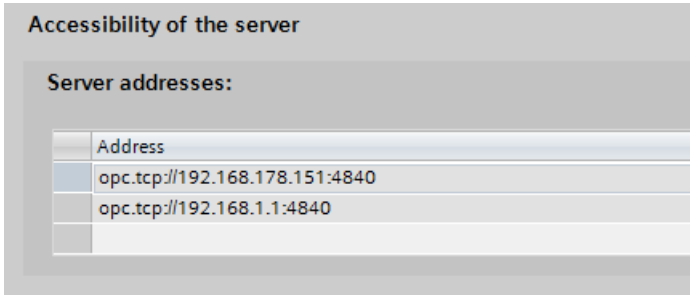


Figure 9-25 Example: URLs of the OPC UA server in STEP 7

The URLs are structured as follows:

- Protocol identifier "opc.tcp://"
- IP address
  - 192.168.178.151

    The IP address at which the OPC UA server can be accessed from Ethernet subnet 192.168.178.
  - 192.168.1.1

    The IP address at which the OPC UA server can be accessed from Ethernet subnet 192.168.1.
- TCP port number
  - Default: 4840 (default port)

    The port number can be changed under "OPC UA server > Settings > Port".

Dynamic IP addresses

In the example below, the IP address for the PROFINET interface [X2] has not yet been specified.

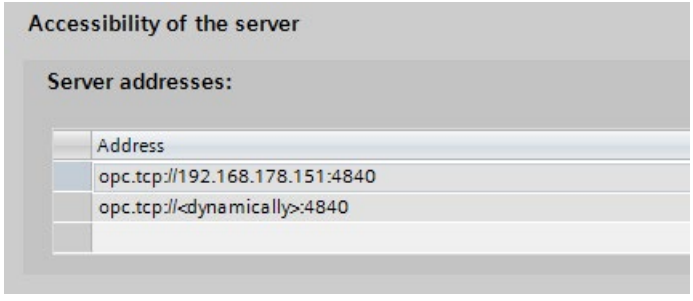


Figure 9-26 Example: URL with dynamic IP address

The wildcard "<dynamically>" appears in the table.

The IP address of this PROFINET interface is set later on the device.

You can, for example, see what IP address has been assigned to the PROFINET interface [X2] (outside the TIA Portal) when you search with an OPC UA client for available OPC UA servers. You then receive a list of available servers together with the IP addresses.

9.4.3 Settings of the OPC UA server

TCP port for OPC UA

By default, OPC UA uses TCP port 4840.

You can, however, select a different port. Entries from 1024 to 49151 are possible.

You must, however, make sure that there are no conflicts with other applications.

OPC UA clients must use the selected port when establishing connections (only default port 4840 can be ignored).

In the example below, port 48400 is selected:

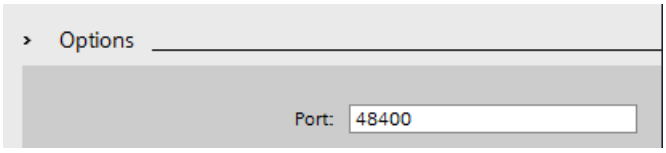


Figure 9-27 Port setting for the OPC UA server in STEP 7

Subscription instead of cyclic queries

An alternative to cyclic queries for a PLC tag (polling) is to supervise the value. This can be done using a subscription: The server then informs the client when the value of PLC tags changes. See section "The OPC UA client (Page 129)".

One server usually monitors a large number of PLC values. In the event of value changes, the server sends the client messages (notifications) containing the new values of the PLC tags.

How frequently does the server send notifications?

When a subscription is set up, the OPC UA client specifies the intervals at which it wants to be sent the new values in the event of changes.

To limit the communication load from OPC UA, you can set a minimum notification interval that must be respected.

Minimum publishing interval

With "Minimum publishing interval", you set the time intervals at which the server sends a notification to the client with the new values in the event of changes.

In the figure below, the "Minimum publishing interval" is set to 200 ms. 100 ms is used as the "minimum sampling interval".

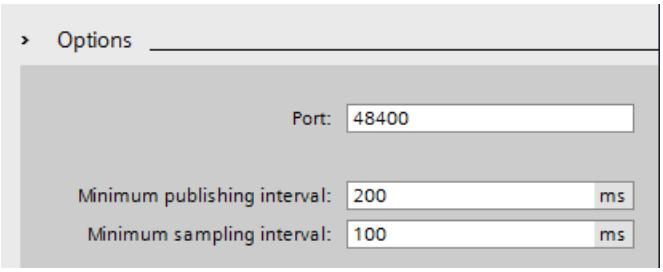


Figure 9-28 "Minimum publishing interval" and "Minimum sampling interval" settings in STEP 7

In the example, the OPC UA server will send a new notification every 200 ms provided the OPC UA client requests such a rapid update when the subscription is set up.

If the OPC UA client requests an update every 1000 ms, for example, the OPC UA server will only send a notification with the new values at most once per second.

If the client requests an update every 100 ms, the server will still only send a message every 200 ms (minimum publishing interval).

Example:

An operator panel is connected to a CPU. A publishing interval of 200 ms is sufficient for the screen refresh because only process values are to be observed that do not change erratically.

The CPU used allows a minimum publishing interval of 10 ms.

The OPC UA client of the operator panel is programmed to request very rapid updates (for example 1 ms).

You can only reduce the communication load with the parameter "Minimum publishing interval" = 200 ms.

Otherwise, an unnecessary number of notifications will be sent to the OPC UA client in the event of value changes.

Minimum sampling interval

With "Minimum sampling interval", you set the time intervals at which the OPC UA server records the value of a CPU tag and compares it with the previous value to detect any changes.

In the example above, an interval of 100 ms is set.

The sampling interval (like the publishing interval) is negotiated between the server and client.

If, in the example, the OPC UA client requests a sampling rate for a specific CPU tag of every 1000 ms, the server will record the value of that tag at intervals of 1000 ms.

If, on the other hand, the OPC UA client in the example requests a sampling rate for a specific CPU tag of every 10 ms, the OPC UA server will record the value of that tag at intervals of 100 ms. In the example, 100 ms is the minimum sampling interval.

If you enter a negative value (for example -1) as the required sampling rate for the OPC UA client, the OPC UA server will use the value set as the "Minimum sampling interval" (in this case 100 ms).

Sampling interval shorter than publishing interval

If the sampling interval is selected smaller than the publishing interval, and an OPC UA client requests such a high sampling rate for certain PLC tags, two or more value changes may be measured during each publishing interval.

In this case, the OPC UA server writes the value changes into the queue and sends all value changes to the client after the completion of the publishing interval. If more value changes occur in the publishing interval than fit in the queue, the OPC UA server overwrites the oldest values. The most recent values are sent to the client.

9.4.4 Generating server certificates with STEP 7

The description below shows the procedure for generating new certificates with STEP 7 and applies in principle to various uses of the certificates. STEP 7 sets the appropriate purpose - in this case "OPC UA Client & Server" - depending on which area of the CPU properties is used to start the following dialog.

Recommendation: To use the full functionality for the security of the OPC UA server, use the global security settings.

Customizing server certificates

STEP 7 automatically generates a certificate for the OPC UA server of the S7-1500 when you activate the server (see "Enabling the OPC UA server (Page 148)").

In the process STEP 7 uses default values for the parameters of the certificate.

If you want to change the parameters, follow these steps:

1. Click the Browse button (three-dot button) in the properties of the CPU under "General > OPC UA > Server > Security > Secure channel > Server certificate".

   A dialog is displayed that lists the certificates available locally.

2. Click "Add".

3. The dialog for generating new certificates is displayed (figure below).

   The values for an example are already entered:

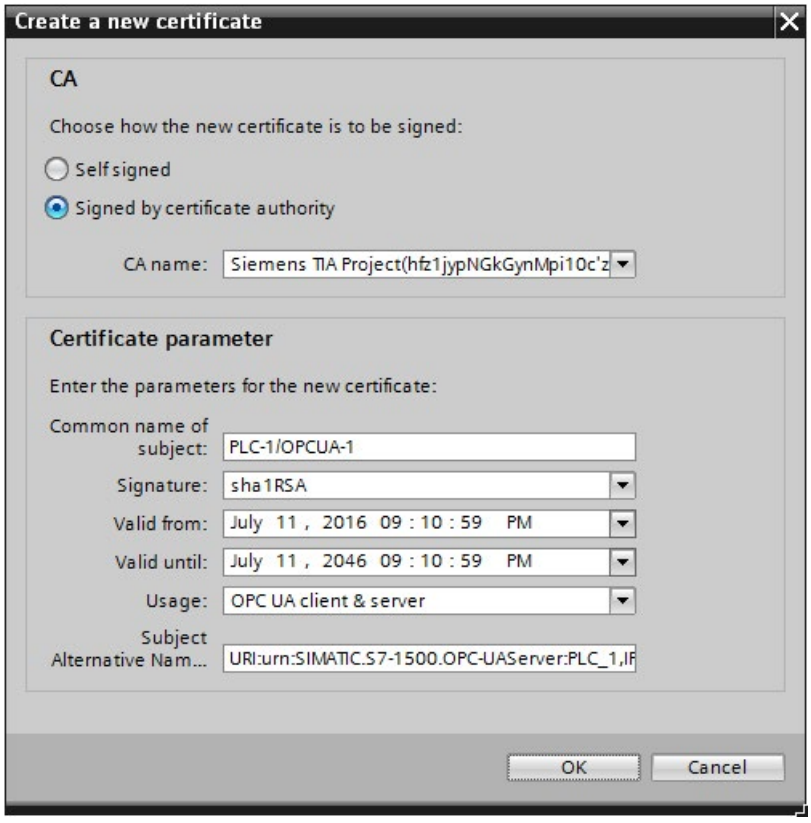


Figure 9-29 Example: Generating an OPC UA server certificate in STEP 7

4. Use other parameters if this is required by the security specifications in your company or by the customer.

- Please note the following:
  - CA

    Select whether the certificate is to be self-signed or to be signed by one of the CA certificates of the TIA Portal.

    The certificates are described in the section "Certificates with OPC UA (Page 136)".

    If you want to generate a certificate that is to be signed by one of the CA certificates of the TIA Portal, you have to be logged in in STEP 7.

    To log in click your project in the "Project tree". Then click "User management under "Global security settings" and log in.
  - Certificate subject

    The default setting always consists of the name of the project and "\OPCUA-1".

    In the example the project name is "HallA-Works1-Heating".

    You set the project name in the properties of the CPU under "General > Project information > Name".

    Retain the default setting or enter a different name for the OPC UA server that is more meaningful in your project for "Certificate subject".
  - Signature

    Here you select the hash and encryption procedure that is to be used when signing the server certificate.

    The following entries are available:

    "sha1RSA" (Secure Hash Algorithm Version 1). The abbreviation RSA stands for the signature algorithm (named after the initials of the inventors Rivest, Shamir and Adleman).

    "sha256RSA" (Secure Hash Algorithm Version 2, the number 256 stands for the length of the hash value).
  - Valid from

    Enter the date and time for the beginning of the validity of the server certificate here.
  - Valid until

    Enter the date and time for the end of the validity of the server certificate here.

    Ensure that the certificate is not only valid for one year or only a few years.

    The certificate is valid for 30 years in the example.

    However, you should renew the certificate at much shorter intervals for security reasons. The long validity leaves the decision up to you when to renew the certificate, for example, when a system has to be serviced.
  - Application

    The default setting is "OPC UA client & server".

    Keep this default setting for the OPC UA server.

    The "Generate new certificate" dialog can be called from several points in STEP 7.

If, for example, you call this dialog for the Web server of the CPU, "Web server" is entered under "Application".

The following entries are available in the application drop-down list:

"OPC UA client",

"OPC UA client & server",

"OPC UA client-server",

"TLS",

"Web server".

– Alternative name of the certificate subject

The following is entered in the example above: "URI:urn:SIMATIC.S7-1500.OPC-UAServer:WorksA-Hall1-Heating,IP:192.168.178.151,IP:192.168.1.1"

The following entry would also be valid: "IP:192.168.178.151,IP:192.168.1.1".

It is important that the IP addresses over which the OPC UA server of the CPU can be accessed are entered here (refer to the section "Access to the OPC UA server (Page 150)").

This means that OPC UA clients can check whether a connection to the OPC UA server of the S7-1500 is really to be established or whether an attacker is possibly trying to send manipulated values from another computer to the OPC UA client.

See also

Handling of the server and client certificates (Page 156)

9.4.5 Handling of the server and client certificates

Certificate of the OPC UA server

A secure connection between the OPC UA server and an OPC UA client is only established if the server can prove its identity to the client.

This is done with the server certificate.

Server certificate is generated automatically

If you have activated the OPC UA server and have confirmed the security information, STEP 7 automatically generates the certificate for the server and stores it in the local certificate directory of the CPU.

You can view and manage this directory with the local certificate manager of the CPU (exporting or deleting certificates).

The figure below shows the local certificate manager of the CPU with the automatically generated certificate for the OPC UA server:

Figure 9-30 Local certificate manager of the CPU

Alternatively, you can also generate a server certificate yourself. Read the information in the section "Generating server certificates with STEP 7 (Page 153)".

The certificate of the server is transferred from the server to the client during establishment of a connection, see section "Secured transferring of messages (Page 142)".

The client checks the certificate.

The client user decides whether the server certificate is to be trusted.

The user at the client side now has to decide whether the server certificate is to be trusted.

If the user trusts the certificate, the client stores the server certificate in its directory that contains the certificates of the servers it trusts.

The following example shows a dialog of the client "UA Sample Client".

If the user clicks "Yes", the client trusts the server certificate:

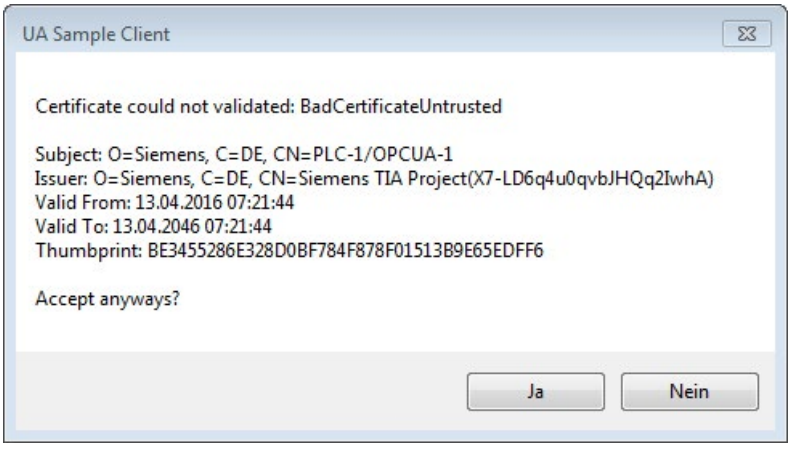


Figure 9-31 Accepting a certificate in the "UA Sample Client"

Certificate of the OPC UA client

A secure connection between the OPC UA server and an OPC UA client is only established if the server also classifies the certificate of the client as trusted.

You decide whether you trust the certificate of the client.

Proceed as follows to trust the client certificate:

1. Activate the "Use global security settings for certificate manager" option in the local certificate manager.

   The global certificate manager is activated as a result.

   The "Global security settings" item is now displayed in the STEP 7 project tree.
2. Double-click "Global security settings".
3. Double-click "User login".
4. Log in.

   The ""Certificate manager" menu item is now displayed under "Global security settings" in the STEP 7 project tree.
5. Double-click "Certificate manager".

   STEP 7 opens the global certificate manager.
6. Click the "Device certificates" tab.
7. Right-click in the tab on a free area (not on a certificate).
8. Select the "Import" item from the shortcut menu.

   The dialog for importing certificates is displayed.
9. Select the client certificate.
10. Click the "Open" button to import the certificate.

    The certificate of the client is now contained in the global certificate manager.

    Note the ID of the client certificate just imported.
11. In the properties of the CPU click the "General" tab.
12. Click the "OPC UA > Security" area.
13. In the "Secure channel" dialog scroll down to the "Trusted clients" section.
14. Double-click the empty row with "<add new>" in the table.

    A button with three dots (Browse button) is displayed in the row.
15. Click this button.
16. Select the client certificate that you have imported.
17. Click the button with the green check mark.
18. Compile the project.
19. Load the configuration onto the S7-1500 CPU.

Result

The server now trusts the client.

If the server certificate is also trusted, server and client can now establish a secure connection.

Automatically accept client certificates

If you activate the "Automatically accept client certificates during runtime" option (below the "Trusted clients" list), the server accepts all client certificates.

Caution: Security risk. Deactivate this option after commissioning.

NOTICE
Setting after commissioning In order to avoid security risks, deactivate the "Automatically accept client certificates during runtime" option again after commissioning.

Where does the client certificate come from?

If you use UA clients of manufacturers or of the OPC Foundation, a client certificate is generated automatically during the installation or during the first program call.

You have to import these certificates with the global certificate manager in STEP 7 and use them for the respective CPU (as shown above).

If you program an OPC UA client yourself, you can generate certificates through the program, see section "Instance certificate for the client (Page 172)".

Or you generate certificates with tools, for example, with OpenSSL or the certificate generator of the OPC Foundation:

- The procedure for OpenSSL is described in the section "Generating PKI key pairs and certificates yourself (Page 138)".
- Working with the certificate generator of the OPC Foundation is described in the sectionCreating self-signed certificates (Page 137).

Configuring security policies of the server

The figure below shows the available server security policies for signing and encrypting messages.

Figure 9-32 Security settings of the OPC UA server in STEP 7

By default a server certificate is created which uses SHA1 signing and the following security policies are enabled:

- None
  Non-secured end point
- Basic128Rsa15 -Sign
  Secure end point, supports a series of algorithms that use the hash algorithm RSA1.5 and 128-bit encryption.
  This end point ensures the integrity of the data through signing.
- Basic128Rsa15 -Sign & Encrypt
  Secure end point, supports a series of algorithms that use the hash algorithm RSA1.5 and 128-bit encryption.
  This end point ensures the integrity and confidentiality of the data through signing and encrypting.
- Basic256Rsa15 -Sign
  Secure end point, supports a series of algorithms that use the hash algorithm RSA1.5 and 256-bit encryption.
  This end point ensures the integrity of the data through signing.
- Basic256Rsa15 -Sign & Encrypt
  Secure end point, supports a series of algorithms that use the hash algorithm RSA1.5 and 128-bit encryption.
  This end point ensures the integrity and confidentiality of the data through signing and encrypting.

In order to achieve higher security you can additionally enable the following security policies:

- Basic256Sha256 - Sign
  Secure end point, supports a series of algorithms for 256-bit hashing and 256-bit encryption.
  This end point ensures the integrity of the data through signing.
- Basic256Sha256 - Sign & Encrypt
  Secure end point, supports a series of algorithms for 256-bit hashing and 256-bit encryption.
  This end point ensures the integrity and confidentiality of the data through signing and encrypting.

To enable a security policy, select the check box in the relevant line.

Note

If you use the security policies "Basic256Sha256 -Sign" and "Basic256Sha256 -Sign & Encrypt", the OPC UA server and OPC UA clients must use "SHA256"-signed certificates.

For the security policies "Basic256Sha256 -Sign" and "Basic256Sha256 -Sign & Encrypt", the certificate authority of STEP 7 automatically signs the certificates with "SHA256".

9.4.6 User authentication

For the OPC UA server of the S7-1500, you can set what authentication is required for a user of the OPC UA client wishing to access the server.

You have the following options:

- **Guest authentication**

  The user does not have to prove their authorization (anonymous access).

  If the OPC UA server is not to check the authorization of the client user, activate the "Activate guest authentication" option.

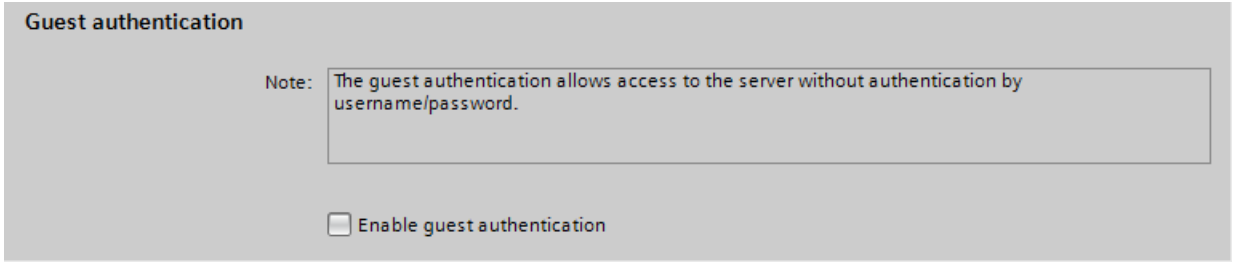


Figure 9-33 Activating the guest authentication in STEP 7

- **Authentication by means of user name and password**

  The user must prove their authorization (not an anonymous access).

  The OPC UA server checks whether the client user is authorized to access the server.

  The user name with the correct password serves as proof.

  If you want to use this type of user authentication, set the "Activate authentication by means of user name and password" option under "OPC UA > Server > Security > User authentication > Authentication by means of user name and password".

  Deactivate the guest authentication.

  Enter the users in the "User management" table.

  To so so, click the entry "<Add new user>" and enter the user name and the corresponding password. You can add a maximum of 21 users.

9.4.7 Licenses for the OPC UA server

Runtime licenses

A license is required for the operation of the OPC UA server of the S7-1500.

The type of license required depends on the performance of the respective CPU.

The following license types are differentiated:

- SIMATIC OPC UA S7-1500 small (required for CPU 1511, CPU 1512, CPU 1513, ET 200SP CPUs, CPU 1515SP PC)
- SIMATIC OPC UA S7-1500 medium (required for CPU 1515, CPU 1516, Software Controller CPU 1507, CPU 1516pro-2PN)
- SIMATIC OPC UA S7-1500 large (required for CPU 1517, CPU 1518)

The required license type is displayed under "Properties > General > Runtime licenses > OPC-UA > Type of license required":

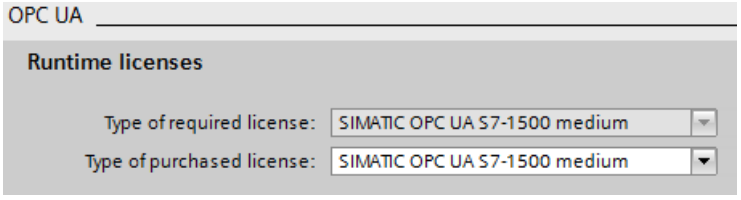


Figure 9-34 Display of the runtime licenses in STEP 7

Proceed as follows to confirm the purchase of the required license:

1. Click in the properties of the CPU on "Runtime licenses > OPC UA".
2. Select the required license from the "Type of purchased license" drop-down list.

9.5 Programming the OPC UA client

9.5.1 OPC UA client in C#

This section describes the example program "UaClient". The example program is located in the ZIP file included in this manual.

The program shows how you can program an OPC UA client yourself.

9.5.2 Requirements for the example program

Requirements

The example assumes fulfillment of the following requirements:

- Microsoft Visual Studio 2013 is used as the development environment
- Programming language C#
- .NET Framework 4.5
- Software Development Kit (SDK) for OPC UA clients from Unified Automation (.NET based OPC UA Client/Server SDK Bundle).

  You can download the SDK free of change and develop and test a client with it.

  A license from Unified Automation is required for productive operation.

9.5.3 Structure of the example program

Basic structure of the program

The program basically consist of the following blocks:

1. Establishing a connection to an OPC UA server
2. You can execute the following actions when the connection is established:
   - Read PLC tags and DB tags from the server
   - Write PLC tags and DB tags to the server
   - Navigate within the address space of the server
   - Read and write registered PLC tags (Registered Read and Registered Write)
   - Establish a subscription and assign items to this subscription
3. Disconnect the connection to the server
4. Generate a certificate for the client

9.5.4 Establishing a connection to an OPC UA server

9.5.4.1 Overview of this section

The OPC UA server of an S7-1500 can be accessed through different security settings (end points).

The following description shows you how to locate these end points and then establish a connection to an end point.

9.5.4.2 Access to the server with different security settings

Querying security requirements

Before you establish a connection to an OPC UA server, you should first find out which security settings are required for connections to the server.

The various security requirements are called Endpoints.

The "FindEndpointsBtn_Click" method shows you how to query the Endpoints of a server. The method is called when you click the "Search" button in the "Connect to Server" tab:

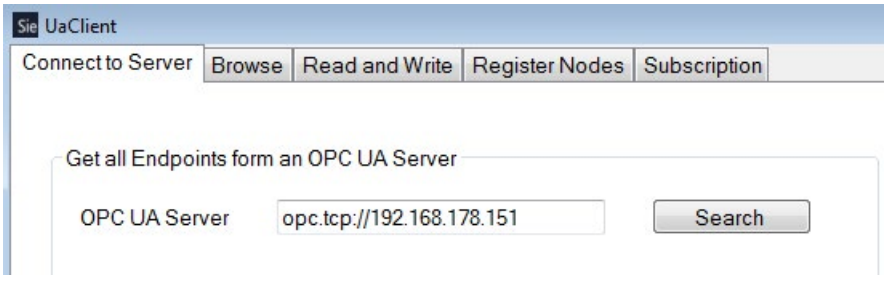


Figure 9-35 End point search in the "UaClient"

The "FindEndpointsBtn_Click" method is contained completely in the "Form1.cs" file located in the enclosed Visual Studio project.

The method runs through the following steps:

1. `Discovery discovery = new Discovery();`

   The method creates an object of the Discovery class.

2. `m_endpoints = discovery.GetEndpoints(ServerUrlTB.Text);`

   At discovery the GetEndpoints method is called.

   The argument is read from the text property of the "ServerUrlTB" text box.

   GetEndpoints establishes a non-secured connection to the OPC UA server and queries the available security requirements.

   The response of the server saves the example program in the list "`m_endpoints`" that holds objects of the type EndpointDescription.

3. ```
   foreach (EndpointDescription endpoint in m_endpoints)
   {
   ListViewItem item = new ListViewItem();
   item.Text = endpoint.EndpointUrl;
   item.SubItems.Add(endpoint.SecurityMode.ToString());
   item.SubItems.Add(SecurityProfiles.GetDisplayName(endpoint.SecurityPolicyUri));
   item.Tag = endpoint;
   EndpointsLV.Items.Add(item);
   }
   ```

   In this Foreach loop, the method prepares the received Endpoints of the server for display in a ListView:

Result

The available end points of the OPC UA server are displayed:

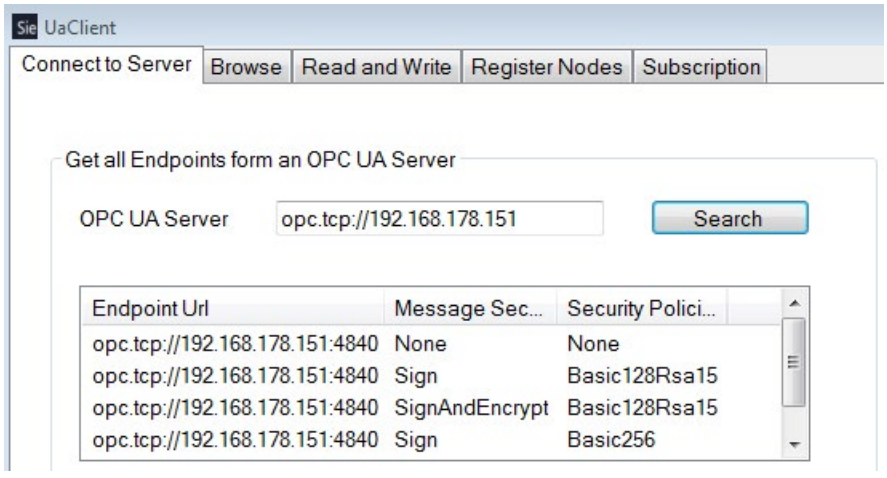


Figure 9-36 Results of the end point search in the "UaClient"
   ```

9.5.4.3 Establishing a connection to an end point of the server

Requirements

You have found out which security requirements (end points) an OPC UA server has (see "Access to the server with different security settings (Page 165)").

Establish connection

You can now establish a connection to a specific end point of the server and open a session.

The procedure is shown in the "ConnectBtn_Click" method.

The method is called when you select a specific end point in the "Connect to Server" tab and then click the "Connect" button.

The following program sections are executed (complete source code in the "Form1.cs" file):

1. `m_session = new Session(m_application);`

   The method creates new session object.

   The constructor receives a reference to the current instance of the client as an argument.

   The m_session tag contains a reference to the new session object.

2. `m_endpoint = (EndpointDescription)m_endpoints[m_selectedEndpointIndex];`

   The method reads the selected end point from the m_endpoints tag and assigns it to the m_endpoint tag.

3. `m_session.Connect(m_endpoint, m_session.DefaultRequestSettings);`

   Structure of a session to the selected end point of the server:

   – The Connect method of the session class is called.

   – The Connect method receives the selected end point and the default settings as arguments.

Result

A connection to the OPC UA server was established.

A session could be established.

The m_session object represents the connection and the session to the selected end point of the server.

UaClient indicates in the "Connect to Server" tab that a connection has been established:

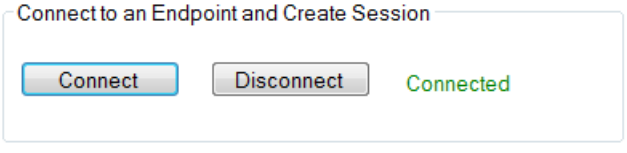


Figure 9-37 Display of the connection to an end point in UaClient

9.5.5 Using an existing connection to an end point of the server

9.5.5.1 Reading PLC tags and DB tags

Overview of this section

This chapter shows how you can read the values of PLC tags of the OPC UA server of an S7-1500 with the example program UaClient.

Querying the namespace index

Requirements

You have established a session to an OPC UA server (see "Establishing a connection to an end point of the server (Page 167)").

Querying the index of the namespace

OPC UA uses namespaces to avoid naming conflicts.

The number of namespaces can change in the course of time: The server can add additional namespaces or delete existing ones.

Therefore it is necessary to query the index of the namespace before the actual write or read access.

The procedure is shown in the "FindNamespaceIndexBtn_Click" method.

The method is called when you click the "Find" button in the "Connect to Server" tab:

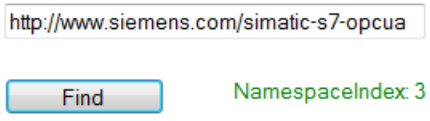


Figure 9-38 Querying the index of the namespace in UaClient

The Siemens namespace is entered as the default for the UaClient. In the example the Siemens namespace has the index 3.

The namespace index is required for access to PLC tags and DB tags.

Reading PLC tags

Requirements

You have established a connection to an OPC UA server and have opened a session (see "Establishing a connection to an end point of the server (Page 167)") as well as queried the index of the namespace.

Addressing PLC tags

From the server, you can read PLC tags and DB tags that are enabled for access via OPC UA.

The procedure is shown, for example, in the "ReadBooleanBtn_Click" method.

The method is called when you click the "Read" button in the "Read from PLC" section of the "Read and write" tab:

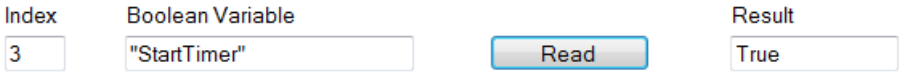


Figure 9-39 Addressing PLC tags in UaClient

The following information is entered in the example above:

- Index

  The current index for the Siemens namespace.

- Boolean tag

  The "StartTimer" identifier is entered here.

  "StartTimer" is the symbolic name of a memory bit that is used in our PLC program to provide a Boolean value for the UaClient. StartTimer is defined in the PLC program which is why it is set in quotation marks.

  The PLC program is described in the section "User program of the CPU (Page 173)".

Source code for the reading of values

Program example for the reading of PLC tags

The "ReadBooleanBtn_Click" method executes the following program sections (complete source code in the "Form1.cs" file in the enclosed Visual Studio project):

1. `List<ReadValueId> nodesToRead = new List<ReadValueId>();`

   The program generates a list for all the tags whose values are to be read.

   The list only includes objects of the `ReadValueId` type.

2. `NodeId nodeId1 = new NodeId(ReadPLCVariable_1_TB.Text, Convert.ToUInt16(NamespaceIndexTB1.Text));`

   The program generates a NodeId.

   The identifier is taken from the text property of the ReadPLCVariable_1_TB text box (in the example "StartTimer").

   The index for the namespace is located in the text property of the NamespaceIndexTB1 text box. The program converts the index into an integer.

3. `nodesToRead.Add(new ReadValueId() { NodeId = nodeId1, AttributeId = Attributes.Value });`

   `The example program adds a new ReadValueId object to the nodesToRead list.`

   The value of the tags is to be read (is located the value attribute of the tags).

4. `List<DataValue> results = m_session.Read(nodesToRead, 0, TimestampsToReturn.Both, new RequestSettings() { OperationTimeout = 10000 });`

   At the m_session object the `Read` method of the Session class is called.

   The method contains the list of nodes to be read (PLC tags, in the example "StartTimer").

   The second argument determines the age of the values in milliseconds. In case of "0", the OPC UA server requests the value again from the data source.

   The third argument determines that the OPC UA server returns two time stamps:

   – The moment at which the value of the tags was detected in the data source.

   – The moment at which the server sent the value to the client.

   The fourth argument sets the timeout for reading to 10 seconds.

   The `results` list contains the read values (in the example, the read value of the PLC tag "StartTimer").

5. `ReadBooleanResultTB.Text = results[0].Value.ToString();`

   The value of the 0th item in the result list results is converted into a string and assigned to the text properties in the ReadBooleanResultTB text box.

9.5.6 Disconnecting a connection to an OPC UA server

9.5.6.1 Disconnecting a connection to the server

Disconnecting connection

The "DisconnectBtn_Click" method shows you how to disconnect a connection to the OPC UA server.

The method is called when you click the "Disconnect" button in the "Connect to Server" tab:

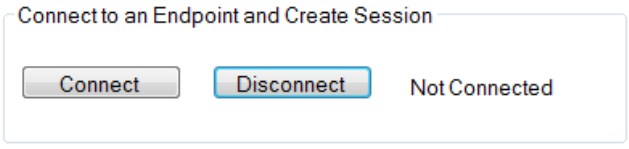


Figure 9-40 Disconnecting the connection to an end point in UaClient

The following program sections are executed (complete source code in the "Form1.cs" file in the enclosed Visual Studio project):

1. `m_session.Disconnect();`

   The method closes an existing session and terminates the connection to the OPC UA server.

2. `m_session.Dispose();`

   Releases the resources of the connection.

9.5.7 Generate a certificate for the client

9.5.7.1 Instance certificate for the client

Each instance requires a certificate

When you start the UaClient for the first time on your computer, a certificate does not yet exist for this instance of the UaClient.

Therefore the "Application_MissingApplicationCertificate" method ("Program.cs" file) calls the following dialog for generating a certificate (source: Unified Automation):

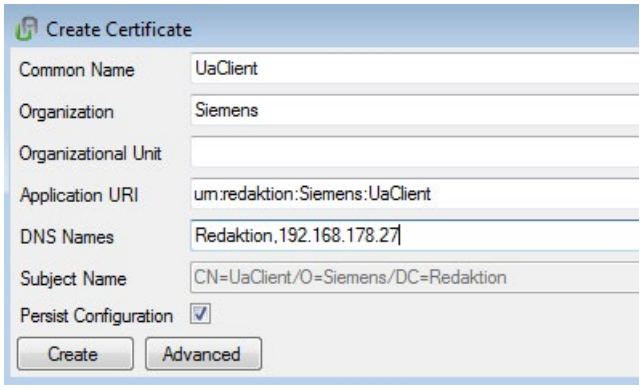


Figure 9-41 Generating a certificate for an instance of the UaClient

In the dialog above, for example, a computer with the DNS name "Redaktion" is entered. In addition, the IP address of this computer is also inserted at "DNS Names".

Click the "Create" button to generate the certificate.

The certificate is inserted into the directory "C:\ProgramData\Siemens\Automation\UaClient\pkiclient\own\certs".

Together with the certificate, a private PKI key was also generated and stored in the following directory: "C:\ProgramData\Siemens\Automation\UaClient\pkiclient\own\private".

The directories are specified in the "App.config" file of the example project.

In order to establish a secure connection to the OPC UA server of an S7-1500, you have to transfer the generated client certificate to the server by means of STEP 7 V14 (TIA Portal).

9.5.8 User program of the CPU

9.5.8.1 Structure of the user program - Main [OB1]

The tag values that you read with a client from the server of the S7-1500 have their origin in a PLC program.

This section describes a PLC program that makes values for PLC tags available. The program solely simulates the values for the PLC tags; it does not fulfill any real task (does not control any machine and any system).

The program makes values for the following PLC tags available as an example:

- StartTimer

  A Boolean tag whose value changes from "1" to "0" for one cycle at intervals of five seconds. In the next cycle of the PLC program, this tag has the value "1" again.

- MyValue

  An integer tag (Int16) whose value is increased by 1 when a time span of five seconds has passed.

User program makes values available

Network 1

The figure below shows Network 1 of the PLC program:

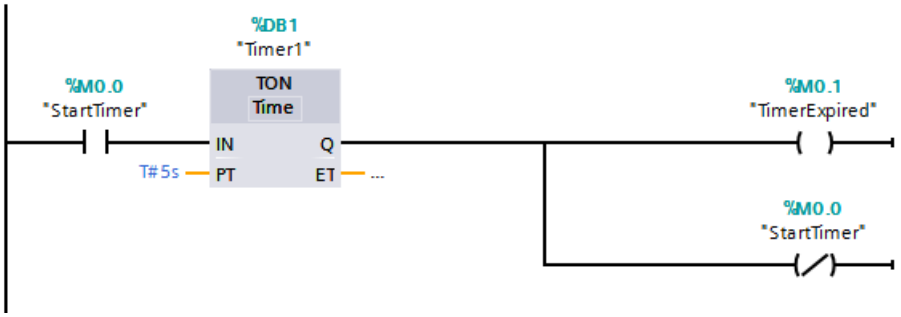


Figure 9-42 User program Network 1

A positive edge (transition from "0" to "1") at the input "IN" starts the on-delay period (T#5s at input "PT").

After five seconds, the output "Q" of the counter switches to "1". This results in the PLC tag "StartTimer" being set to "0" and "TimerExpired" to "1".

"TimerExpired" indicates with signal level "1" that the set time has expired.

Network 2

The figure below shows Network 2 of the PLC program:

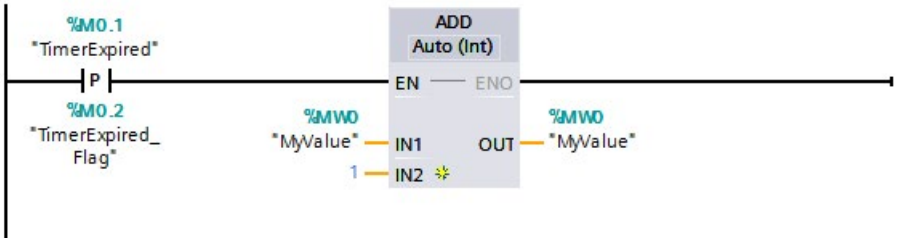


Figure 9-43 User program Network 2

The change from "0" to "1" sets the input "EN" of an ADD instruction to 1 and thus activates the ADD instruction.

The ADD instruction reads the current value of "MyValue", increases it by 1 and writes the new value to the "MyValue" tag.

Network 3

The figure below shows Network 3 of the PLC program:

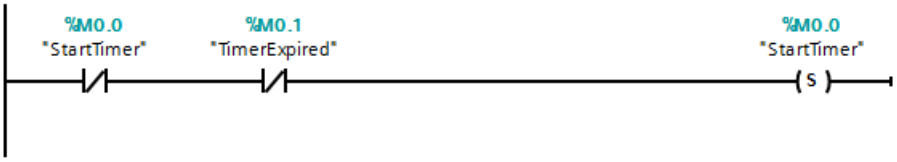


Figure 9-44 User program Network 3

When "StartTimer" and "TimerExpired" have the value "0", "StartTimer" is set to "1" and thus Timer1 is started.

9.5.8.2 Enabling PLC tags for access over OPC UA

Enabling PLC tags in STEP 7

The figure below shows the configuration of the PLC tags of the PLC program that generates values for "UaClient".

PLC tags

	Name	Tag ...	Data type	Accessible from HMI/OPC UA	Writable from HMI/OPC UA
	StartTimer	Stan...	Bool	☑	☑
	TimerExpired	S...	Bool	☑	☑
	TimerExpired_Flag	Stan...	Bool	☑	☑
	MyValue	Stan...	Int	☑	☑

Figure 9-45 Enabling PLC tags in STEP 7

All PLC tags in this example are configured so that they can be accessed from OPC UA.

In addition, OPC UA clients can write new values to the tags.

Routing 10

10.1 S7 routing

Definition of S7 routing

S7 routing is the transfer of data beyond S7 subnet boundaries. You can send information from a transmitter to a receiver across several s7 subnets. The gateway from one S7 subnet to one or more other subnets is provided by the S7 router The S7 router is a device which has interfaces to the respective S7 subnets. S7 routing is possible via various S7 subnets (PROFINET/Industrial Ethernet and/or PROFIBUS).

Requirements for S7 routing

- All devices that can be reached in a network have been configured in a project in STEP 7 and downloaded.
- All devices involved in the S7 routing must receive routing information about the S7 subnets that can be reached through specific S7 routers. The devices obtain the routing information by downloading the hardware configuration to the CPUs, since the CPUs play the role of an S7 router.

  In a topology with several consecutive S7 subnets, the following order must be kept to when downloading: First download the hardware configuration to the CPU(s) directly connected to the same S7 subnet as the PG/PC, then download one by one the CPUs of the S7 subnets beyond this starting with the nearest S7 subnet through to the S7 subnet furthest away.
- The PG/PC you want to use to establish a connection via a S7 router must be assigned to the S7 subnet it is physically connected to. You can assign the PG/PC to a PG/PC in STEP 7 under Online & Diagnostics > Online accesses > Connection to interface/subnet.
- For S7 subnets of the type PROFIBUS: Either the CPU must be configured as DP master or, if it is configured as a DP slave, the "Test, commissioning, routing" check box must be selected in the properties of the DP interface of the DP slave.
- S7 routing for HMI connections is possible as of STEP 7 V13 SP1.

An overview of the devices that support the "S7 routing" function is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/584459).

S7 routing for online connections

With the PG/PC, you can reach devices beyond S7 subnets, for example to do the following:

- Download user programs
- Download a hardware configuration
- Execute test and diagnostics functions

In the following figure, CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2.

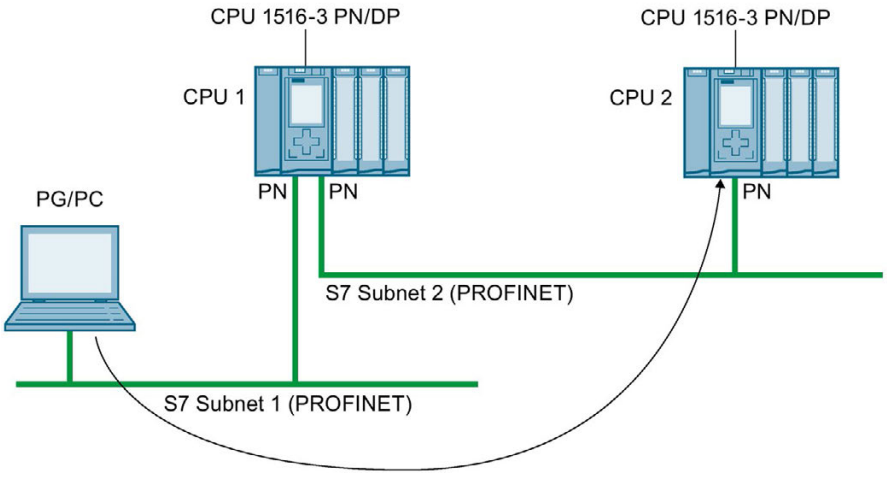


Figure 10-1 S7 routing: PROFINET - PROFINET

The following figure shows the access from a PG via PROFINET to PROFIBUS. CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2; CPU 2 is the S7 router between S7 subnet 2 and S7 subnet 3.

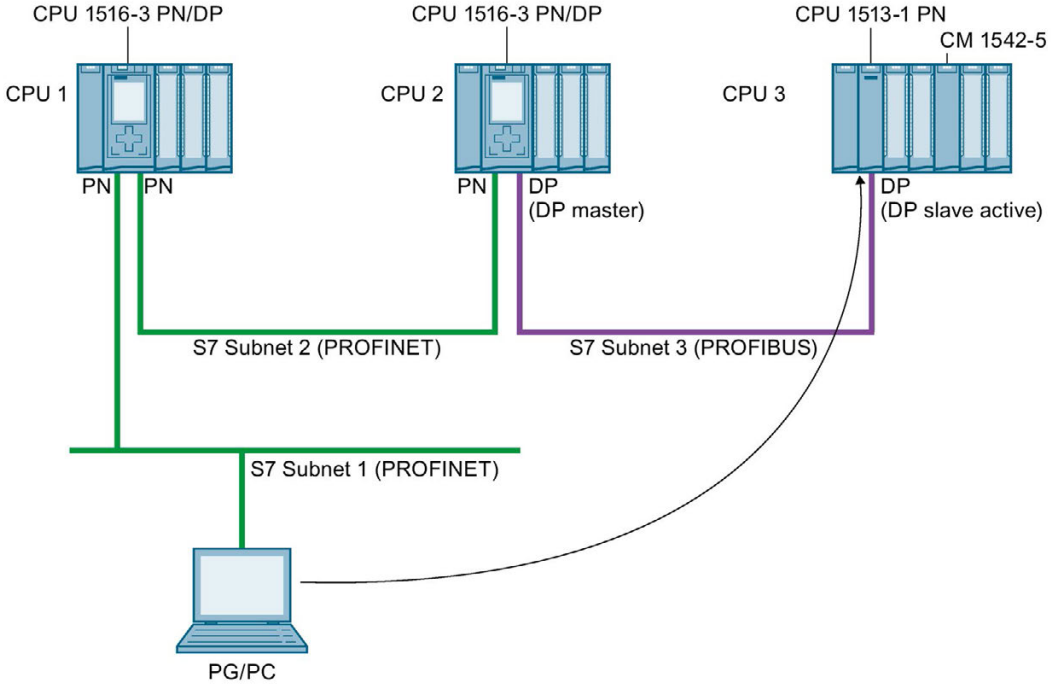


Figure 10-2 S7 routing: PROFINET - PROFIBUS

S7 routing for HMI connections

You have the option of setting up an S7 connection from an HMI to a CPU via different subnets (PROFIBUS and PROFINET or Industrial Ethernet). In the following figure, CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2.

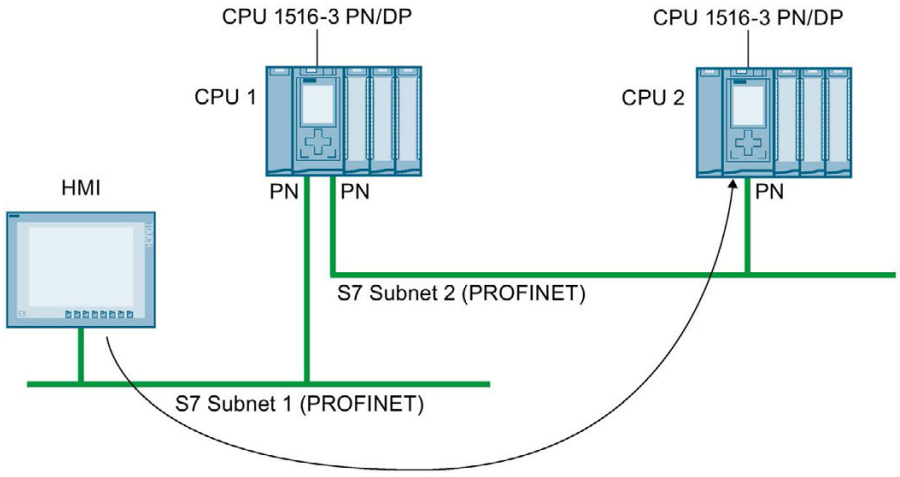


Figure 10-3 S7 routing via HMI connections

S7 routing for CPU-CPU communication

You have the option of setting up an S7 connection from a CPU to another CPU via different subnets (PROFIBUS and PROFINET or Industrial Ethernet). The procedure is described based on examples in the section S7 communication (Page 105).

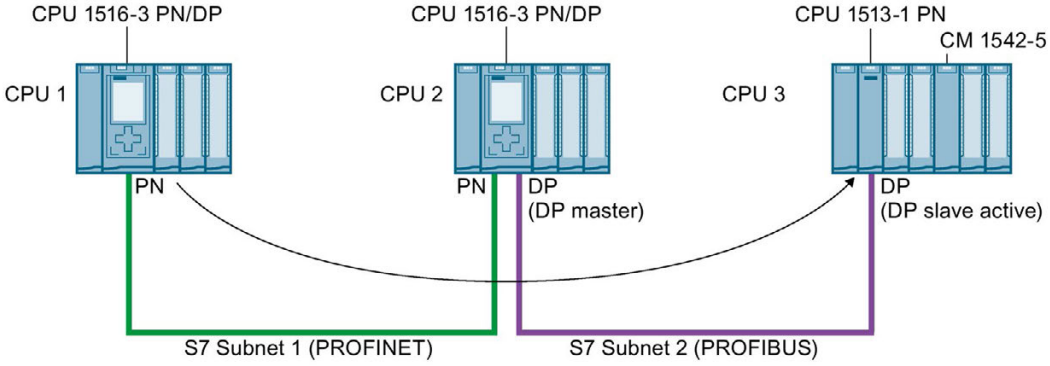


Figure 10-4 S7 routing via CPU-CPU communication

Using S7 routing

For the CPU, select the PG/PC interface and the S7 subnet in the "Go online" dialog of STEP 7. S7 routing is performed automatically.

Number of connections for S7 routing

The number of connections available for S7 routing in the S7 routers (CPUs, CMs or CPs) can be found in the technical specifications in the manuals of the relevant CPU/CM/CP.

S7 routing: Example of an application

The figure below shows the example of an application for remote maintenance of a system using a PG. The connection is made here beyond two S7 subnets via a modem connection.

You configure a remote connection via TeleService in STEP 7 using "Online access" or "Go online".

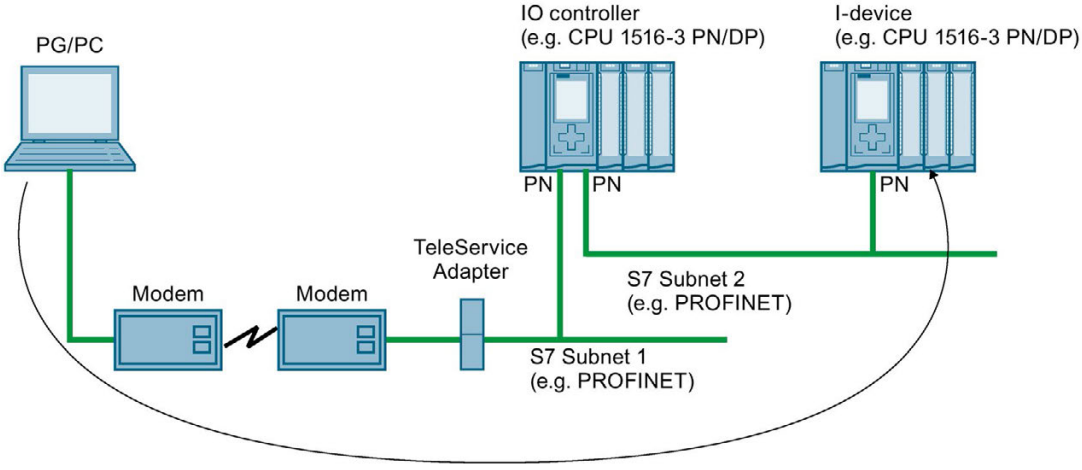


Figure 10-5 Remote maintenance of a plant using TeleService

Additional information

- The allocation of connection resources with S7 routing is described in the section Allocation of connection resources (Page 184).
- You can find more information on setting up TeleService in the STEP 7 online help.
- You can find more information on S7 routing and TeleService adapters when you search the Internet using the following links:
  - Device manual Industrial Software Engineering Tools TS Adapter IE Basic (http://support.automation.siemens.com/WW/view/en/51311100)
  - Downloads for the TS Adapter (http://support.automation.siemens.com/WW/view/en/10805406/133100)

See also

HMI communication (Page 40)

10.2 Data record routing

Definition of data record routing

Data can be sent over PROFINET from an engineering station to field devices via multiple networks. Since the engineering station addresses the field devices using standardized records and these records are routed via S7 devices, the term "data record routing" is used to refer to this type of routing.

The data sent using data record routing include the parameter assignments for the participating field devices (slaves) and device-specific information (e.g. setpoint values, limit values).

Data record routing is used, for example, when field devices of different manufacturers are used. The field devices are addressed using standardized data records (PROFINET) for configuration and diagnostics.

Data record routing with STEP 7

You can perform data routing with STEP 7 by calling a device tool (for example, PCT) via the TCI interface (Tool Calling Interface) and passing call parameters. The device tool uses the communication paths that STEP 7 also uses for communication with the field device.

No configuration is required for this type of routing except the installation of the TCI tools on the STEP 7 computer.

Example: Data record routing with the Port Configuration Tool (PCT)

You can use the Port Configuration Tool (PCT) to configure the IO link master of the ET200 and assign parameters to connected IO link devices. The subnets are connected via data record routers. Data record routers are, for example, CPUs, CPs, IMs, IO link master.

You can learn about the constellations of data record routers supported by the PCT in this FAQ (http://support.automation.siemens.com/WW/view/en/87611392).

The figure below shows an example configuration with the data record routing with PCT.

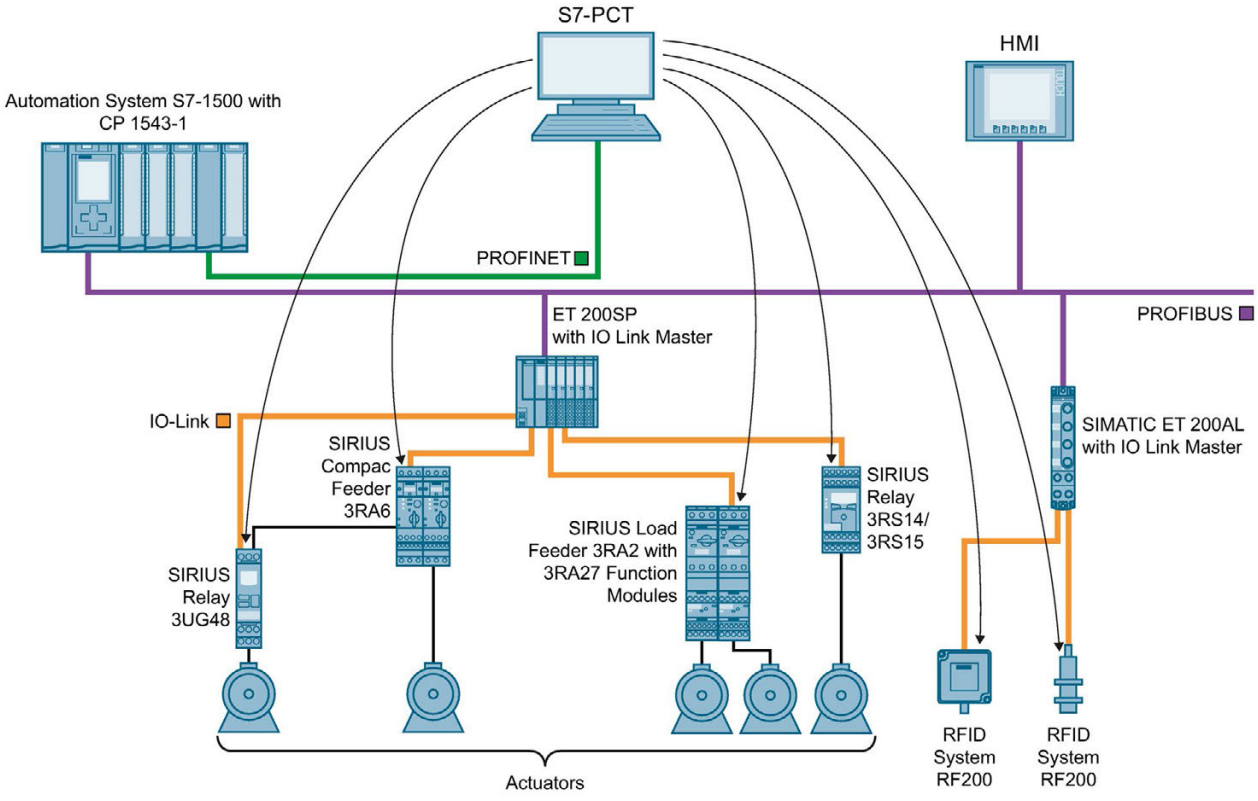


Figure 10-6 Example configuration for data record routing with PCT

Additional information

- The differences that exist between "normal" routing and data record routing are described in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/7000978).
- Whether or not the CPU, CP or CM you are using supports data record routing can be found in the relevant manuals.
- The allocation of connection resources with data record routing is described in the section Allocation of connection resources (Page 184).
- You can find additional information on configuration with STEP 7 in the STEP 7 online help.

Connection resources 11

11.1 Connection resources of a station

Introduction

Some communications services require connections. Connections occupy resources in the automation system (station). The connection resources are made available to the station by the CPUs, communications processors (CPs) and communications modules (CMs).

Connection resources of a station

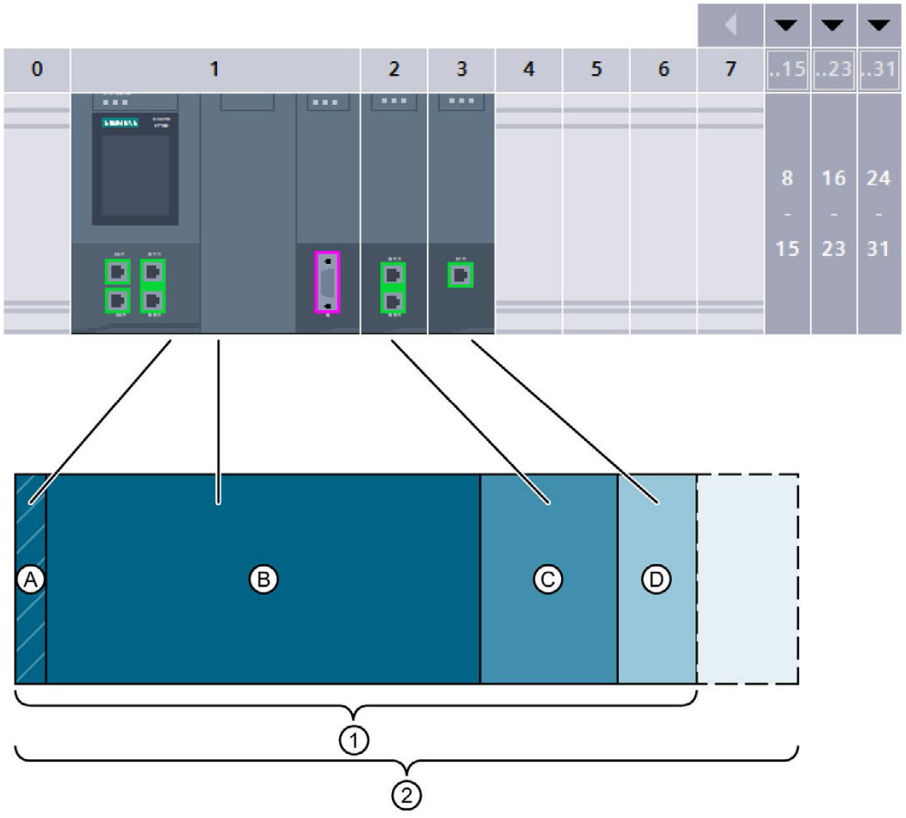
The connection resources available depend on the CPUs, CPs and CMs being used and must not exceed a maximum number per station.

The maximum number of resources of a station is determined by the CPU.

Each CPU has reserved connection resources for PG, HMI and Web server communication. This ensures, for example, that a PG can always establish at least one online connection with the CPU regardless of how many other communications services are already using connection resources.

In addition, dynamic resources exist. The difference between the maximum number of connection resources and the number of reserved connection resources is the maximum number of dynamic connection resources. The communications services PG communication, HMI communication, S7 communication, Open User Communication, Web communication and other communication (for example OPC UA) use the dynamic connection resources from the pool.

The figure below shows an example of how individual components make connection resources available to an S7-1500 station.



① Available connection resources of the station, of which

A	Reserved connection resources of the station
A + B	Connection resources of CPU 1518
C	Connection resources of communications module CM 1542-1
D	Connection resources of communications processor CP 1543-1

② Maximum communications resources of the station using the example of a configuration from CPU 1518, CM 1542-1 and CP 1543-1

Figure 11-1 Connection resources of a station

Number of connection resources of a station

Table 11- 1 Maximum number of connection resources supported for some CPU types

Connection resources of a station	1511 1511C	1512C 1513	1515	1516	1517	1518
Maximum connection resources of the station	96	128	192	256	320	384
of which reserved	10					
of which dynamic	86	118	182	246	310	374
Connection resources of the CPU	64	88	108	128	160	192
Max. additionally usable connection resources by plugging in CMs/CPs	32	40	84	128	160	192
Additional connection resources CM 1542-1	64					
Additional connection resources CP 1543-1	118					
Additional connection resources CM 1542-5	40					
Additional connection resources CP 1542-5	16					

The number of connection resources that a CPU or a communication module supports is specified in the device manuals in the Technical Specifications.

Example

You have configured a CPU 1518-4PN/DP with a communications module CM 1542-1 and a communications processor CP 1542-5.

- Maximum connection resources of the station: **384**
- Available connection resources:
  - CPU 1518-4 PN/DP: 192
  - CM 1542-1: 64
  - CP 1542-5: 16
  - Total: **272**

The setup provides 272 connection resources. By adding additional communications modules, the station can support a maximum of 112 additional connection resources.

Reserved connection resources

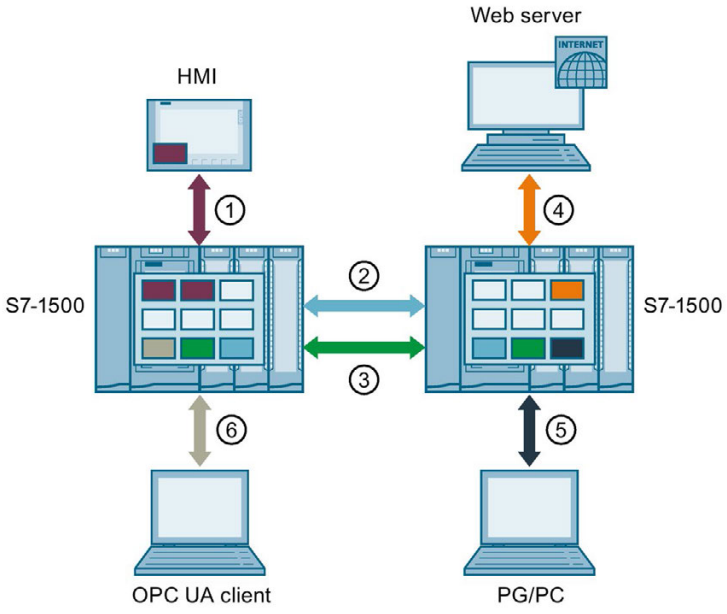
10 connection resources are reserved for stations with S7-1500 CPU, ET 200SP CPU and ET 200pro CPU based on S7-1500:

- 4 for PG communication required by STEP 7, for example, for test and diagnostics functions or downloading to the CPU
- 4 for HMI communication which are occupied by the first HMI connections configured in STEP 7
- 2 for communication with the Web server

11.2 Allocation of connection resources

Overview - occupation of connection resources

The following figure shows how different connections occupy the resources of the S7-1500.



① HMI communication: See below.

② Open User Communication: Connections of Open User Communication occupy a connection resource in every end point.

③ S7 communication: Connections of S7 communication occupy a connection resource in every end point.

④ Web communication: The Web server connection occupies at least one connection resource in the station. The number of occupied connections depends on the browser.

⑤ PG communication: The PG connection occupies one connection resource in the station.

⑥ OPC UA communication: Each session that the OPC UA server of the CPU establishes with an OPC UA client as a rule occupies one connection resource (other communication) in the station.

Connection resource for HMI communication

Connection resource for Open User Communication

Connection resource for S7 communication

Connection resource for Web communication

Connection resource for PG communication

Connection resource for other communication (for example OPC UA)

Figure 11-2 Allocation of connection resources

Connection resources for HMI communication

With HMI communication, the occupation of connection resources in the station depends on the HMI device being used.

Table 11- 2 Maximum occupied connection resources for different HMI devices

HMI device	Maximum occupied connection resources of the station per HMI connection
Basic Panel	1
Comfort Panel	2[1]
RT Advanced	2[1]
RT Professional	3

[1] If you do not use system diagnostics or alarm configuration, the station occupies only one connection resource per HMI connection.

Example: You have configured the following HMI connections for a CPU 1516-3 PN/DP:

- Two HMI connections to an HMI TP700 Comfort. (2 connection resources each)
- One HMI connection to an HMI KTP1000 Basic. (1 connection resource)

In total 5 connection resources are occupied for HMI communication in the CPU.

Connection resources for routing

To transfer data beyond S7 subnets ("S7 routing"), an S7 connection is established between two CPUs. The S7 subnets are connected via gateways known as S7 routers. CPUs, CMs and CPs in S7-1500 are S7 routers.

The following applies for a routed S7 connection:

- A routed connection occupies one connection resource each in both end points. STEP 7 shows these connection resources in the "Connection resources" table.
- On the S7 router, two special connection resources are occupied for S7 routing. STEP 7 does not show the special connection resources for S7 routing in the "Connection resources" table. The number of resources for S7 routing depends on the CPU. You will find the resources for S7 routing in the technical specifications of the CPU in "Number of S7 routing connections".

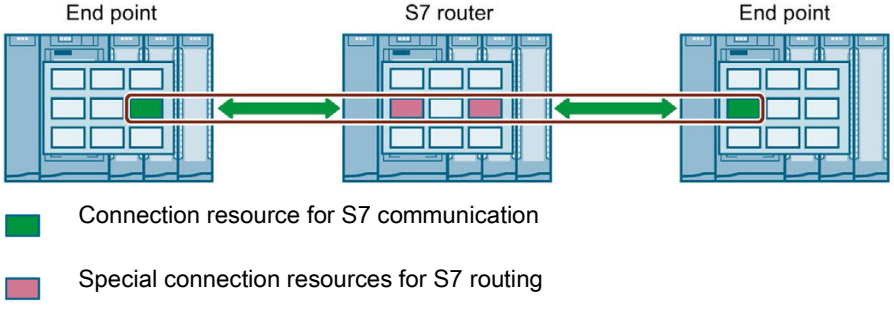


Figure 11-3 Connection resources with S7 routing

Data record routing also enables transfer of data beyond S7 subnets from an engineering station connected to PROFINET to various field devices via PROFIBUS.

With data record routing, as with S7 routing, two of the special connection resources for S7 routing are also occupied on every data record router.

Note

Connection resources with data record routing

With data record routing, on the data record router, two special connection resources for S7 routing are occupied. Neither the data record connection nor the allocated connection resources are displayed in the table of connection resources.

When are connection resources occupied?

The time for the occupation of connection resources depends on how the connection is set up (see section Setting up a connection (Page 24)).

- **Programmed setup of a connection**:
  As soon as an instruction to establish a connection is called in the user program (TSEND_C/TRCV_C or TCON), a connection resource is occupied.

  With suitable parameter assignment of the CONT parameter of the TSEND_C/TRCV_C instructions or by calling the TDISCON instruction, the connection can be terminated following data transfer and the connection resource is available again. If the connection is terminated, the connection resources on the CPU/CP/CM are available again.
- **Configured connections** (e.g. HMI connection):
  If you have configured a connection in STEP 7, the connection resource is occupied as soon as the hardware configuration is downloaded to the CPU.

  After using a configured connection for data transfer, the connection is not terminated. The connection resource is permanently occupied. To release the connection resource again, you need to delete the configured connection in STEP 7 and download the modified configuration to the CPU.
- **PG connection**:
  As soon as you have connected the PG to a CPU online in STEP 7, connection resources are occupied.
- **Web server**:
  As long as you have opened the Web server of the CPU in a browser, connection resources are occupied in the CPU.
- **OPC UA server**:
  As long as a session exists between the OPC UA server of the CPU and an OPC UA client, a connection resource is occupied in the CPU.

Monitoring the maximum possible number of connection resources

Offline

During configuration of connections, STEP 7 monitors the occupation of the connection resources. If the maximum possible number of connection resources is exceeded, STEP 7 signals this with a suitable warning.

Online

The CPU monitors the use of connection resources in the automation system. If you establish more connections in the user program than those provided by the automation system, the CPU acknowledges the instruction to establish the connection with an error.

11.3 Display of the connection resources

Display of the connection resources in STEP 7 (offline view)

You can display the connection resources of an automation system in the hardware configuration. You will find the connection resources in the Inspector window in the properties of the CPU.

Connection resources

	① Station resources			② Module reso...	Module reso..	Module reso...
	Reserved		Dynamic ⚠	PLC_1 [CPU ...	CP 1543-1_...	CM 1542-5_...
Maximum number of resources:	10		246	128	118	48
	Maximum	Configured	Configured	Configured	Configured	Configured
PG communication:	4	-	-	-	-	-
HMI communication:	4	4	6	6	4	0
S7 communication:	0	-	23	2	0	21
Open user communication:	0	-	52	39	13	0
Web communication:	2	-	-	-	-	-
Other communication:	-	-	0	0	0	0
Total resources used:		4	81	47	17	21
Available resources:		6	165	81	101	27

Figure 11-4 Example: Reserved and available connection resources (offline view)

① Station-specific connection resources

The columns of the station-specific connection resources provide information about the used and available connection resources of the station.

In the example, a maximum of 256 station-specific connection resources are available for the automation system.

- 10 reserved connection resources, of which 4 are already in use and a further 6 available. The used resources are divided up as follows:
  - 4 Resources for HMI communication
- 246 dynamic connection resources, of which 81 are already in use and a further 165 available.
  The used resources are divided up as follows:
  - 6 resources for HMI communication
  - 23 Resources for S7 communication
  - 52 resources for Open User Communication

The warning triangle in the column of the dynamic station resources is therefore displayed because the sum of the maximum available connection resources of CPU, CP and CM (= 294 connection resources) exceeds the station limit of 256.

Note

Available connection resources exceeded

STEP 7 signals the exceeding of the station-specific connection resources with a warning. To make full use of the connection resources from the CPU, CP and CM, either use a CPU with a higher maximum number of available station-specific connection resources or reduce the number of communications connections.

② Module-specific connection resources

The columns of the module-specific connection resources provide information about the use of resources on the CPUs, CPs and CMs of an automation system:

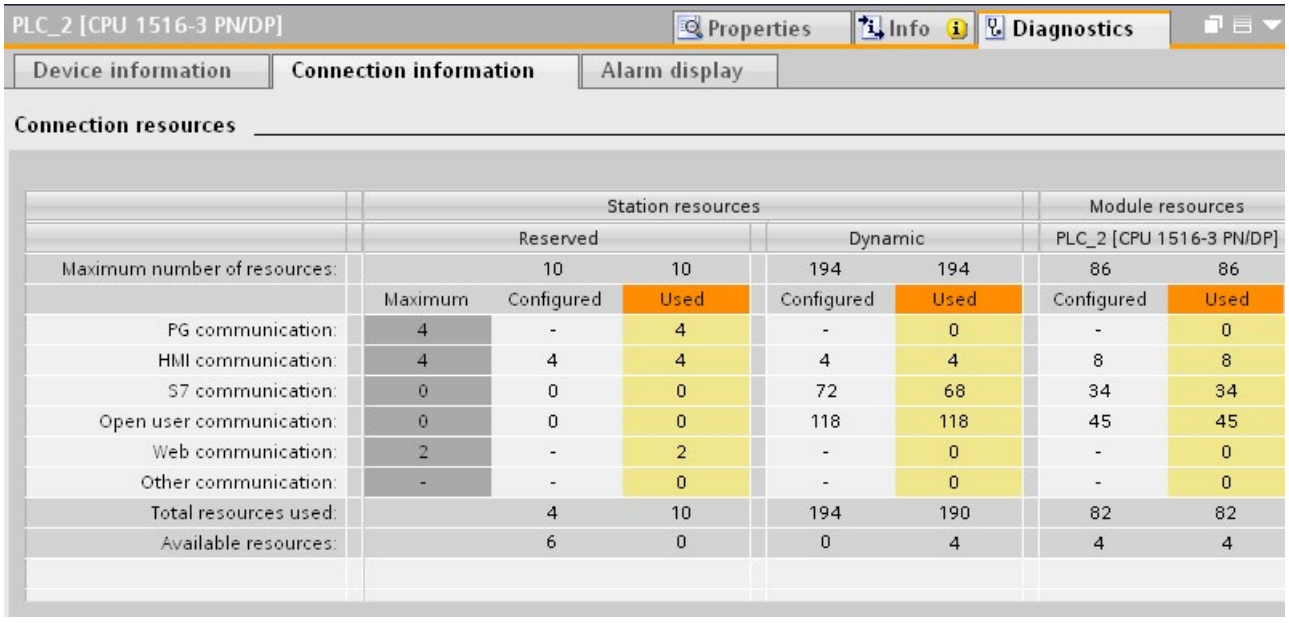
The display is per module and not per interface.

In the example, the CPU makes 128 connection resources available, of which 47 are already in use and a further 81 still available.
The used resources are divided up as follows:

- 6 resources for HMI communication
- 2 resources for S7 communication
- 39 resources for Open User Communication

Display of the connection resources in STEP 7 (online view)

If you are connected to the CPU online, you can also see how many resources are currently being used under "Connection information".



	Station resources					Module resources	
	Reserved			Dynamic		PLC_2 [CPU 1516-3 PN/DP]	
Maximum number of resources:		10	10	194	194	86	86
	Maximum	Configured	Used	Configured	Used	Configured	Used
PG communication:	4	-	4	-	0	-	0
HMI communication:	4	4	4	4	4	8	8
S7 communication:	0	0	0	72	68	34	34
Open user communication:	0	0	0	118	118	45	45
Web communication:	2	-	2	-	0	-	0
Other communication:	-	-	0	-	0	-	0
Total resources used:		4	10	194	190	82	82
Available resources:		6	0	0	4	4	4

Figure 11-5 Connection resources - online

The online view of the "Connection resources" table in addition to the offline view also contains columns with the connection resources currently being used. Thus, the online view displays **all** used connection resources in the automation system, regardless of how the connection was set up.

The "Other communication" row displays connection resources assigned for communication with external devices. The table is updated automatically.

Note

If a routed S7 connection goes through a CPU, the required connection resources of the CPU do not appear in the table of connection resources!

Display of the connection resources for HMI

For information regarding the availability and assignment of connection resources for HMI connections, refer to the "Connection resources" properties in the Inspector window of the offline view (in the context of the HMI device).

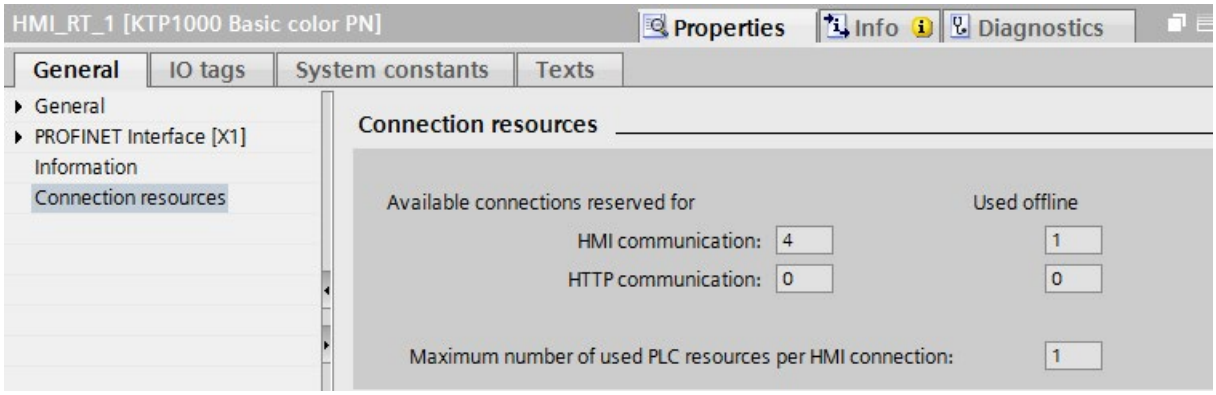


Figure 11-6 Connection resources - HMI communication

The following is displayed in the connection resources area:

- Number of available connections on the HMI reserved for HMI communication and HTTP communication
- Number of connection resources for HMI communication and HTTP communications used offline in the HMI

  If the maximum number of available connection resources for an HMI device is exceeded, a corresponding message is output by STEP 7.
- "Maximum number of used PLC resources per HMI connection". This parameter is a factor that is to be multiplied by the number of HMI connections used offline. The product is the number of HMI resources occupied on the CPU.

Displaying the connection resources in the Web server

You can display the connection resources not only in STEP 7, but also with a browser that displays the relevant page of the Web server.

You will find information on displaying connection resources in the Web server in the Web Server (http://support.automation.siemens.com/WW/view/en/59193560)function manual.

Connection diagnostics

12

Connections table in the online view

After selecting a CPU in the Devices & networks editor of STEP 7, you will see the status of your connections displayed in the online view of the connections table.

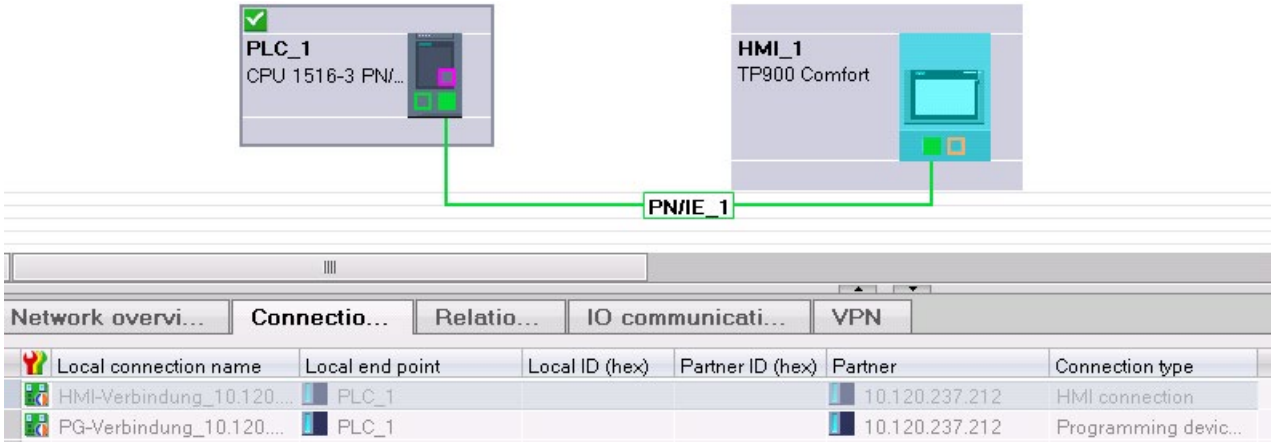


Figure 12-1 Online view of the connections table

After selecting the connection in the connections table, you obtain detailed diagnostic information in the "Connection information" tab.

"Connection information" tab: Connection details

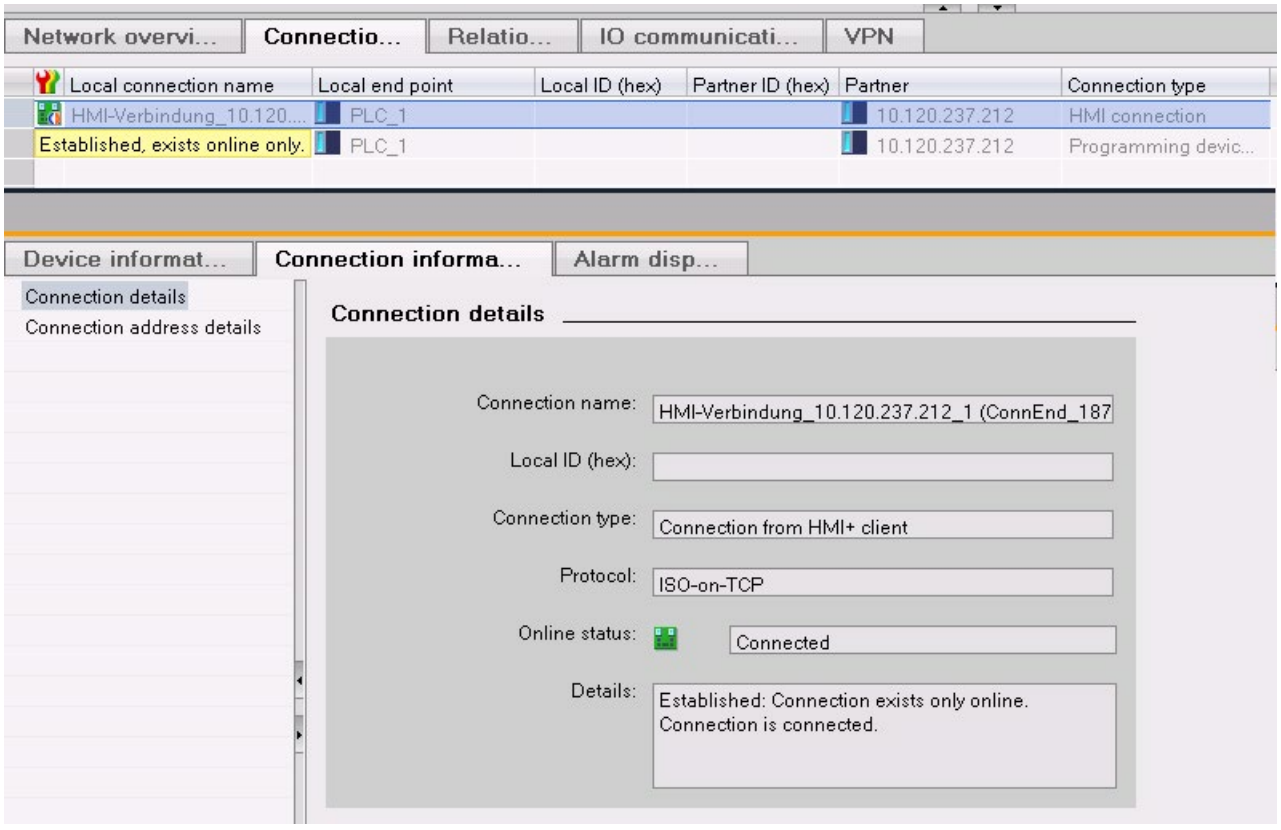


Figure 12-2 Diagnostics of connections - connection details

"Connection information" tab: Address details

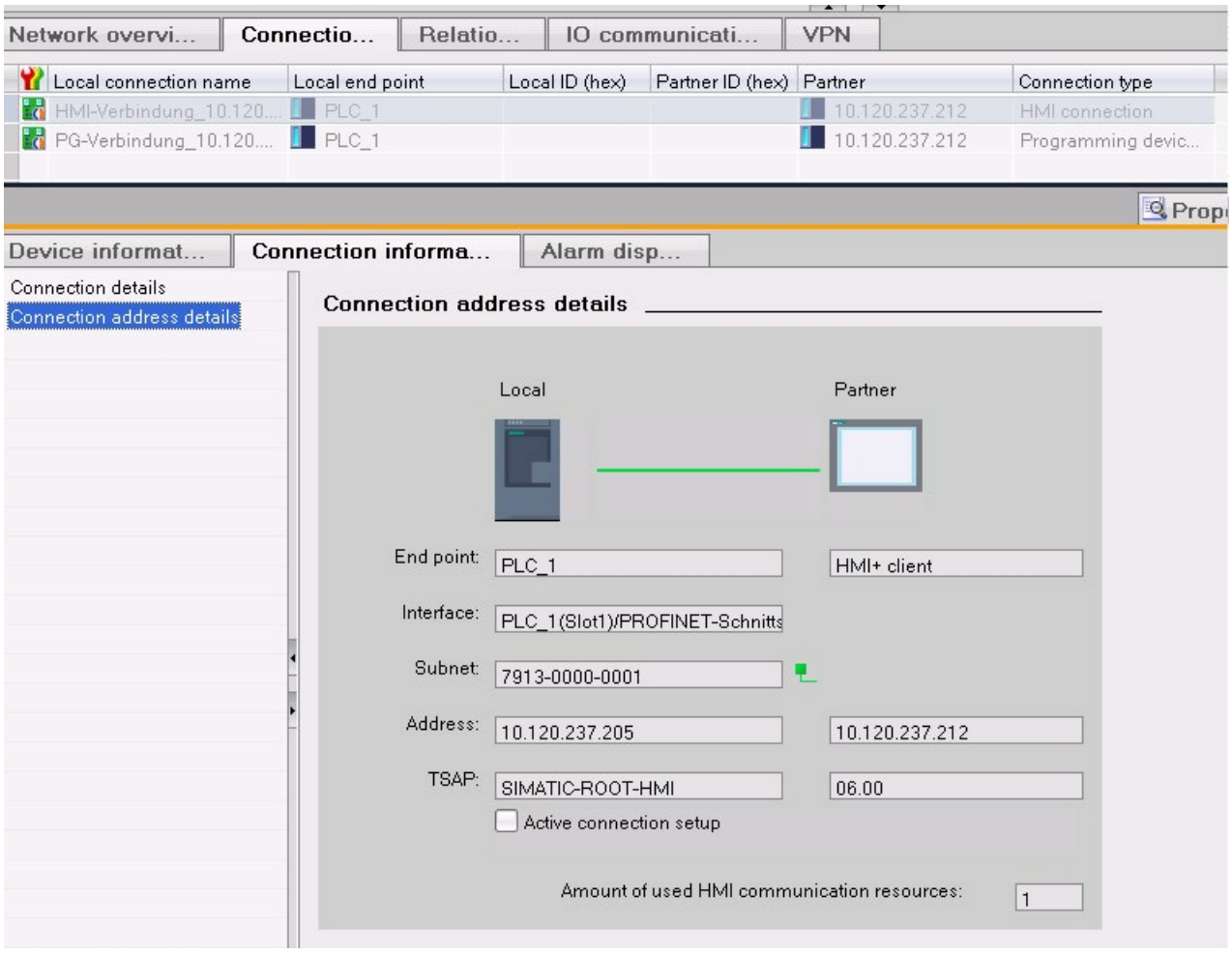


Figure 12-3 Diagnostics of connections - address details

Diagnostics via web server

You can evaluate diagnostic information from the CPU using a web browser via the integrated web server of a CPU.

On the "Communication" Web page, you will find the following information about communication via PROFINET in various tabs:

- Information on the PROFINET interfaces of the CPU (for example addresses, subnets, physical properties).
- Information on the quality of the data transfer (for example number of data packets sent/received error-free).
- Information about the allocation/availability of connection resources.
- The "Connections" page is similar to the online view in STEP 7 and also provides an overview of all connections with detail view.

Diagnostics with the user program

When you program the T_DIAG instruction, you can evaluate diagnostic information about the configured and programmed connections of the CPU using the user program.

Additional information

You will find the description of the web server functionality in the function manual Web server (http://support.automation.siemens.com/WW/view/en/59193560).

Industrial Ethernet Security 13

All-round protection - the task of Industrial Ethernet Security

With Industrial Ethernet Security, individual devices, automation cells or network segments of an Ethernet network can be protected. Data transfer can also be protected by a combination of different security measures:

- Data espionage
- Data manipulation
- Unauthorized access

Security measures

- Firewall
  - IP firewall with stateful packet inspection (layer 3 and 4)
  - Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)
  - Bandwidth limitation
  - Global firewall rules

  All network nodes located in the internal network segment of a CP 1543-1 are protected by its firewall.
- Logging

  To allow monitoring, events can be stored in log files that can be read out using the configuration tool or can be sent automatically to a Syslog server.
- HTTPS

  For encrypted transfer of websites, for example during process control.
- FTPS (explicit mode)

  For encrypted transfer of files.
- Secure NTP

  For secure time-of-day synchronization and transmission.
- SNMPv3

  For secure transmission of network analysis information safe from eavesdropping.
- VPN groups
  You can combine the CP 1543-1 with other security modules into VPN groups through configuration. IPsec tunnels are established between all the security modules of a VPN group (VPN). All internal nodes of these security modules can communicate securely with each other through this tunnel.
- Protection for devices and network segments

  The firewall and VPN groups protective functions can be applied to the operation of single devices, multiple devices, or entire network segments.

Additional information

An overview with links to the most important contributions on Industrial Security is available in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/92651441).

13.1 Firewall

Tasks of the firewall

The purpose of the firewall functionality is to protect networks and stations from outside influences and disturbances. This means that only certain previously specified communications relations are permitted.

To filter the data traffic, IPv4 addresses, IPv4 subnets, port numbers or MAC addresses among other things can be used.

The firewall functionality can be configured for the following protocol levels:

- IP firewall with stateful packet inspection (layer 3 and 4)
- Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)

Firewall rules

Firewall rules describe which packets are permitted or forbidden in which direction.

13.2 Logging

Functionality

For test and monitoring purposes, the security module has diagnostics and logging functions.

- Diagnostics functions

  These include various system and status functions that you can use in online mode.

- Logging functions

  This involves the recording of system and security events. Depending on the event type, the recording is made in volatile or non-volatile local buffer areas of the CP 1543-1. As an alternative, it is also possible to record on a network server.

  The parameter assignment and evaluation of these functions is only possible with a network connection.

Recording events with logging functions

You specify which events should be recorded with the log settings. Here you can configure the following recording variants:

- Local logging

  With this variant, you record the events in local buffers of the CP 1543-1. In the online dialog of the Security Configuration Tool, you can then access these recordings, visualize them and archive them on the service station.

- Network Syslog

  With the network Syslog, you use a Syslog server in the network. This records the events according to the configuration in the log settings.

13.3 NTP client

Functionality

To check the time validity of a certificate and the time stamp of log entries, the date and time are maintained on the CP 1543-1 as on the CPU. This time can be synchronized with NTP. The CP 1543-1 forwards the synchronized time to the CPU via the backplane bus of the automation system. This way the CPU also receives a synchronized time for the time events in program execution.

The automatic setting and periodic synchronization of the time takes place either via a secure or non-secure NTP server. You can assign a maximum of 4 NTP servers to the CP 1543-1. A mixed configuration of non-secure and secure NTP servers is not possible.

13.4 SNMP

Functionality

Like the CPU, the CP 1543-1 supports the transfer of management information using the Simple Network Management Protocol (SNMP). To achieve this, an "SNMP agent" is installed on the CP/CPU that receives and responds to the SNMP queries. Information about the properties of devices capable of SNMP is contained in so-called MIB files (Management Information Base) for which the user needs to have the appropriate rights.

With SNMPv1, the "community string" is also sent. The "community string" is like a password that is sent along with the SNMP query. The requested information is sent when the "community string" is correct. The request is discarded when the string is incorrect.

With SNMPv3, data can be transferred encrypted. To do this, select either an authentication method or an authentication and encryption method.

Possible selection:

- Authentication algorithm: none, MD5, SHA-1
- Encryption algorithm: none, AES-128, DES

You can deactivate the use of SNMP for the CP/CPU. Deactivate SNMP if the security guidelines in your network do not permit SNMP or if you use your own SNMP solution.

To find out how to deactivate SNMP for the CPU, refer to section Disabling SNMP (Page 34).

13.5 VPN

Functionality

For security modules that protect the internal network, VPN (Virtual Private Network) tunnels provide a secure data connection through the non-secure external network.

The module uses the IPsec protocol (tunnel mode of IPsec) for tunneling.

In STEP 7 you can assign VPN groups to security modules. VPN tunnels are automatically established between all modules of a VPN group. A module in one project can belong to several different VPN groups at the same time in the process.

Glossary

Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Bus

Transmission medium that connects several devices together. Data transmission can be performed electrically or via optical fibers, either in series or in parallel.

Client

Device in a network that requests a service from another device in the network (server).

CM

→ *Communications module*

Communications module

Module for communications tasks used in an automation system as an interface expansion of the CPU (for example PROFIBUS) and providing additional communications options (PtP).

Communications processor

Module for expanded communications tasks covering special applications, for example in the area of security.

Consistent data

Data that belongs together in terms of content and must not be separated when transferred.

CP

→ *Communications processor*

CPU

Central **P**rocessing **U**nit - Central module of the S7 automation system with a control and arithmetic unit, memory, operating system and interface for programming device.

Device

Generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices) and
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

Device certificates

Such certificates are signed by a certificate authority (CA).

The signature of an end-entity certificate is checked with the public key of the certificate authority certificate.

The "Subject" attribute must not be identical to the "Issuer" attribute.

The "Subject", for example, contains the name of a program as with the OPC UA application certificate.

"Issuer" is the certificate authority that signed the certificate.

The "CA" field must be set to "False".

DP master

Within PROFIBUS DP, a master in the distributed I/O that behaves according to the EN 50170 standard, Part 3.

→ *See also DP slave*

DP slave

Slave in the distributed I/O that is operated on PROFIBUS with the PROFIBUS DP protocol and behaves according to the EN 50170 standard, Part 3.

→ *See also DP master*

Duplex

Data transmission system; a distinction is made between full and half duplex.

Half duplex: One channel is available for alternate data exchange (sending or receiving alternately but not at the same time).

Full duplex: Two channels are available for simultaneous data exchange in both directions (simultaneous sending and receiving in both directions).

End-entity certificate

→ *See also device certificate*

Ethernet

International standard technology for local area networks (LAN) based on frames. It defines types of cables and signaling for the physical layer and packet formats and protocols for media access control.

Ethernet network adapter

Electronic circuitry for connecting a computer to an Ethernet network. It allows the exchange of data / communication within the network.

FETCH/WRITE

Server services using TCP/IP, ISO-on-TCP and ISO for access to system memory areas of S7 CPUs. Access (client function) is possible from a SIMATIC S5 or a third-party device/PC. FETCH: Read data directly; WRITE: Write data directly.

Field device

→ *Device*

Freeport

Freely programmable ASCII protocol; here for data transfer via a point-to-point connection.

FTP

File **T**ransfer **P**rotocol; a network protocol for transferring files via IP networks. FTP is used to download files from the server to the client or to upload files from the client to the server. FTP directories can also be created and read out and directories and files can be renamed or deleted.

HMI

Human **M**achine **I**nterface, device for visualization and control of automation processes.

IE

→ *Industrial Ethernet*

IM

→ *Interface module*

Industrial Ethernet

Guideline for setting up an Ethernet network in an industrial environment. The essential difference compared with standard Ethernet is the mechanical ruggedness and immunity to noise of the individual components.

Instruction

The smallest self-contained unit of a user program characterized by its structure, function or purpose as a separate part of the user program. An instruction represents an operation procedure for the processor.

Interface module

Module in the distributed I/O system. The interface module connects the distributed I/O system via a fieldbus to the CPU (IO controller/DP master) and prepares the data for the I/O modules.

Intermediate CA certificate

This is a certificate authority certificate that is signed with the private key of a root certificate authority.

An intermediate certificate authority signs end-entity certificates with its private key.

The signature of these end-entity certificates is verified with the public key of the intermediate certificate authority.

The "Subject" and "Issuer" attributes of the intermediate CA certificate must not be identical. This certificate authority has after all not signed its certificate itself.

The "CA" field must be set to "True".

IO controller, PROFINET IO controller

Central device in a PROFINET system, usually a classic programmable logic controller or PC. The IO controller sets up connections to the IO devices, exchanges data with them, thus controls and monitors the system.

IO device, PROFINET IO device

Device in the distributed I/O of a PROFINET system that is monitored and controlled by an IO controller (for example distributed inputs/outputs, valve islands, frequency converters, switches).

IP address

Binary number that is used as a unique address in computer networks in conjunction with the Internet Protocol (IP). It makes these devices uniquely addressable and individually accessible. An IPv4 address can be evaluated using a binary subnet mask that results in a network part or a host part as a structure. The textual representation of an IPv4 address consists, for example, of 4 decimal numbers with the value range 0 to 255. The decimal numbers are separated by periods.

IPv4 subnet mask

Binary mask, with which an IPv4 address (as a binary number) is divided into a "network part" and a "host part".

ISO protocol

Communications protocol for message or packet-oriented transfer of data in an Ethernet network. This protocol is hardware-oriented, very fast and allows dynamic data lengths. The ISO protocol is suitable for medium to large volumes of data.

ISO-on-TCP protocol

Communications protocol capable of S7 routing for packet-oriented transfer of data in an Ethernet network; provides network addressing. The ISO-on-TCP protocol is suitable for medium and large volumes of data and allows dynamic data lengths.

Linear bus topology

Network topology characterized by the arrangement of the devices in a line (bus).

MAC address

Worldwide unique device identification for all Ethernet devices. The MAC address is assigned by the manufacturer and has a 3-byte vendor ID and 3-byte device ID as a consecutive number.

Master

Higher-level, active participant in the communication/on a PROFIBUS subnet. The master has rights to access the bus (token), requests data and sends it.

→ *See also DP master*

Modbus RTU

Remote **T**erminal **U**nit; Open communications protocol for serial interfaces based on a master/slave architecture.

Modbus TCP

Transmission **C**ontrol **P**rotocol; Open communications protocol for Ethernet based on a master/slave architecture. The data are transmitted as TCP/IP packets.

Network

A network consists of one or more interconnected subnets with any number of devices. Several networks can exist alongside each other.

NTP

The **N**etwork **T**ime **P**rotocol (NTP) is a standard for synchronizing clocks in automation systems via Industrial Ethernet. NTP uses the connectionless UDP transport protocol for the Internet.

OPC UA

Protocol for communication between machines, developed by the OPC Foundation.

Operating system

Software that allows the use and operation of a computer. The operating system manages resources such as memory, input and output devices and controls the execution of programs.

PG

→ *Programming device*

PNO

→ *PROFIBUS user organization*

Point-to-point connection

Bidirectional data exchange via communications modules with a serial interface between two communications partners (and two only).

Port

Physical connector to connect devices to PROFINET. PROFINET interfaces have one or more ports.

Process image

Address area of a programmable logic controller (PLC), in which the signal states of the inputs and the logical states of the outputs from the connected modules are stored digitally.

PROFIBUS

Process **Fi**eld **Bus** - European Fieldbus standard.

PROFIBUS address

Unique identifier of a device connected to PROFIBUS. The PROFIBUS address is sent in the frame to address a device.

PROFIBUS device

Device with at least one PROFIBUS interface either electrical (for example RS-485) or optical (for example Polymer Optical Fiber).

PROFIBUS user organization

Technical committee dedicated to the definition and development of the PROFIBUS and PROFINET standard.

PROFIBUS DP

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O = fast, real-time capable, cyclic data exchange. From the perspective of the user program, the distributed I/O is addressed in exactly the same way as the centralized IO.

PROFINET

Open component-based industrial communications system based on Ethernet for distributed automation systems. Communications technology promoted by the PROFIBUS user organization.

PROFINET device

Device that always has a PROFINET interface (electrical, optical, wireless).

PROFINET interface

Interface of a module capable of communication (for example CPU, CP) with one or more ports. A MAC address is assigned to the interface in the factory. Along with the IP address and the device name (from the individual configuration), this interface address ensures that the PROFINET device is identified uniquely in the network. The interface can be electrical, optical or wireless.

PROFINET IO

IO stands for input/output; distributed I/O (fast, cyclic data exchange with real-time capability). From the perspective of the user program, the distributed I/O is addressed in exactly the same way as the centralized IO.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS & PROFINET International defines a cross-vendor communication, automation, and engineering model.

With PROFINET IO, a switching technology is used that allows all devices to access the network at any time. In this way, the network can be used much more efficiently through the simultaneous data transfer of several devices. Simultaneous sending and receiving is enabled via the full-duplex operation of Switched Ethernet.

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps.

Programming device

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software configuration for programmable logic controllers.

Protocol

Agreement on the rules by which the communication between two or more communication partners transpires.

PtP

Point-**t**o-**P**oint, interface and/or transmission protocol for bidirectional data exchange between two (and only two) communications partners.

Ring topology

All devices of a network are connected together in a ring.

Root CA certificates

→ *See also root certificate*

Root certificate

This is the certificate of a certificate authority: It signs end-entity certificates and intermediate CA certificates with its private key.

The "Subject" attribute and the "Issuer" of this certificate must be identical. This certificate authority has signed its certificate itself.

The "CA" field must be set to "True".

TIA Portal V14 has such a root CA certificate:

If you configure the OPC UA server of an S7-1500 in the TIA Portal, the TIA Portal generates an end-entity certificate for the OPC UA server and signs that certificate with its own private key.

The signature of this end-entity certificate can be verified with the public key of the TIA Portal. This key can be found in the root CA certificate of the TIA Portal.

Router

Network node with a unique identifier (name and address) that connects subnets together and allows transportation of data to uniquely identified communications nodes in the network.

RS232, RS422 and RS485

Standard for serial interfaces.

RTU

Modbus RTU (RTU: **R**emote **T**erminal **U**nit, transfers the data in binary form; allows a good data throughput. The data must be converted to a readable format before it can be evaluated.

S7 routing

Communication between S7 automation systems, S7 applications or PC stations in different S7 subnets via one or more network nodes functioning as S7 routers.

SDA service

Send Data with Acknowledge. SDA is an elementary service with which an initiator (for example DP master) can send a message to other devices and then receives acknowledgment of receipt immediately afterwards.

SDN service

Send Data with No Acknowledge. This service is used primarily to send data to multiple stations and the service therefore remains unacknowledged. Suitable for synchronization tasks and status messages.

Security

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

Self-signed certificates

These are certificates that you sign with your private key and use as end-entity certificates.

The signature of these end-entity certificates is verified with your public key.

The "Subject" and "Issuer" attributes of self-signed certificates must be identical: You have signed your certificate yourself.

The "CA" field must be set to "False".

You can, for example, use self-signed certificates as application certificates for an OPC UA client.

The procedure required to generate a self-signed certificate with the certificate generator of the OPC Foundation is described here.

Server

A device or more generally an object that can provide certain services; the service is performed at the request of a client.

Slave

Distributed device in a fieldbus system that can only exchange data with a master after the master has requested this.

→ *See also DP slave*

SNMP

Simple **N**etwork **M**anagement **P**rotocol, uses the wireless UDP transport protocol. SNMP works in much the same way as the client/server model. The SNMP manager monitors the network nodes. The SNMP agents collect the various network-specific information in the individual network nodes and makes this information available in a structured form in the MIB (**M**anagement **I**nformation **B**ase). This information allows a network management system to run detailed network diagnostics.

Subnet

Part of a network whose parameters must be matched up on the devices (for example in PROFINET). A subnet includes the bus components and all connected stations. Subnets can be linked together, for example using gateways or routers to form one network.

Switch

Network components used to connect several terminal devices or network segments in a local network (LAN).

TCP/IP

Transmission **C**ontrol **P**rotocol / **I**nternet **P**rotocol, connection-oriented network protocol, generally recognized standard for data exchange in heterogeneous networks.

Time-of-day synchronization

Capability of transferring a standard system time from a single source to all devices in the system so that their clocks can be set according to the standard time.

Tree topology

Network topology characterized by a branched structure: Two or more bus nodes are connected to each bus node.

Twisted-pair

Fast Ethernet via twisted-pair cables is based on the IEEE 802.3u standard (100 Base-TX). The transmission medium is a shielded 2x2 twisted-pair cable with an impedance of 100 Ohms (22 AWG). The transmission characteristics of this cable must meet the requirements of category 5.

The maximum length of the connection between the terminal and the network component must not exceed 100 m. The connectors are designed according to the 100Base-TX standard with the RJ-45 connector system.

UDP

User **D**atagram **P**rotocol; communications protocol for fast and uncomplicated data transfer, without acknowledgment. There are no error checking mechanisms as found in TCP/IP.

User program

In SIMATIC, a distinction is made between the CPU operating system and user programs. The user program contains all instructions, declarations and data by which a system or process can be controlled. The user program is assigned to a programmable module (for example, CPU, FM) and can be structured in smaller units.

USS

Universal Serial Interface protocol (**U**niverselles **S**erielles **S**chnittstellen-Protokoll); defines an access method according to the master-slave principle for communication via a serial bus.

Web server

Software/communications service for data exchange via the Internet. The web server transfers the documents using standardized transmission protocols (HTTP, HTTPS) to a Web browser. Documents can be static or put together dynamically from different sources by the web server on request from the Web browser.

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Function manual

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Function Manual

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Preface

Purpose of the documentation

This function manual provides an overview of the PROFINET communication system with SIMATIC STEP 7 V14.

STEP 7 V14 is integrated into the powerful graphical Totally Integrated Automation Portal (TIA Portal), the new integration platform for all automation software tools.

This function manual supports you in planning a PROFINET system. The manual is structured into the following subject areas:

- PROFINET basics
- PROFINET diagnostics
- PROFINET functions

Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Knowledge about how to use STEP 7 (TIA Portal)

Scope

This documentation is the basic documentation for all SIMATIC products from the PROFINET environment. The product documentation is based on this documentation.

The examples are based on the functionality of the S7-1500 automation system.

Changes compared to previous version

This manual encompasses the following new functions compared to the previous version (version 12/2014):

Function	Applications	User benefits
PROFINET IO on the 2nd PROFINET interface	You can operate another PROFINET IO system on the CPU or connect additional IO devices.	You use a fieldbus type in the plant. The CPU can perform fast and deterministic data exchange as an I-device with a higher-level controller (PROFINET/Ethernet) through the second line.
IRT with very short data cycle times down to 125 µs	You realize high-end applications with IO communication which place very high performance demands on the IO processing.	You make PROFINET IO communication and standard communication possible via one cable even with a send clock of 125 µs.
MRPD: Media Redundancy with Planned Duplication of frames	PROFINET IO IRT enables you to realize applications that place particularly high demands on the reliability and accuracy (isochronous mode).	By sending the cyclic IO data in both directions in the ring, the communication to the IO devices is maintained even when the ring is interrupted and does not result in device failure even with fast update times. You achieve higher reliability than with MRP.
PROFINET performance upgrade	You can implement applications with high speed and send clock requirements. This is interesting for applications with high demands on performance.	Better utilization of the bandwidth results in short reaction times.
Limitation of the data infeed into the network	You limit the network load for standard Ethernet communication to a maximum value.	You flatten peaks in the data feed. You share the remaining bandwidth based on demand.

Conventions

STEP 7: We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This documentation contains pictures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

Note

A note contains important information on the product, on handling of the product and on the section of the documentation to which you should pay particular attention.

See also

PRODIS (http://www.siemens.com/simatic-tech-doku-portal)

Catalog (http://mall.industry.siemens.com)

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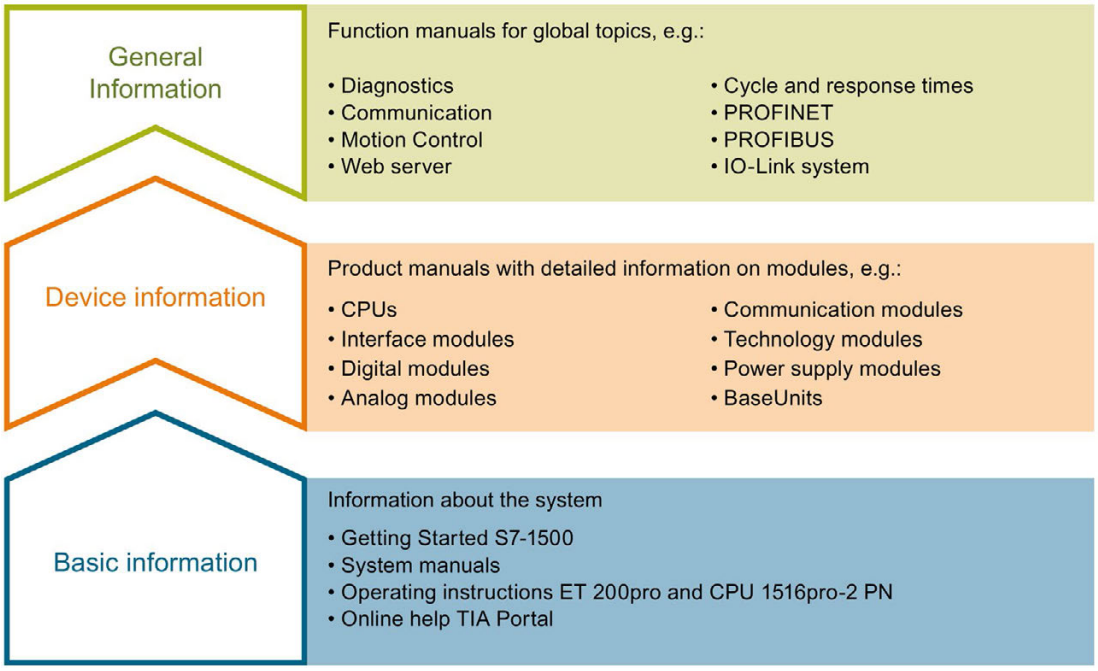
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

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In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Description 2

2.1 Introduction to PROFINET

What is PROFINET IO?

Within the framework of Totally Integrated Automation (TIA), PROFINET IO is the logical further development of:

- PROFIBUS DP, the established fieldbus and
- Industrial Ethernet

PROFINET IO is based on 20 years of experience with the successful PROFIBUS DP and combines the normal user operations with the simultaneous use of innovative concepts of Ethernet technology. This ensures the integration of PROFIBUS DP into the PROFINET world.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS/PROFINET International defines a cross-vendor communication, automation, and engineering model.

Objectives of PROFINET

The objectives of PROFINET:

- Industrial networking, based on Industrial Ethernet (open Ethernet standard)
- Compatibility of Industrial Ethernet and standard Ethernet components
- High robustness due to Industrial Ethernet devices. Industrial Ethernet devices are suited to the industrial environment (temperature, noise immunity, etc.).
- Use of IT standards such as TCP/IP, http.
- Real-time capability
- Seamless integration of other fieldbus systems

Implementation of PROFINET in SIMATIC

PROFINET is implemented in SIMATIC as follows:

- We have implemented communication between field devices in SIMATIC with **PROFINET IO**.
- Installation technology and network components are available as SIMATIC NET products.
- Ethernet standard protocol and procedures (e.g., SNMP = Simple Network Management Protocol for network parameter assignment and diagnostics) are used for remote maintenance and network diagnostics.

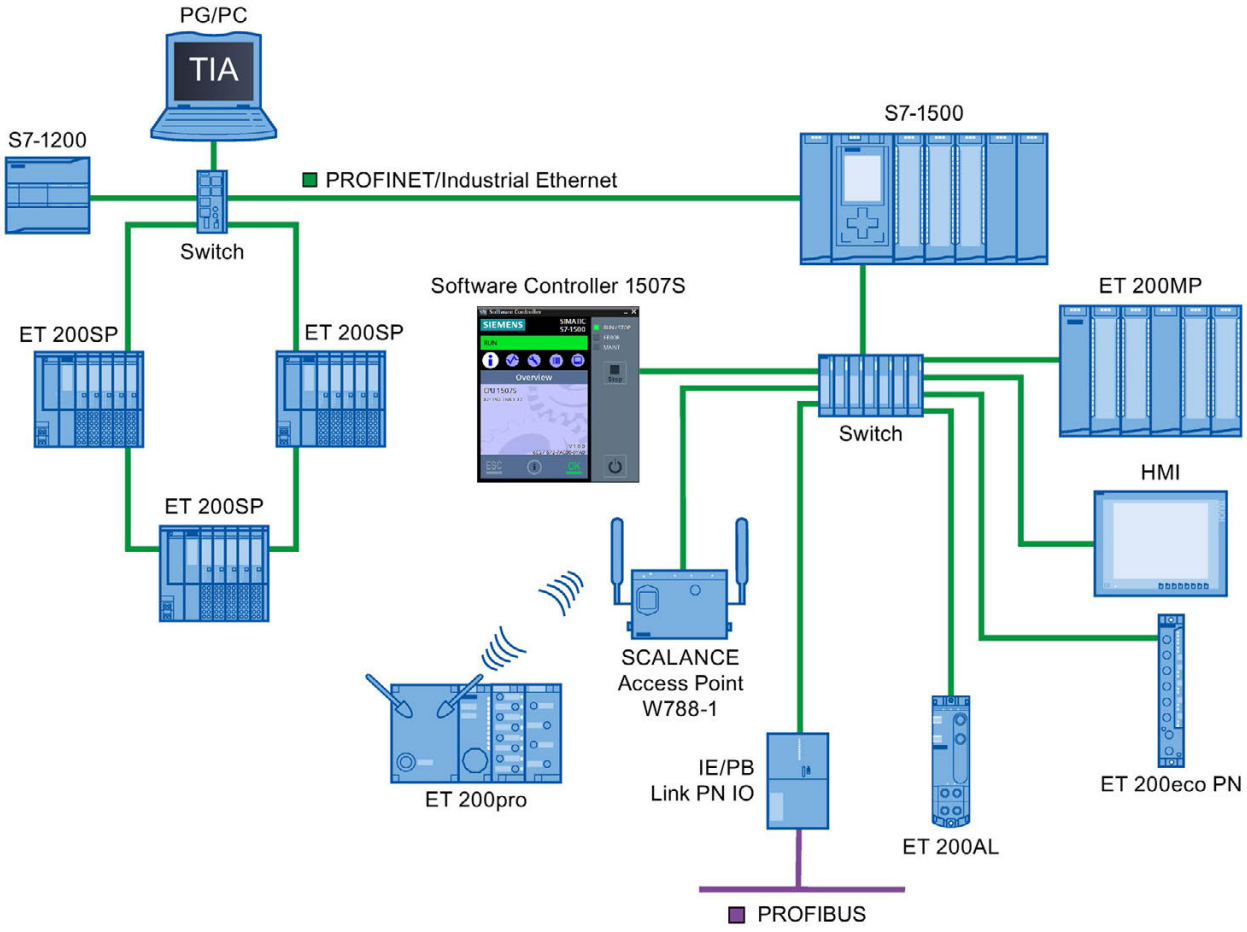


Figure 2-1 PROFINET overview configuration

STEP 7

The STEP 7 engineering tool supports you in setting up and configuring an automation solution. STEP 7 provides a uniform application view over all bus systems.

Documentation from PROFIBUS & PROFINET International on the Internet

You will find numerous documents on the topic of PROFINET at the Internet address (http://www.profibus.com) of the "PROFIBUS & PROFINET International" PROFIBUS user organization, which is also responsible for PROFINET.

Additional information can be found on the Internet (http://www.siemens.com/profinet).

Overview of the most important documents and links

A compilation of the most important PROFINET application examples, FAQs and other contributions in the Industry Online Support is available in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/108165711).

2.1.1 PROFINET terms

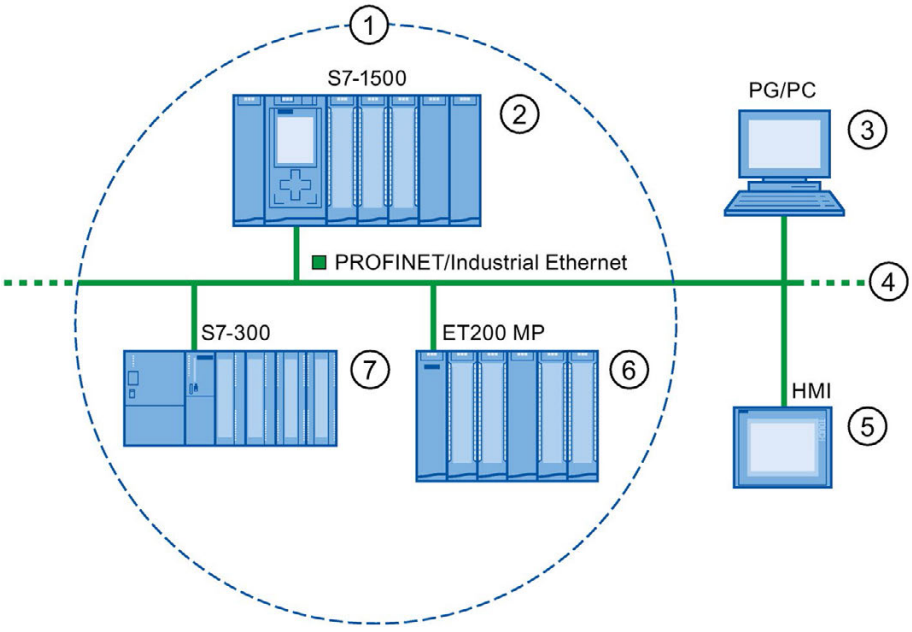
Definition: Devices in the PROFINET environment

In the PROFINET environment, "device" is the generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

PROFINET IO devices

The following graphic shows the general names used for the most important devices in PROFINET. In the table below the graphic you can find the names of the individual components in the PROFINET IO context.

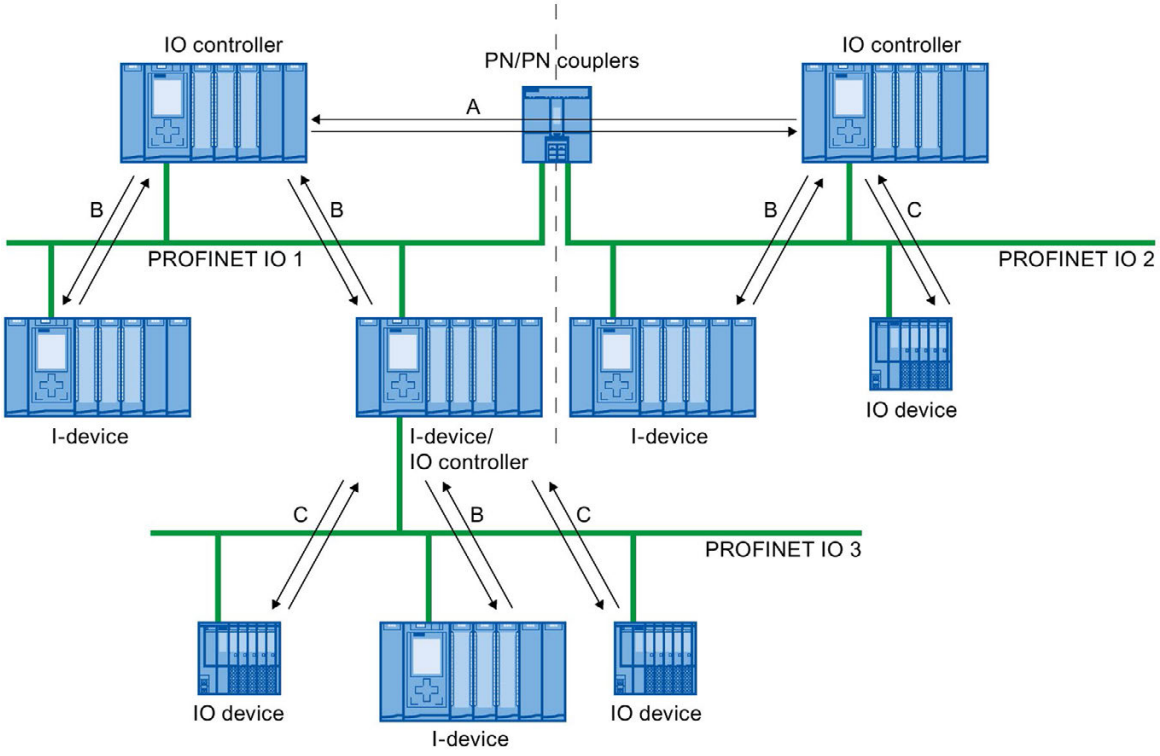


Number	PROFINET	Explanation
①	PROFINET IO System	
②	IO controller	Device used to address the connected IO devices. This means that: The IO controller exchanges input and output signals with field devices.
③	Programming device / PC (PROFINET IO supervisor)	PG/PC/HMI device used for commissioning and for diagnostics
④	PROFINET/Industrial Ethernet	Network infrastructure
⑤	HMI (Human Machine Interface)	Device for operating and monitoring functions.
⑥	IO device	A distributed field device that is assigned to one of the IO controllers (e.g., Distributed IO, valve terminals, frequency converters, switches with integrated PROFINET IO functionality)
⑦	I-device	Intelligent IO device

Figure 2-2 PROFINET devices

IO communication via PROFINET IO

The inputs and outputs of distributed I/O devices are read and written by means of PROFINET IO using what is referred to as IO communication. The following figure provides an overview of IO communication by means of PROFINET IO.



A IO controller - IO controller communication via PN/PN coupler

B IO controller - I-device communication

C IO controller - IO-device communication

Figure 2-3 IO communication via PROFINET IO

IO communication via PROFINET IO

Table 2- 1 IO communication via PROFINET IO

Communication between ...	Explanation
IO controllers and IO devices	The IO controller sends data cyclically to the IO devices of its PROFINET IO system and receives data from these devices.
IO controller and I-device	A fixed quantity of data is transferred cyclically between the user programs in CPUs of IO controllers and I-devices. The IO controller does not access the I/O module of the I-device, but instead accesses configured address ranges, i.e. transfer ranges, which may be located inside our outside the process image of the CPU of the I-device. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules. Data transfer takes place using load- and transfer operations via the process image or via direct access.
IO controller and IO controller	A fixed quantity of data is cyclically transferred between the user programs in CPUs of IO controllers. A PN/PN coupler is required as additional hardware. The IO controllers mutually access configured address ranges, i.e. transfer ranges, which may be located inside or outside the process image of the CPU. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules. Data transfer takes place using load- and transfer operations via the process image or via direct access.

See also

Network security (Page 36)

Functions (Page 93)

Communication (http://support.automation.siemens.com/WW/view/en/59192925)

2.1.2 Basic terminology of communication

PROFINET communication

PROFINET communication takes place via Industrial Ethernet. The following transmission types are supported:

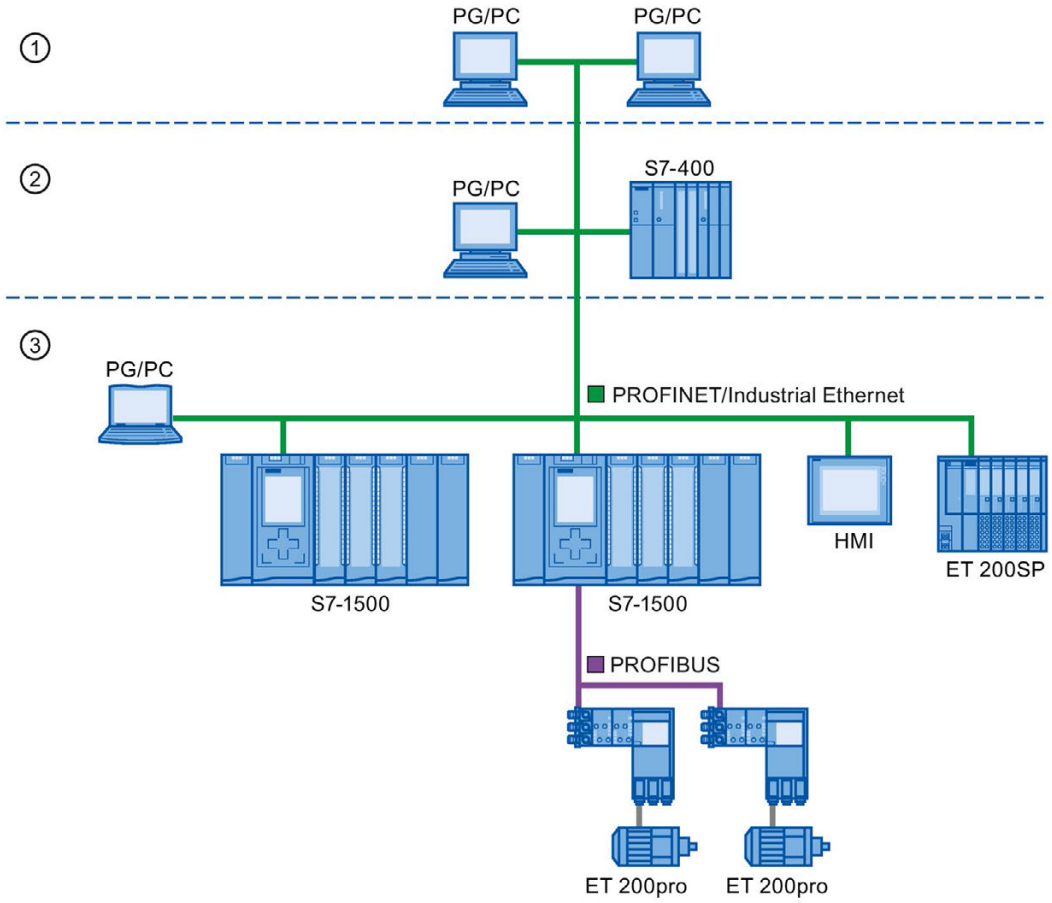
- Acyclic transmission of engineering and diagnostics data and interrupts
- Cyclic transmission of user data

The PROFINET-IO communication takes place in real-time.

For additional information on the real-time communication, refer to chapter Real-time communication (Page 157).

Transparent data access

Access to process data from different levels of the factory is supported by PROFINET communication. By using Industrial Ethernet, standard mechanisms of communication and information technology such as OPC/XML can now be used along with standard protocols such as UDP/TCP/IP and HTTP in automation engineering. This allows transparent access from company management level directly to the data from the automation systems at the control level and production level.



① Management level
② Control level
③ Production level

Figure 2-4 Access to process data

Update time

The update time is a time interval. IO controller and IO device/I-device exchange IO data cyclically in the IO system within this time interval. The update time can be configured separately for each IO device and determines the interval at which output data is sent from the IO controller to the IO device (output module/submodule) as well as input data from the IO device to the IO controller (input module/submodule).

STEP 7 calculates the update time automatically in the default setting for each IO device of the PROFINET IO system, taking into account the volume of data to be exchanged as well as the set send clock.

For additional information on the update time, refer to section Real-time communication (Page 157).

Watchdog time

The watchdog time is the time interval that an IO controller or IO device permits, without receiving IO data. If the IO device is not supplied by the IO controller with data within the watchdog time, the device detects the missing frames and outputs substitute values. This is reported in the IO controller as a station failure.

In STEP 7, the watchdog time is made up from an integral multiple of the update time and can be set by the user.

Send clock

The period of time between two consecutive communication cycles. The send clock is the shortest possible interval in data exchange.

Relationship between the update time and send clock

The calculated update times are reduction ratios (1, 2, 4, 8, ..., 512) of the send clock. The minimum possible update time thus depends on the minimum send clock of the IO controller that can be set and the efficiency of the IO controller and IO device. Depending on the send clock, it can be that only some of the reduction ratios are available (STEP 7 guarantees this through a pre-selection).

The following tables illustrate the dependency of the update time that can be set on the send clock, using an example of the CPU 1516-3 PN/DP. The update times satisfy the requirements of the PROFINET standard IEC 61158.

Table 2- 2 With real-time communication the following applies:

Send clock	Update time	Reduction ratios
250 µs	250 µs to 128 ms	1,2, ..., 512
500 µs	500 µs to 256 ms	1,2, ..., 512
1 ms	1 ms to 512 ms	1,2, ..., 512
2 ms	2 ms to 512 ms	1,2, ..., 256
4 ms	4 ms to 512 ms	1,2, ..., 128

Additional information

For information on real-time communication, refer to the section Real-Time Communication (RT) (Page 158).

2.1.3 PROFINET interface

Overview

PROFINET devices of the SIMATIC product family have one or more PROFINET interfaces (Ethernet controller/interface). The PROFINET interfaces have one or more ports (physical connection options).

In the case of PROFINET interfaces with multiple ports, the devices have an integrated switch.

PROFINET devices with two ports on one interface allow you to configure the system in a line or ring topology. PROFINET devices with three or more ports on one interface are also ideal for setting up tree topologies.

Properties and rules for naming the PROFINET interface and its representation in STEP 7 are explained in the following.

Properties

Every PROFINET device on the network is uniquely identified via its PROFINET interface. For this purpose, each PROFINET interface has:

- A MAC address (factory default)
- An IP address
- A PROFINET device name

Identification and numbering of the interfaces and ports

Interfaces and ports for all modules and devices in the PROFINET system are identified with the following characters:

Table 2- 3 Identification for interfaces and ports of PROFINET devices

Element	Symbol	Interface number
Interface	X	In ascending order starting from number 1
Port	P	In ascending order starting from number 1 (for each interface)
Ring port	R	

Examples of identification

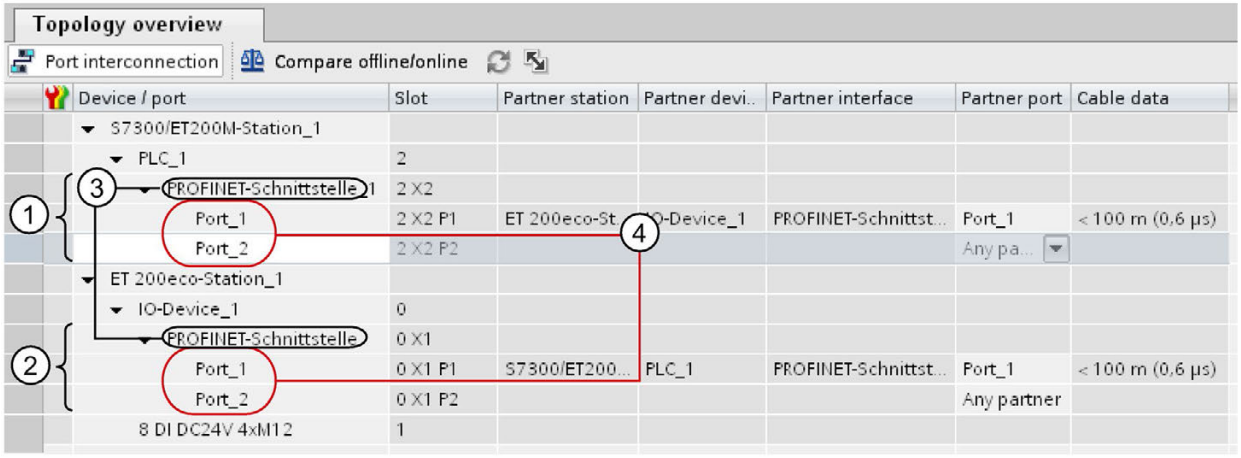
Three examples illustrate the rules for identifying PROFINET interfaces:

Table 2- 4 Examples for identifying PROFINET interfaces

Sample labeling	Interface number	Port number
X2 P1	2	1
X1 P2	1	2
X1 P1 R	1	1 (ring port)

Representation of PROFINET Interfaces in the Topology Overview in STEP 7

You can find the PROFINET interface in the topology overview in STEP 7. The PROFINET interface for an IO controller and an IO device is represented as follows in STEP 7:



Number	Description
①	PROFINET interface of an IO controller in STEP 7
②	PROFINET interface of an IO device in STEP 7
③	These lines represent the PROFINET interface.
④	These lines represent the "ports" of a PROFINET interface.

Figure 2-5 Representation of the PROFINET interfaces in STEP 7

Schematic Representation of a PROFINET Interface with Integrated Switch

The following schematic diagram shows the PROFINET interface with integrated switch and its ports for all PROFINETdevices.

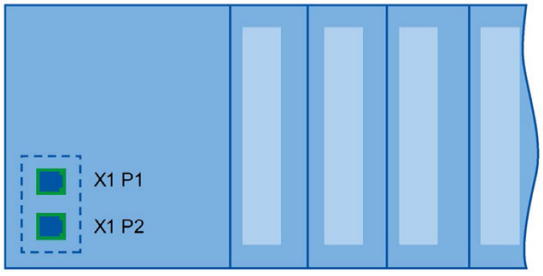


Figure 2-6 PROFINET interface with integrated switch

Functional differences of the PROFINET interfaces

PROFINET interfaces can provide different functions. PROFINET interface functions include identification, configuration, diagnostics and communication services (e.g., open communication). PROFINET interfaces that provide PROFINET IO functions and network security functions are also available.

The following table illustrates the differences using the example of the CPU 1516-3 PN/DP (as of firmware version V2.0), which features two PROFINET interfaces with different functionality.

Table 2- 5 Differences between the PROFINET interfaces of the CPU 1516-3 PN/DP (as of firmware version V2.0)

PROFINET interface (X1)	**PROFINET interface (X2)**
2 ports with PROFINET IO functionality:	**1 port with PROFINET IO functionality:**
Identification, configuration and diagnostics	
PG communication	
HMI communication	
S7 communication	
Time-of-day synchronization	
Web server	
Open communication	
OPC UA server	
IO controller	
I-device	
RT	
IRT	-
Isochronous mode	-
Media redundancy	-
Prioritized startup	-

Additional Information on the Functionality of PROFINET interfaces

You can find information on the number and functionality of the interfaces of a PROFINET device in the documentation for the specificPROFINET device.

PROFINET communication services are described in the Communication function manual.

In the Network security section you can find components that are used to protect networks against hazards.

The Functions section describes the PROFINET IO functions.

2.1.4 Implementation of the PROFINET device model in SIMATIC

Slots and modules

A PROFINET device can have a modular and compact structure. A modular PROFINET device consists of slots into which the modules are inserted. The modules have channels which are used to read and output process signals. A compact device has the same design and can include modules, however, it cannot be physically expanded, which means that no modules can be inserted.

This is illustrated by the following graphic.

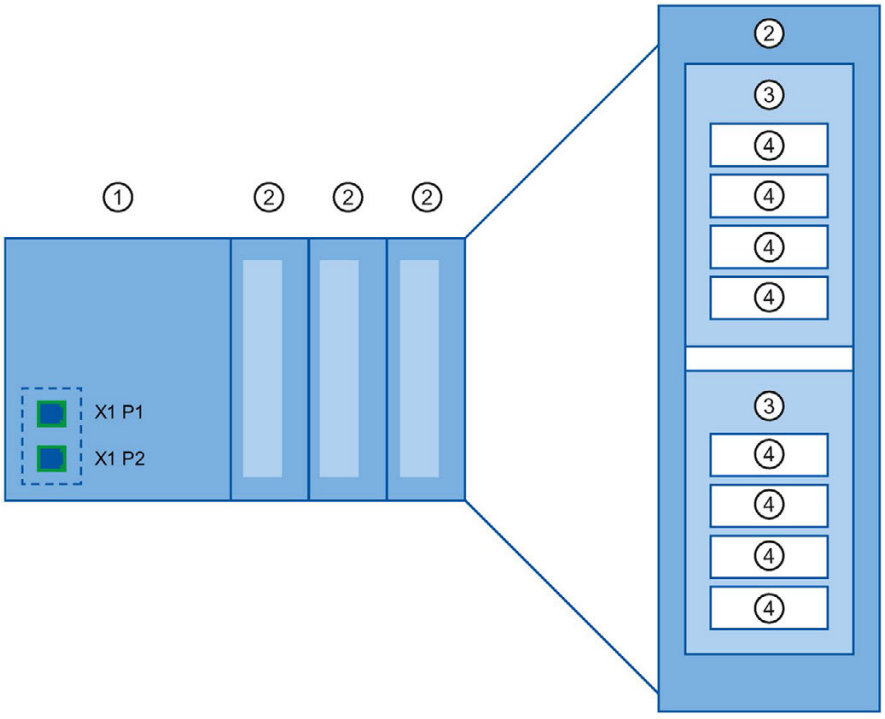


Figure 2-7 Configuration of a PROFINET device

Number	Description
①	Slot with bus interface
②	Slot with module
③	Subslot with submodule
④	Channel

A module can contain multiple submodules.

Representation of PROFINET Device Model in the Device View of STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:

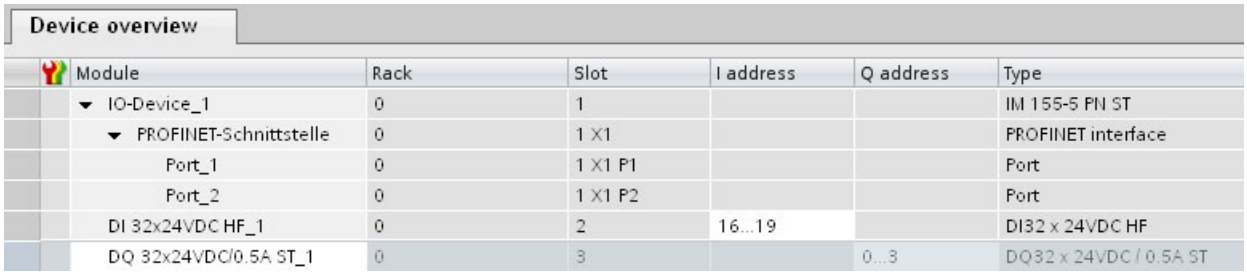


Figure 2-8 PROFINET device model in the device view of STEP 7

2.2 Setting up PROFINET

Contents of this chapter

The following chapter provides background information on building your communication network.

- Overview of the most important passive network components: These are network components that forward a signal without the possibility of actively influencing it, for example, cables, connectors, etc.
- Overview of the most important active network components: These are network components that actively affect a signal, for example switches, routers, etc.
- Overview of the most common network structures (topologies).

Physical connections of industrial networks

PROFINET devices can be networked in industrial systems in two different physical ways:

- Connected line
  - By means of electrical pulses via copper cables
  - By means of optical pulses via fiber-optic cables
- Wireless via wireless network using electromagnetic waves

PROFINET devices and cabling technology in SIMATIC are suited for industrial use, as they are based on Fast Ethernet and Industrial Ethernet.

- **Fast Ethernet**

  You can use Fast Ethernet to transfer data at a speed of 100 Mbps. This transmission technology uses the 100 Base-T standard for this.

- **Industrial Ethernet**

  Structure of Ethernet in industrial environment.

  The biggest difference from standard Ethernet is the mechanical current carrying capacity and noise immunity of the individual components.

2.2.1 Active Network Components

Introduction

The following active network components are available for PROFINET:

- Switch
- Router

Switched Ethernet

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps. In this way, the network can be used much more efficiently through the simultaneous data transfer of several devices. The PROFINET IO frames are processed with high priority.

Switches

Switches are network components used to connect several terminal devices or network segments in a local network (LAN).

For the communication of a device with several other devices on PROFINET, the device is connected to the port of a switch. Other communication devices (including switches) can then be connected to the other ports of the switch. The connection between a communication device and the switch is a point-to-point connection.

A switch has the task of receiving and distributing frames. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those frames that are intended for the connected PROFINET device or the connected switch.

Switch variants

Switches are available in two models:

- Integrated into a PROFINET device

  For PROFINET devices with multiple ports (two or more), we are dealing with devices with an integrated switch (for example, CPU 1516-3 PN/DP).

- As autonomous device (for example, switches of the SCALANCE product family)

Selection Guide for Switches

To use PROFINET with the RT class "RT", you can use any switch of "PROFINET Conformance Class A" or higher. All switches of the SCALANCE product family meet these requirements.

If you want to use PROFINET functions that provide an additional value, such as topology recognition, diagnostics, device exchange without exchangeable medium/programming device, you have to use a switch of the "PROFINET Conformance Class B" or higher.

To use PROFINET with the RT class "IRT", you must use a switch of "PROFINET Conformance Class C". With switches of the SCALANCE product family, watch out for the catalog feature "IRT PROFINET IO switch".

To select appropriate switches, we recommend the SIMATIC NET Selection Tool on the Internet (http://support.automation.siemens.com/WW/view/en/39134641).

Switches of the SCALANCE product family

Use the switches of the SCALANCE product family if you want to use the full scope of PROFINET. They are optimized for use in PROFINET IO.

In the SCALANCE X device family, you will find switches with electrical and optical ports and with a combination of both variants. SCALANCE X202-2IRT, for example, has two electrical ports and two optical ports and supports IRT communication.

Beginning with the SCALANCE X200, you can configure, diagnose and address switches of the SCALANCE X device series as PROFINET IO devices using STEP 7.

Router

A router connects separated network segments with each other (e.g. management level and control level). The volume of data volume must be coordinated with the services of the respective network segment. A router also separates two networks and acts as a mediator between both networks. It thus reduces the network load. Routing functionality is provided in the SCALANCE X device family, with SCALANCE X300 or higher.

Communication devices on different sides of a router can only communicate with one another if you have explicitly enabled communication between them via the router.

If you want to access manufacturing data directly from SAP, for example, use a router to connect your Industrial Ethernet in the factory with the Ethernet in your office.

Note

If devices need to communicate beyond the limits of a network, you must configure the router so that it allows this communication to take place.

Information on routing with STEP 7 is available in the function manual Communication (http://support.automation.siemens.com/WW/view/en/59192925).

2.2.2 Cabling technology

Cables for PROFINET

Electrical and optical cables are available for PROFINET. The type of cable depends on the data transfer requirements and on the ambient conditions.

Simple method for the prefabrication of twisted pair cables

When you set up your PROFINET system, you can cut the twisted-pair cable to the required length on site, strip it with the *stripping tool* (for Industrial Ethernet), and fit the *Industrial Ethernet Fast Connect RJ45 plugs* using the cut-and-clamp method. For more information on installation, refer to the installation instructions in the "SIMATIC NET Industrial Ethernet Network Manual" (http://support.automation.siemens.com/WW/view/en/8763736).

Note

A maximum of four plug-in pairs are allowed between two switches per Ethernet path.

Simple method for the prefabrication of fiber-optic cables

The FastConnect FO cabling system is available for the easy, fast and error-free prefabrication of fiber-optic cables. The glass-fiber optic cable consists of:

- FC FO Termination Kit for SC and BFOC plug (cleave tool, Kevlar scissors, buffer grip, fiber remains container)
- FC BFOC Plug
- FC SC Duplex plug
- FO FC Standard cable
- FO FC Trailing cable

Simple method for the prefabrication of POF and PCF cables

The following special tools provide an easy and safe way to prefabricate POF / PCF cables and fit the SC RJ POF plugs:

- POF cable

  Prefabrication case IE Termination Kit SC RJ POF plug
- PCF cable

  Prefabrication case IE Termination Kit SC RJ PCF plug

Overview of transmission media with PROFINET

The following table summarizes the technical specifications of a PROFINET interface with integrated switch or an external switch, and possible transmission media.

Table 2- 6 Transmission media with PROFINET

Physical properties	**Connection methods**	**Cable type / transmission medium** **standard**	**Transmission rate / mode**	**Max. segment length** (between two devices)	**Advantages**
Electrical	RJ45 connector ISO 60603-7	100Base-TX 2x2 twisted, symmetrical and shielded copper cable, CAT 5 transmission requirement IEEE 802.3	100 Mbps, full duplex	100 m	Simple and cheap cable connection
Optical	SCRJ 45 ISO/IEC 61754-24	100Base-FX POF fiber-optic cable (Polymer Optical Fiber, POF) 980/1000 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	50 m	Use when there are large differences in potential Insensitive towards electromagnetic radiation Low line attenuation Considerably longer segments possible[1]
		Plastic-cladded glass fiber (Polymer Cladded Fiber, PCF) 200/230 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	100 m	

Physical properties	**Connection methods**	**Cable type / transmission medium** **standard**	**Transmission rate / mode**	**Max. segment length** (between two devices)	**Advantages**
	BFOC (Bayonet Fiber Optic Connector) and SC (Subscriber Connector) ISO/IEC 60874	Monomode glass fiber optic cable 10/125 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	26 km	
		Multimode glass fiber optic cable 50/125 µm and 62.5/125 µm (core diameter / external diameter) ISO/IEC 9314-4	100 Mbps, full duplex	3000 m	
Electromagnetic waves	-	IEEE 802.11 x	Depends on the extension used (a, g, h, etc.)	100 m	Greater mobility Cost-effective networking to remote, difficult to access devices

[1] Applies for fiber-optic cables only

See also

PROFINET interface (Page 23)

Assembly Instructions for SIMATIC NET Industrial Ethernet (http://support.automation.siemens.com/WW/view/en/27069465)

PROFINET Installation Guideline (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/)

2.2.3 Wireless design

2.2.3.1 Basics

What is Industrial Wireless LAN?

In addition to data communication in accordance with the IEEE 802.11 standard, the SIMATIC NET Industrial Wireless LAN provides a number of enhancements which offer significant benefits for industrial customers. IWLAN is particularly suitable for demanding industrial applications that require reliable wireless communication. This is supported by the following properties:

- Automatic roaming when the connection to Industrial Ethernet is interrupted (Forced Roaming)
- Cost savings generated by using a single wireless network for reliable operation of a process with both process-critical data (alarm message, for example) and non-critical communication (service and diagnostics, for example)
- Cost-effective connection to devices in remote environments that are difficult to access
- Predictable data traffic (deterministic) and defined response times
- Cyclical monitoring of the wireless link (link check)

Objectives and advantages of Industrial Wireless LAN

Wireless data transmission achieves the following objectives:

- Seamless integration of PROFINET devices into the existing bus system via the wireless interface
- Mobile use of PROFINET devices for different production-linked tasks
- Flexible configuration of the system components for fast development in accordance with customer requirements
- Maintenance costs are minimized by savings in cables

Application examples

- Communication with mobile subscribers (mobile controllers and devices, for example), conveyor lines, production belts, translation stages , and rotating machines
- Wireless coupling of communication segments for fast commissioning or cost-effective networking where routing of wires is extremely expensive (e.g. public streets, railroad lines)
- Stacker trucks, automated guided vehicle systems and suspended monorail systems

The following graphic illustrates the many possible applications and configurations for SIMATIC device family wireless networks.

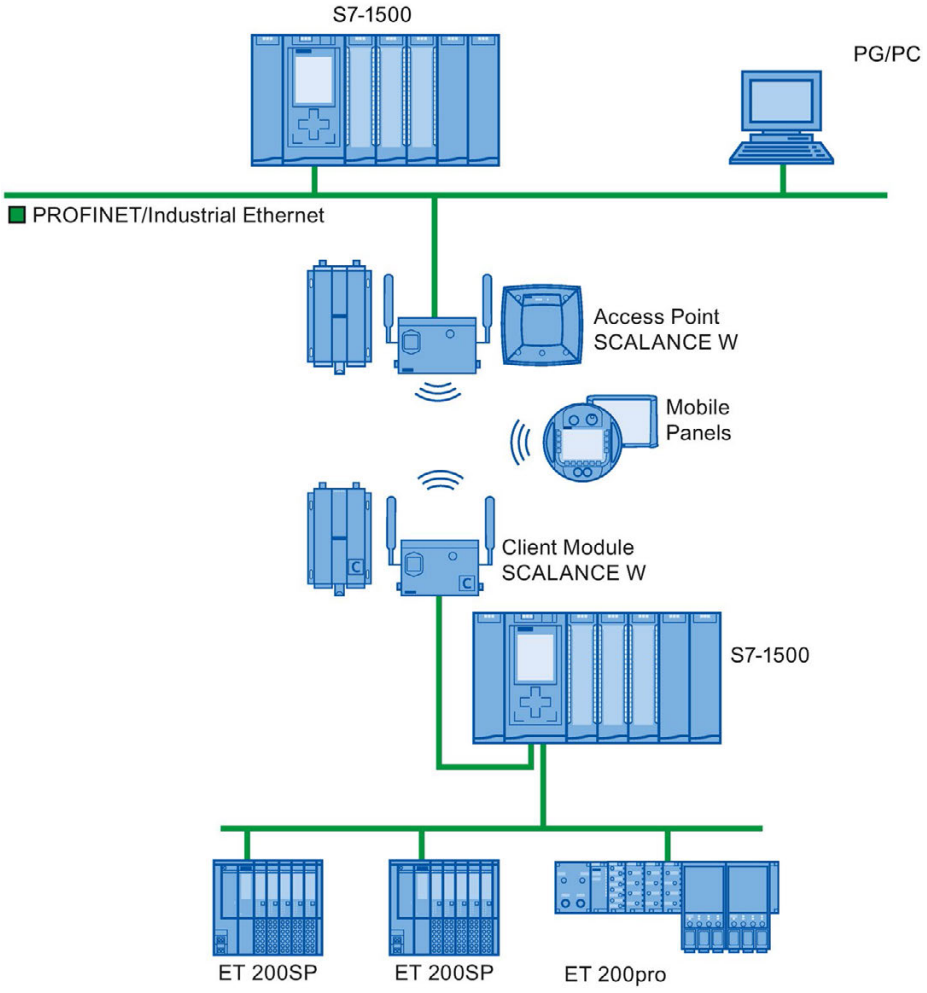


Figure 2-9 Application example for the use of Industrial Wireless LAN

Data transmission rate

In Industrial Wireless LAN, gross data transmission rates of 11 Mbps or 54 Mbps without full duplex are permitted.

Range

With SCALANCE W (access points), wireless networks can be set up indoors and outdoors. Multiple access points can be installed to create large wireless networks in which mobile subscribers are transferred seamlessly from one access point to another (roaming).

As an alternative to a wireless network, point-to-point connections of Industrial Ethernet segments can also be set up over large distances (several hundred meters). In this case, the range and characteristics of the RF field are determined by the antennas used.

Note

Range

The range can be considerably less, depending on spatial factors, the wireless standard used, the data rate, and the antennas on the send and receive sides.

2.2.3.2 Tips on assembly

Wireless networks, SCALANCE device family

With PROFINET, you can also set up wireless networks with Industrial Wireless Local Area Network (IWLAN) technology. We recommend implementing the SCALANCE W device line for this.

Update time in STEP 7

If you set up PROFINET with Industrial Wireless LAN, you may have to increase the update time for the wireless devices. The IWLAN interface provides lower performance than the wired data network: Several communication stations have to share the limited transmission bandwidth. For wired solutions, 100 Mbps is available for each communication device.

The Update time parameter can be found in the "Realtime settings" section in the Inspector window of IO devices in STEP 7.

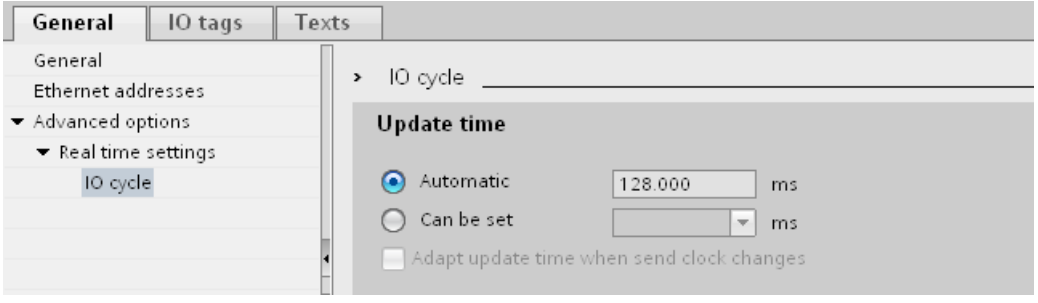


Figure 2-10 Update time in STEP 7

Additional information

More information about SCALANCE W Industrial Wireless LAN components can be found in the manual SIMATIC NET SCALANCE W-700 (http://support.automation.siemens.com/WW/view/en/42784493).

More information about wired data transmission can be found in the manual SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736).

More information about wireless data transmission can be found in the manual Basics for configuring an industrial wireless LAN (http://support.automation.siemens.com/WW/view/en/9975764).

You should also read the PROFINET installation guideline of the PROFIBUS User Organization on the Internet (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/). Various documents that assist with the setting up of your PROFINET automation solution are available here:

- PROFINET planning guideline
- PROFINET installation guideline
- PROFINET commissioning guideline
- Additional documents for setup of PROFINET

2.2.4 Network security

2.2.4.1 Basics

Introduction

The topic of data security and access protection (Security) has become increasingly important in the industrial environment. The increased networking of entire industrial systems, vertical integration and networking of levels within a company and new techniques such as remote maintenance all result in higher requirements for protecting the industrial plant.

Data security solutions for office environments cannot simply be transferred one-to-one to industrial applications to protect against manipulation in sensitive systems and production networks.

Requirements

Additional security requirements arise from the specific communication requirements in the industrial environment (real-time communication, for example):

- Protection against interaction between automated cells
- Protection of network segments
- Protection against faulty and unauthorized access
- Scalability of network security
- Must not influence the network structure

Definition of security

Generic term for all the measures taken to protect against:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to destruction of data, for example, through faulty configuration and denial-of-service attacks

Threats

Threats can arise from external and internal manipulation. The loss of data security is not always caused by intentional actions.

Internal threats can arise due to:

- Technical errors
- Operator errors
- Defective programs

Added to these internal threats there are also external ones. The external threats are not really any different to the known threats in the office environment:

- Software viruses and worms
- Trojans
- Man-in-the-middle attacks
- Password Phishing
- Denial of Service

Protective measures

The most important precautions to prevent manipulation and loss of data security in the industrial environment are:

- Filtering and control of data traffic by means of firewall
- A virtual private network (VPN) is used to exchange private data on a public network (Internet, for example).

  The most common VPN technology is IPsec. IPsec (Internet Protocol Security) is a collection of security protocols that are used as the basis for the IP protocol at the mediation level and allow a secured communication via potentially unsecure IP networks.
- Segmenting in protected automation cells

  This concept has the aim of protecting the lower-level network devices by means of security modules. A group of protected devices forms a protected automation cell.
- Authentication (identification) of the devices

  The security modules identify each other over a safe (encrypted) channel using authentication procedures. It is therefore impossible for unauthorized parties to access a protected segment.
- Encrypting the data traffic

  The confidentiality of data is ensured by encrypting the data traffic. Each security module is given a VPN certificate which includes the encryption key.

2.2.4.2 Network components and software

Protection against unauthorized access

The following solutions may be used to connect industrial networks to the intranet and Internet to protect against internal and external threats:

- Communication processors, such as the SIMATIC CP 1543-1
- SCALANCE X-300 and SCALANCE S - the data security components of the SIMATIC NET product family
- SOFTNET security client for use on PCs

Features

Both of these products have a wide variety of features, such as:

- Easy integration of existing networks without configuration, with integrated firewall.
- Segmenting in protected automation cells
- Authentication (identification) of the devices
- Encrypting the data traffic

2.2.4.3 Application example

Data security at the office and production levels

The following graphic contains an application example with protected areas at different levels of the company created using SCALANCE S and the security client. The protected areas are highlighted in light gray.

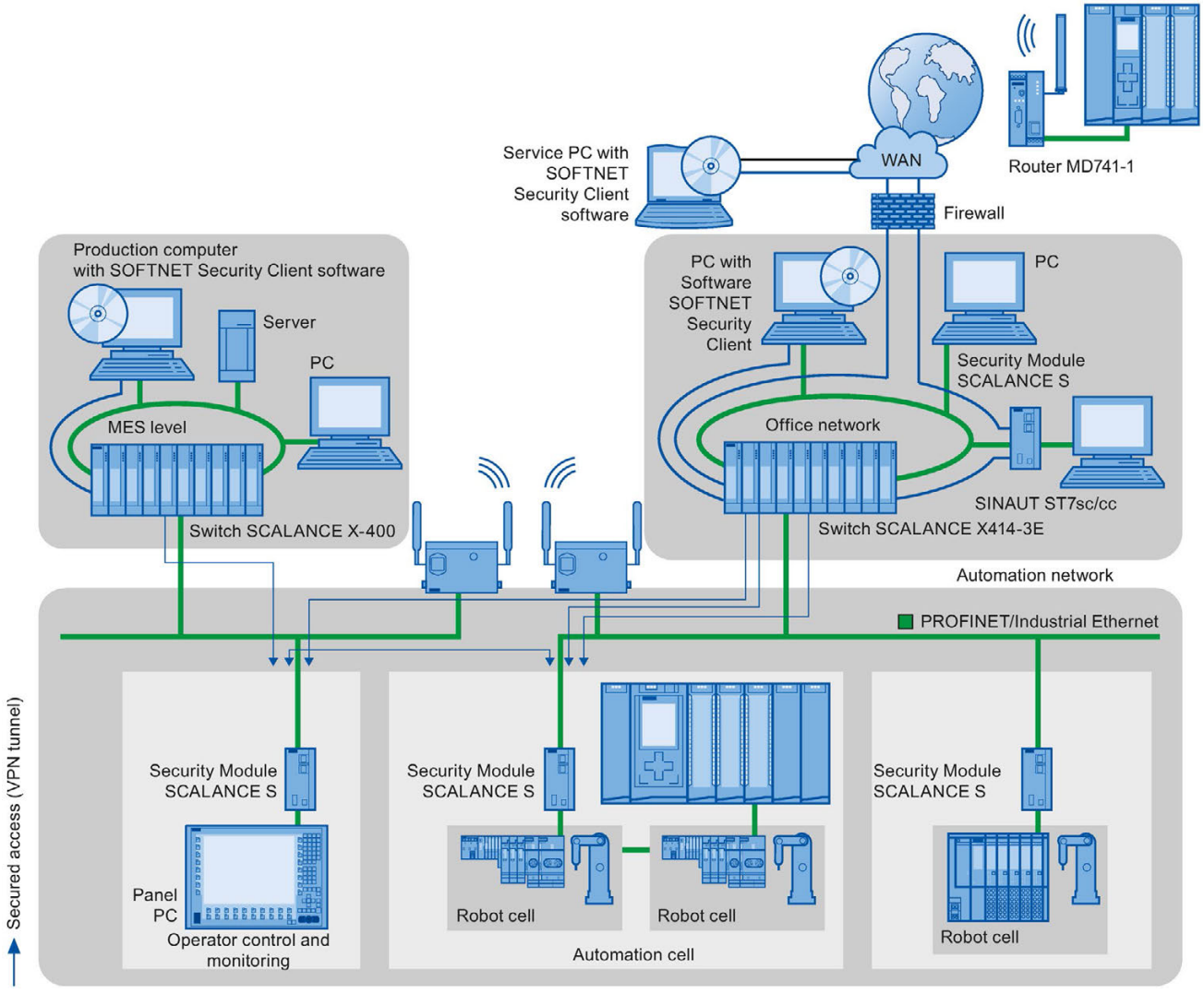


Figure 2-11 Network configuration with the SCALANCE S security module and the SOFTNET security client

Additional information

Additional information on the configuration of a security standard in PROFINET, is available:

- In the PROFINET security guideline. These guidelines can be found on the homepage of the PROFIBUS user organization on the Internet (http://www.profinet.com).
- In the Industrial Ethernet Security (http://support.automation.siemens.com/WW/view/en/56577508) manual
- In the SCALANCE S and SOFTNET Security Client (http://support.automation.siemens.com/WW/view/en/21718449) manual

You can find general information on industrial security concepts, functions and news on the Industrial Security website (http://www.siemens.com/industrialsecurity).

Parameter assignment/addressing 3

To set up an automation system, you will need to configure, assign parameters and interlink the individual hardware components. In STEP 7, the work needed for this is undertaken in the device, topology and network view.

Configuring

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device, topology or network view.

An I/O address is automatically assigned to each module. The I/O addresses can be subsequently modified.

The CPU compares the configuration preset in STEP 7 with the actual current configuration of the system. In this way, potential errors can be detected and reported straight away.

The exact procedure for configuring devices is described in detail in the STEP 7 online help.

Assigning parameters

"Assigning parameters" is understood to mean setting the properties of the components used. The settings for the hardware components and for data communication are configured at the same time.

In STEP 7, you can "assign parameters" for the following settings PROFINET:

- Device names and IP address parameters
- Port interconnection and topology
- Module properties / parameters

The parameters are loaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules are easy to replace from spare parts, as the parameters assigned for the SIMATIC CPUs are automatically loaded into the new module at each startup.

Adjusting the hardware to the project requirements

You need to configure hardware if you want to set up, expand or change an automation project. To do this, add hardware components to your structure, link these with existing components, and adapt the hardware properties to the tasks.

The properties of the automation systems and modules are preset such that in many cases they do not have to be assigned parameters again.

Parameter assignment is however needed in the following cases:

- You want to change the default parameter settings of a module.
- You want to use special functions.
- You want to configure communication connections.

3.1 Assigning an IO device to an IO controller

PROFINET IO System

A PROFINET IO system is comprised of a PROFINET IO controller and its assigned PROFINET IO devices. After these devices have been placed in the network or topology view, STEP 7 assigns default values for them. Initially, you only have to worry about the assignment of IO devices to an IO controller.

Requirement

- You are in the network view of STEP 7.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An IO device has been placed (e.g., IM 155-6 PN ST).

Procedure

To assign IO devices to an IO controller, proceed as follows:

1. Place the pointer of the mouse over the interface of the IO device.
2. Press and hold down the left mouse button.
3. Move the pointer.

   The pointer now uses the networking symbol to indicate "Networking" mode. At the same time, you see the lock symbol on the pointer. The lock symbol disappears only when the pointer is over a valid target position.
4. Now move the pointer onto the interface of the IO controller. You can keep the left mouse button pressed or release it when performing this action.
5. Now release the left mouse button or press it again (depending on your previous action).

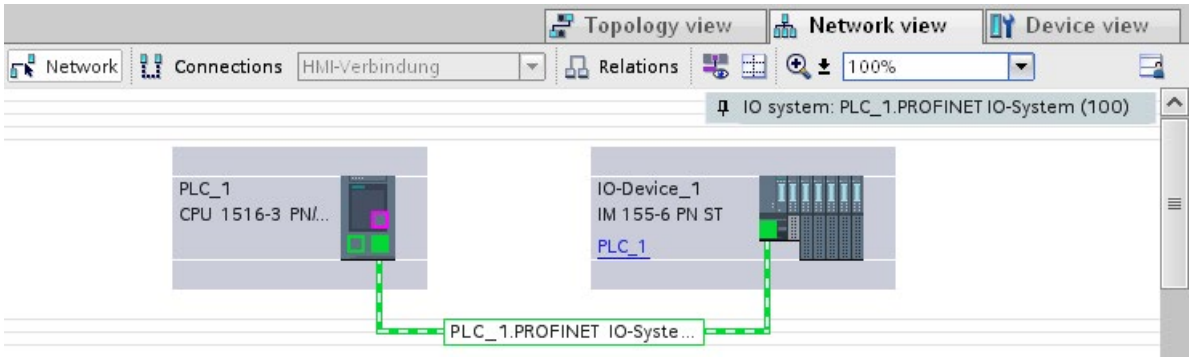


Figure 3-1 Assigning an IO device to an IO controller in the network view of STEP 7

Result

You have assigned an IO device to an IO controller.

Checking the assignment

You can find an overview of the communication relationships in the "IO communication" tab in the tabular area of the network view. This table is context-sensitive for selection in the graphic area:

- Selection of the interface shows the I/O communication of the respective interface.
- Selection of the CPU shows all I/O communication of the CPU (including PROFIBUS).
- Selection of the station (as in the above figure) interface shows the I/O communication of the complete station.

3.2 Device name and IP address

Introduction

In order that the PROFINET device can be addressed as node on PROFINET, the following are required:

- A unique PROFINET device name
- A unique IP address in the relevant IP subnet

STEP 7 assigns a device name during the arrangement of a PROFINET device in the hardware and network editor. The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name.

You can change the name and IP address manually.

In STEP 7

You can find the device name and the IP address under "Ethernet addresses" in the properties of the PROFINET interface in the Inspector window.

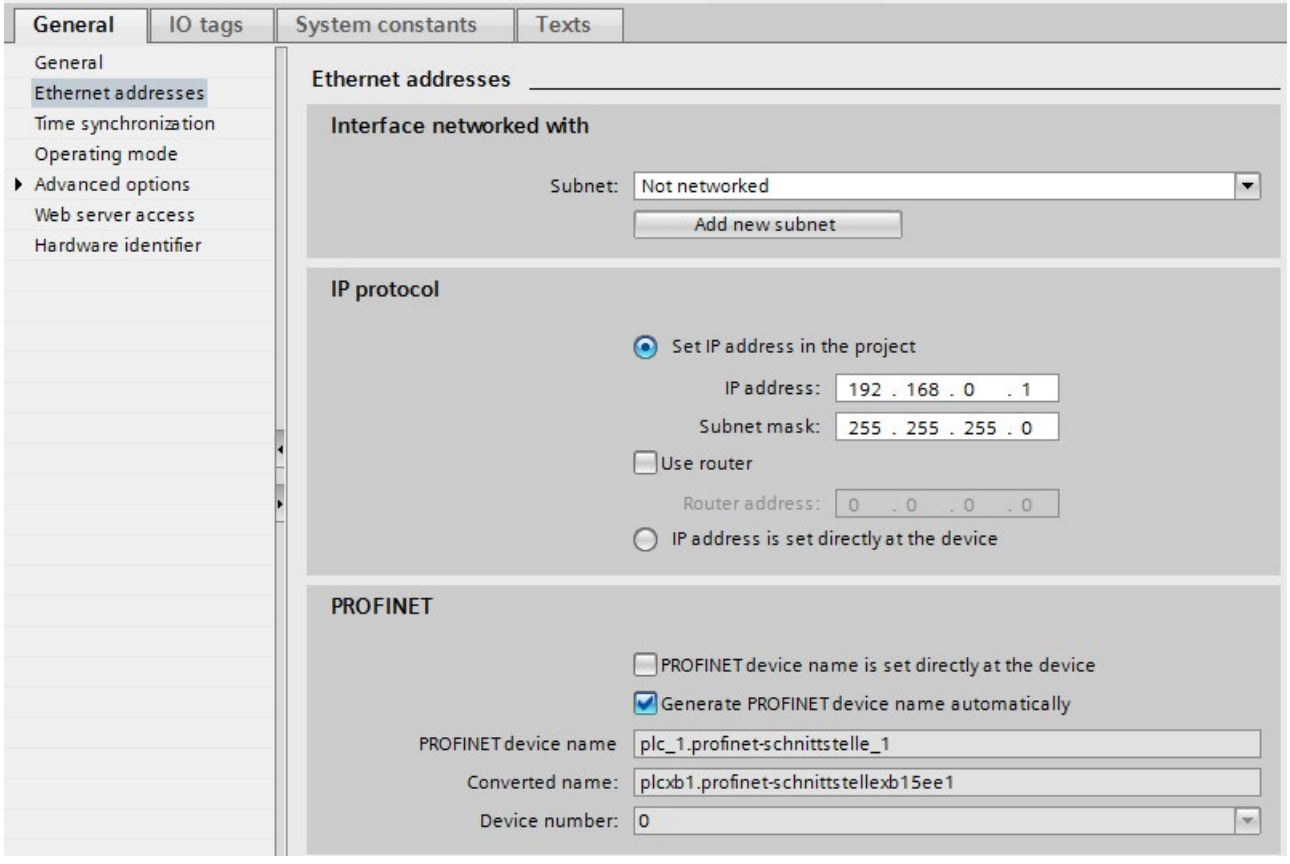


Figure 3-2 Device name and IP address in STEP 7

The function, the assignment and the changing of the device name and the IP address are described in the following sections.

3.2.1 Device name

Device names

Before an IO device can be addressed by an IO controller, it must have a device name. In PROFINET, this method was selected because it is simpler to work with names than with complex IP addresses.

The assignment of a device name for a specific IO device can be compared to setting the PROFIBUS address of a DP slave.

In delivery state, an IO device does not have a device name. A device name must first be assigned before an IO device can be addressed by an IO controller, for example, for transferring configuration data during startup or for exchanging user data in cyclic mode. You assign the device names to the IO device, for example, with the programming device / PC.

IO devices that have a slot for removable storage media provide the option of writing the device name directly to the removable storage medium in the programming device.

When a device is replaced by a device without removable medium, the IO controller assigns the device name based on topological configuration (see section Configuring topology (Page 59)).

Structured device names

The device name is automatically assigned by default for PROFINET devices S7-1200, S7-1500, ET 200MP, ET 200SP and ET 200AL when these are configured in STEP 7. The device names are formed from the name of the CPU or the name of the interface module. For devices with several PROFINET interfaces, the name of the interface is enhanced, for example, "plc_1.profinet-interface_2" or "io-device_1".

You can structure the device names using DNS conventions.

These conventions are defined by "Internationalizing Domain Names in Applications (IDNA). According to this, device names are written in lower case.

The "Domain Name System" (DNS) is a distributed database (http://iana.org), which manages the name space on the Internet. To structure the names, you use the dot ("."). The hierarchy is shown in ascending order from left to right.

...<Subdomain name>.<Domain name>.<Top-level domain name>

If the name is not DNS-compliant, the name will be converted by STEP 7, for example, to "plcxb1.profinet-schnittstellexb2022c" or "io-devicexb15b32".

Device number

In addition to the device name, STEP 7 also assigns a device number beginning with "1" when an IO device is allocated.

The device number is located in the Inspector window in the properties of the PROFINET interface, under "Ethernet addresses" in the area PROFINET.

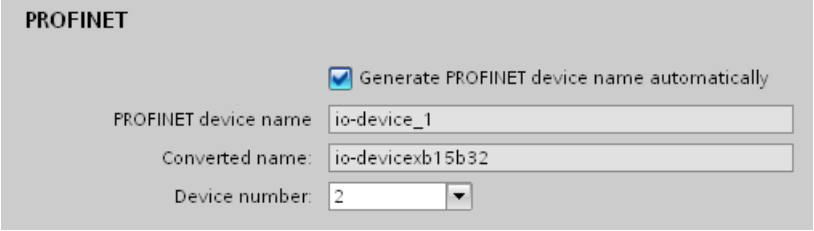


Figure 3-3 Device number

This device number can be used to identify an IO device in the user program (for example, with the instruction "LOG2GEO").

3.2.2 IP address

IP address

To allow a PROFINET device to be addressed as a device on Industrial Ethernet, this device also requires an IP address that is unique within the network. The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name. If it is a standalone network, you can apply the IP address and subnet mask suggested by STEP 7. If the network is part of an existing Ethernet company network, obtain the information from your network administrator.

Configuration of the IP address

In accordance with Internet Protocol version 4 (IPv4), the IP address is made up of four decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by periods (for example, 192.162.0.0).

The IP address consists of the following:

- Address of the network
- Address of the device (PROFINET interface of the IO controller/IO device)

Generating IP addresses

The IP addresses of the IO devices are generated by STEP 7 and first assigned to the IO devices when the CPU starts up. In addition, for some IO devices (e.g., SCALANCE X, S7-300 CPs), it is possible not to obtain the IP address during startup of the IO controller, but rather to set it beforehand on the device (see Permitting changes to the device name and IP address directly on the device (Page 57)).

The IP addresses of the IO devices always have the same subnet mask as the IO controller and are assigned from the IP address of the IO controller in ascending order. The IP address can be changed manually, if necessary.

For devices with several PROFINET interfaces (e.g., CPU 1516-3 PN/DP), the IP addresses must be located in different subnets.

Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general, the following applies:

- The network address is obtained from the AND operation of the IP address and subnet mask.
- The device address is obtained from the AND NOT operation of the IP address and subnet mask.

Example of the subnet mask

Subnet mask: 255.255.0.0 (decimal) = 11111111.11111111.00000000.00000000 (binary)

IP address: 192.168.0.2 (decimal) = 11000000.10101000.00000000.00000010 (binary)

Meaning: The first 2 bytes of the IP address determine the network - i.e., 192.168. The last two bytes address the device, i.e. 0.2.

Default router

The default router is used when data has to be forwarded via TCP/IP or UDP to a partner located outside the local network.

In STEP 7, the default router is named Router. You can activate the use of a router in the Inspector window of a CPU with the "Use router" check box in the"IP protocol" section. STEP 7 assigns the local IP address to the default router by default.

The router address that is set on the PROFINET interface of the IO controller is automatically transferred for the configured IO devices.

Relation between IP address and default subnet mask

An agreement exists relating to the assignment of IP address ranges and so-called "Default subnet masks". The first decimal number (from the left) in the IP address determines the structure of the default subnet mask with respect to the number of "1" values (binary) as follows:

IP address (decimal)	IP address (binary)	Address class	Default subnet mask
0 to 126	0xxxxxxx.xxxxxxxx....	A	255.0.0.0
128 to 191	10xxxxxx.xxxxxxxx...	B	255.255.0.0
192 to 223	110xxxxx.xxxxxxxx...	C	255.255.255.0

Note

Range of values for the first decimal point

A value between 224 and 255 is also possible for the first decimal number of the IP address (address class D etc.). However, this is not recommended because there is no address check for these values.

Masking other subnets

You can use the subnet mask to add further structures and form "private" subnets for a subnet that is assigned one of the address classes A, B or C. This is done by setting other, less significant bits of the subnet mask to "1". For each bit set to "1", the number of "private" networks doubles and the number of devices they contain is halved. Externally, the network continues to function as an individual network.

Example:

You have a subnet of address class B (for example, IP address 129.80.xxx.xxx) and change the default subnet mask as follows:

Masks	Decimal	Binary
Default subnet mask	255.255.0.0	11111111.11111111.00000000.00000000
Subnet mask	255.255.128.0	11111111.11111111.10000000.00000000

Result:

All devices with addresses from 129.80.001.000 to 129.80.127.254 are located in a subnet, all devices with addresses from 129.80.128.000 to 129.80.255.254 in a different subnet.

Reading out an IP address in the user program

You can read out the IP address of a PROFINET device in the user program of a S7-1500 CPU. You can find information in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/82947835).

3.2.3 Assigning a device name and IP address

Assigning an IP address and subnet mask for an IO controller for the first time

You have the following options:

- **Using a programming device or PC:**

  Connect your programming device/PC to the same network as the relevant PROFINET device. The interface of the programming device/PC must be set to TCP/IP mode. During the download, first of all display all available devices via the "Accessible devices" download dialog box. Select the target device via its MAC address and then assign its IP address before you download the hardware configuration including the configured IP address (IP address is saved retentively).

- **Using the display of a S7-1500 CPU:**

  The S7-1500 CPUs have a front cover with a display and operating keys. You can use this display to assign or change the IP address. To set the IP address, navigate on the display via the menu items "Settings" > "Addresses" > "X1 (IE/PN)" > "Parameters".

- **Using a memory card:**

  If your PROFINET device is equipped for a memory card (Micro Memory Card/SIMATIC memory card), plug this into your programming device/PC and save the hardware configuration together with the configured IP address on this memory card. Then plug the memory card into the PROFINET device. Once inserted, the PROFINET device automatically applies the IP address.

  If you have saved a configuration to the memory card with the "IP address is set directly at the device" option, you must assign the IP address using a different method after inserting the memory card (see section Permitting changes to the device name and IP address directly on the device (Page 57)).

Assigning device names and IP address for "Device replacement without exchangeable medium/programming device"

For devices without exchangeable medium (e.g., ET 200MP, ET 200SP) and devices that support "Device replacement without exchangeable medium/PG" (e.g., ET 200S), the IO controller can identify the device without name from the neighbor relationships specified by the set topology and from actual neighbor relationships determined by the real PROFINET devices. The IO controller then assigns the PROFINET device the configured name and incorporates the PROFINET device in the user data traffic. (See also Device replacement without exchangeable medium (Page 193)).

IP address assignment when replacing IO devices with exchangeable mediumPG

The following is contained on the memory card of the programmable logic controller:

- On the IO controller: Device name and IP address
- On the IO device: Device name

When you remove the memory card from a PROFINET device and insert it in another PROFINET device with exchangeable medium (e.g., ET 200S), device-specific information and the device name are loaded to the device.

If an IO device has to be replaced in its entirety due to a device or module defect, the IO controller automatically assigns parameters and configures the replaced device or module. The cyclic exchange of user data is then restarted. In addition to this, before the power ON of the IO device, the memory card with the valid name must be removed from the faulty IO device and added to the replaced device.

In the event of an error in the PROFINET device, the memory card allows you to replace a module without a programming device/PC. You can also transfer the device data directly from the programming device/PC to the memory card.

Procedure: Changing the device name using properties of the PROFINET interface

You can change the PROFINET name via the properties of the PROFINET interface. This is useful when the PROFINET device has not received its previous name from the automatic generation, for example, in the case of a migration.

1. In the network or device view of the STEP 7 hardware and network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the PROFINET area.
3. Clear the "Generate PROFINET device name automatically" check box.
4. Enter the new PROFINET device name in the relevant field.

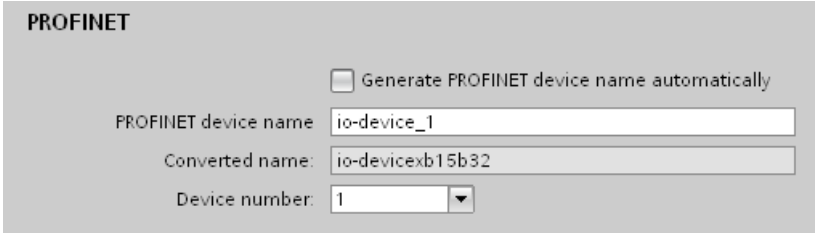


Figure 3-4 Changing the device name of a PROFINET device in the properties

Alternative procedure: Changing the device name of a PROFINET device in the network view

Requirement: The "Generate PROFINET device name automatically" check box is selected.

1. In STEP 7, select the "Network overview" tab in the tabular area of the network view.
2. In the "Device" column, overwrite the name in the row of the relevant PROFINET device.

The name is also changed accordingly in the graphic area of the network view.

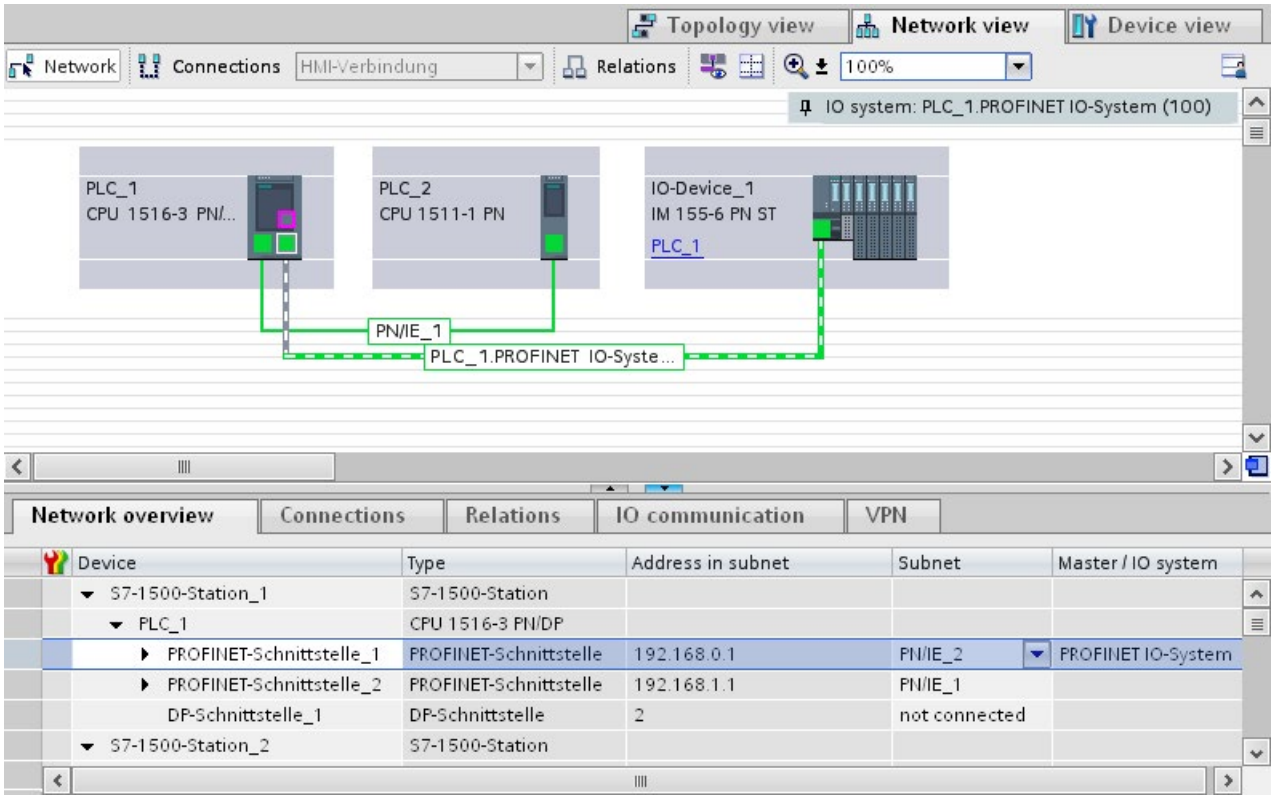


Figure 3-5 Changing the device name of a PROFINET device in STEP 7

Procedure: Changing the IP address

To change the IP address, follow these steps:

1. In the network or device view of the STEP 7 hardware and network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the "IP protocol" area.

3. Check that the option "Set IP address in the project" is selected.
4. Enter the new IP address in the relevant field.

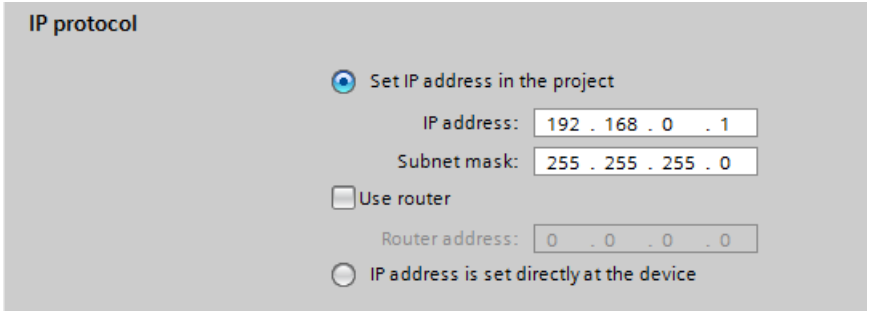


Figure 3-6 Changing the IP address of a PROFINET device in STEP 7

Downloading configured device name to IO device

To load the configured device names to the IO device, follow these steps:

1. Connect your programming device/PC to the same network as the relevant IO device. The interface of the programming device/PC must be set to TCP/IP mode.
2. In STEP 7, select the relevant IO device in the "Accessible devices" dialog based on the MAC address.
3. Click "Assign name" to download the configured device name to the IO device.

   The IO controller recognizes the IO device automatically by its device name and automatically assigns the configured IP address to it.

Identification of the PROFINET device

To clearly identify a device from several identical devices in a control cabinet, for example, you can flash the link LED of the PROFINET device.

To do this, select the menu command **Online > Accessible devices...** in STEP 7. In the "Accessible devices" dialog, set the "PG/PC" interface by means of which you are connected to the devices. STEP 7 now automatically searches for the accessible devices and displays them in the "Accessible devices in target subnet" table. Select the desired PROFINET device and click on the "Flash LED" button. The PROFINET device is identified based on its MAC address.

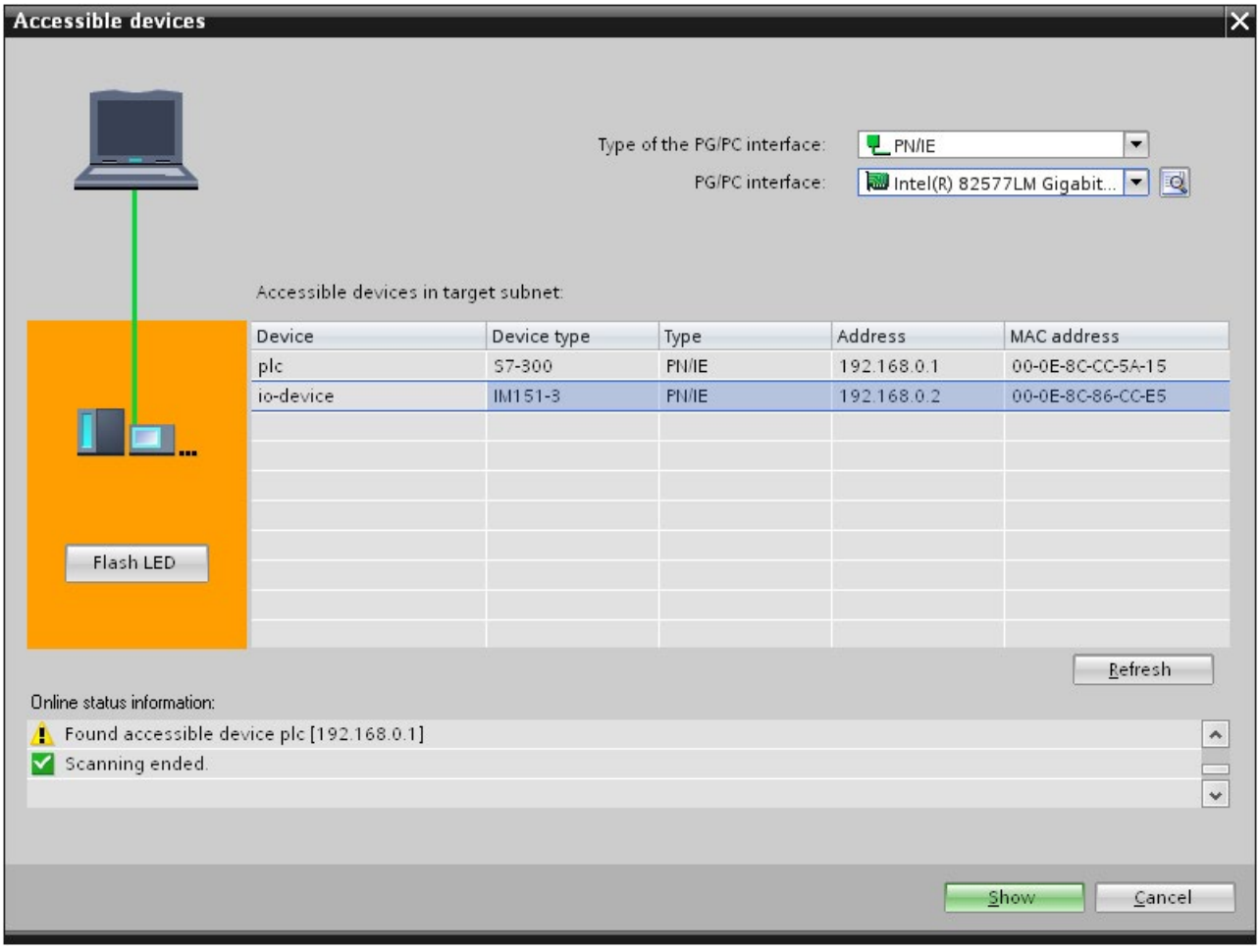


Figure 3-7 "Accessible devices" dialog

Using an different way to assign IP addresses for IO devices

Various IO devices, for example, SCALANCE X,S7-300 CPs, support the option of not having the IP addresses assigned by the IO controller during startup. In this case, the IP address is assigned in a different way. For additional information, refer to the manual of the respective PROFINET device of the SIMATIC device family.

Additional information

You can find a detailed description of the operation and functions of the display of the S7-1500 CPUs in the system manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792).

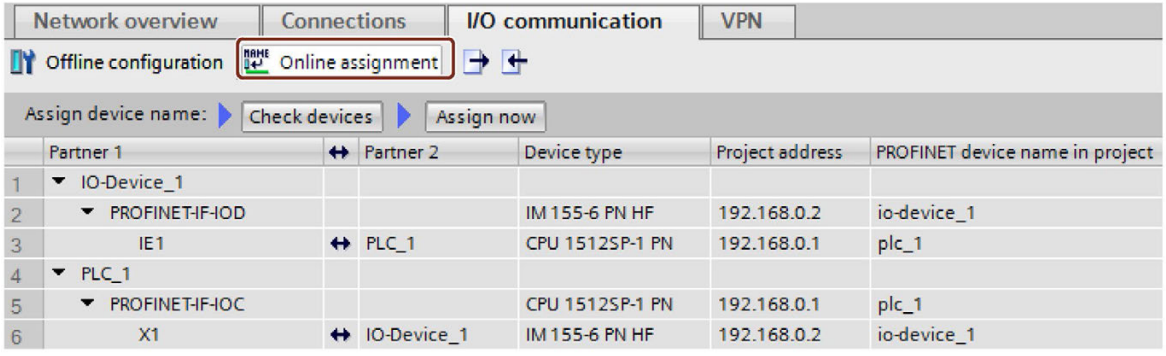
3.2.4 Assign device name via communication table

Introduction

You can assign the device names of PROFINET IO devices configured offline to the devices online. You can do this in the table area of the network view in the table "I/O communication". You can also assign the device names to several devices at the same time.

"Online assignment" tab

In the I/O communication table, you will find the tabs "Offline configuration" and "Online assignment". In the "Online assignment" tab, you can assign the PROFINET device names that were assigned offline to the corresponding IO devices online. To do this, use the buttons "Check devices" and "Assign now".



	Partner 1		Partner 2	Device type	Project address	PROFINET device name in project
1	IO-Device_1					
2	PROFINET-IF-IOD			IM 155-6 PN HF	192.168.0.2	io-device_1
3	IE1	↔	PLC_1	CPU 1512SP-1 PN	192.168.0.1	plc_1
4	PLC_1					
5	PROFINET-IF-IOC			CPU 1512SP-1 PN	192.168.0.1	plc_1
6	X1	↔	IO-Device_1	IM 155-6 PN HF	192.168.0.2	io-device_1

Figure 3-8 Assign device name via communication table

The objects displayed in the table of the "Online assignment" tab depend on the setting of the filter function. If only selected objects should be displayed, only objects of the corresponding context are displayed depending on the selection in the network view.

- PROFINET subnet: All connected devices and their PROFINET interfaces
- IO system All devices involved and their PROFINET interfaces
- Sync domain: All devices involved and their PROFINET interfaces
- Devices: The device and any existing PROFINET interfaces
- Other subnets or interfaces such as MPI or PROFIBUS are not displayed

If the display is set for all devices using the filter function, all devices are displayed that have a PROFINET interface, regardless of whether they are connected via a PROFINET subnet or are part of an IO system. Devices without a PROFINET interface, for example only with a DP or MPI interface, are not displayed.

General procedure

To assign PROFINET device names, you must first detect the IO devices available online. With this procedure, it matters whether the MAC addresses are known or unknown. This results in a general procedure in two steps:

1. Detecting the IO devices available online
2. Assigning configured PROFINET device names to the IO devices available online

Requirements

- You are in the network view.
- There is an online connection to the devices.

Procedure (step 1)

To detect IO devices available online from the I/O communication table, follow these steps:

1. Optional: Entered known MAC addresses in the "MAC address" column. After every valid entry, the check box under "Assign device" is selected for the relevant row.

   Note

   You can enter, insert or import the MAC address in different formats. The correct format is automatically entered in the cell. The following entries are supported and then converted to the required format:

   - "08:00:06:BA:1F:20"
   - "08 00 06 BA 1F 20"
   - "080006BA1F20"

   The formats used in the example are automatically converted to "08-00-06-BA-1F-20".

2. Click "Check devices" to start the check of the IO devices available online.
3. Set the PG/PC interface in the dialog window and click "Start".

Intermediate result

After the check, the result is displayed for every device in the table. Online data found is automatically entered in the table and the check box "Assign device" is set to "checked" in the rows in which a MAC address was entered or found online. The result of the check is shown as an icon in the "Status" column.

Status	Meaning
	Matching device and compatible type
	Matching device and incompatible type
	Non-matching device
	Device cannot be reached (with a known MAC address)
	Ready for assignment (with known MAC address)

Note

The icon "Ready for assignment" appears when a MAC address exists and matching device data was found, but no PROFINET device name was found online.

You can update the data of the detected devices again via their MAC addresses at any time. To do this, you specify the MAC address and the status of the device is displayed immediately without having to re-detect the device.

Procedure (step 2)

All PROFINET device names configured offline will be assigned to the devices available online in a bulk operation.

1. Click the "Assign now" button.

   Note

   The bulk operation cannot be reversed. A message to this effect appears in a dialog window.

2. Click "Start" in the dialog window to start the assignment of the PROFINET device names.

Result

The PROFINET device names configured offline will be assigned to the devices available online. This relates to devices in whose row the check box under "Assign device" is selected, that have a MAC address and have the status "Ready for assignment".

Importing and exporting data

Using the import and export button, you can import or export the data of the I/O communication table for the online assignment:

- When you export, the currently displayed data of the table is exported to a CSV file. Using the filter function of the table, you can select which data will be exported.
- When you import, the data of the CSV file is written to the table. If there are conflicts with values already existing in the table, you can decide whether the data should be overwritten or whether the import needs to be stopped.

3.2.5 Permitting changes to the device name and IP address directly on the device

Introduction

Machines are frequently commissioned on site or integrated into the existing infrastructure without STEP 7. You can find typical applications in all areas of the series machine building. Alternative means for assigning the IP address are available for this.

Procedure

1. In the network or device view of the STEP 7 Hardware and Network editor, select the PROFINET interface of an IO controller.
2. Navigate in the Inspector window to "Ethernet addresses".
3. Select the "IP address is set directly at the device" option in the "IP protocol" area.
4. In the "PROFINET" area, select the " PROFINET device name is set directly at the device" check box.

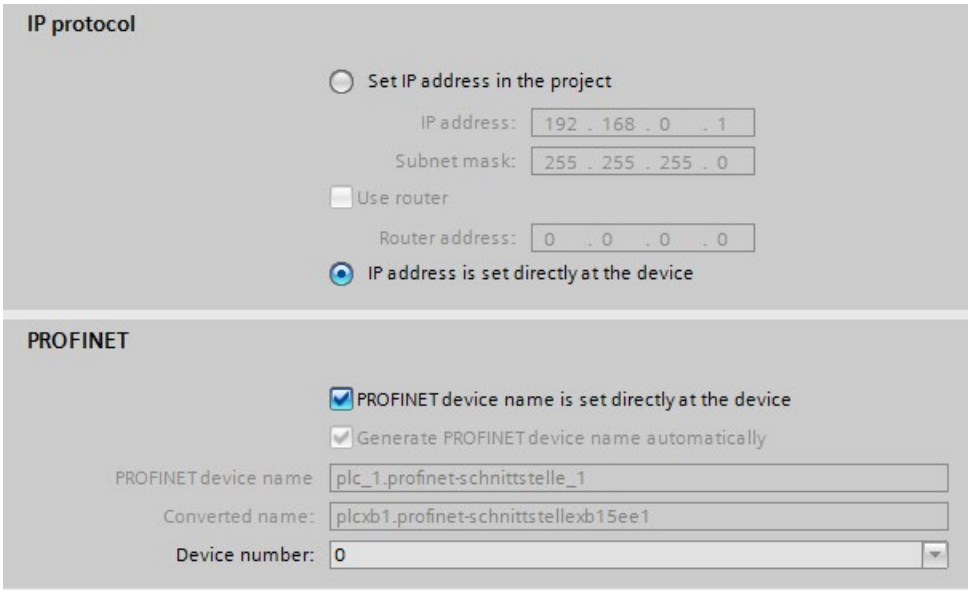


Figure 3-9 Setting the device name and IP address on the device

Note

Gateway

When you operate a PROFINET device with the option "Allow adaption of the device name/IP address directly on device", you cannot use this PROFINET device as gateway for S7 routing.

Options for assigning IP addresses and device names

Apart from the known address and device name assignment in the "Ethernet addresses" section of the Inspector window, there are other ways in which the IP address and name can be assigned:

- Assigning by means of the user program with the instruction "T_CONFIG"
- Assignment when downloading the configuration to the target system via the "Extended download to device" dialog box.
- Assignment via the Primary Setup Tool (PST)
- Assignment via the PRONETA ("PROFINET network analysis") commissioning and diagnostics tool
- Assignment via the SIMATIC Automation Tool

Additional information

For information on the "T_CONFIG" instruction and on downloading to the target system, refer to the STEP 7 online help.

A free Download (http://support.automation.siemens.com/WW/view/en/14929629) of the Primary Setup Tool (PST) can be found on the Internet. On this Internet page, you will also find a list of devices for which the PST is approved.

3.3 Configuring topology

Introduction

If an IO device is assigned to an IO controller, this does not yet specify how the ports are connected to each other.

A port interconnection is not required to use RT, but it provides the following advantages:

- A set topology is assigned with the port interconnection. Based on an online-offline comparison, it is possible to conduct a set-actual comparison with all devices that support this function.
- The "Device replacement without exchangeable medium" function can be used.

A port interconnection is an essential requirement for using IRT.

An overview of various options for setting up a PROFINET network is given below.

Line

All the communication devices are connected in a linear bus topology.

In PROFINET, the linear bus topology is implemented with switches that are already integrated into the PROFINET devices. Therefore, the linear bus topology at PROFINET is merely a special form of tree / star topology.

If a link element (switch, for example) fails, communication across the failed link element is no longer possible. The network is then divided into 2 subsegments.

Linear bus topology structures require the least cabling.

Star

If you connect communication devices to a switch with more than two PROFINET ports, you automatically create a star network topology.

If an individual PROFINET device fails, this does not automatically lead to failure of the entire network, in contrast to other structures. It is only if a switch fails that part of the communication network will fail as well

Tree

If you interconnect several star structures, you obtain a tree network topology.

Ring

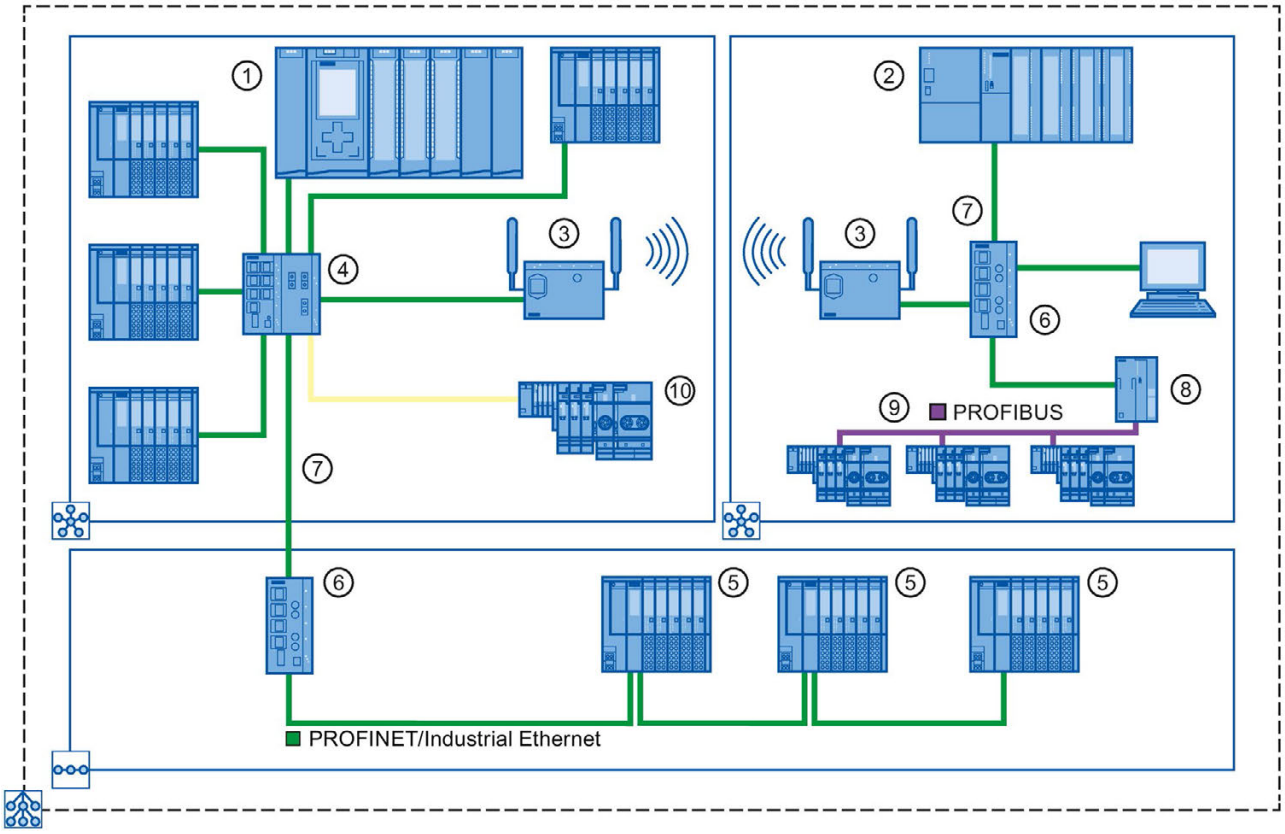
In order to increase the availability of a network, use ring structures. In principle, a linear bus topology is connected to a ring through a so-called redundancy manager.

The task of the redundancy manager is managed by an external switch SCALANCE X, a CPU that supports the Media Redundancy Protocol MRP (e.g., CPU 1516-3 PN/DP) or a CP (e.g., CP 343-1 Lean).

If there is a break in the network, the redundancy manager ensures that the data is redirected over an alternative network connection in the ring.

Example for topology

The following example shows a combination of different topologies.



Number	Meaning
①	S7-1500 as IO controller
②	S7-300 as IO controller
③	Industrial WLAN with SCALANCE W
④	SCALANCE X 307-3 with seven electrical and three optical ports
⑤	ET 200SP with integrated 2-port switch
⑥	SCALANCE X 204 with four electrical ports
⑦	PROFINET/Industrial Ethernet
⑧	IE/PB-Link PN IO
⑨	PROFIBUS DP
⑩	ET 200S with two optical ports
	Star topology
	Linear bus topology
	The combination of topology forms results in a tree topology.

Figure 3-10 Combined topology

Additional information

Observe the PROFINET Installation Guideline (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/) of the PROFIBUS User Organization when planning your PROFINET topology.

For more detailed information, see the SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736) manual.

You can find basic information in the Communication with SIMATIC (http://support.automation.siemens.com/WW/view/en/1254686) manual.

3.3.1 Topology view in STEP 7

Introduction

The topology view is one of three working areas of the hardware and network editor. You undertake the following tasks here:

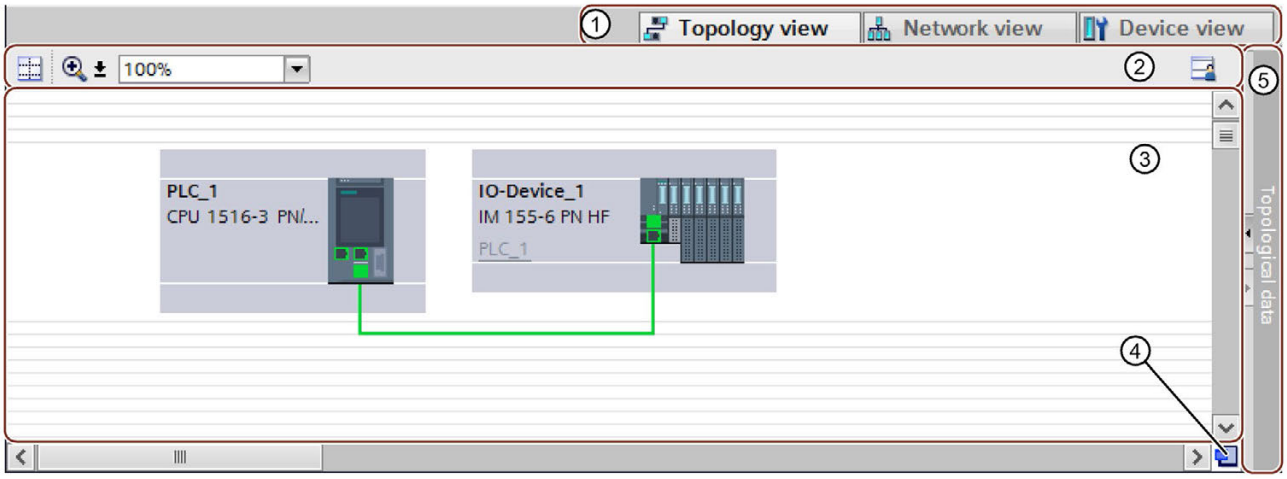
- Displaying the Ethernet topology
- Configuring the Ethernet topology
- Identify and minimize differences between the set and actual topology (online)

The topology view in STEP 7 consists of a graphic area and a table area.

Graphic area

The graphic area of the topology view displays PROFINET devices with their appropriate ports and port connections. Here you can add more PROFINET devices.

The following figure shows the graphic area of the topology view.



① Selector: Device view/Network view/Topology view
② Toolbar
③ Graphic area of the topology view
④ Overview navigation
⑤ Selector for the table area of the topology view

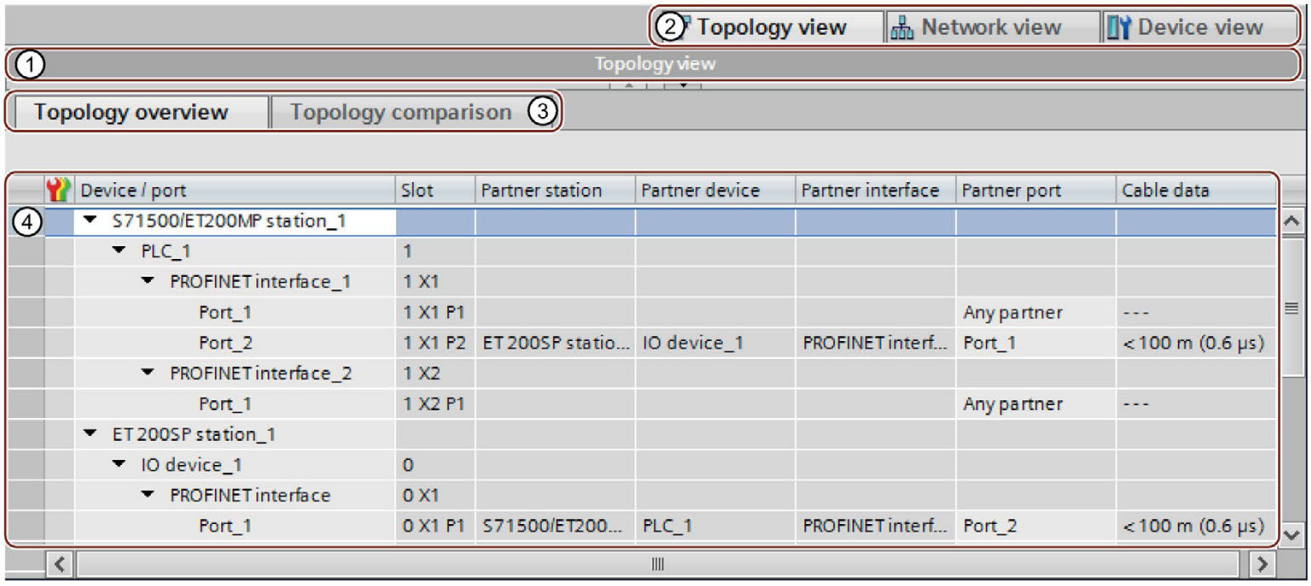
Figure 3-11 Graphic area of the topology view

Overview navigation

Click in the overview navigation to obtain an overview of the created objects in the graphic area. By holding down the mouse button, you can quickly navigate to the desired objects and display them in the graphic area.

Table area

- Topology overview: This displays the Ethernet or PROFINET devices with their appropriate ports and port connections in a table. This table corresponds to the network overview table in the network view.
- Topology comparison: Here you can import devices and port interconnections automatically through offline/online comparison or extended Offline/Online comparison into STEP 7.



① Selector for the graphic area of the topology view
② Selector: Device view/Network view/Topology view
③ Selector: Topology overview/Topology comparison
④ Table area of the topology view

Figure 3-12 Table area of the topology view

3.3.2 Interconnecting ports in the topology view

Requirement

You are in the graphic view of the topology view.

Procedure

To interconnect ports in the topology view, follow these steps:

1. Place the pointer of the mouse on the port you want to interconnect.
2. Press and hold down the left mouse button.
3. Move the pointer.

   The pointer now uses the networking symbol to indicate "Interconnecting" mode. At the same time, you see the lock symbol on the pointer. The lock symbol disappears only when the pointer is over a valid target position.
4. Now drag the pointer to the target port. You can keep the left mouse button pressed or release it when performing this action.
5. Now release the left mouse button or press it again (depending on your previous action).

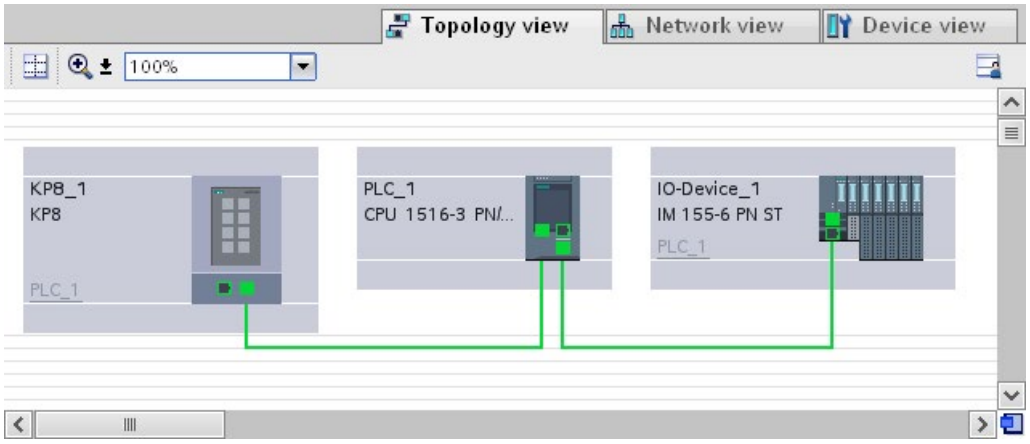


Figure 3-13 Interconnecting ports in the topology view

Result

You have created a port interconnection.

3.3.3 Interconnecting ports - Inspector window

Interconnecting ports in the Inspector window

To interconnect ports, follow these steps:

1. In the device or network view, select the PROFINET device or PROFINET interface.
2. In the Inspector window, navigate to the port property "Port interconnection".

   When the PROFINET interface is selected, you can find this setting in the Inspector window as follows: "Properties > General > Advanced Options > Port [...] > Port Interconnection."
3. In the "Local port" section, you can find the settings at the local port. In the case of fiber-optic cable you can, for example, set the cable names here.

   In the "Partner port" area, select the drop-down list for "Partner port" in order to display the available partner ports and make a selection.

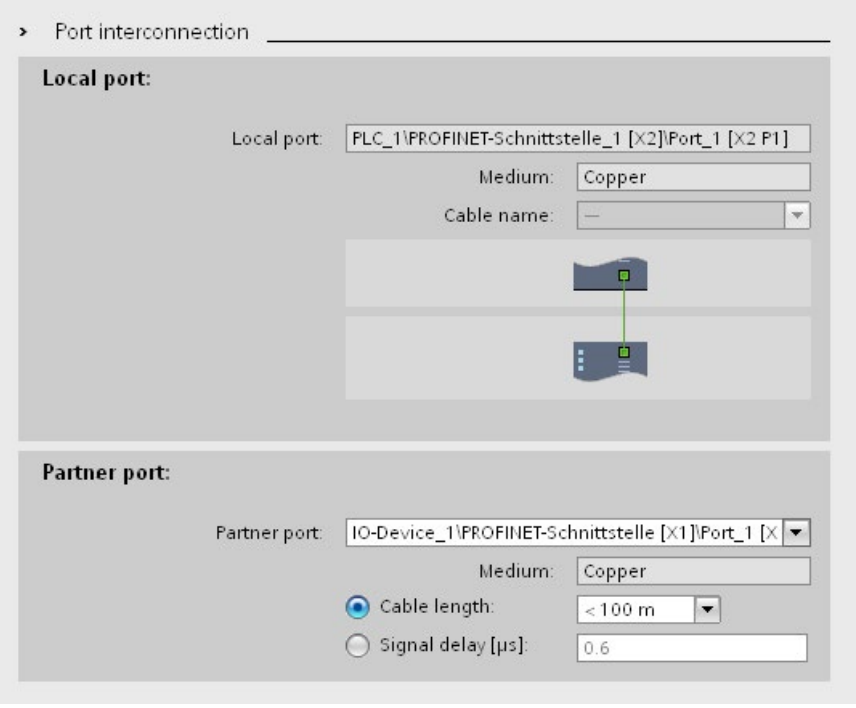


Figure 3-14 Interconnecting ports in the Inspector window in STEP 7

If the PROFINET interface was disconnected, it is automatically connected by this action. In the properties of the subnet you can set whether this subnet should or should not be used for the networking.

3.3.4 Automatic assignment of devices by offline/online comparison

Overview

During the offline/online comparison, the configured topology is compared with the actual existing topology. Devices identified online are automatically assigned to configured devices as far as this is possible.

Start of availability detection

You start the availability detection the first time by clicking the "Compare offline/online" button in the toolbar of the "Topology comparison" tab.

You restart availability detection by clicking the "Update" button.

Note

The availability detection can take several seconds. During this time, no user input is possible.

Automatic assignment of a PNIO device

A PNIO device identified online is automatically assigned to a configured device if the following properties of the two devices match up:

- Article no.
- Type
- PROFINET device name

No automatic assignment

In the following situations, no automatic assignment is possible:

- No device can be identified online to match a configured device. (This means that the corresponding columns in the "Online topology" area of the topology comparison table are empty.)

  In this case, you should add the already configured device to your system or delete the configured device from the configuration.

- A device identified online can be assigned to a configured device, but there are differences in the port interconnections.

  In this case, you can Apply the port interconnections identified online manually to the project (Page 67).

- A device identified online cannot be assigned to a configured device. (In this case, the corresponding columns in the "Offline topology" area of the topology comparison table are empty.)

  In this case, you can Include the devices identified online manually in the project (Page 68).

3.3.5 Apply the port interconnections identified online manually to the project

Requirements

You have run an offline/online comparison in the topology view. The result of this is that at least one device identified online was automatically assigned to a configured device, but that there are differences relating to the interconnection.

Procedure

To adopt one more port interconnections identified online in the project manually, follow these steps:

1. Select the row belonging to the port interconnection.
2. If applicable, select further roles using multi-selection.
3. Select "Apply" > "Use selected" in the shortcut menu.

   The content of the corresponding table cells in the "Action" column changes to "Apply".
4. If you have mistakenly prepared too many port interconnections to be included in the project:

   Select the rows belonging to the port interconnections you have mistakenly prepared for inclusion in the project using multi-selection.

   Select "Reset" > "Reset selected" in the shortcut menu.

   The content of the corresponding table cells in the "Action" column change to "No action".
5. Click the "Synchronize" button.

Result

The port interconnections identified online for the corresponding devices are included in the project. Successful adoption is indicated by the diagnostics icon "Identical topology information" for each port.

Note

If other port interconnections are recognized for a device identified online and these differ from those that exist in the project, adopting these in the project means that the port interconnections that were previously in the project are replaced by those identified online. If no port interconnections are detected for a device identified online, adopting in the project means that all the port interconnections of this device are deleted in the project.

3.3.6 Include the devices identified online manually in the project

Requirements

You have run an offline/online comparison in the topology view. The result of this is that at least one device identified online could not be assigned to any configured device.

Procedure

To adopt one more devices identified online in the project manually, follow these steps:

1. For a configured device without an online partner, move the mouse pointer to the "Device/port" column of the online topology.
2. Select the device you want to assign to the configured device from the drop-down list of this box.
3. Repeat the previous steps if necessary for other configured devices without an online partner.

Result

The selected device that was identified online is moved up from the end of the table. Following this, it is in the row of the configured device to which you have just assigned it.

3.3.7 Automatic assignment of devices by advanced offline/online comparison

Overview

With the advanced offline/online comparison, ICMP is also used alongside DCP to be able to detect devices that do not support DCP.

Automatic assignment of devices detected by ICMP

With devices detected by ICMP, no type is available.

With passive devices, no article number is available. For this reason, passive devices can only be assigned automatically if you have not assigned an article number in the configured data and the offline and online IP addresses match.

With switches, automatic assignment is possible if the offline and online article number, IP address and PROFINET device name match.

Diagnostics

4

4.1 Diagnostics mechanisms of PROFINET IO

Totally Integrated Diagnostics Concept

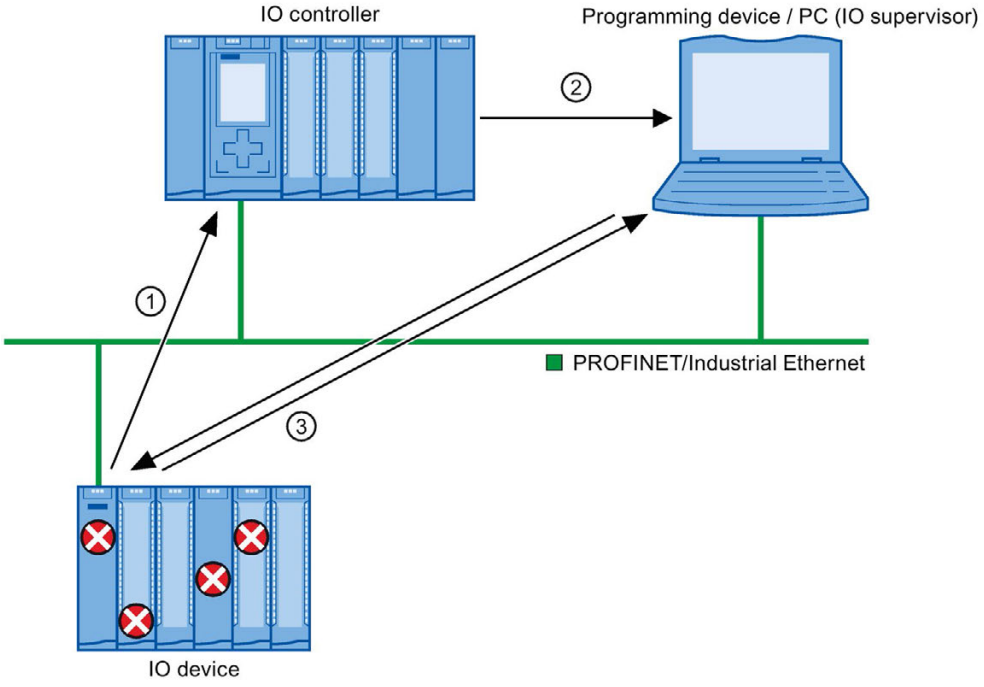
All SIMATIC products have integrated diagnostics functions that they can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information.

Each individual error or several errors occurring concurrently are transferred from the IO device to the IO controller. If you require the full status of the IO device including any pending errors, you can also read the status directly from the IO device.

The following sections provide basic information on using diagnostics via PROFINET IO. You can find a detailed description of the system diagnostics for S7-1500, ET 200MP, ET 200SP and ET 200AL in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

Accessing the status of an IO device with a PG/PC or an HMI device

If you are connected to the Industrial Ethernet via a PG/PC with STEP 7 or an HMI device, you can also call up diagnostics information online. This is illustrated by the following graphic.



Number	Description
①	The IO device detects an error and sends diagnostics data to the IO controller.
②	The IO controller notifies the programming/HMI device. The display of the system diagnostics is updated.
③	In STEP 7, you can read the station status for "Accessible devices" directly from the IO device regardless of the IO controller. This is only possible if the programming device is connected to Industrial Ethernet. This means that you can access diagnostics information during the commissioning phase or for servicing even if the IO controller is not operational.

Figure 4-1 PROFINET IO diagnostics with PG/PC or HMI device

4.1.1 Diagnostics levels in PROFINET IO

Concept

The IO device sends all error messages that occur to the IO controller. The scope and volume of diagnostics information varies according to the level of diagnostics data evaluation and the PROFINET devices you are using.

Diagnostics levels

You can evaluate diagnostics data at different levels. The number and type of channels is selected, for example, at the diagnostics level 4.

The following figure shows the diagnostics levels with PROFINET IO.

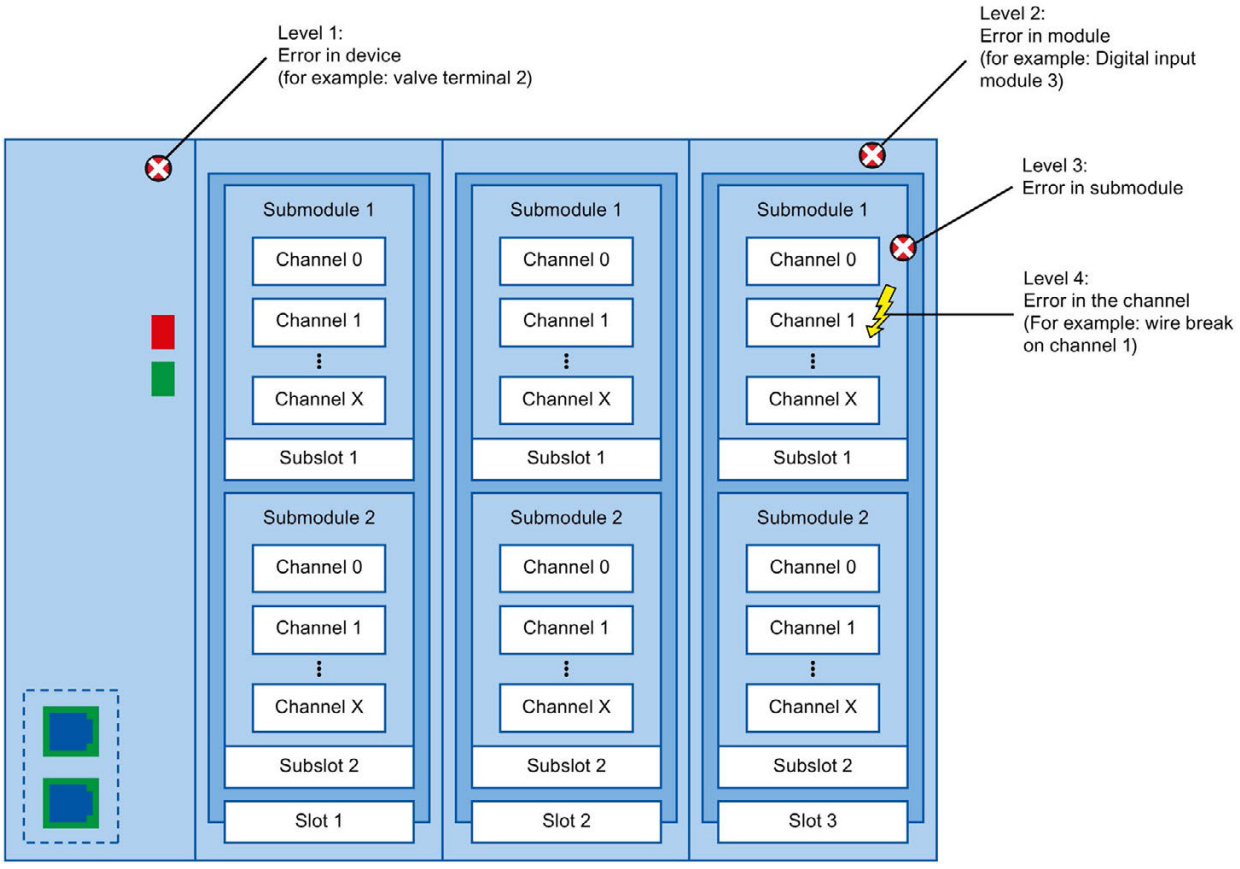
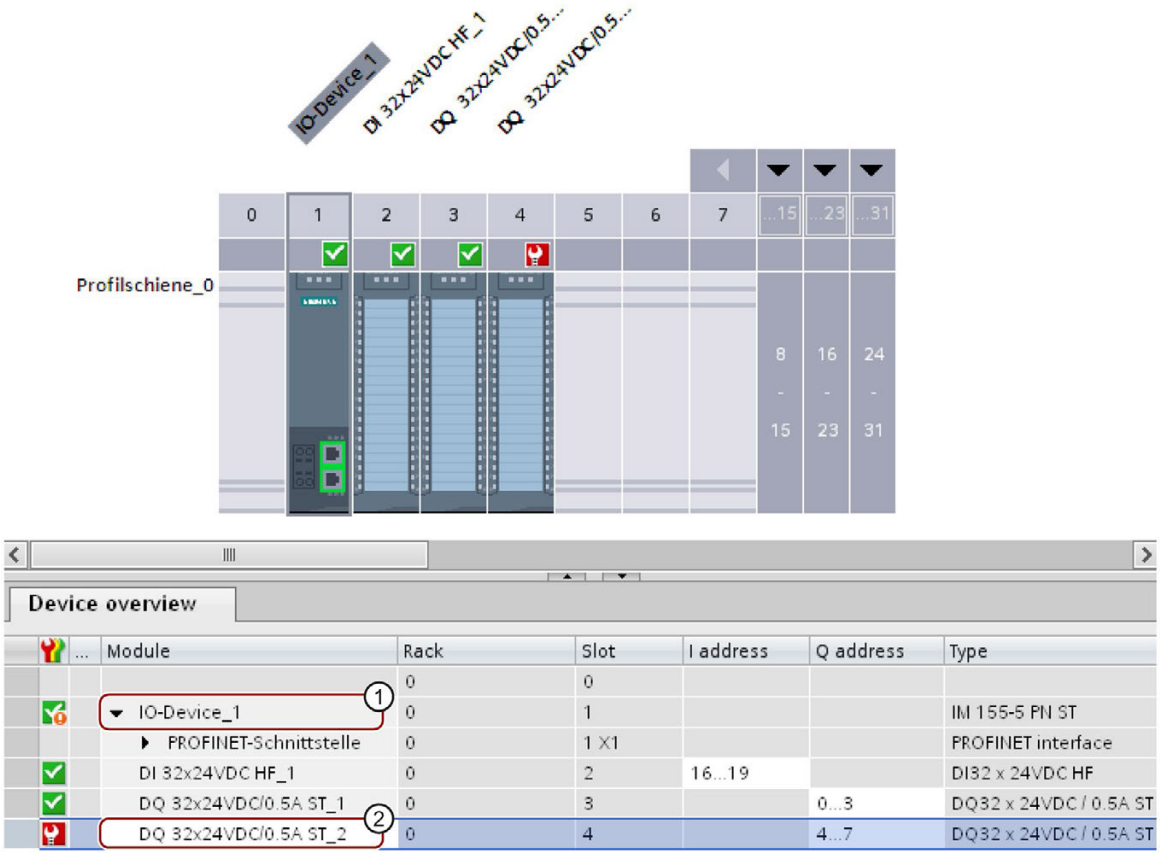


Figure 4-2 Diagnostics levels with PROFINET IO

Representation of diagnostics levels in the device view in STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:



Number	Description	
①	Level 1:	Error(s) in the device
②	Level 2:	Error(s) in the module

Figure 4-3 Diagnostics levels in the device view of STEP 7

Which PROFINET nodes support the extended PROFINET diagnostics?

An overview of the PROFINET nodes that support extended PROFINET diagnostics and of what you have to configure is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/23678970).

4.1.2 I&M data (identification and maintenance)

Definition and properties

Identification and maintenance data (I&M) is information saved to module memory in order to provide support when:

- Checking the plant configuration
- Locating hardware changes in a plant

Identification data (I data) is module information (some of which may be printed on the module housing) such as the order and serial number. I data is read-only vendor-specific module data.

Maintenance data (M data) is plant-specific information such as the location identifier and installation date. M data is created during configuration.

The modules can be uniquely identified in online mode by means of the I&M data.

Further information

To find out whether and to what extent a PROFINET device supports I&M data, refer to the documentation of the relevant device.

4.1.3 Loading I&M data to PROFINET IO devices and your modules

Which I&M data can be loaded to PROFINET IO devices and your modules?

You can load I&M 1 data (plant designation and location identifier) and/or I&M 2 data (installation date) and/or I&M 3 data (additional information) to the actual hardware.

Requirements

- In the project settings (Options > Settings, Hardware configuration > Compiling and downloading), the option "Download I&M data" must be enabled.
- There is an online connection to the PROFINET IO devices and the modules to which you want to load I&M data.
- You have entered the I&M data you want to download in the properties of the respective PROFINET IO devices and your modules (Inspector window: "Properties" tab > "General" tab, Settings > Identification & Maintenance).

Where do I specify which I&M data is downloaded to which PROFINET IO devices?

You specify which I&M data you want to download to which PROFINET IO devices in the "Load preview" dialog. You will find the following alternatives in the drop-down list of the "Identification and maintenance data (I&M)" row:

- Load nothing

  The check boxes for all PROFINET IO devices as well as the check boxes for the loadable I&M data are cleared.

  No I&M data is transferred to the actual hardware during loading with this setting.

- Load data

  The check boxes for all PROFINET IO devices as well as the check boxes for the loadable I&M data are selected.

  The respective I&M 1, I&M 2 and I&M 3 data is transferred to all PROFINET IO devices during loading with this setting.

- Load selected

  You select the check boxes of those PROFINET IO devices to which you want to load I&M data. You also select the check boxes of the identification data you want to load.

  With this setting, you transfer the selected I&M data to the selected PROFINET IO devices during loading.

Note

Language dependency of the I&M data to be loaded

The I&M data are loaded to the real hardware in the form that you specified in the properties of the relevant PROFINET IO devices and your modules. There is no language dependency.

4.2 Diagnostics using status LEDs

LEDs for diagnostics on PROFINET

Each port of a PROFINET interface of a SIMATIC device has one LED.

The following table shows a summary of the meaning of these LEDs in the S7-1500, ET 200MP, ET 200SP and ET 200AL systems.

Table 4- 1 S7-1500, ET 200MP, ET 200SP, ET 200AL: LEDs for diagnostics on PROFINET

Meaning	LED image	S7-1500	ET 200MP	ET 200SP	ET 200AL
		LINK/TX/RX LED		LK LED	P1 Link LED P2 Link LED
There is no connection between the PROFINET interface of your PROFINET device and a communication partner (for example, IO controller).	LED off	X	X	X	X
There is a connection between the PROFINET interface of your PROFINET device and a communication partner (for example, IO controller).	LED green	X	X	X	X
The "Node flash test" is performed.	LED flashes green	X	X	X	X
There is active data traffic (sending/receiving) via the Ethernet connection.	LED yellow	X	X	-	-

Additional information

You can find a detailed description of all LEDs of the module with cause of the error and remedies in the relevant documentation for the module.

4.3 Diagnostics via the display of the S7-1500 CPUs

Display of the S7-1500 CPUs

Each CPU in the S7-1500 automation system has a front cover with a display. Control and status information is shown in various menus on the display. You use the operating keys to navigate through the menus.

Diagnostics via the display

The following indicators can be evaluated for diagnostics purposes on the display:

- Error and alarm texts (system diagnostics, alarm messages)
- Module status for central and distributed modules

In the following example of a display of the CPU 1516-3 PN/DP, you can see a warning on the diagnostics icon and an exclamation mark on the icon for module.

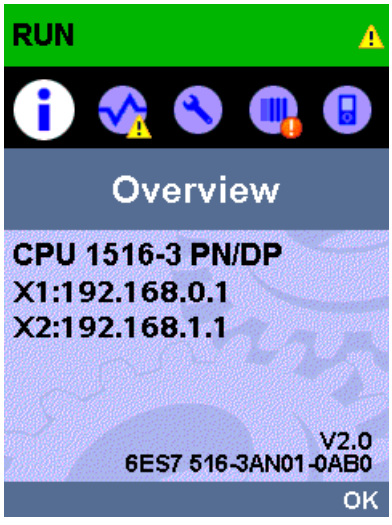


Figure 4-4 Display of overview

Module status

To show the module status, navigate on the display through the menu items "Module" > "PROFINET I/O (X1)" > "Station" > "Slot" > "Status" > "Module status".

The module status indicates that a fault has occurred in the module. The "lower-level status" is the status of the module in the diagnostics level below this. In the example, the status is "good", i.e., the fault is not in the lower diagnostics level submodule or channel, but instead in the module.

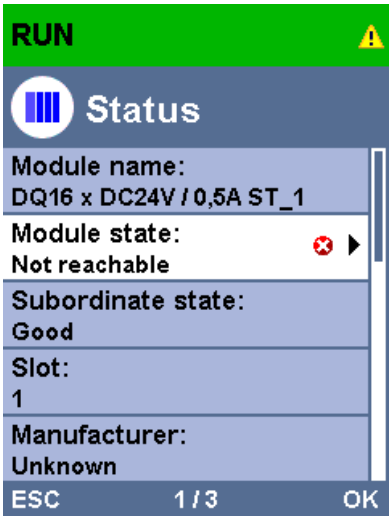


Figure 4-5 Display of module status

Error and alarm texts

You can show diagnostics buffer entries and alarm messages for the relevant automation system on the display.

To show the diagnostics buffer entries of the CPU, navigate on the display via the menu items "Diagnostics" > "Diagnostics buffer".

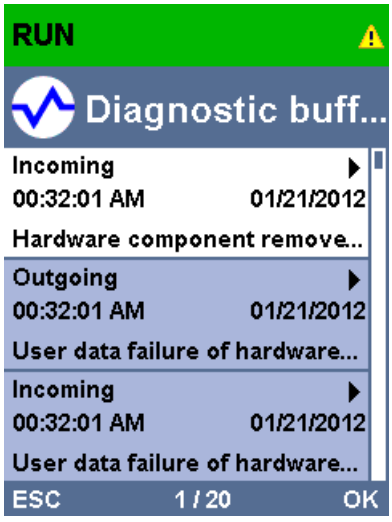


Figure 4-6 Display of diagnostics buffer

To show the alarm messages of the automation system, navigate through the menu items "Diagnostics" > "Alarms" > "Alarm text" on the display.

Note

Updating the alarm display

The display shows the currently read status of the CPU in static form, the display is not automatically updated. The alarm display is updated after it has been exited and opened again.

You set the automatic updating of the diagnostics information under: "Display" > "DiagnosticRefresh".

Figure 4-7 Display of alarms

Figure 4-8 Display of alarm message

Additional information

You can find the description of the operation and functions of the display in the SIMATIC S7-1500 Display Simulator (http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_de.html).

4.4 Diagnostics via Web server

The CPUs belonging to the S7 family have their own integrated Web server with a wide range of functions.

For diagnostics, the Web server supports you with the following displays:

- Contents of the diagnostic buffer
- Module status
- Actual topology of the PROFINET system
- Set topology of the PROFINET system (from the configuration)

Set topology and actual topology - graphic view

Requirements for displaying the set and actual topology:

- You have configured the PROFINET ports in the topology editor of the hardware and network editor of STEP 7.
- You have loaded the entire project with STEP 7 in the CPU.

The following shows an example of the graphic view.

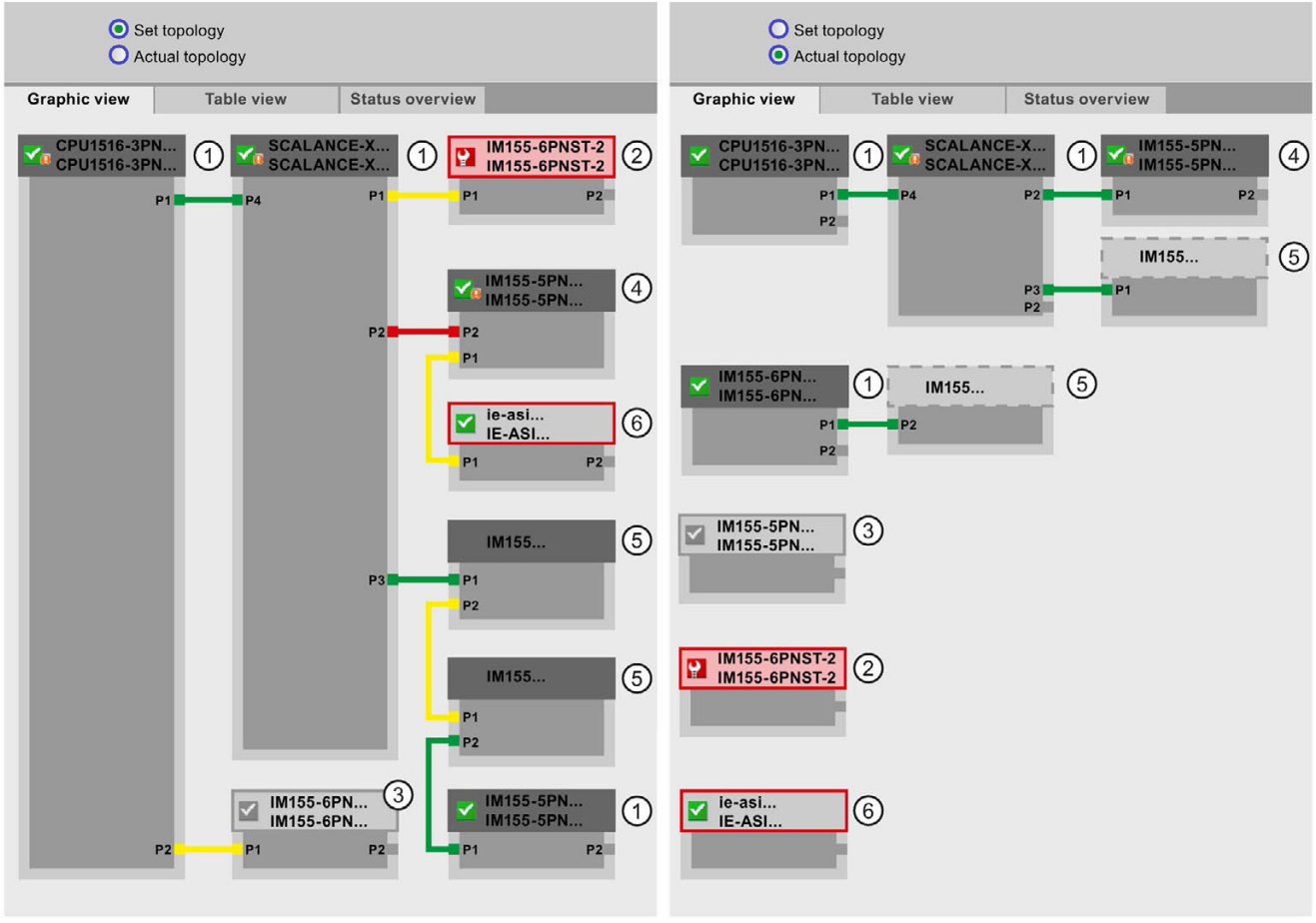


Figure 4-9 Topology - graphic view via the Web server

Meaning of the colored connections in the set/actual topology:

Table 4- 2 Meaning of the colored connections in the set/actual topology:

Connection	Meaning	
	Set topology	Actual topology
green	The current actual connection matches the configured set connection.	detected connections
red	The current actual connection does not match the configured set connection (e.g., port interchanged).	-
yellow	The connection cannot be diagnosed. Causes: • The communication to an IO device has been disrupted (e.g., cable removed) • Connection to a passive component • Connection to PROFINET devices of another IO controller or PROFINET system	-

① Configured and accessible PROFINET devices

Configured and accessible PROFINET devices are displayed dark-gray. Connections show the ports through which the PROFINET devices of a station are connected.

① Configured but not accessible PROFINET devices

The configured but not accessible PROFINET devices are displayed in pink with red border (e.g., device has failed, cable disconnected).

③ Disabled devices

All disabled, configured PROFINET devices are displayed light-gray.

④ Interchanged ports

Interchanged ports are marked red in the set topology view. The currently connected ports are displayed in the actual topology, the configured set connection in the set topology.

⑤ PROFINET devices of another PROFINET IO system

- In the set topology:

  A PROFINET device of another PROFINET IO system is displayed with a green connection (or red connected if the ports have been interchanged), when it is directly adjoining a configured and accessible PROFINET device ① and it is also accessible. When the PROFINET device of another PROFINET IO system is not accessible, a yellow connection line is displayed.

  The connection between two PROFINET devices that both belong to a different PROFINET IO system, cannot be determined and is always displayed in yellow.

- In the actual topology:

  A PROFINET device of another PROFINET IO system is only displayed if the PROFINET device is in direct proximity to a configured PROFINET device. The PROFINET device is displayed light-gray and with dashed line.

For PROFINET devices of a different PROFINET IO system, **no** status display is shown on the device head.

⑥ Representation of faulty neighbor relations

The devices whose neighbor relations cannot be read out completely or correctly are displayed light-gray with red border.

Additional information

The tabular view of the actual topology and the status overview of the PROFINET devices in the project are possible.

You can find these views, additional topology examples, and detailed information on the operation and the functions of the Web server in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) manual.

4.5 Diagnostics in STEP 7

For PROFINET, you have the following options to evaluate diagnostics in STEP 7:

- Online & diagnostics - Devices & networks
- Online & diagnostics - diagnostics of PROFINET ports

Online & diagnostics network view

In the hardware and network editor (launched from the "Project tree" by double-clicking "Devices & networks"), you can get an overview of the current state of your system by clicking on the "Go online" button. It also shows the configuration information (for example, non-configured modules). This option is also available in the topology view in similar form.

Schematic drawing of the network view (online):

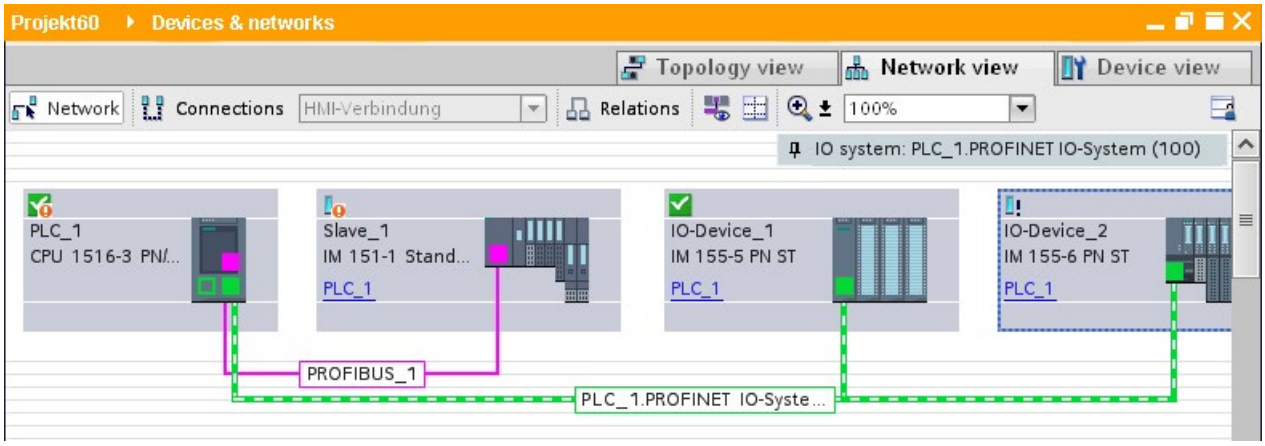


Figure 4-10 Online & diagnostics network view

Online & diagnostics device view

In STEP 7, you can display an overview of the modules in which faults have occurred. To do this, select the menu command "Online > Online & diagnostics". Once you are connected, you can see the status of the accessible devices in the project tree.

Double-click the device which displays an alarm message to access the faulty module directly. The device view is opened in the work area. In the device view of the device that reports the fault you can see directly in which module the fault occurs.

Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

Schematic drawing of the device view (online):

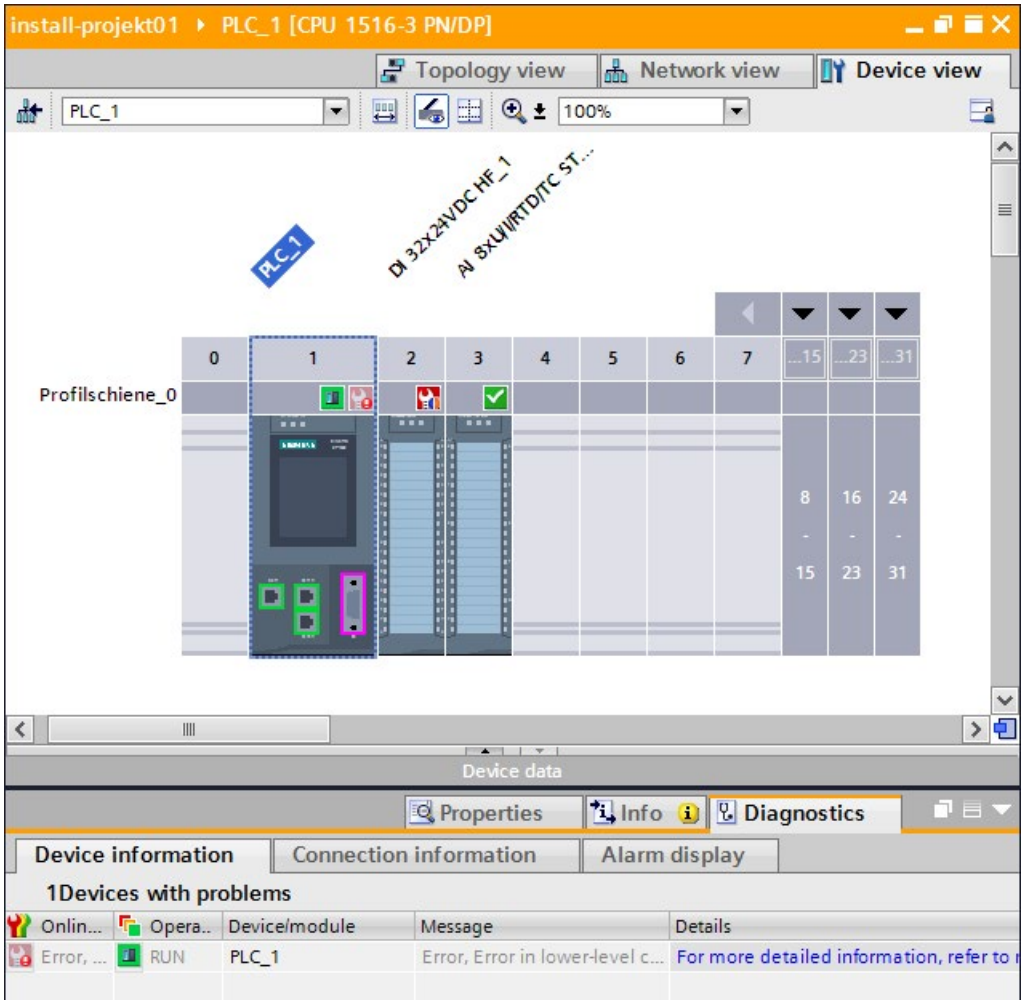


Figure 4-11 Online & diagnostics device view

Diagnostics of PROFINET ports

If you select "PROFINET interface > Ports" in the Diagnostics area in the online & diagnostics device view of a PROFINET device, the ports of the PROFINET interface are listed in a table.

The table provides you with the following information about the ports of the PROFINET interface.

- Name
- Status
- Settings
- Operating mode

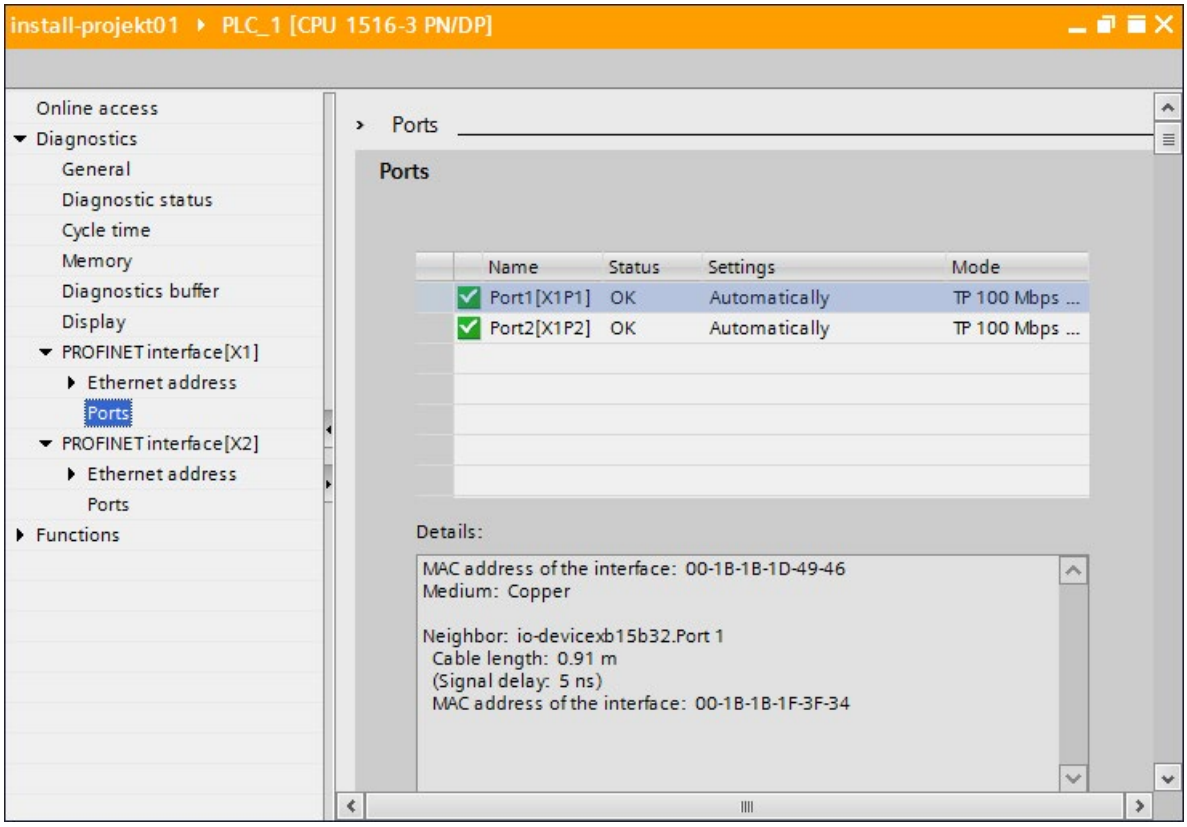


Figure 4-12 Diagnostics of PROFINET ports in STEP 7

Additional information

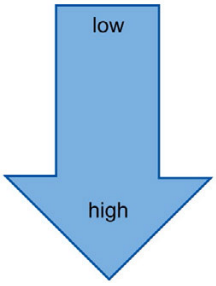
You can find information on the system diagnostics for S7-1500, ET 200MP, ET 200SP and ET 200AL in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual and online help for STEP 7.

4.6 Extended maintenance concept

Extended maintenance concept

The PROFINET interfaces with integrated switch of the SIMATIC devices support the four-level diagnostics concept in accordance with PROFINET specification Version V2.3 or higher with the following status:

Table 4- 3 Classification of the diagnostic status

Diagnostic status	Symbol		Severity of the error
Good	Green checkmark		
Maintenance required	Green wrench		
Maintenance demanded	Yellow wrench		
Bad	Red wrench		

The aim of the diagnostics concept is the early detection and elimination of potential faults - before they cause a production outage.

Other status information is defined in addition to the Good (no fault) and Bad (fault) status information for a PROFINET device.

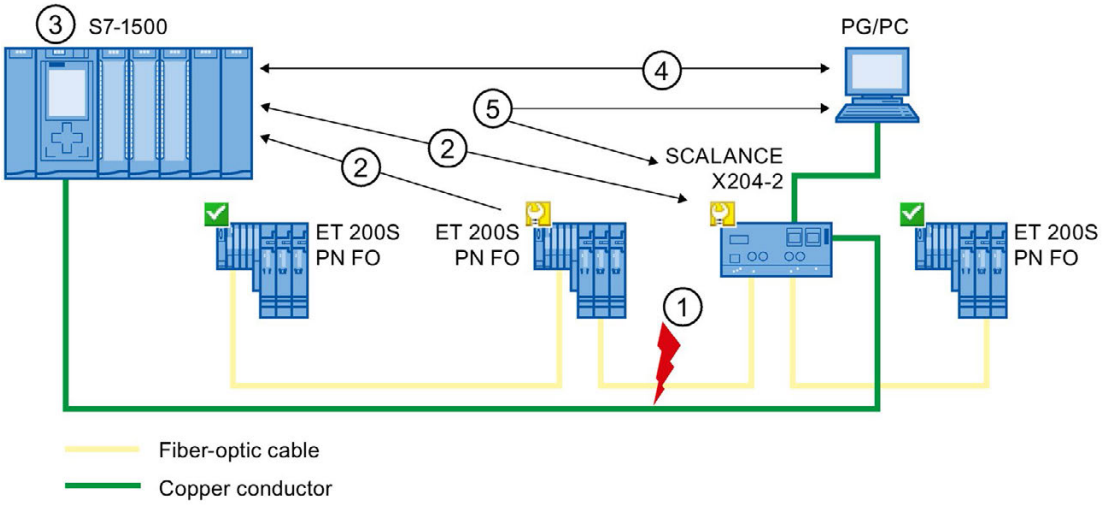
The maintenance information is generated with the following system alarms:

- Maintenance required (symbolized by a green wrench) and
- Maintenance demanded (symbolized by a yellow wrench)

The times at which the two system alarms are generated can be customized for most wear parameters.

Example: Maintenance demanded for a PROFINET cable

The following graphic illustrates how diagnostics information is exchanged when the transmission quality on the optical cable decreases due to ageing, for example. In this example, the scenario is considered after a maintenance required has already been diagnosed.



Number	Description
①	The system reserve of the fiber-optic cable drops below 0 dB.
②	Both the ET 200S PN FO and the switch send the maintenance demanded alarm to the IO controller.
③	Based on the interrupts, the IO controller detects the maintenance demanded from the switch and from the IO device. The module information data is updated in the IO controller and the corresponding error OBs are called. Note: To be able to start the error OBs in the IO controller, the "Call the user program if communication errors occur" property must be selected in STEP 7 for the relevant IO controller.
④	In STEP 7 (on the programming device/PC), the maintenance demanded message is indicated on the IO device and at the switch by a yellow wrench symbol.
⑤	STEP 7 can also read out detailed information directly from the switch.

Figure 4-13 Maintenance demanded for a PROFINET cable

4.7 Diagnostics of the network topology

Availability

As an open standard, you can use any SNMP based systems or software solutions for diagnostics in PROFINET.

Network diagnostics

The network management protocol SNMP (Simple Network Management Protocol) uses the wireless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP clients collect the various network-specific information in the individual network nodes and store it in a structured form in the **MIB** (Management Information Base). This information allows a network management system to run detailed network diagnostics.

MIB

The MIB (Management Information Base) is the database of a device. SNMP clients access this database in the device. The S7 device family supports the following standard MIBs:

- MIB II, standardized in the RFC 1213
- LLDP-MIB, standardized in the international standard IEC 802.1AB
- LLDP-PNIO-MIB, standardized in the international standard IEC 61158-6-10

Detecting the network topology

LLDP (Link Layer Discovery Protocol) is a protocol that is used to detect the closest neighbor. LLDP enables a device to send information about itself and to receive information from its neighbor devices. This information is then saved in the LLDP MIB, for example, and can be queried using SNMP. This information allows a network management system to determine the network topology.

Use of SNMP (Simple Network Management Protocol)

SNMP can be used as follows:

- By users to integrate network diagnostics into a central HMI/SCADA system using the SIMATIC NET OPC server
- By the IT administration of machine and plant operators to monitor their Industrial Ethernet network using standard network management systems.
- By the IT administration, to monitor the automation network, alongside the office network, using standard network management systems.

Use of SNMP in the SIMATIC NET environment

SNMP-compliant devices from the SIMATIC NET family can be monitored and operated via a conventional standard Internet browser. The management system known as web-based management offers a wide range of device-specific information (network statistics, status of redundant supply, for example).

4.8 Diagnostics in the user program

4.8.1 Diagnostics and configuration data records

Diagnostics mechanism

The IO device outputs a diagnostics interrupt to the IO controller when it detects faults such as wire break on an IO module. This interrupt calls a corresponding organization block in the user program (diagnostics interrupt OB82), in order to generate a defined (programmed) response to the fault and passes a diagnostics data record.

Diagnostics data records in PROFINET IO

There are two different types of diagnostics data record:

1. Channel diagnostics data records

   Channel diagnostics data records are generated if a channel is in an error state and / or has triggered an interrupt.

   A diagnostics data record of length 0 is returned if there is no fault.

2. Vendor-specific diagnostics data records

   The structure and size of vendor-specific diagnostics data records depend on the vendor's settings.

   For information about vendor-specific diagnostics data records, refer to the appropriate device manual.

Addressing levels of diagnostics data records

Diagnostics and configuration data is evaluated at the following addressing levels:

- Device level
- AR (Application Relation)
- API (Application Process Identifier)
- Slot
- Subslot

A group of diagnostics and configuration data records are available for each address level (exception: device level always 0xF80c). In HEX representation, the individual groups of data records are distinguished by the first letter of the data record number.

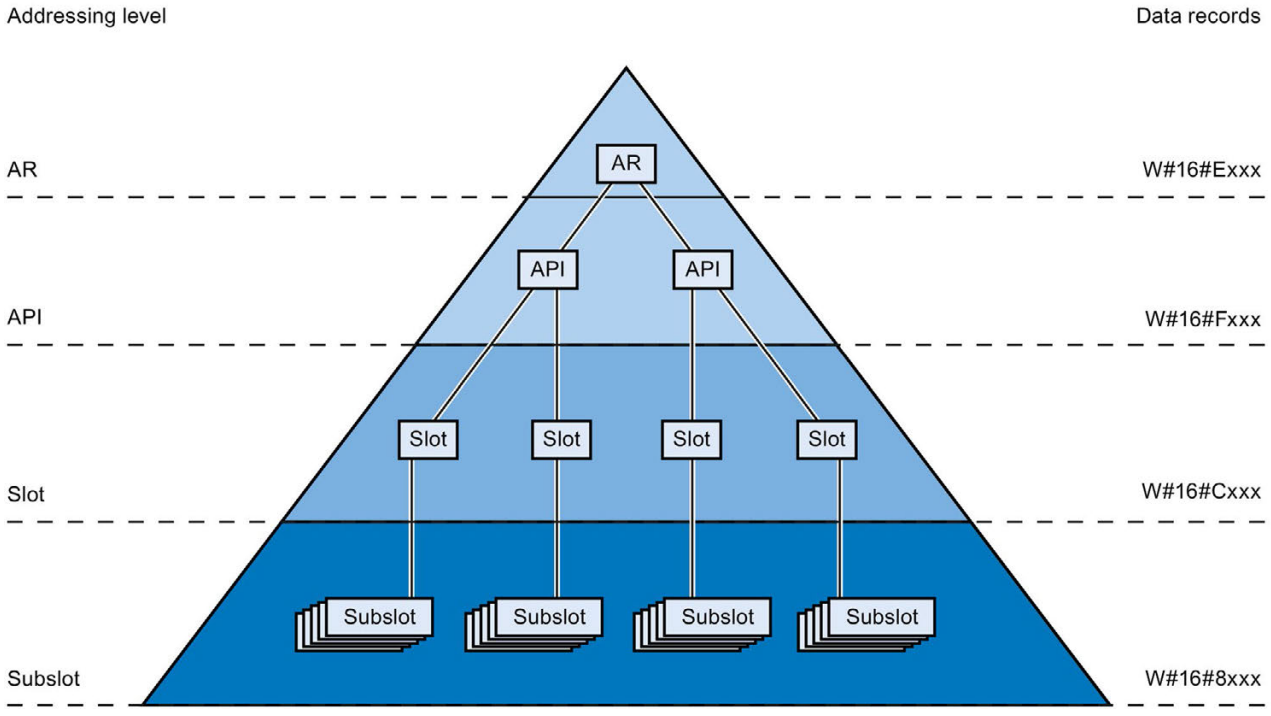


Figure 4-14 Addressing levels of diagnostics data records

The information for each IO device (addressing level AR), module (addressing level slot) or submodule (addressing level subslot) is always transferred in separate diagnostics or configuration data records. The data record returns diagnostics data or configuration data for one or more subslots, slots and APIs, depending on the addressing level.

Note

The diagnostics information is only generated for configured modules / submodules / channels.

4.8.2 Evaluate diagnostics in the user program

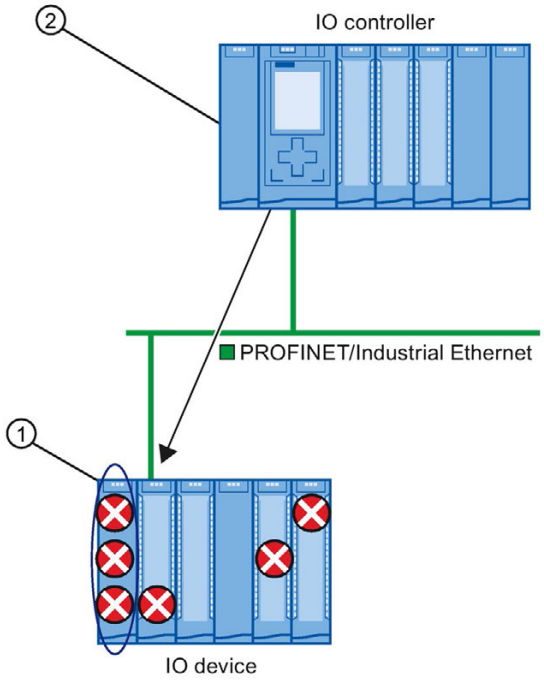
Diagnostics in the user program

For PROFINET IO, a cross-vendor structure of data records with diagnostics information applies. Diagnostics information is created only for channels on which a fault has occurred. With PROFINET, there are two basic ways to obtain diagnostics information.

1. Evaluating the diagnostics status

Read out the diagnostics of your PROFINET IO system using the instructions "DeviceStates" and "ModuleStates", to localize those stations / modules or station / modules with maintenance demanded or maintenance required that have faults within a PROFINET IO system.

The instruction RDREC (read data record) is then used to read various diagnostics data records directly from the module concerned and thus obtain detailed information about the error.

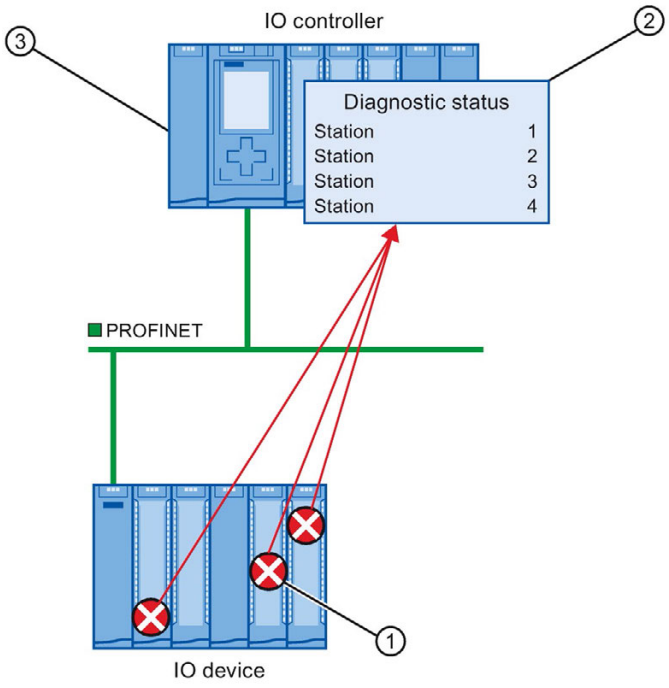


Number	Description
①	All individual errors are collected in a single data record on the interface module.
②	In your user program, the instruction "RDREC" reads the entire station status asynchronously directly from the IO device.

Figure 4-15 Example: Evaluating diagnostics data records with the instruction "RDREC"

2. Evaluation of interrupts

When the error OB (OB 82) is called, the OB's start information provides you with information on the cause and location of the error. Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).



Number	Description
①	Every error is sent to the IO controller individually as channel diagnostics information in the form of an interrupt.
②	In the IO controller, the module status data is updated automatically and the error OB (OB 82) is started.
③	In your user program in the error OB (OB 82), the instruction "RALRM" reads the error synchronously from the IO controller without addressing the IO device.

Figure 4-16 Diagnostics with OB 82 and the instruction "RALRM"

Instructions and OBs

You will find information on the instructions and OBs in the STEP 7 online help.

Functions

5

Introduction

The following section describes the PROFINET IO functions for field of application, properties and configuration in STEP 7.

Refer to the documentation for the respective device to see to what extent the PROFINET devices support the described functions.

You can find a tabular overview of the PROFINET devices and the functions these support on the Internet (https://support.industry.siemens.com/cs/ww/en/view/102325771).

5.1 Connecting other bus systems

5.1.1 Connecting other bus systems

Fieldbus integration

PROFINET allows you to use a proxy-capable PROFINET device to integrate existing fieldbus systems (for example, PROFIBUS, AS interface). The devices of these fieldbus systems are mapped on proxy PROFINET devices. In this way, you can set up any hybrid systems consisting of fieldbus and Ethernet-based subsystems. This allows a continuous exchange of information.

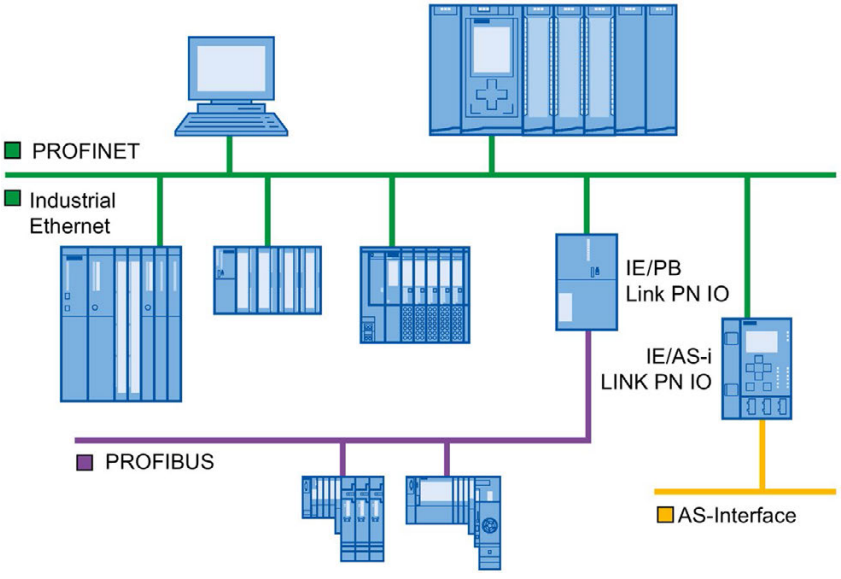


Figure 5-1 Gateways on PROFINET IO

Gateways of an S7-1500 CPU

An overview of the gateways at an S7-1500 CPU is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/88778900).

5.1.2 Linking PROFINET and PROFIBUS

Linking PROFINET and PROFIBUS

With a proxy-capable PROFINET device which is equipped with a PROFINET interface in addition to a PROFIBUS interface (for example, IE/PB Link PN IO), you can integrate existing PROFIBUS configurations into the PROFINET configuration.

The following figures shows how a PROFIBUS system is connected via IE/PB Link to a CPU S7-1500 (as of firmware version 1.7).

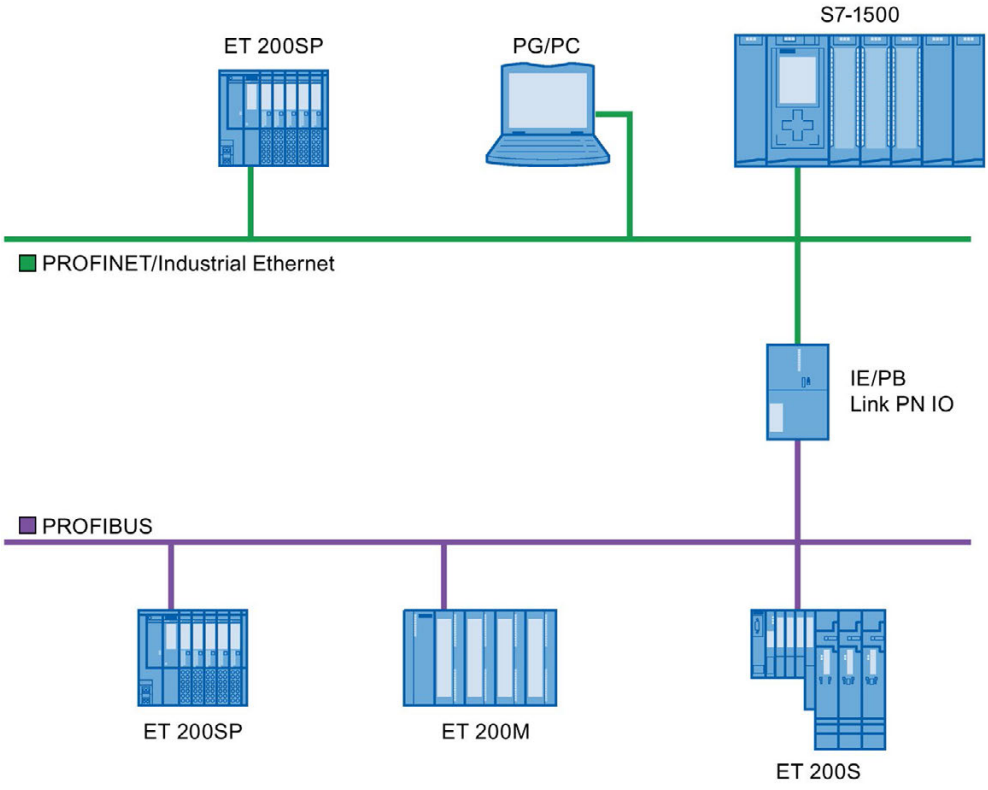


Figure 5-2 Gateway from PROFINET and PROFIBUS via IE/PB link

PROFINET device with proxy functionality

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET you can connect an existing PROFIBUS system to an IO controller, for example with the help of an IE/PB Link PN IO.

From the IO controller perspective, the PROFIBUS DP slaves are connected to the same network as the IE/PB Link PN IO. These slaves have the same device name and IP address as the IE/PB Link PN IO, but different device numbers. Furthermore, each also has a specific PROFIBUS address.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

For information on how to connect a DP slave to a PROFINET IO system, refer to section Connect the DP slave via the IE/PB Link to a PROFINET IO system (Page 96).

Diagnostic options with a CPU S7-1500 as IO controller

The CPU S7-1500 (as of firmware version 1.7) as IO controller detects disrupted DP slaves behind the IP/PB link.

5.1.3 Connect the DP slave via the IE/PB Link to a PROFINET IO system

Requirements

- STEP 7 as of V12
- S7-1500 CPU as of firmware version 1.7
- ET 200SP CPU as of firmware version 1.7
- CPU 1516pro-2 PN as of firmware version 2.0
- S7-1500 Software Controller as of firmware version 1.7
- S7-300/400 CPU

Procedure for connecting a DP slave via an IE/PB Link

To connect a DP slave to a PROFINET IO system via an IE/PB Link in STEP 7, follow these steps:

1. Drag-and-drop a PROFINET CPU, for example CPU 1513-1 PN, from the hardware catalog into the network view of STEP 7.
2. Drag-and-drop an IE/PB Link PN IO from the hardware catalog into the network view of STEP 7. The IE/PB Link PN IO is located under Network components > Gateways > IE/PB Link PN IO.
3. Assign the IE/PB Link PN IO to the CPU.
4. Drag a PROFIBUS interface module e.g. IM155-6 DP HF, from the hardware catalog to the network view.
5. Assign the interface module to the IE/PB Link.

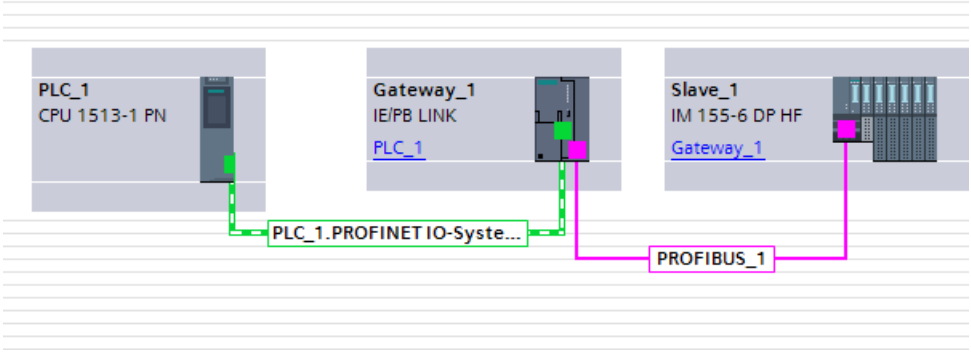


Figure 5-3 Configuring an IE/PB link

6. Select the IE/PB Link PN IO in the network view of STEP 7.

7. In the Inspector window, go to the "Gateway" area and select the "Network gateway as PROFINET IO proxy" option.

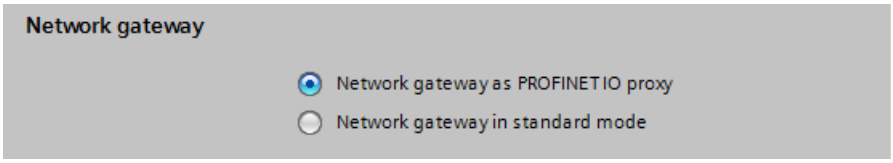


Figure 5-4 Setting a gateway

8. In the PROFINET device number area, you can assign a PROFINET device number for the DP slave.
   If you have selected the "Device number = PB address" check box (default), STEP 7 automatically assigns the device number according to the PROFIBUS address of the slave. In addition, you no longer need to update the device number if the PROFIBUS address changes.

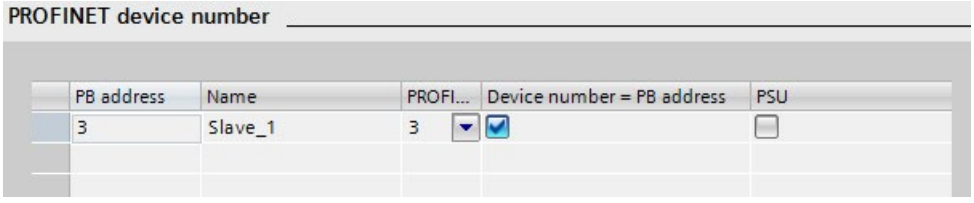


Figure 5-5 Assigning PN device numbers for IE/PB link

Result

You have connected the DP slave to the PROFINET IO system.

Reference

Additional information on the IE/PB link is available in the manual Gateway IE/PB Link PN IO (http://support.automation.siemens.com/WW/view/en/19299692).

5.2 Intelligent IO devices (I-devices)

5.2.1 I-device functionality

I-device functionality

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller and operation of the CPU as intelligent preprocessing unit of sub processes, for example. The I-device is linked as an IO device to a "higher-level" IO controller.

The preprocessing is handled by the user program in the I-device. The process values acquired in the centralized or distributed (PROFINET IO or PROFIBUS DP) I/O are preprocessed by the user program and made available to the IO controller.

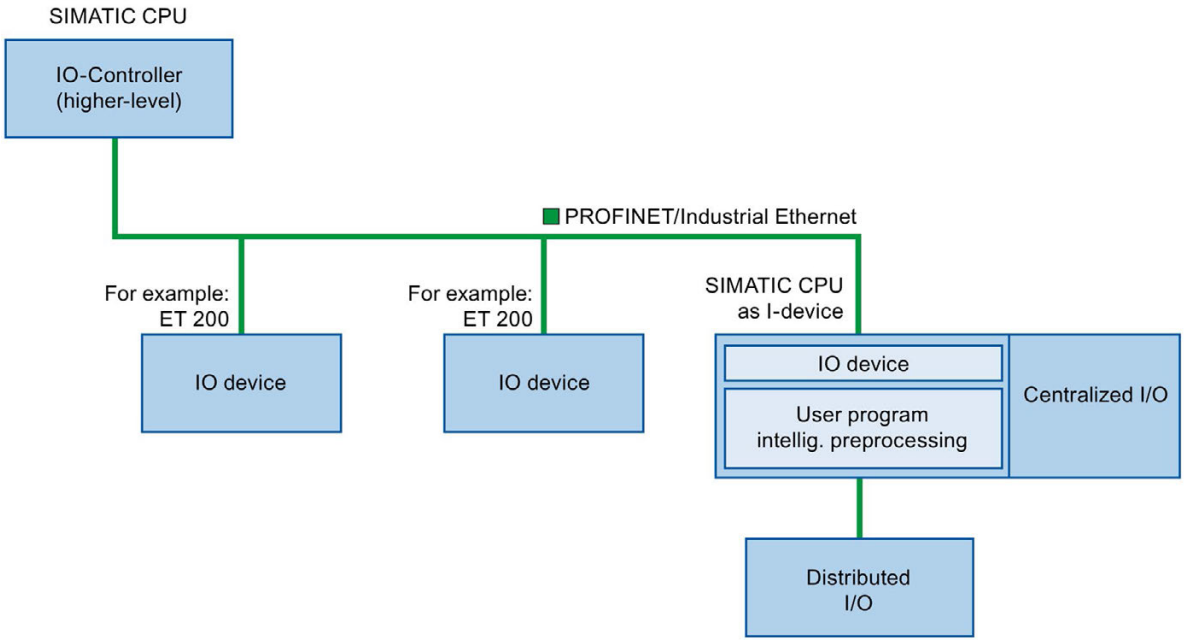


Figure 5-6 I-device

"I-device" naming conventions

In the remainder of this description, a CPU or a CP with I-device functionality is simply called an "I-device".

Application example: Configuration and application of the PROFINET I-device function

A detailed application example is available here (https://support.industry.siemens.com/cs/ww/en/view/109478798).

5.2.2 Properties and Advantages of the I-Device

Fields of application

Fields of application of the I-device:

- Distributed processing

  A complex automation task can be divided into smaller units/subprocesses. This results in manageable processes which lead to simplified subtasks.

- Separating subprocesses

  Complicated, widely distributed and extensive processes can be subdivided into several subprocesses with manageable interfaces by using I-devices. These subprocesses can be stored in individual STEP 7 projects if necessary, which can later be merged to form one master project.

- Know-how protection

  Components can only be delivered with a GSD file for the I-device interface description instead of with a STEP 7 project. The know-how of the user program may no longer be published.

Properties

Properties of the I-device:

- Unlinking STEP 7 projects

  Creators and users of an I-device can have completely separated STEP 7 automation projects. The GSD file forms the interface between the STEP 7 projects. This allows a link to standard IO controllers via a standardized interface.

- Real-time communication

  The I-device is provided with a deterministic PROFINET IO system via a PROFINET IO interface and therefore supports RT (real-time communication) and IRT (isochronous real time).

Advantages

The I-device has the following advantages:

- Simple linking of IO controllers
- Real-time communication between IO controllers
- Relieving the IO controller by distributing the computing capacity to I-devices.
- Lower communication load by processing process data locally.
- Manageable, due to processing of subtasks in separate STEP 7 projects

5.2.3 Characteristics of an I-Device

Principle

An I-device is included in an IO system like a standard IO device.

I-device without lower-level PROFINET IO system

The I-device does not have its own distributed I/O. The configuration and parameter assignment of the I-devices in the role of an IO device is the same as for a distributed I/O system (for example ET 200).

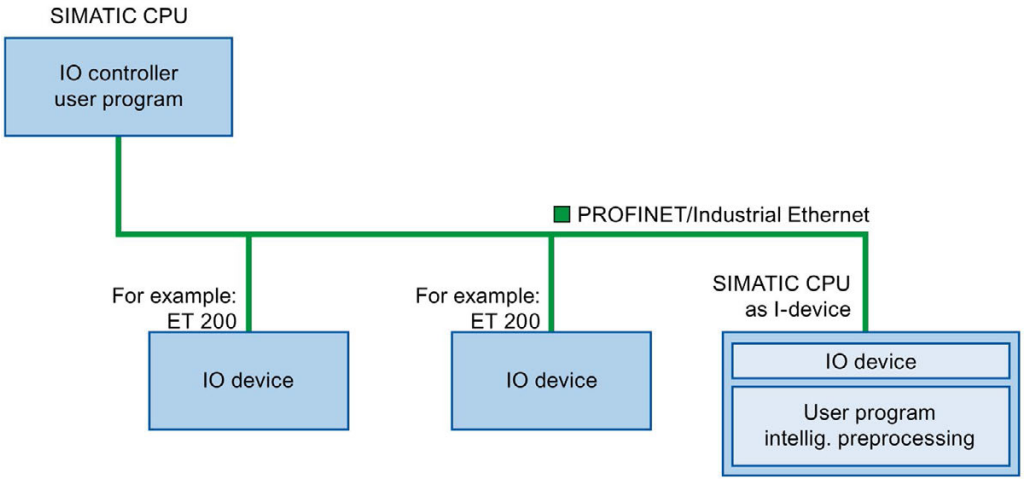


Figure 5-7 I-device without lower-level PROFINET IO system

I-device with lower-level PROFINET IO system

Depending on the configuration, an I-device can also be an IO controller on a PROFINET interface in addition to having the role of an IO device.

This means that the I-device can be part of a higher-level IO system via its PROFINET interface and as an IO controller can support its own lower-level IO system.

The lower-level IO system can, in turn, contain I-devices (see figure below). This makes hierarchically structured IO systems possible.

In addition to its role as IO controller, an I-device can also be used via a PROFIBUS interface as DP master for a lower-level PROFIBUS system.

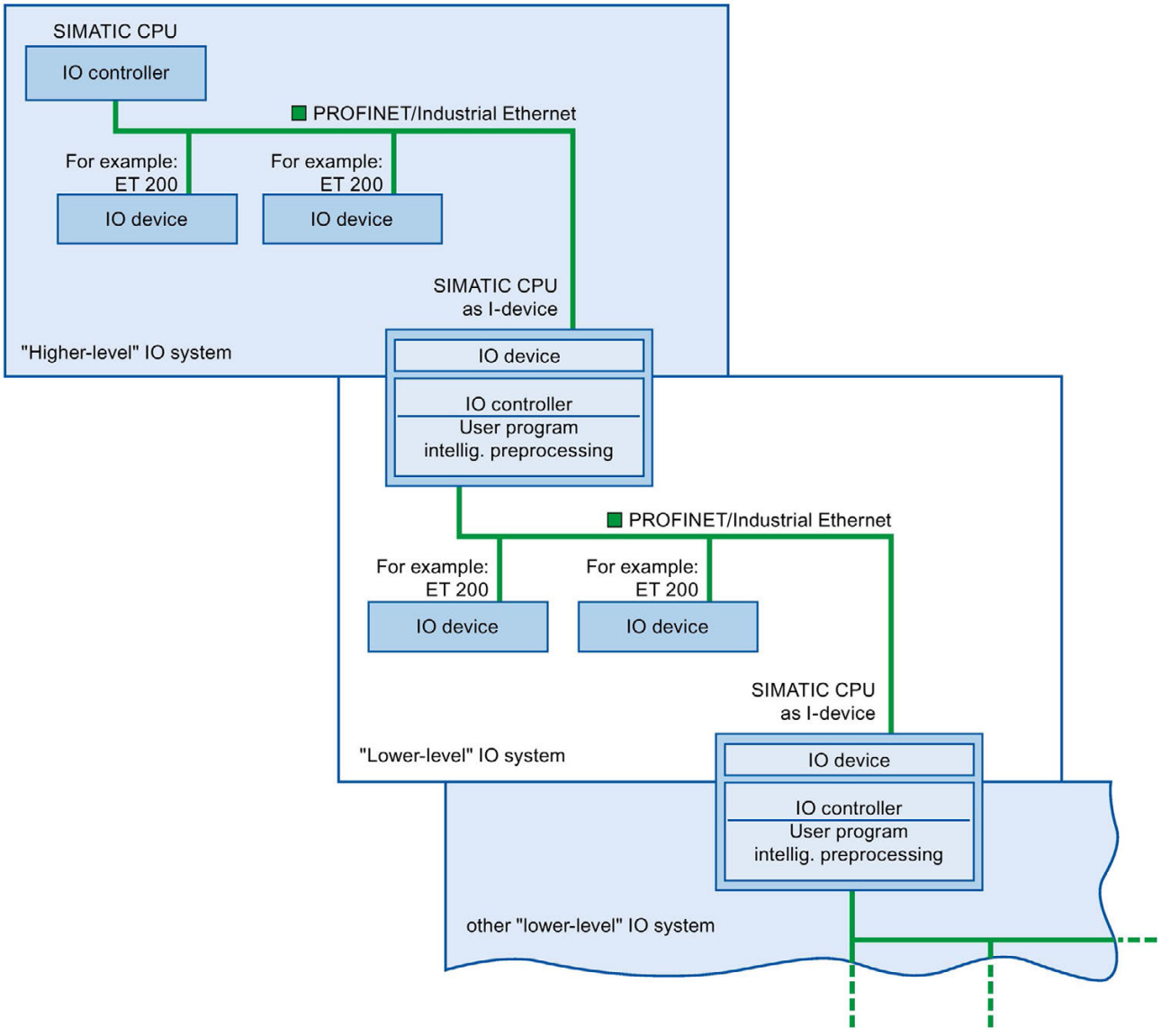


Figure 5-8 I-device with lower-level IO system

Example - the I-device as IO device and IO controller

The I-device as IO device and IO controller is explained based on the example of a print process. The I-device controls a unit (a subprocess). One unit is used, for example, to insert additional sheets such as flyers or brochures in a package of printed material.

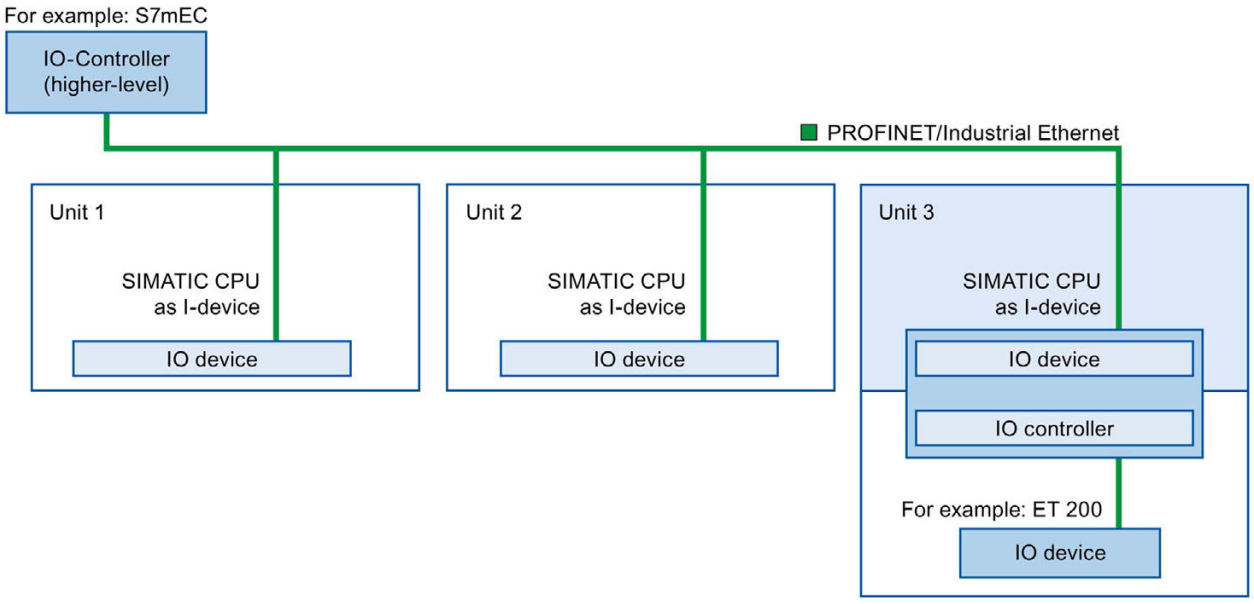


Figure 5-9 Example - the I-device as IO device and IO controller

Unit 1 and unit 2 each consist of an I-device with centralized I/O. The I-device along with the distributed I/O system (for example ET 200) forms unit 3.

The user program on the I-device is responsible for preprocessing the process data. For this task, the user program of the I-device requires default settings (for example control data) from the higher-level IO controller. The I-device provides the higher-level IO controller with the results (for example status of its subtask).

I-device as a shared device

An I-device can also be used simultaneously by multiple IO controllers as a shared device.

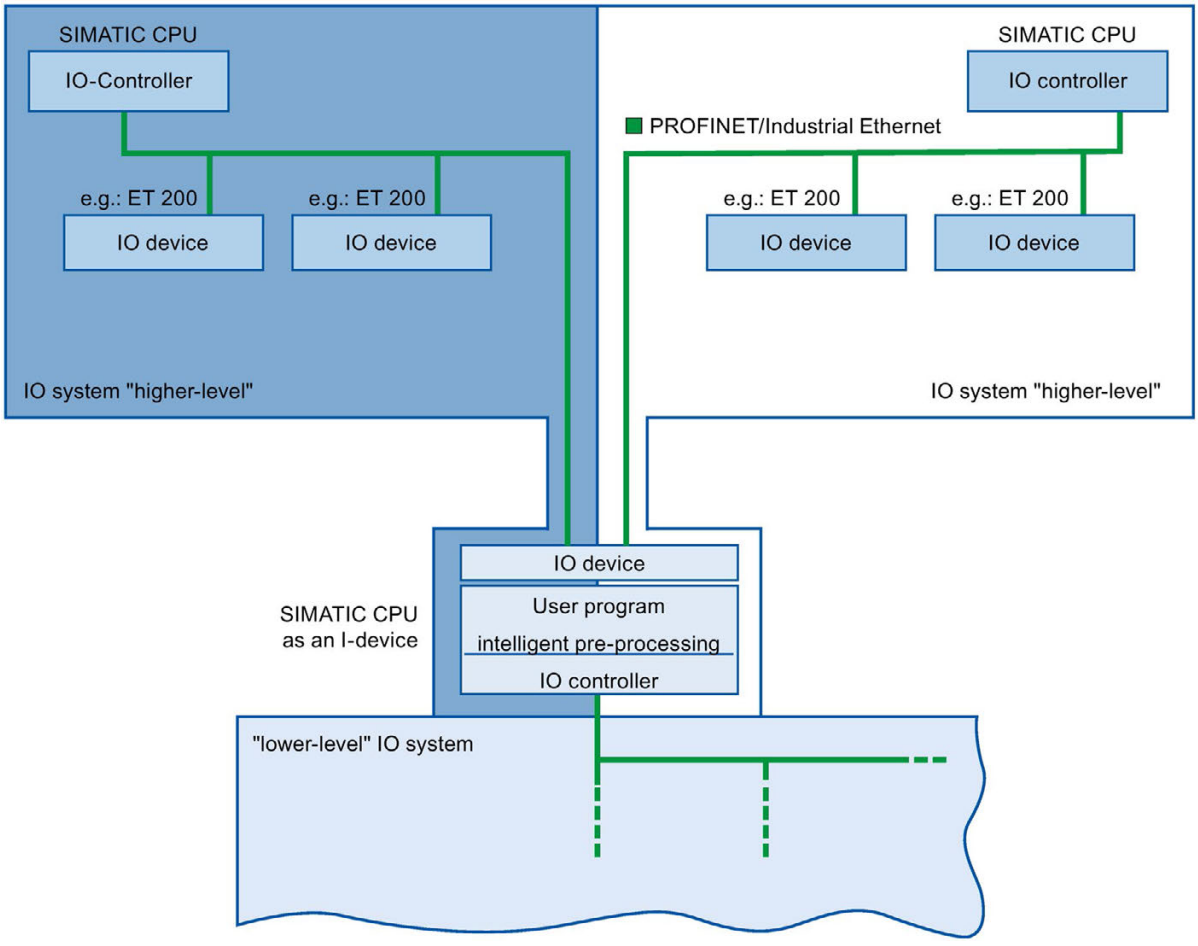


Figure 5-10 I-device as a shared device

Information about configuring an I-device as a shared device is available in the section Configuring an I-device as a shared device (Page 128).

5.2.4 Data Exchange between higher- and lower-level IO system

Introduction

The next chapter shows the data exchange between the higher- and lower-level IO system.

Transfer areas

Transfer areas are an interface to the user program of the I-device CPU. Inputs are processed in the user program and outputs are the result of the processing in the user program.

The data for communication between IO controller and I-device is made available in the transfer areas. A transfer area contains an information unit that is exchanged consistently between IO controller and I-device. You can find more information on configuration and use of transfer areas in the section Configuring the I-device (Page 106).

The next figure shows the data exchange between the higher- and lower-level IO system. The individual communication relations are explained below based on the numbers.

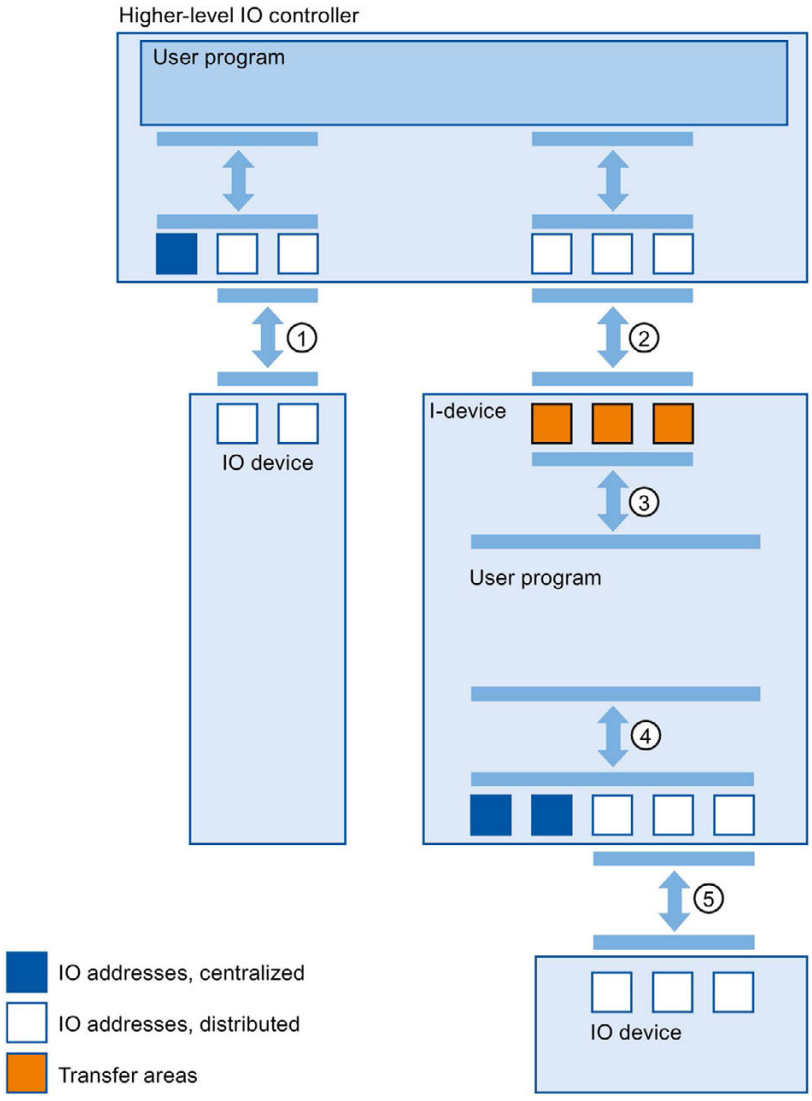


Figure 5-11 Data exchange between higher- and lower-level IO system

① Data exchange between higher-level IO controller and normal IO-device

In this way, the IO controller and IO devices exchange data through PROFINET.

② Data exchange between higher-level IO controller and I-device

In this way, the IO controller and the I-device exchange data through PROFINET.

The data exchange between a higher-level IO controller and an I-device is based on the conventional IO controller / IO device relationship.

For the higher-level IO controller, the transfer areas of the I-devices represent submodules of a preconfigured station.

The output data of the IO controller is the input data of the I-device. Analogously, the input data of the IO controller is the output data of the I-device.

③ Transfer relationship between the user program and the transfer area

In this way, the user program and the transfer area exchange input and output data.

④ Data exchange between the user program and the I/O of the I-device

In this way, the user program and the centralized / distributed I/O exchange input and output data.

⑤ Data exchange between the I-device and a lower-level IO device

In this way, the I-device and its IO devices exchange data. The data transfer is via PROFINET.

5.2.5 Configuring the I-device

Introduction

There are basically two possibilities for configuration:

- Configuration of an I-device within a project
- Configuration of an I-device that is used in another project or in another engineering system.

STEP 7 allows you to configure an I-device for another project or for another engineering system by exporting a configured I-device to a GSD file. You import the GSD file in other projects or engineering systems as with other GSD files. The transfer areas for the data exchange, among other data, are stored in this GSD file.

Configuration of an I-device within a project

1. Drag-and-drop a PROFINET CPU from the hardware catalog into the network view.
2. Drag-and-drop a PROFINET CPU, which can also be configured as an IO device, from the hardware catalog into the network view. This device is configured as I-device (e.g., CPU 1516-3 PN/DP).
3. Select the PROFINET interface for the I-device.
4. In the Inspector window in the area navigation choose "Operating mode" and select the check box "IO device".

5. Now you have the option of choosing the IO controller in the "Assigned IO controller" drop-down list.

   Once you have chosen the IO controller, the networking and the IO system between both devices are displayed in the network view.

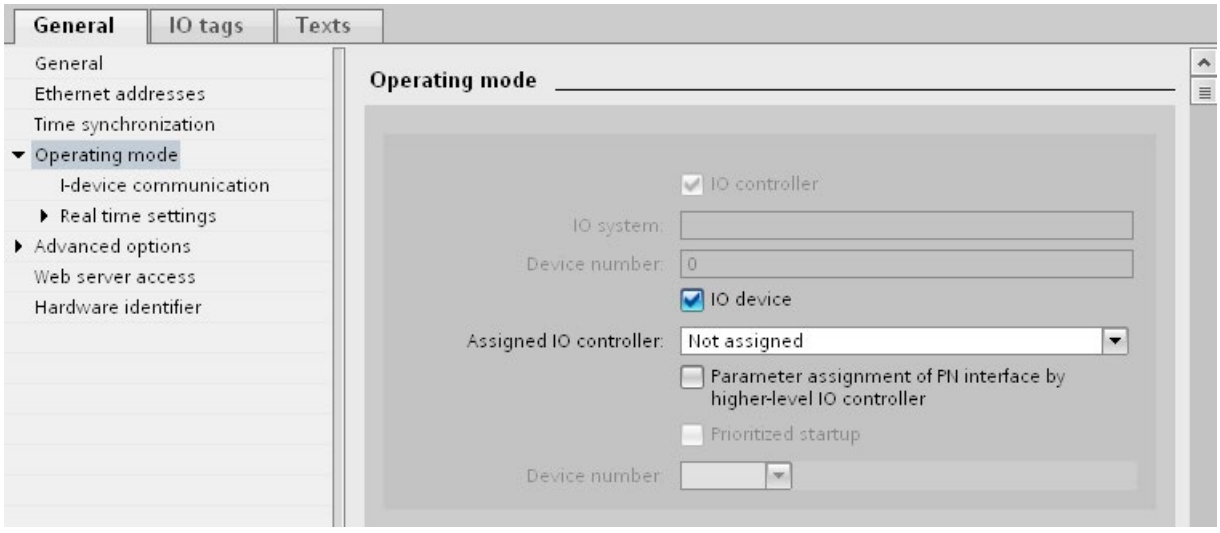


Figure 5-12 Configuring the I-device

6. With the "Parameter assignment of PN interface by higher-level IO controller" check box, you specify whether the interface parameters will be assigned by the I-device itself or by a higher-level IO controller.

   If you operate the I-device with a lower-level IO system, then the parameters of the I-device PROFINET interface (for example, port parameter) cannot be assigned with the higher-level IO controller.

7. Configure the transfer areas. The transfer areas are found in the area navigation section "I-device communication".
   - Click in the first field of the "Transfer area" column. STEP 7 assigns a default name which you can change.
   - Select the type of communication relation: you can currently only select CD or F-CD for "Controller-device communication relation".
   - Addresses are automatically preset; you can correct addresses if necessary, and determine the length of the transfer area which is to be consistently transferred.

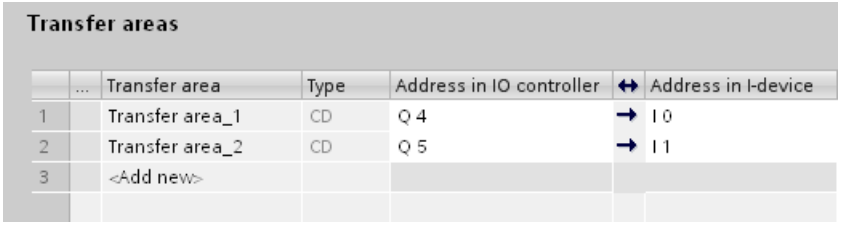


Figure 5-13 Configuring the transfer areas

8. A separate entry is created in the area navigation for each transfer area. If you select one of these entries, you can adjust the details of the transfer area, or correct them and comment on them.

Configuring an I-device with a GSD file

If you use an I-device in another project, or if the I-device is used in another engineering system, then configure the higher-level IO controller and the I-device as described above.

However, click on the "Export" button after configuring the transfer areas so a new GSD file is created from the I-device. This GSD file represents the configured I-device in other projects.

The "Export" button is found in the "I-device communication" section of the Inspector window.

The hardware configuration is compiled and the export dialog opened.

Assign a name for the I-device proxy as well as a description in the fields provided. Click the "Export" button to complete your process.

Finally, import the GSD file, for example, in another project.

5.2.6 Program examples

Introduction

This simple program example shows how you use the transfer areas of an I-device.

Requirements

You have configured an I-device.

Task

The result of an "AND logic operation" of two inputs (preprocessing) in the I-device is to be provided to the higher-level IO controller. This result is to be assigned to a local output in the IO master (further processing).
Use a transfer area with the following addresses for this purpose:

- Address in the I-device: Q568
- Address in the IO controller: I68

Required steps

The following steps to solve the task:

1. Configuring the transfer area
2. Programming I-device
3. Programming IO controller

Configuring the transfer area

Configure a transfer area with the following properties in the I-device:

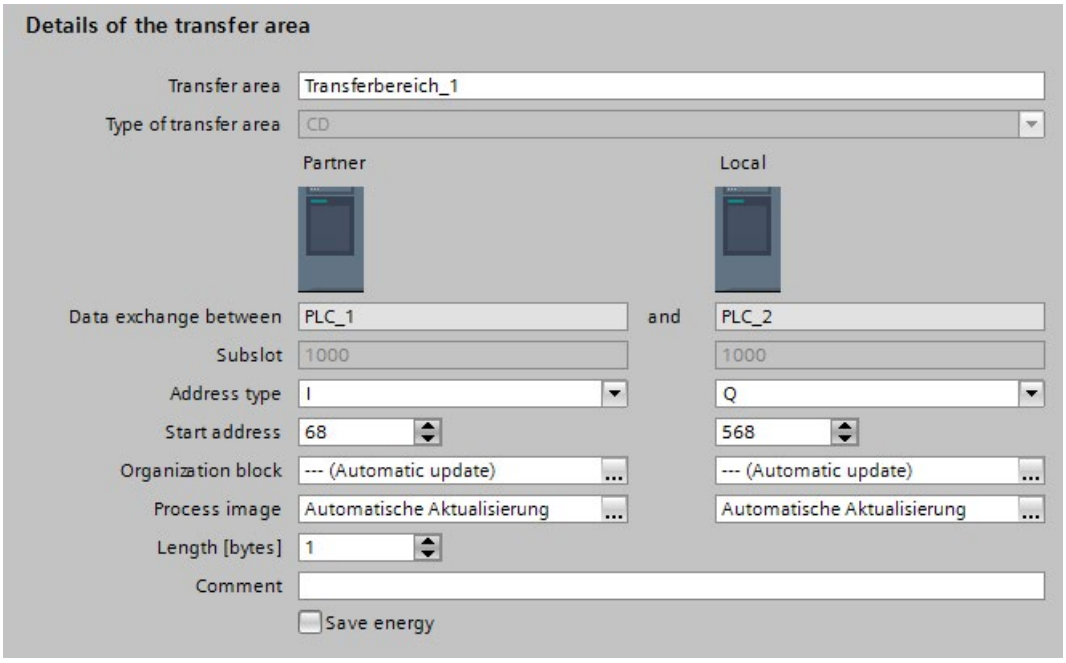


Figure 5-14 I-device transfer area, sample program

Programming I-device

To program the sample program for the I-device, follow these steps:

1. Using the SCL programming language, create a new function with the name "preprocessing" in the project tree in "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "preprocessing", create the following tags:

Name	Data type	Input / output type
input 1	bool	Input
input 2	bool	Input
result	bool	Output

3. In the instruction window of the function "preprocessing", write the following program code:
   #result:=#input 1&#input 2;

4. Call the function "preprocessing" in a program cycle OB, for example, in OB1.
5. Wire the function "preprocessing" in the program cycle OB as follows:

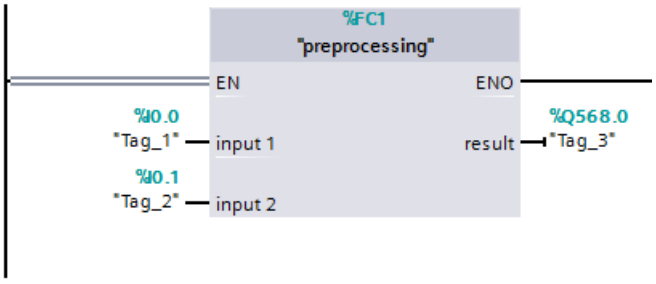


Figure 5-15 I-device sample program

Programming IO controller

To program the sample program for the IO controller, follow these steps:

1. Using the SCL programming language, create a new function with the name "further processing" in the project tree in "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "further processing", create the following tags:

Name	Data type	Input / output type
result	bool	Input
output	bool	Output

3. In the instruction window of the function "further processing", write the following program code:
   #output:=#result;
4. Call the function "further processing" in a program cycle OB, for example, in OB1.
5. Wire the function "further processing" in the program cycle OB as follows:

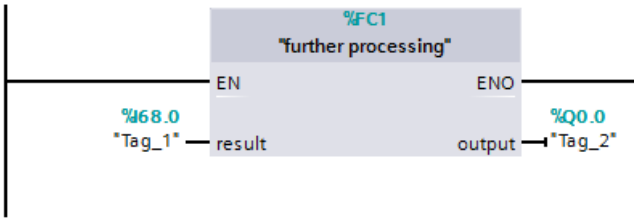


Figure 5-16 IO controller sample program

Result

The IO controller and the I-device can exchange data with each other through the input/output transfer areas.

5.2.7 Diagnostics and interrupt characteristics

Diagnostics and interrupt characteristics

S7 CPUs have numerous diagnostics and interrupt functions that can, for example, report errors or failures of lower-level IO systems. These diagnostics messages reduce down times and simplify localization and elimination of problems.

Diagnostics options in the higher-level IO controller and in the I-device

The following diagnostics functions are available to the higher-level IO controller and the I-device CPU:

- OB 83 (pull/plug)
- OB 86 (rack failure)
- OB 122 (I/O access error)

Note

The diagnostics messages of the I/O can be processed in the user program of the I-device CPU and passed on from there to the higher-level IO controller via transfer areas.

Operating state changes and station failure / station return

In the following table, you can see which consequences an operating state change or the failure of an IO controller / I-device of the SIMATIC family has on the respective other(s):

Table 5- 1 Operating state changes and station failure / station return

Initial status	Event	I-device response	Higher-level IO controller
I-device CPU is in RUN, higher-level IO controller is in RUN	The I-device CPU changes to STOP	-	During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error).
I-device CPU is in STOP higher-level IO controller is in RUN	The I-device CPU is starting up	Call of OB 100 (startup). Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 83 (pull/plug) for all transfer areas to the I-device. Until call of OB 83 in the case of direct access to the transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error).

Initial status	Event	I-device response	Higher-level IO controller
I-device CPU is in RUN, higher-level IO controller is in RUN	The higher-level IO controller changes to STOP	During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error). Note: Output transfer areas can still be accessed.	-
Higher-level IO controller is in STOP, I-device CPU in RUN	The higher-level IO controller starts up	Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 100 (startup).
I-device CPU is in RUN, higher-level IO controller is in RUN	Station failure I-device, for example, through bus interruption	If the I-device continues to run without a bus connection: Call of OB 86 (rack failure). During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 86 (rack failure). During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error).
I-device CPU is in RUN, higher-level IO controller is in RUN, communication connection between IO controller and I-device is interrupted (bus interruption).	The bus connection between the IO controller and I-device has been reestablished and the I-device is again included in the user data traffic.	Call of OB 86 (rack failure). Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 86 (rack failure). Until reporting of station re-integration by OB 86 with direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error)

Note

Special characteristic during startup of the higher-level IO controller

In contrast to the station return message from IO devices in the IO controller, which are covered completely by the call of the OB 86, the station return message of a higher-level IO controller in the I-device is separated into 2 parts:

1. Call of the OB 86: The initial values for the outputs of the I-device are set. However, the input values are not yet valid. These values will first be valid with the opening of OB 86 in the higher-level IO controller.
2. Call of OB 83 for each input transfer area; with this call, the validity of an input transfer area is displayed. The starting up of the I device is first complete when the OB 83 has been called for the input transfer areas. This step can be delayed or not occur at all in the following situations:
   – Higher-level IO controller is in STOP: OB 83 is first called at the STOP-RUN transition of the higher-level IO controller.
   – The IRT communication has been disrupted (sync-master failure, topology error, ...). OB 83 is opened only after the IRT communication has taken place.

Reference

For more information on error handling in the case of direct I/O access, refer to "Error handling" in the STEP 7 online help.

5.2.8 Rules for the Topology of a PROFINET IO System with I-Device

Introduction

The following recommendations for the structure and configuration of an IO system when using I-devices will help you to keep the bandwidths required for keeping communication small.

The following communication paths should not overlap:

- Communication paths between the IO controller and the IO device of its IO system.
- Communication paths of the I-device CPU and the IO devices of your IO system.

I-device with one port

Connect an I-device with only one port to a PROFINET switch that is uncoupled from the higher-level IO system. Connect the lower-level IO system to another port of the switch as shown in the following figure.

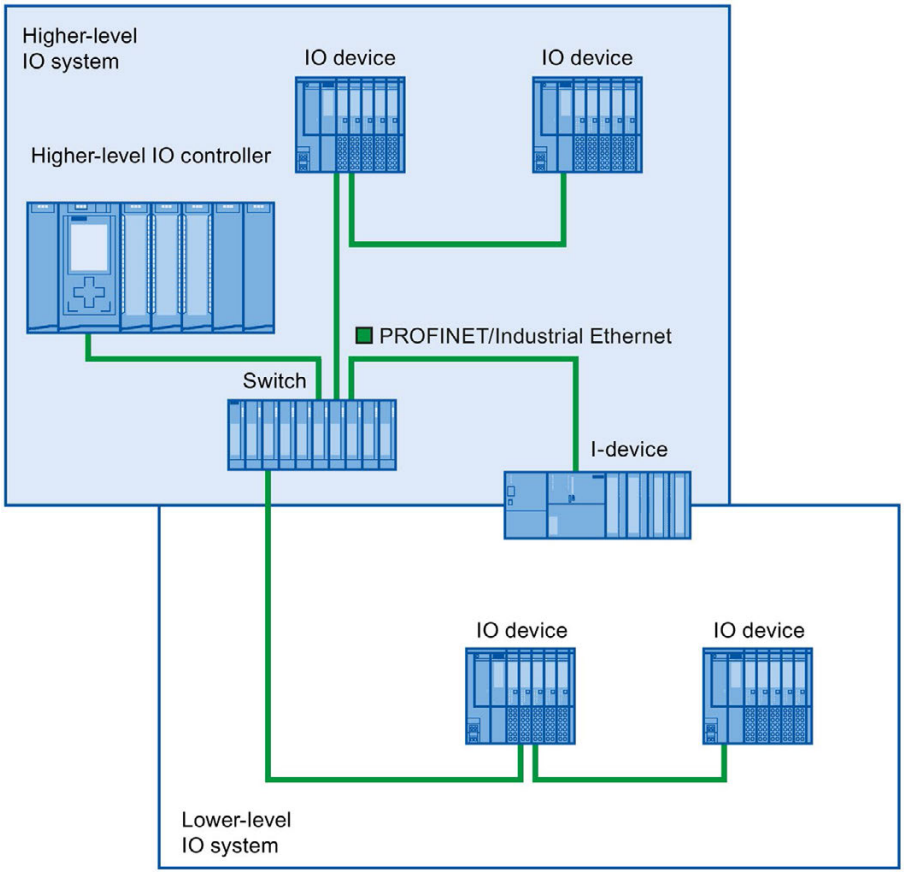


Figure 5-17 I-device with one port

I-device with two ports

With an I-device with two ports, connect one port, uncoupled from the higher-level IO system, to the port of the PROFINET switch. Use the second port for the lower-level IO system as shown in the following figure.

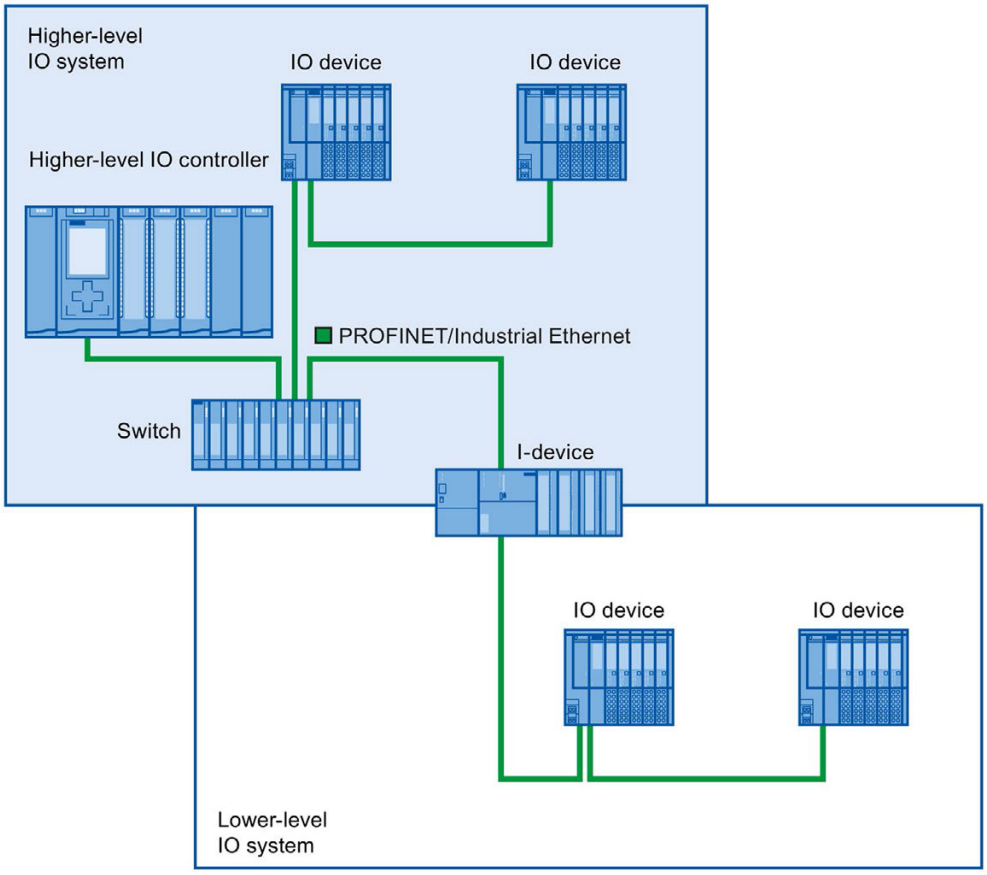


Figure 5-18 I-device with two ports

I-device with three or more ports

If you have an I-device with three or more ports, connect the I-device to one or both ports to the higher-level IO system in a linear bus topology. Connect the third port to the lower-level IO system uncoupled from the linear bus topology as shown in the following figure.

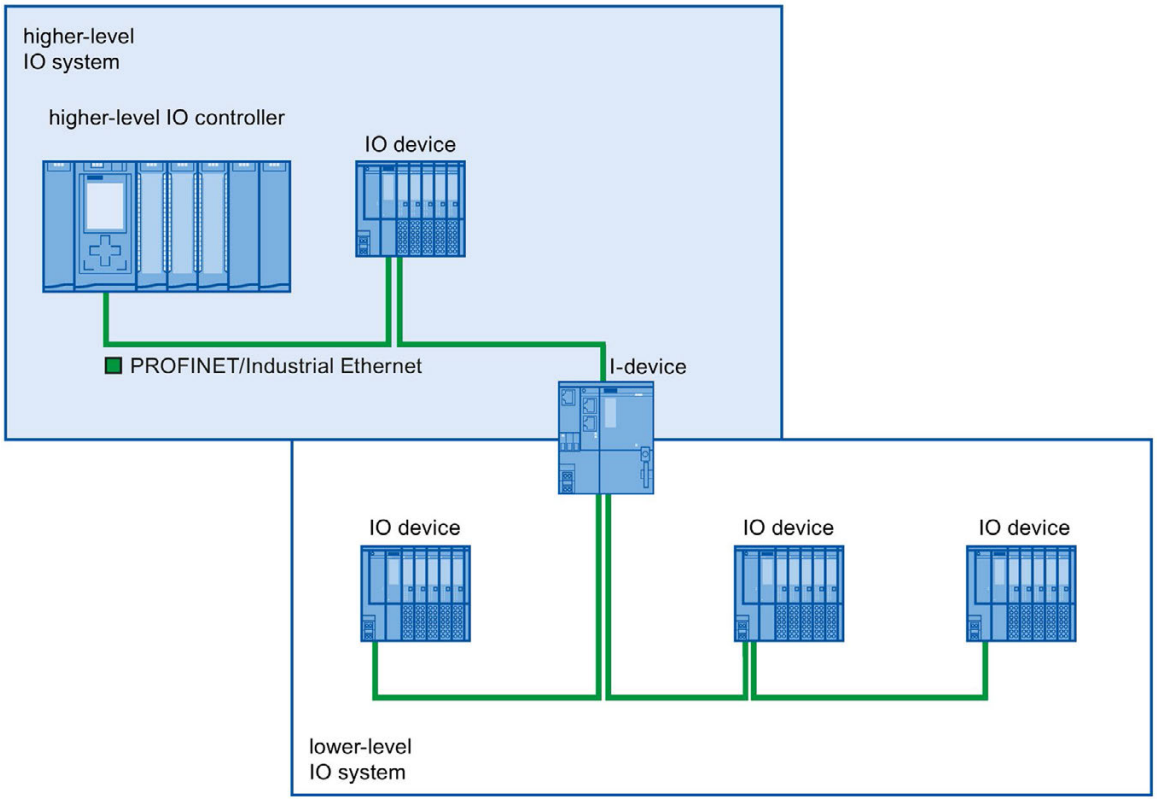


Figure 5-19 I-device with three or more ports

5.2.9 Boundary conditions when using I-devices

Note the following boundary conditions when using I-devices:

Bandwidth

The number of addresses of the configured transfer areas affects the usable bandwidth of the I-device:

- Bandwidth of the transfer areas + bandwidth of the lower-level IO system = total bandwidth used on the I-device

If the address space of the transfer areas is too large, this indicates a larger bandwidth requirement and can thus lead to longer update times.

Tip: Keep the address space of the transfer area as small as possible.

Rules for RT and IRT communication.

IO systems with I-devices are also suitable for setting up real-time applications with RT and IRT communication. The following rules must be followed for this:

- Both the higher-level and the lower-level IO system support RT communication. You can use RT communication for both IO systems at the same time.
- IRT communication can be combined with RT communication. However, IRT communication cannot take place in both IO systems simultaneously. Use IRT either in a higher-level or in a lower-level IO system.

5.2.10 Configuring PROFIenergy with I-devices

The requirement for program-controlled pauses for saving energy with PROFINET devices is that the PROFINET devices support the PROFIenergy protocol.

Only if a PROFINET device (I/O device) supports the PROFIenergy protocol does an I/O controller actually send PE commands to this I/O device, for example to start or stop pauses.

If an I/O device supports the PROFIenergy protocol, this property is saved in its PROFINET GSD file and is available for configuration in an engineering system.

For S7-1500 CPUs as intelligent I/O devices (I-devices), you have the option with STEP 7 V13 service pack 1 or later to set PROFIenergy support for each transfer area.

If you have enabled the option "Use PROFIenergy to save energy" for a transfer area and import the generated PROFINET GSD file into another project, you can handle an I-device as a PE entity there.

Requirements

- STEP 7 as of V13 service pack 1
- CPU supports PROFIenergy with I-devices, for example CPU 1215C DC/DC/DC as of firmware version 4.2
- You use the PROFINET IO interface as an I-device and have created transfer areas.
- The user program in the I-device handles PROFIenergy commands

  Background: You need to program PROFIenergy functions with I-devices in the user program using the "PE_I_DEV" instruction and corresponding auxiliary blocks; this is different compared with IO devices for which this functionality is made available by the firmware. You may therefore only activate the PROFIenergy support for transfer areas if the user program in the I-device is configured correspondingly as well.

Enabling PROFIenergy for transfer areas of I-devices

Proceed as follows to assign parameters for the support of PROFIenergy:

1. Select the PROFINET interface (X1) of the CPU.
2. Select the required transfer area in the area navigation, for example:

   Operating mode > I-device communication > Transfer_area_1.
3. Select the check box "Enable PROFIenergy communication".

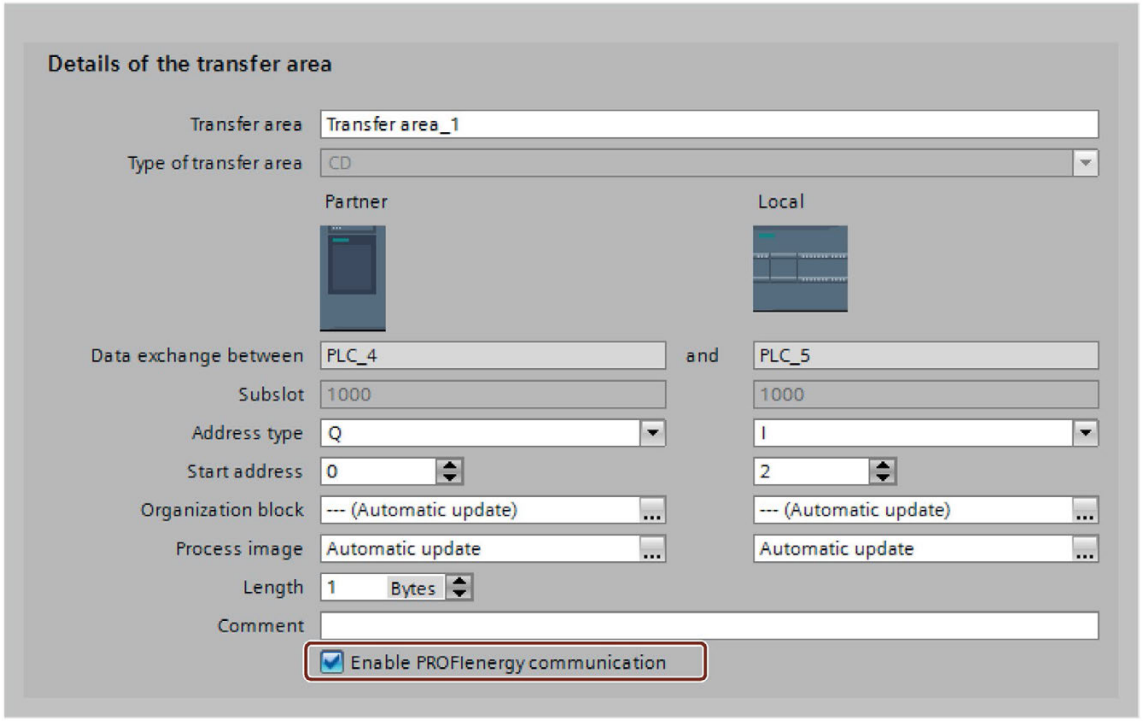


Figure 5-20 Configuring PROFIenergy with I-devices

Once the I-device is fully configured, generate the GSD file for the I-device and import this file in the project for the I/O controller. The GSD file generated is compatible with GSD version 2.31 and contains an entry that specifies that the I-device supports the PROFIenergy profile.

To address the I-device, for example for the PE command "PE_START_END", use the hardware identifier of the "PROFIenergy supporting" transfer area in the I-device.

To address the IO controller for the PE command "PE_I_DEV", use the hardware identifier of the transfer area that is supplied with the data for PROFIenergy on the IO controller.

You can find more information on PROFIenergy in the sectoin Saving energy with PROFIenergy (Page 227).

5.3 Shared device

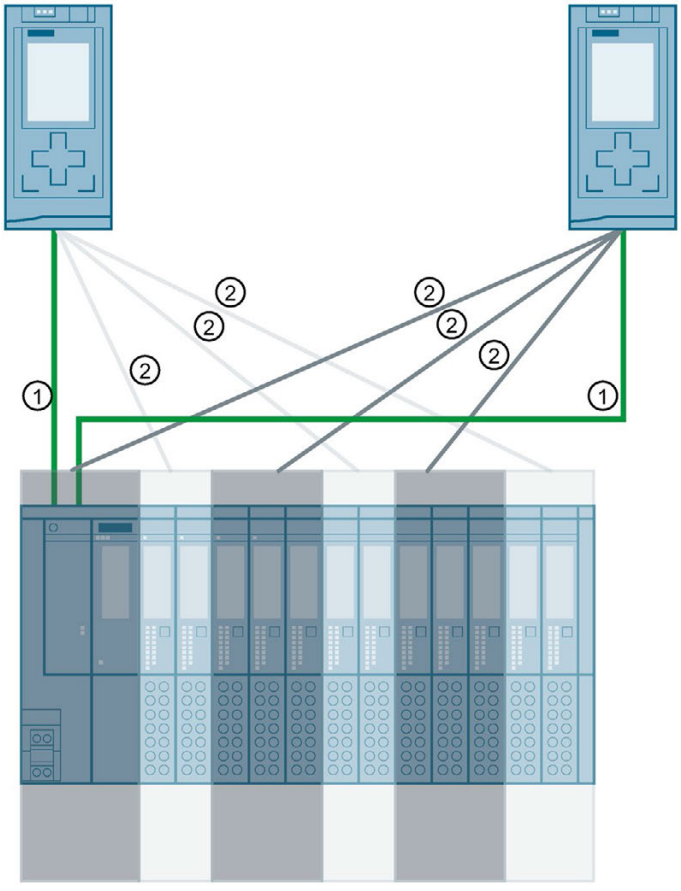
5.3.1 Useful information on shared devices

shared device functionality

Numerous IO controllers are often used in larger or widely distributed systems.

Without the "Shared Device" function, each I/O module of an IO device is assigned to the same IO controller. If sensors that are physically close to each other must provide data to different IO controllers, several IO devices are required.

The "Shared Device" function allows the modules or submodules of an IO device to be divided up among different IO controllers. Thus allowing flexible automation concepts. You have, for example, the possibility of combining I/O modules lying near other into an IO device.



① PROFINET
② Logical assignment

Figure 5-21 Example: Shared device with 2 IO controllers

Principle

Access to the submodules of the shared device is then divided up among the individual IO controllers. Each submodule of the shared device is assigned exclusively to one IO controller.

Requirements

- STEP 7 V12 Service Pack 1 or higher
- IO device supports the shared device function, e.g. interface module IM 155-5 PN ST
- IO controller supports the shared device function, for example CPU 1516-3 PN/DP as of firmware version 1.1 or CPU 1215 DC/DC/DC as of firmware version 4.1

Explanatory notes:

- A CPU that is configured as an I-device can be used as a shared device. For this purpose, you create a GSD file for the I-device in STEP 7 via "GSD export". You then import the GSD file into a different project and assign the I-device to the IO controller there. The CPU has to support the GSD export, for example CPU 1215C DC/DC/DC as of firmware version 4.1.
  The maximum number of IO controllers that you can assign to a CPU configured as a shared I-device is given in the technical specifications in the CPU manuals.

Configuring the access

The IO device must be present in several projects so that the modules or submodules of an IO device can be assigned to different IO controllers. A separate project is required for each IO controller.

You use the "Shared device" parameter of the interface module to determine the modules or submodules to which the IO controller has access:

- If the local IO controller has access to the configured module, select the name of the IO controller from the list.
- If the IO controller from a different project and not the local IO controller is to have access to the configured module, select the entry "---".

The configuration is consistent regarding access if each module or submodule in exactly one project is assigned to an IO controller.

Module or submodule is assigned to another IO controller

The paragraph below describes the consequences of the "---" setting of the "Shared device" parameter from the point of view of the local IO controller.

In this case, the local IO controller does not have access to the module configured in this way. Specifically, this means:

- No data exchange with the module or submodule
- No reception of alarms or diagnostics, which means no display of the diagnostics status in the online view
- No parameter assignment of the module or submodule

Setting of the real-time properties

STEP 7 calculates the communication load and thus the resulting update times. You must enter the number of project-external IO controllers in the project in which the PROFINET interface of the shared device is assigned to the IO controller so that a calculation is possible with shared device configurations.

The maximum possible number of IO controllers for the shared device depends on the device. This number is stored in the GSD file of the shared device.

You can set a very short send clock with a CPU as IO controller. The send clock can be shorter than the shortest send clock supported by the shared device. In this case, the shared device is operated by the IO controller with a send clock that it supports (send clock adaptation).

Example:

A CPU supports send clocks starting from 0.25 ms. A configured IO device also supports send clocks starting at 0.25 ms; another IO device supports send clocks starting at 1 ms. In this case, you have the option of setting the short send clock of 0.25 ms for the CPU. The CPU operates the "slow" IO device with the send clock of 1 ms, for example.

Rules for the configuration

- IO controllers that use the shared device are created in different projects. In each project, care must be taken that the shared device is configured identically in each station. Only one IO controller may ever have full access to a submodule. Inconsistencies in the configuration result in a failure of the shared device.
- I/O addresses of a module or submodule can only be edited if a module or submodule is assigned to the IO controller in the same project.
- The shared device must have the same IP parameters and the same device name in each project.
- The send clock must be identical for all IO controllers that have access to the shared device.
- The S7 subnet ID of the subnet to which the shared device is connected must be identical in all projects.
- The following functions are only available if the PROFINET interface of the shared device is assigned to the local IO controller:
  - IRT operation
  - Prioritized startup
  - Parameter assignment of the port properties

Boundary conditions

The following boundary conditions result because a shared device configuration is distributed across several projects:

- The addresses of modules or submodules that are not assigned to this IO controller are missing in the address overview of each IO controller that has access to a shared device.
- The modules or submodules that are not assigned are not taken into consideration in the configuration limit calculation for the shared device during the consistency check. For this reason, you must verify for yourself that the maximum number of submodules or the maximum amount of cyclic IO data for the shared device will not be exceeded.
  For information on the maximum quantities, refer to the documentation for the devices you are using.
- Configuration errors such as the assignment of a module or submodule to several IO controllers are not detected in STEP 7.
- CPUs that are loaded with a shared device configuration do not have any information on whether the IO device is a shared device. Modules or submodules that are assigned to other IO controllers and therefore other CPUs are missing in the loaded configuration. These modules or submodules are therefore displayed neither in the CPU web server nor in the CPU display.

Response in the event of fault

Information about how PROFINET IO controllers behave in the event of a fault when accessing the data of a shared device is available in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109572804).

5.3.2 Configuring shared device

Below, you will find a description of how to configure a distributed I/O system as a shared device with STEP 7 V12, Service Pack 1 or higher.

A "distributed" configuration with different engineering tools for different IO controller families is always possible. However, the description of the procedure is based solely on STEP 7 as of V12, service pack 1. The description is limited to two IO controllers of the S7-1500 family that share a shared device.

Two projects are created (Shared-Device-1 and Shared-Device-2), each with one IO controller (PLC1 and PLC2). You must create the shared device in both projects, even though it is physically one and the same IO device.

Requirements

- STEP 7 V12 Service Pack 1 or higher
- The IO controller supports the shared device function, for example CPU 1513-1 PN as of firmware version 1.1.
- IO device supports shared device functionality, for example interface module IM 155-5 PN ST as of firmware version 2.0.

Procedure - Creating project 1

To create the first project with a shared device, follow these steps:

1. Start STEP 7.
2. Create a new project with the name "Shared-Device-1".
3. Insert, for example, a CPU 1513-1 PN from the hardware catalog in the network view. Name it "PLC1".
4. Insert an IO device with the "Shared device" function from the hardware catalog.
5. Assign the IO controller "PLC1" to the IO device.
6. Double-click the IO device and insert all required modules and submodules from the hardware catalog in the device overview table.
7. Assign the module parameters.
8. Save the project.

Procedure - Creating project 2

To create the second project with a shared device, follow these steps:

1. Start STEP 7 once again.

   A new instance of STEP 7 opens.
2. In the new instance, create a new project with the name "Shared-Device-2".
3. Insert, for example, a CPU 1513-1 PN in the network view. Name it "PLC2".
4. Copy the IO device from the project "Shared-Device-1" and insert it in the network view of project "Shared-Device-2".
5. Assign the IO controller "PLC2" to the IO device.
6. Save the project.

Both projects now have an identically structured IO device that must be configured in the next step for the different types of IO controller access.

Procedure - Configuring access to the shared device

The modules and submodules you insert in the shared device are automatically assigned to the local CPU. To change the assignment, follow these steps:

1. Select the interface module in the network view or device view of project "Shared-Device-1".
2. Select the "Shared Device" area in the Inspector window.

   A table shows which CPU has access to the respective module or submodule for all configured modules. The default setting is that the local CPU has access to all modules and submodules.
3. Keep the "PLC1" setting for all modules and submodules that are to remain in the address range of the local CPU.

Select the setting "---" for all modules and submodules that are to be located in the address range of the CPU from the "Shared-Device-2" project (PLC2). This means that an IO controller outside the project is to have access to the module or submodule.

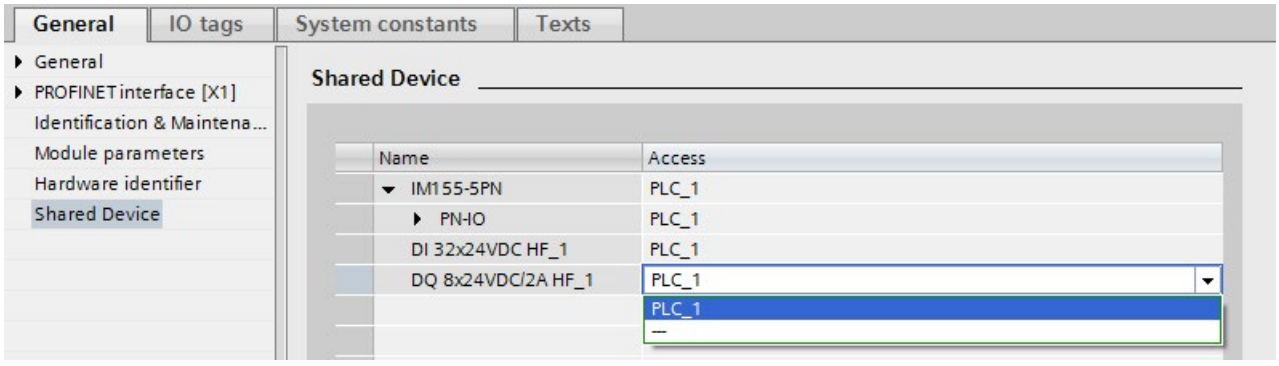


Figure 5-22 Configuring shared device

4. Select the interface module in the network view or device view of project "Shared-Device-2".
5. Select the "Shared Device" area in the Inspector window.

   A table shows which CPU has access to the respective module or submodule for all configured modules.
6. Select the setting "---" for all modules and submodules that are to be located in the address range of the CPU from the "Shared-Device-1" project (PLC1).
7. Finally, check whether the settings for access are "complementary" for each module or submodule in both projects. This means that if the local CPU has access in one project, the option "---" must be set in the other project and vice versa.

   Special consideration: The option "---" for the PROFINET interface and therefore for the ports makes the associated parameters read-only and not changeable. Parameters of the PROFINET interface and port parameters can only be edited in the project in which the PROFINET interface is assigned to the local CPU. The ports can be interconnected in both projects regardless of this.
8. Check whether the same IP address parameters and device name are set for the shared device in all projects.

   Check whether the same S7 subnet ID is set in all projects for the subnet to which the shared device is connected (subnet properties, "General" area in the Inspector window).

Note

If you make changes to the shared device: Make the same changes in each project on the shared device. Make sure that only one IO controller has access to a module or submodule.

Procedure - Adjusting the real-time settings

To ensure that all IO controllers and shared devices are operated with the appropriate send clock and that the update times are calculated correctly based on the communication load, you must adjust and check the following settings:

1. Select the project whose IO controllers have access to the PROFINET interface and the ports of the shared device.
2. Select the interface module of the shared device in the network view.
3. In the Inspector window, navigate to the "PROFINET interface > Advanced options > Real time settings > IO cycle" area.
4. In the "Shared Device" area, set the number of project-external IO controllers. The maximum number depends on the IO device (specification in GSD file).
5. You must set the same send clock for each IO controller that has access to modules and submodules of the shared device:
   - If you configure the IO controller with STEP 7 (TIA Portal):

     Open the corresponding project.

     Select the PROFINET interface of the IO controller.

     Select the "Advanced options > Real time settings > IO communication" area in the Inspector window and set the shared send clock.
   - If you configure the IO controller with a different engineering tool:

     Select the PROFINET interface of the shared device in STEP 7 (TIA Portal) and read out the send clock on the shared device ("Advanced options > Real time settings" area)

     Enter the read send clock in the engineering tool.
   - Special consideration: If you configure **all** IO controllers that have access to the shared device in STEP 7 (TIA Portal or V5.5), you can set shorter send clocks on the IO controller than supported by the shared device (send clock adaptation).

Compiling and loading

You must compile the configurations for the different IO controllers and load them to the CPUs one after the other.

Due to the distributed configuration with separate projects, STEP 7 does not output consistency errors in the case of incorrect access parameter assignment. Example for incorrect access parameter assignment:

- Several IO controllers have access to the same module
- IP address parameters or send clocks are not identical

These errors do not show up until operation and are output as configuration errors, for example.

Note

After a configuration has been loaded in the IO controller, non-assigned modules or submodules retain their current parameterization state to ensure the independence from the parameterizations of other IO controllers.

5.3.3 Configuring an I-device as a shared device

Below, you will find a description of how you configure an S7-1500 as an I-device with STEP 7 Version 13 or higher and then use it in two projects as a shared device.

A "distributed" configuration with different engineering tools for different IO controller families is generally also possible here. The procedure described below is based on STEP 7 V13 and is limited to a configuration with two IO controllers of the S7-1500 family that share the transfer areas of an I-device as a shared device. The I-device itself is also an S7-1500 CPU.

Three projects are created with one IO controller each (PLC-I-Device, PLC_1, and PLC_2).

PLC-I-Device is used to configure the I-device. The PROFINET GSD variant of PLC-I-Device is used in the PLC_1 and PLC_2 projects in order to assign the transfer areas in the respective higher-level IO controller.

Shared I-device concept

For the introduction of the shared I-device concept, two roles are distinguished:

- The role of manufacturer (e.g., machine manufacturer): The manufacturer configures and programs an I-device that performs a particular automation task. Transfer areas are defined as the I/O interface to the operator of the machine. These transfer areas can be assigned to different IO controllers. For the connection to higher-level IO controllers, the manufacturer provides a PROFINET GSD file and discloses the transfer areas via which the I-device can be accessed.
- The role of the operator: The operator uses the I-device as a PROFINET GSD variant during configuration of the PROFINET IO system and, in this process, specifies the I/O addresses under which the IO controllers access the transfer areas.

Manufacturer view

You assign the following parameters for an S7-1500 CPU as an I-device: centralized and distributed I/O, the desired transfer areas, and the number of IO controllers having access to this I-device (always greater than 1 for a shared device!).

Special consideration: The I-device is configured without a higher-level IO controller. As a result, only the local I/O addresses of the transfer area are available (= "Address in the I-device") in order to create the user program for editing the addresses from the transfer area. The I-device that has been completely configured except for the connection to the higher-level IO controller is loaded to the S7-1500 CPU.

You export a PROFINET GSD file from the I-device configuration.

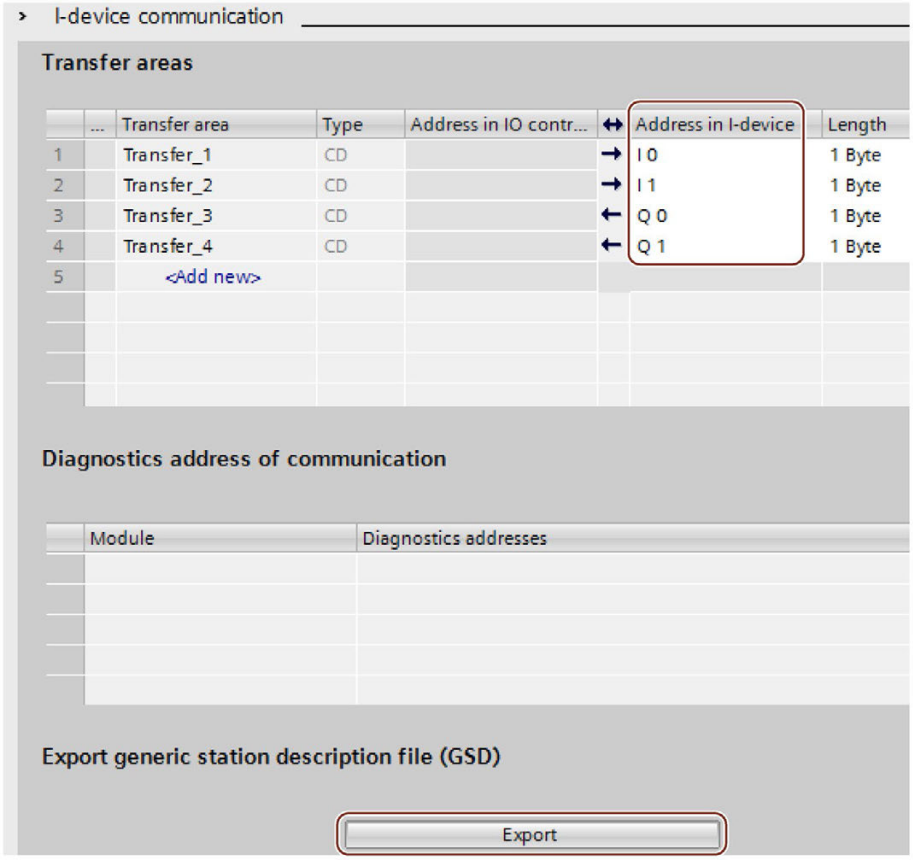


Figure 5-23 Exporting an I-device as a GSD file

Operator view

You must install the PROFINET GSD file created from the I-device configuration in all engineering systems that are involved in configuring a PROFINET IO system with this shared I-device. If all uses of this I-device will be configured with STEP 7 V13, it is sufficient to install the GSD file in STEP 7.

You configure the I-device as a GSD variant on the PROFINET IO system in the projects involved. In STEP 7 V13, this I-device can be found under "Other field devices > PROFINET IO > PLCs & CPs" following installation.

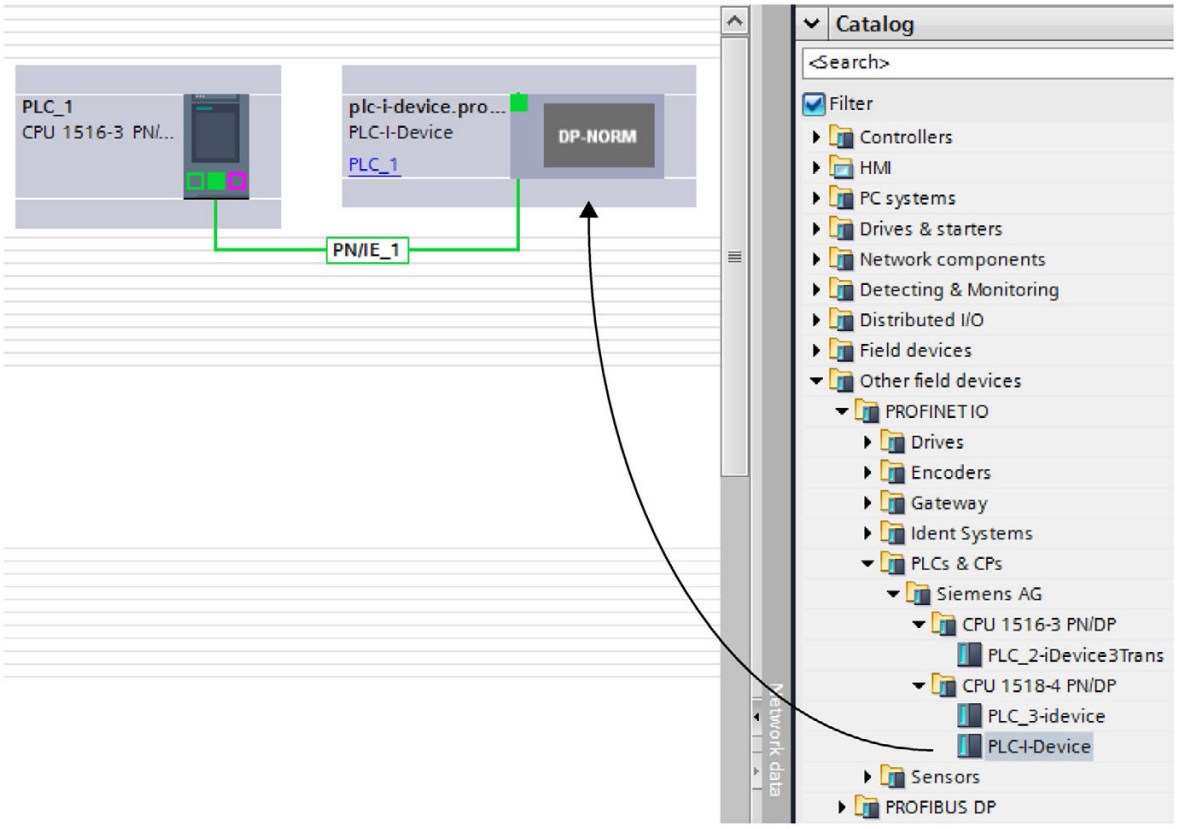


Figure 5-24 Configuring an I-device as a GSD file

In each of the projects involved, you define which transfer areas are assigned exclusively to the higher-level IO controller (default setting: all). You set the other transfer areas to "---" (not assigned). As a result of this setting, the local IO controller has no access to this transfer area and it can therefore be assigned to another IO controller in another project.

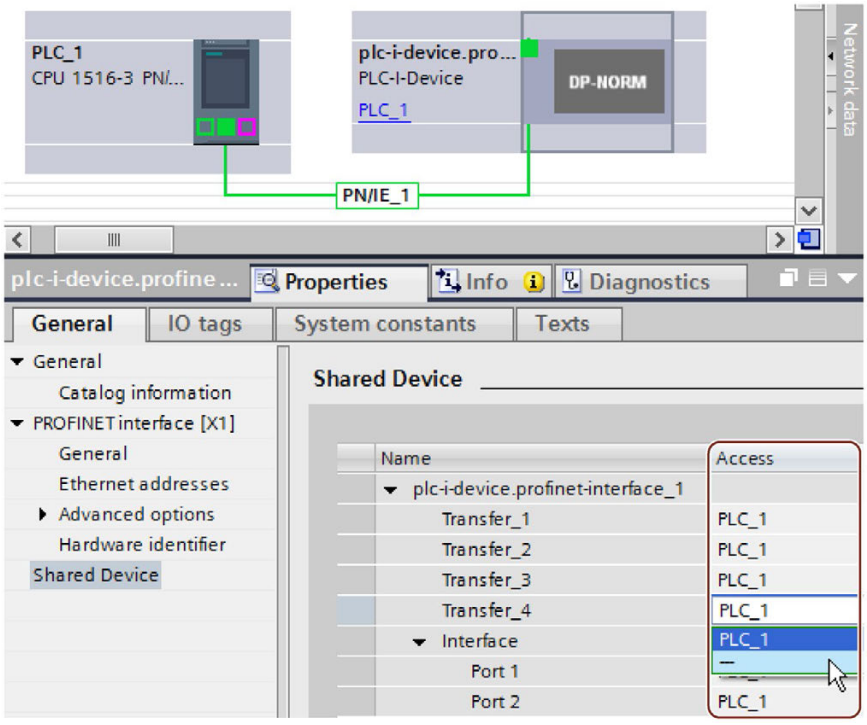


Figure 5-25 Setting the access to the shared I-device.

You adapt the addresses from the view of the IO controller in the device overview. To open the device overview, double-click the I-device.

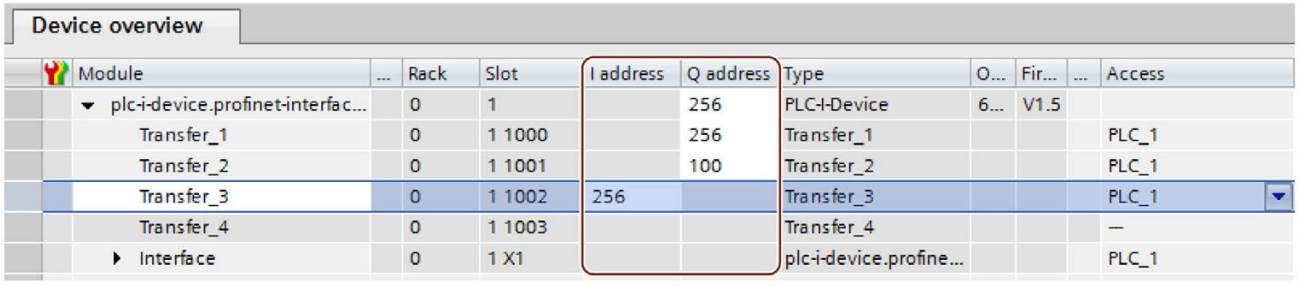


Figure 5-26 I/O addresses of the transfer areas in the device overview

Requirements

- STEP 7 as of V13

Procedure - Creating the PLC-I-device project

To create the project with a shared I-device, follow these steps:

1. Start STEP 7.
2. Create a new project with the name "PLC-I-device".
3. Insert, for example, a CPU 1518-4 PN/DP from the hardware catalog in the network view. Assign the name "PLC-I-device".
4. Double-click the IO device and configure all required modules and submodules.

5. Assign the module parameters.

   In particular, the following settings for the CPU are necessary in the area of the PROFINET interface [X1]:

   – Enable the "IO device" option in the "Operating mode" area.

   – Configure the transfer areas in the "Operating mode" > "I-device configuration" area. The "Address in IO controller" column remains empty because no IO controller is assigned.

     Note: To change an input area to an output area, and vice versa, you must navigate to the area of the corresponding transfer area.

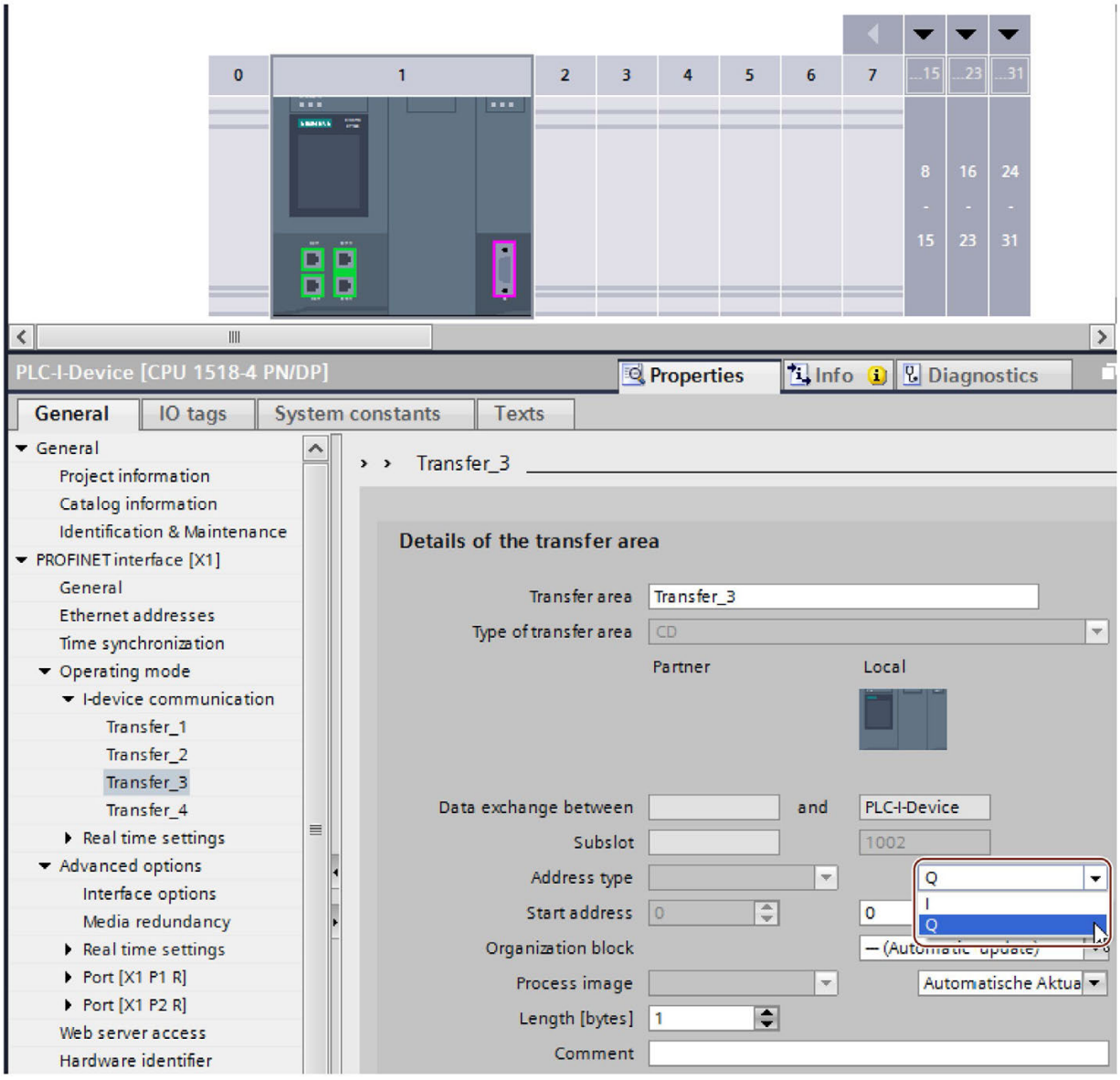


Figure 5-27 Changing the address type for the transfer area

   – Select the number of IO controllers (at least two) that will access the shared I-device during operation ("Operating mode" > "Real time settings" area, "Shared Device" area).

6. Save the project.
7. Click the "Export" button ("Mode" > "I-device configuration" area, "Export general station description file (GSD)" section).

   If you do not change the name in the Export dialog, the GSD file has a name in the form "GSDML-V2.31-#Siemens-PreConf_PLC-I-Device-20130925-123456", for example.

Procedure - Creating the PLC_1 project

To create the first project with a shared I-device, follow these steps:

1. Start STEP 7.
2. Install the PROFINET GSD file from the export of the I-device CPU (PLC-I-Device).
3. Create a new project with the name "PLC_1".
4. Insert, for example, a CPU 1516-3 PN/DP in the network view. The name of the CPU should be "PLC_1".
5. Insert the I-device from the hardware catalog (Hardware catalog: Other field devices > PROFINET IO > PLCs & CPs).
6. Assign the IO controller "PLC_1" to the I-device.
7. Select the "Shared Device" area in the properties of the I-device.

   In the table, all transfer areas and the PROFINET interface are assigned to the local IO controller (PLC_1).
8. Define the transfer areas to which the PLC_1 CPU should **not** have access. Select the "---" entry for these areas. These transfer areas are provided for PLC_2.
9. Save the project.

Procedure - Creating the PLC_2 project

To create the second project with a shared I-device, follow these steps:

1. Start STEP 7 once again.

   A new instance of STEP 7 opens.
2. In the new instance, create a new project with the name "PLC_2".
3. Insert, for example, a CPU 1516-3 PN/DP in the network view. Assign the name "PLC_2".
4. Insert the I-device from the hardware catalog (Hardware catalog: Other field devices > PROFINET IO > PLCs & CPs).
5. Assign the IO controller "PLC_2" to the I-device.
6. Adapt the access to the transfer areas as in the PLC_1 project. Ensure that no duplicate assignments result.

7. Adapt the parameters of the subnet and PROFINET interface. Because the shared I-device involves the same device in different projects, these data must match.
8. Save the project.

Both projects now have an identically configured shared I-device. The IO controller access and the parameters of the PROFINET interface should still be checked in the different projects during the next step.

Summary - Assigning parameters for access to the shared device

The transfer areas are automatically assigned to the local IO controller. To change the assignment, follow these steps:

1. Click the "PLC_I-Device" device in the network view of the "PLC_1" project, and select the "Shared Device" area.
2. A table shows which CPU has access to each of the configured transfer areas. The default setting is that the local CPU has access to all modules and submodules.
3. Keep the setting "PLC_1" for all transfer areas that are to remain in the address range of the local CPU

   Select the setting "---" for all transfer areas that are to be located in the address range of the "PLC_2" CPU from the "PLC_2" project. This means that an IO controller outside the project is to have access to the transfer area.
4. Follow the same procedure for the remaining projects.
5. Finally, check whether the settings for access are "complementary" for each module or submodule in both projects. This means that if the local CPU has access in one project, the option "---" must be set in the other project and vice versa.

   Special consideration: The option "---" for the PROFINET interface and therefore for the ports makes the associated parameters read-only and not changeable. Parameters of the PROFINET interface and port parameters can only be edited in the project in which the PROFINET interface is assigned to the local CPU. The ports can be interconnected in both projects regardless of this.
6. Check whether the same IP address parameters and device name are set for the shared device in all projects.

   Check whether the same S7 subnet ID is set in all projects for the subnet to which the shared device is connected (subnet properties, "General" area in the Inspector window).

Note

If you make changes to the I-device (e.g., change the number or length of the transfer areas):

Export the I-device as a GSD file again. Re-install the GSD file in each project that uses the I-device as a shared device. Make sure that only one IO controller has access to a transfer area.

Procedure - Adjusting the real-time settings

To ensure that all IO controllers and shared devices are operated with the appropriate send clock and that the update times are calculated correctly based on the communication load, you must adjust and check the following settings:

1. You must set the same send clock for each IO controller that has access to modules and submodules of the shared device:
   - If you configure the IO controller with STEP 7 (TIA Portal):

     Open the corresponding project.

     Select the PROFINET interface of the IO controller.

     Select the "Advanced options > Real time settings > IO communication" area in the Inspector window and set the shared send clock.
   - If you configure the IO controller with a different engineering tool:

     Select the PROFINET interface of the shared device in STEP 7 (TIA Portal) and read out the send clock on the shared device ("Advanced options > Real time settings" area)

     Enter the read send clock in the engineering tool.
   - Special consideration: If you configure **all** IO controllers that have access to the shared I-device in STEP 7 (TIA Portal or V5.5), you can set shorter send clocks on the IO controller than supported by the shared device (send clock adaptation).

Compiling and loading

You must compile the configurations for the different IO controllers and load them to the CPUs one after the other.

Due to the distributed configuration with separate projects, STEP 7 does not output consistency errors in the case of incorrect access parameter assignment. Example for incorrect access parameter assignment:

- Several IO controllers have access to the same module
- IP address parameters or send clocks are not identical

These errors do not show up until operation and are output as configuration errors, for example.

Note

After a configuration has been loaded in the IO controller, non-assigned modules or submodules retain their current parameterization state to ensure the independence from the parameterizations of other IO controllers.

5.3.4 Module-internal shared input/shared output (MSI/MSO)

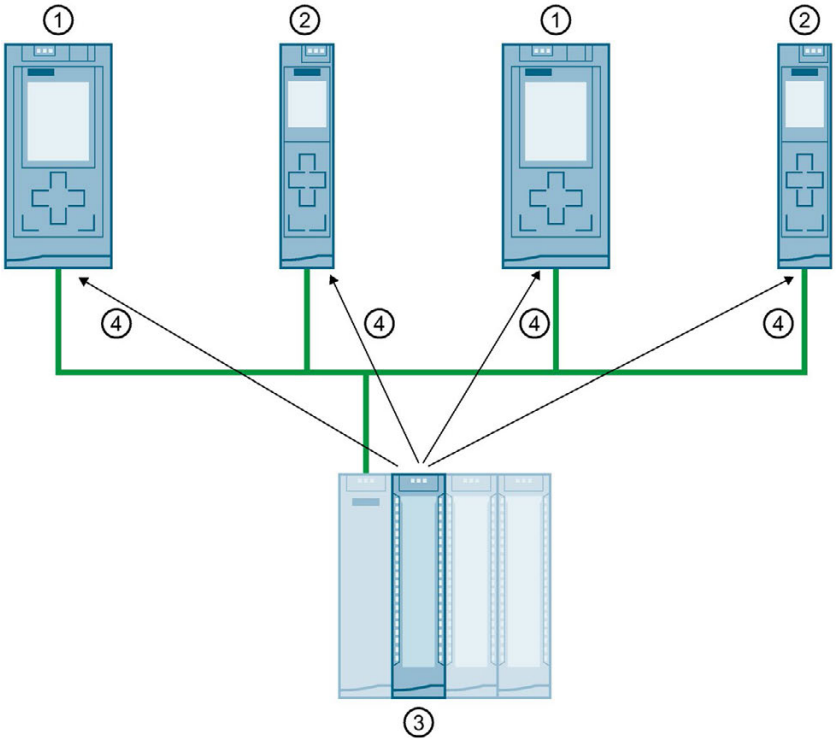
Introduction

This section describes the module-internal shared input/shared output (MSI/MSO) functionality for I/O modules that are operated on PROFINET.

Module-internal shared input/shared output functionality

The module-internal shared input (MSI) function allows an input module to make its input data available to up to four IO controllers. Each controller has read access to the same channels.

The following figure shows the MSI functionality.

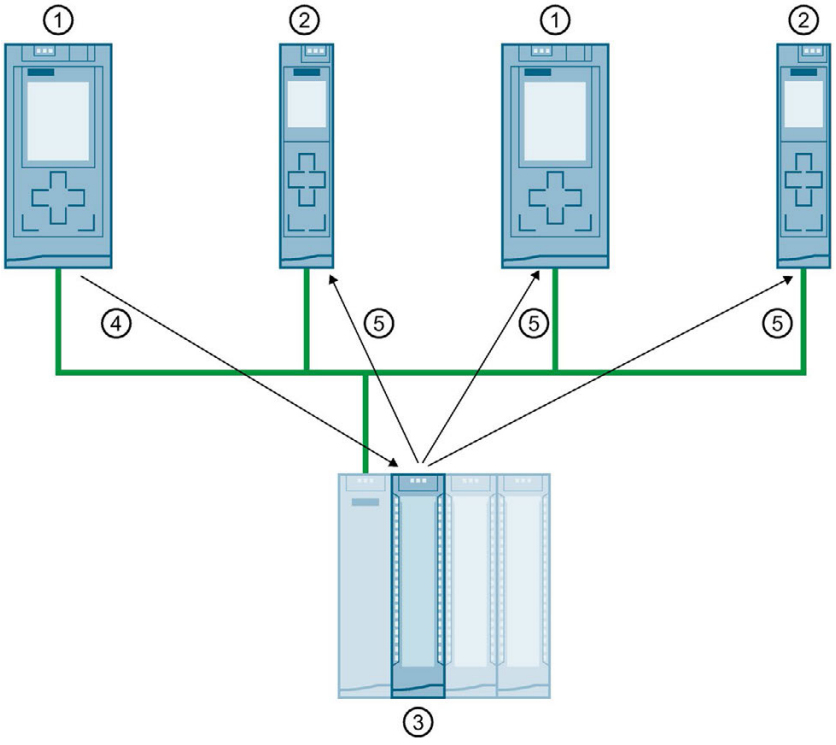


① CPU 1516-3 PN/DP as IO controller
② CPU 1511-1 PN as IO controller
③ Input module with MSI
④ Read access to the input channels of the input module
⑤ Write access to the channels of the I/O module (only with MSO)

Figure 5-28 Example configuration with MSI

The module-internal shared output (MSO) function allows an output module to make its output data available to up to four IO controllers. An IO controller has write access to the channels of the output module. Up to three IO controllers can additionally have read-access to the channels.

The following figure shows the MSO functionality.



① CPU 1516-3 PN/DP as IO controller
② CPU 1511-1 PN as IO controller
③ Output module with MSO
④ Write access to the output channels of the output module
⑤ Read access to the output channels of the output module

Figure 5-29 Example configuration with MSO

Advantages of MSI/MSO

Module-internal shared input/shared output (MSI/MSO) offers the following advantages:

- Real-time acquisition in multiple CPUs
- Lower costs due to saving on additional IO devices and modules
- Lower space requirements due to saving on additional IO devices and modules
- Reduced communication load because no CPU-CPU communication is needed
- No additional programming effort is needed for CPU-CPU communication

Requirements for the use of MSI/MSO

Observe the following requirements:

- MSI/MSO can only be used with PROFINET IO
- Configuration software: STEP 7 (TIA Portal) as of V12 SP1 with GSD file; the modules are integrated in the hardware catalog as of V13.
- The IM 155-5 PN ST interface module and the modules support MSI/MSO as of firmware version V2.0.0.

Boundary conditions for the use of MSI/MSO

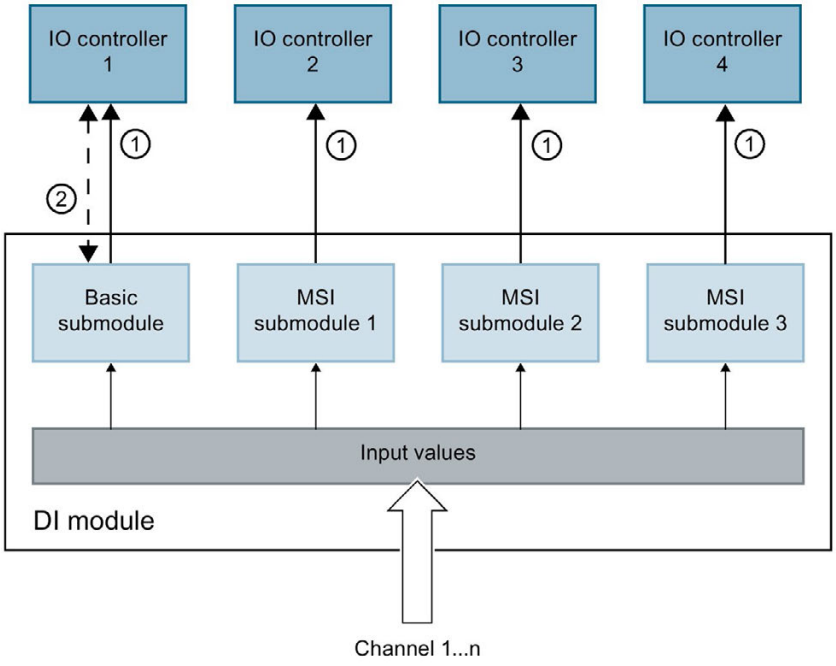
Note the following boundary conditions:

- The use of MSI/MSO is not possible in the case of module grouping.
- Modules with MSI/MSO cannot be operated in isochronous mode.
- The maximum number of IO controllers is dependent on the interface module. To find out how many IO controllers the interface module supports, refer to the manual for the respective interface module.

MSI submodules

The input values of all channels are copied to a basic submodule and up to three other MSI submodules during MSI configuration of an input module. The channels of the module are then available with identical input values in the basic submodule and the MSI submodules. The MSI submodules can be assigned to up to three IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The following figure shows a digital input module with the basic submodule and three MSI submodules. Each submodule is assigned to an IO controller. Diagnostics and parameter assignment of the digital input module can be performed from the IO controller 1 via the basic submodule.



① Read access
② Parameter assignment and system diagnostics

Figure 5-30 DI module with MSI submodules

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule to which it pertains.

With basic submodule (= 1st submodule), the "0" value status indicates that the value is incorrect.

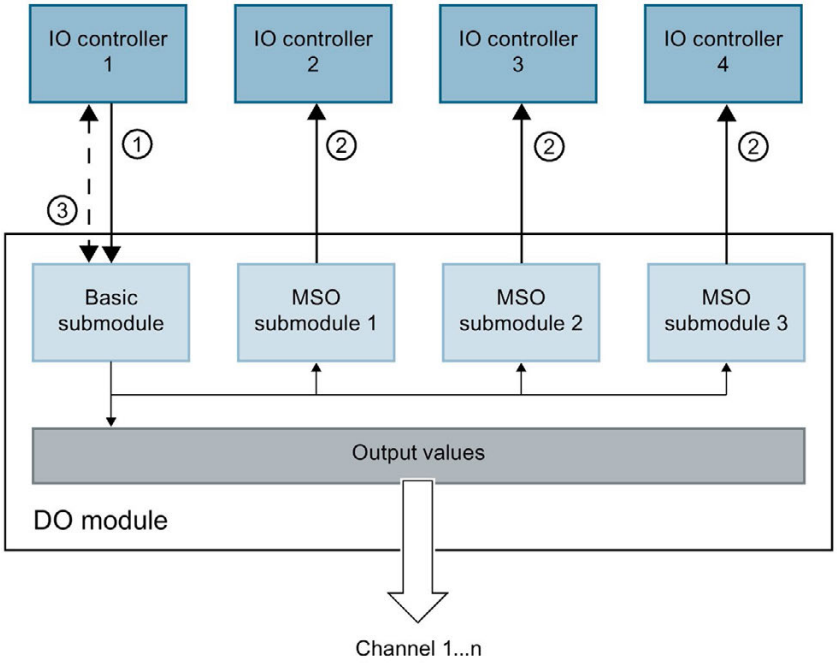
With an MSI submodule (2nd to 4th submodule), the "0" value status indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

MSO submodules

During MSO configuration of an output module, the output values of all channels of the module are copied from a basic submodule to up to three other MSO submodules. The channels of the module are then available with identical values in the basic submodule and the MSO submodules. The MSO submodules can be assigned to up to three IO controllers when the module is used in a shared device.

- The IO controller to which the basic submodule is assigned has write access to the outputs of the module. The basic submodule therefore occupies output addresses in the process image of the IO controller.
- The IO controllers to which the MSO submodules are assigned have read access to the outputs of the module. MSO submodules therefore occupy input addresses in the process image of the IO controller.

The following figure shows a digital output module with the basic submodule and three MSO submodules. Each submodule is assigned to an IO controller. Diagnostics and parameter assignment of the digital output module can be performed from IO controller 1 via the basic submodule.



① Write access
② Read access
③ Parameter assignment and system diagnostics

Figure 5-31 DQ module with MSO submodule

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule to which it pertains.

With basic submodule (= 1st submodule), the "0" value status indicates that the value is incorrect.

With MSO submodule (= 2nd to 4th submodule) the "0" value status indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule parameters have not yet been assigned (not ready for operation).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

Configuring I/O modules with MSI/MSO submodules

Requirements

- Configuration software STEP 7 as of V13
- IO device supports MSI/MSO (for example IM 155-5 PN ST as of firmware version 2.0.0)

Procedure

1. In the network view of STEP 7, insert an IM 155-5 PN ST interface module as of V2.0.
2. Double-click the IO device.

   You are now in the device view.

3. Place the I/O modules from the hardware catalog in a suitable slot.
4. Add MSI/MSO submodules to the I/O modules:
   - Input modules: Select the number of MSI submodules under "Module parameters " > "DI configuration" or "AI configuration" in the area "Copy of module for Shared Device (MSI)".
   - Output modules: Select the number of MSO submodules under "Module parameters " > "DQ configuration" or "AW configuration" in the area "Copy of module for shared device (MSO)".

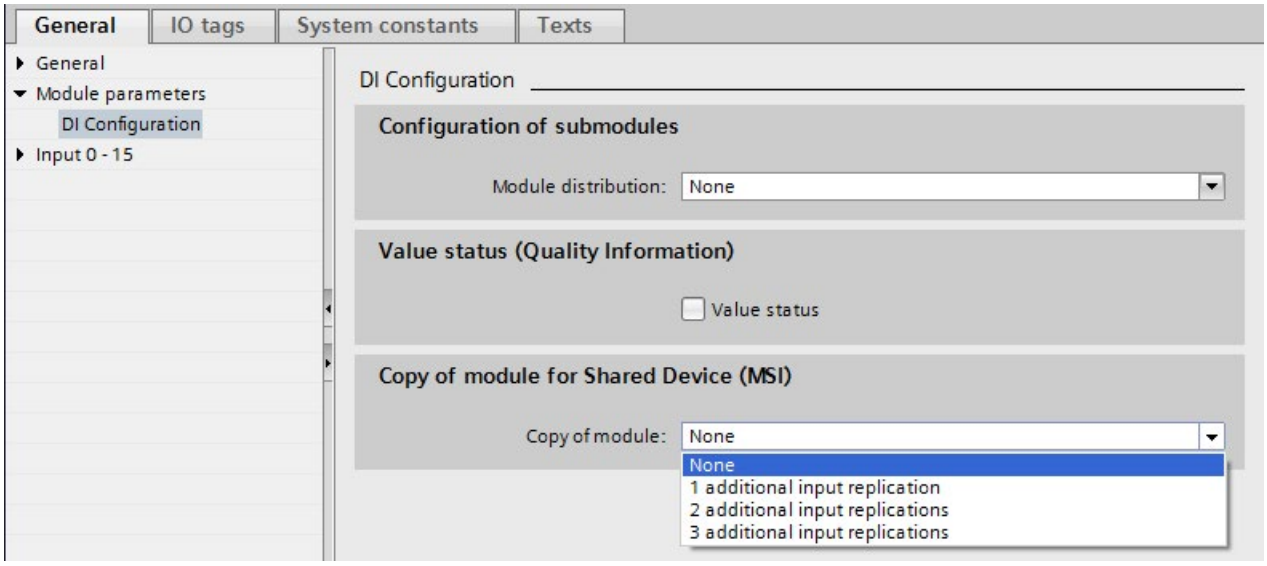


Figure 5-32 Configuring I/O modules with MSI/MSO

Assigning MSI/MSO submodules to an IO controller

You can assign the submodules in a shared device to an IO controller.

For more information, refer to Configuring shared device (Page 124).

Configuring access to a shared device and the module-internal shared input / shared output (MSI /MSO) function

You can learn how to access a shared device and the MSI /MSO function in STEP 7 with this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

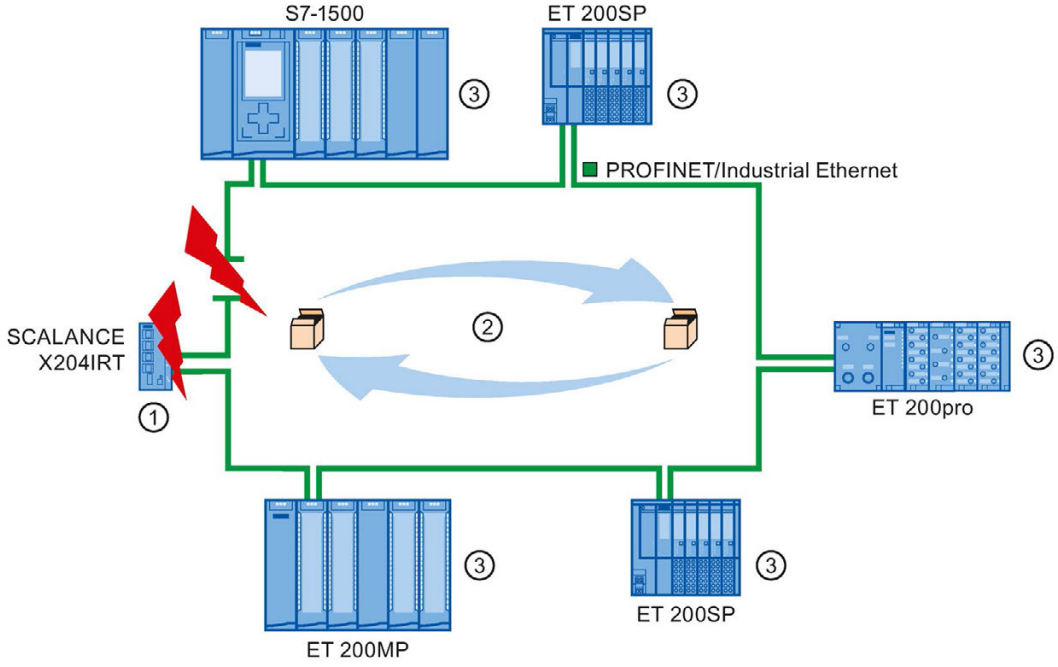
5.4 Media redundancy (ring topologies)

In order to increase the network availability of an Industrial Ethernet network with optical or electrical linear bus topologies, you can convert a linear bus topology to a ring topology by joining the ends together.

Media redundancy in ring topologies

Devices in a ring topology can be IO devices, IO controllers, external switches and/or the integrated switches of communication modules.

To set up a ring topology with media redundancy, you need to bring together the two free ends of a linear bus topology in one device. Closing the linear bus topology to form a ring is achieved with two ports (ring ports) of a device in the ring. One device of the resulting ring then takes over the role of the redundancy manager. All other devices in the ring are redundancy clients.



① Redundancy manager
② Test frames
③ Redundancy clients

Figure 5-33 Media redundancy in ring topology

The ring ports of a device are the ports that establish the connection to the two neighboring devices in the ring topology. The ring ports are selected and set in the configuration of the relevant device (is also preset, if applicable).

How media redundancy works in a ring topology

The data paths between the individual devices are automatically reconfigured if the ring is interrupted at any point. The devices are available again after reconfiguration.

In the redundancy manager, one of the two ring ports is blocked in uninterrupted network operation for normal communication so that no data frames are circulated. In terms of data transmission, the ring topology is a linear bus topology. The redundancy manager monitors the ring for interruptions. For this purpose, it sends test frames not only from ring port 1 but also from ring port 2. The test frames pass through the ring in both directions until they arrive at the other ring port of the redundancy manager.

An interruption of the ring can be caused by loss of the connection between two devices or by failure of a device in the ring.

If the test frames of the redundancy manager no longer arrive at the other ring port during an interruption of the ring, the redundancy manager connects its two ring ports. This substitute path once again restores a functioning connection between all remaining devices in the form of a linear bus topology.

The time between the ring interruption and restoration of a functional linear topology is known as the reconfiguration time.

As soon as the interruption has been eliminated, one of the two ring ports is blocked again in the redundancy manager. The redundancy clients are informed about the change and use the original paths to the other devices again.

Media redundancy method

The standard method of media redundancy in SIMATIC is MRP (Media Redundancy Protocol) with a typical reconfiguration time of 200 ms. Up to 50 devices can participate per ring.

In addition, the real-time capable media redundancy process MRPD (Media Redundancy with Planned Duplication of frames) is also available.

5.4.1 Media Redundancy Protocol (MRP)

Media Redundancy Protocol (MRP)

The "MRP" process works in conformity with the Media Redundancy Protocol (MRP) that is specified in the standard IEC 62439-2.

Requirements

- All devices in the ring support MRP.
- You have complied with the rules for topology set out below. STEP 7 monitors compliance with the rules during compilation and outputs corresponding alarms.

Topology

The following schematic shows a possible topology for devices in a ring with MRP. The devices inside the shaded oval are in the redundancy domain.

Example of a ring topology with the MRP media redundancy protocol:

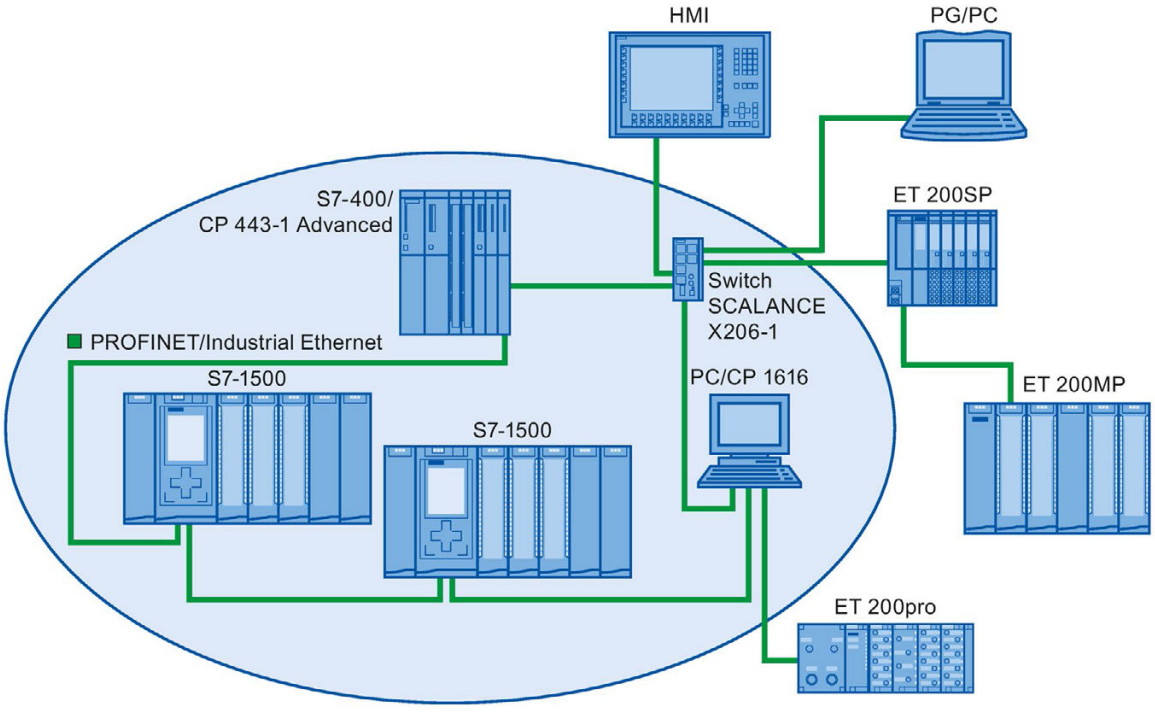


Figure 5-34 Example of a ring topology with the MRP media redundancy protocol:

The following rules apply to a ring topology with media redundancy using MRP:

- All devices must be connected to one other via their ring ports.
- All devices in the ring belong to the same redundancy domain.
- A device in the ring takes on the task of a redundancy manager.
  - One device only has the role of "Manager". No other device may have the role of "Manager". Or
  - Several devices in the ring have the role of "Manager (auto)". The devices with the role of "Manager (auto)" then negotiate between themselves which device is to take on the role of redundancy manager. In this case, no device is permitted to have the role of "Manager".
- All other devices in the ring are redundancy clients.
- You can connect up to 50 devices in a ring.

Non MRP-compliant devices can, for example, be connected to the ring via a SCALANCE X switch or via a PC with a CP 1616.

Rules for loading the devices of an MRP domain

When loading devices of an MRP domain, frame loops can occur and result in network failure if there is an invalid MRP configuration.

Example: You change the MRP roles of several devices and consecutively load the configuration into the devices involved. Configurations can arise that contradict the roles mentioned above, for example, there may be devices that simultaneously have the "Manager" and "Manager (auto)" roles in the ring.

In order to ensure that an invalid MRP configuration does not result in the failure of the network, delete the ring before loading.

Follow these steps:

1. Delete the ring.
2. Load the error-free and consistent MRP configuration from your project onto all the devices involved and ensure that the devices are in data exchange mode (i.e. the application relations (ARs) are set up).
3. Close the ring.

Boundary conditions

MRP and RT

RT operation is possible with the use of MRP.

Note

The RT communication is disrupted (station failure) if the reconfiguration time of the ring is greater than the selected response monitoring time of the IO device. This is why you should select a response monitoring time of the IO devices that is sufficiently large.

MRP and IRT

IRT mode is not possible together with MRP.

If you want to use media redundancy together with IRT in a ring, only use devices that support MRPD.

MRP and TCP/IP (TSEND, HTTP, ...)

The TCP/IP communication with MRP is possible, because lost data packages are resent, if applicable.

MRP and prioritized startup

If you configure MRP in a ring, you cannot use the "prioritized startup" function in PROFINET applications on the devices involved.

If you want to use the "prioritized startup" function, then you must disable MRP in the configuration (the device may also not be part of the ring).

5.4.2 Configuring media redundancy

Configuring MRP

Proceed as follows to create a PROFINET IO configuration with MRP in STEP 7:

1. Generate a ring via the port interconnections in the topology view. First interconnect the devices to a line topology. Connect the unassigned port of the last device in the line with the unassigned port of the first device.
   The following example shows one CPU 1516-3 PN/DP and two interface modules IM 155-6 PN HF that are interconnected in a ring in the topology view of STEP 7.

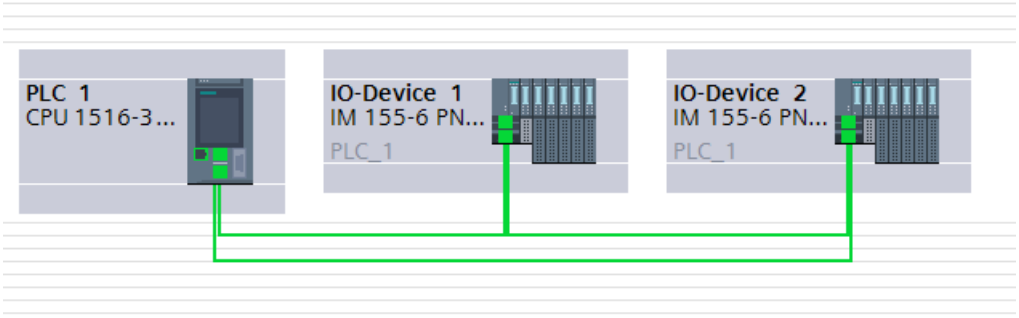


Figure 5-35 Configuring media redundancy

2. Select the PROFINET IO system in the network view.
3. In the Inspector window, navigate to "Properties" > "General" > "PROFINET" > "MRP domains" in the "Ring interconnections" field.
   This field shows you all the topological rings in the IO system with the associated MRP domains.

4. Select the ring generated above in the "Ring interconnections" field.
   The table below it shows all the PROFINET devices in the ring.
5. Set the media redundancy role for the PROFINET devices in the MRP role column.

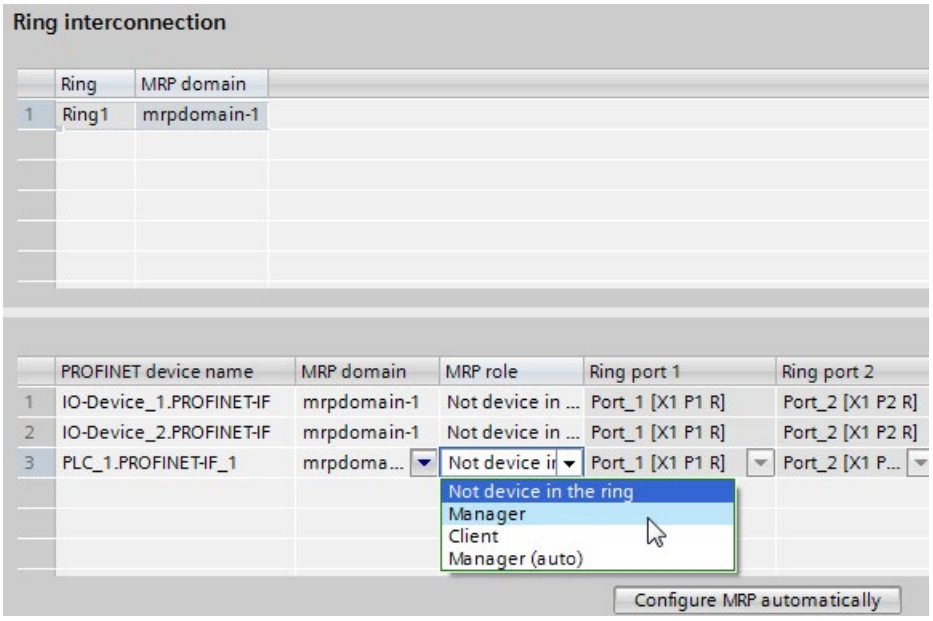


Figure 5-36 MRP domain

Automatic MRP configuration

You can also have the media redundancy roles assigned automatically for your PROFINET devices in the ring.

To have the media redundancy roles assigned automatically, click the "Configure MRP automatically" button. STEP 7 automatically assigns the media redundancy role for each device in the ring. After the automatic MRP configuration, you can make modifications to the media redundancy roles in the "MRP role" column.

"Media redundancy" setting options

Media redundancy role

Depending on the device used, the roles "Manager", "Manager (Auto)", "Client" and "Not device in the ring" are available.

Rules:

- A ring must have precisely one device with the role "Manager". No additional devices with the role "Manager" or "Manager (Auto)" are permissible. All the other devices may only have the "Client" role.
- If a ring has no device with the "Manager" role, the ring must at least have a device with the role "Manager (Auto)". Any number of devices with the "Client" role may exist.

Ring port 1 / Ring port 2

Select one at a time those ports you want to configure as ring port 1 or ring port 2. The drop-down list box shows the selection of possible ports for each device type. If the ports are set at the factory, then the fields are unavailable.

If you use single-stage commissioning, use the preset ring ports in STEP 7.

Diagnostic interrupts

If diagnostic interrupts to the MRP state are to be output in the local CPU, select the "Diagnostic interrupts" check box. The following diagnostic interrupts can be configured:

- Wiring or port error

  Diagnostic interrupts will be generated for the following errors in the ring ports:

  – A neighbor of the ring port does not support MRP.

  – A ring port is connected to a non-ring port

  – A ring port is connected to the ring port of another MRP domain.

- Interruption / return (redundancy manager only)

  If the ring is interrupted and the original configuration is returned, diagnostic interrupts will be generated. If both of these interrupts occur within 0.2 seconds, this indicates an interruption of the ring.

You can respond to these events in the user program by programming the appropriate response in the diagnostic error interrupt OB (OB 82).

5.4.3 Media Redundancy with Planned Duplication of frames (MRPD)

MRP extension "Media Redundancy with Planned Duplication of frames" (MRPD)

The MRP extension "Media Redundancy with Planned Duplication of frames" (MRPD) provides the advantage that, in the case of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times.

MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.

Requirements for media redundancy with MRPD

- All the devices of the ring must support MRPD, for example interface module IM 155-6 PN HS as of firmware version 4.0.
- You have configured MRP for all the devices of the ring. You have assigned the MRP role "Not device in the ring" to devices that are not located in the ring.
- You have configured IRT for all the involved components.

Configuring MRPD

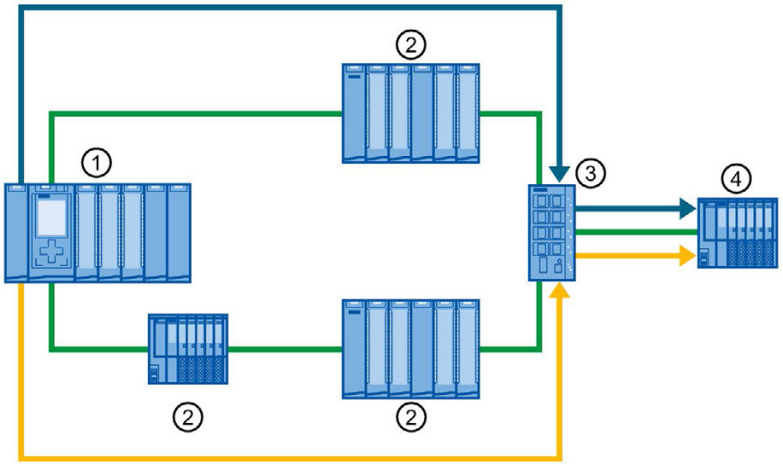
You do not have to explicitly activate MRPD in STEP 7. The function is available automatically as soon as all the requirements for MRPD are fulfilled.

Redundancy levels of IO devices with MRPD

The redundancy level of an IO device specifies how strongly the real-time communication is influenced in the case of a power interruption between an IO device and its IO controller.

- Full redundancy: No influence, because the IO controller and IO device are located in the same ring.
- Partial redundancy:
  - If the interruption takes place on a non-redundant part (line) between the IO device and IO controller, real-time communication is influenced.
  - If the interruption takes place on a redundant part (ring), real-time communication is not influenced.
- No redundancy: No redundant path between the IO device and its IO controller, communication is always influenced.

The figure below shows the redundancy levels of the IO devices for an example configuration with MRPD. The three devices in the ring and the switch have the redundancy level "Full redundancy". Device 4 has the redundancy level "Partial redundancy", because the connection between the switch and the device is not redundant.



① IO controller in the ring
② IO device in the ring with redundancy level "Full redundancy"
③ Switch in the ring with redundancy level "Full redundancy"
④ IO device in the spur with the redundancy level "Partial redundancy"

Figure 5-37 Example configuration with MRPD

The figure below shows the display of the redundancy levels in STEP 7 for the example configuration.

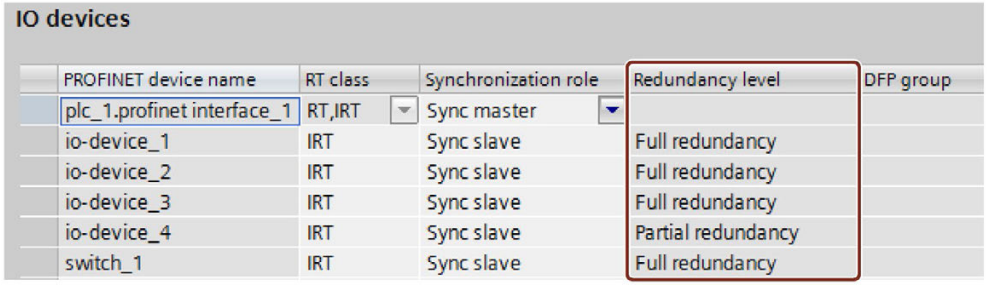


Figure 5-38 Display of the redundancy levels in STEP 7

5.4.4 Multiple rings

Multiple rings

Use multiple rings to achieve higher availability for PROFINET IO networks with star topology.

In a multiple ring configuration, several PROFINET lines lead from a switch (star topology). The individual PROFINET lines lead from IO device to IO device. Redundant PROFINET cables run back to the switch from the last IO device on each individual line.

The switch operates as a manager. The manager must have two ring ports for each ring. Several rings are possible. For example, the SCALANCE X414 as of firmware version 3.10 supports up to 4 rings.

The manager monitors all the rings individually: It checks for each particular ring (an MRP domain) whether the transmission path is intact. To do this, it uses an MRP instance in each case. An MRP instance is required for each connected ring (set up automatically by STEP 7).

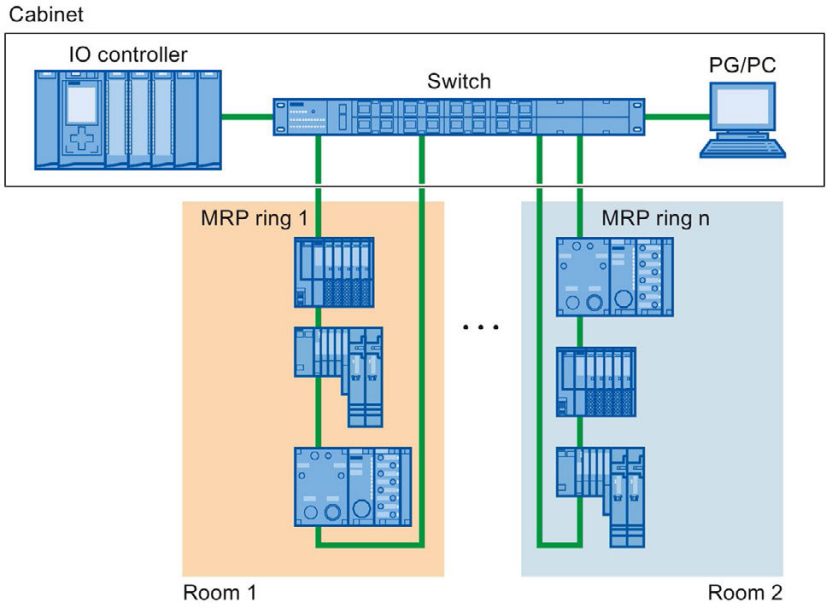


Figure 5-39 Configuration with several rings

Requirements

- SCALANCE X300 as of version 4.0
- SCALANCE X414 as of version 3.10

Rules for the configuration of multiple rings

- MRP role at multiple rings:
  - The device that belongs to all the rings must have the MRP role in every instance that is entered in the GSD file in the "SupportedMultipleRole" attribute.
  - The switches from the series SCALANCE X300 as of version 4.0 and the switch X414 as of version 4.10 support the MRP role "Manager" for multiple rings.
- If the device that belongs to all rings has the "Manager" role in one ring, no devices with the "Manager (Auto)" role may exist in this ring.

Configuring multiple rings

To configure an MRP configuration with multiple rings, follow these steps:

1. In the topology view, interconnect the ring ports of the devices that are intended to belong to an MRP domain to form a ring.
2. Select the PROFINET IO system in the network view.
3. In the Inspector window, navigate to "Properties" > "General" > "PROFINET" > "MRP domains" in the "Ring interconnections" field.
   This field shows you all the topological rings in the IO system with the associated MRP domains.
4. Select one of the rings generated above in the "Ring interconnections" field.
   The table below it shows all the PROFINET devices in the ring.
5. Set the media redundancy role for the PROFINET devices in the MRP role column.

Example of multiple rings

The following figure shows an example configuration for multiple rings.

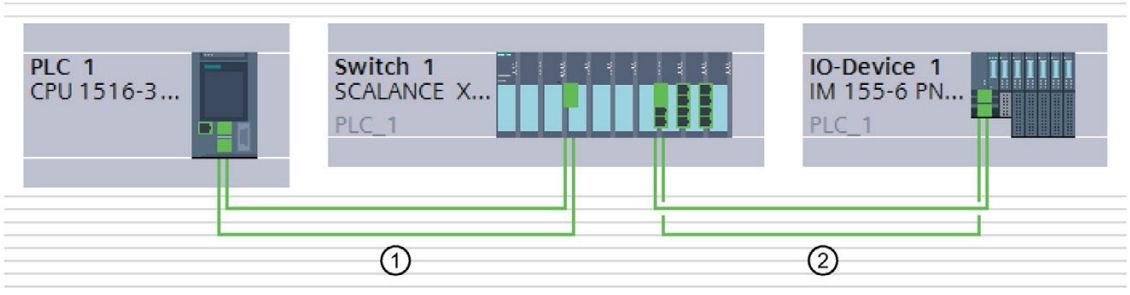


Figure 5-40 Example configuration with two rings ① and ②

In the example, Switch 1 belongs to two MRP rings. Ring 1 is formed by Switch 1 and PLC 1, Ring 2 by Switch 1 and IO device 1.

STEP 7 automatically assigns the "Manager" role to the switch. The other devices receive the "Client" role.

The manager is located at the point of intersection of the two rings 1 and 2. The manager monitors the two rings separately. To do this, it uses two MRP instances.

One MRP instance checks whether all devices in ring 1 are reachable, another instance monitors whether all devices in ring 2 are reachable (only one device in each case in the example).

You can configure each MRP instance separately.

The following figure shows the two MRP instances in the manager (PROFINET interface of the switch). Here in the example, MRP instance 1 checks whether the devices in the MRP domain "mrpdomain-1" can be reached. The MRP instance 2 is responsible for monitoring the devices of the MRP domain "mrpdomain-2".

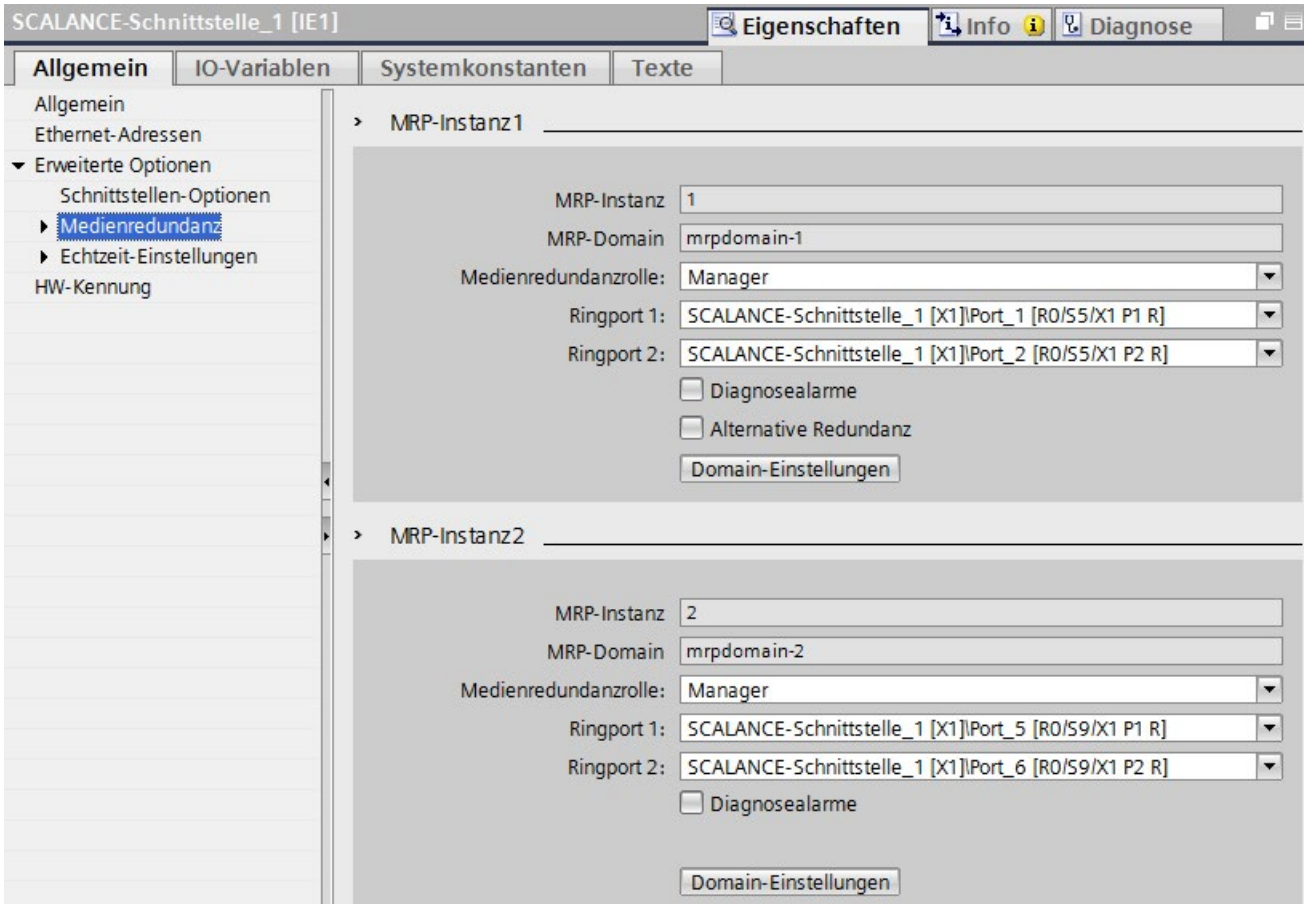


Figure 5-41 Setting media redundancy for multiple rings

The following figure shows Ring 1 (mrpdomain-1). The participants of the mrpdomain-1 are the PROFINET interface of the CPU as the "Client" and the MRP interface 1 of the PROFINET interface of the switch as the "Manager".

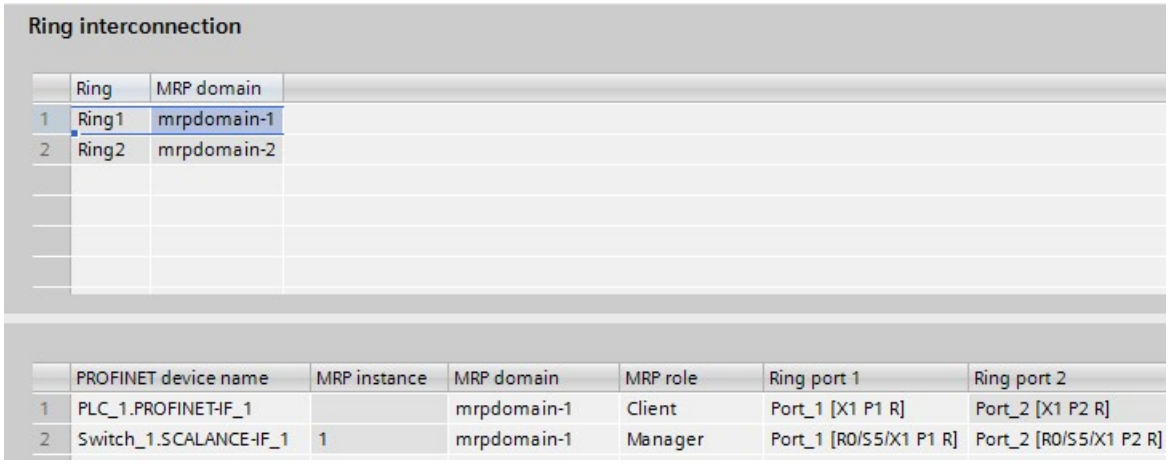


Figure 5-42 Ring 1

The following figure shows Ring 2 (mrpdomain-2). The participants of the mrpdomain-2 are the PROFINET interface of the IO device as the "Client" and the MRP instance 2 of the PROFINET interface of the switch as the "Manager".

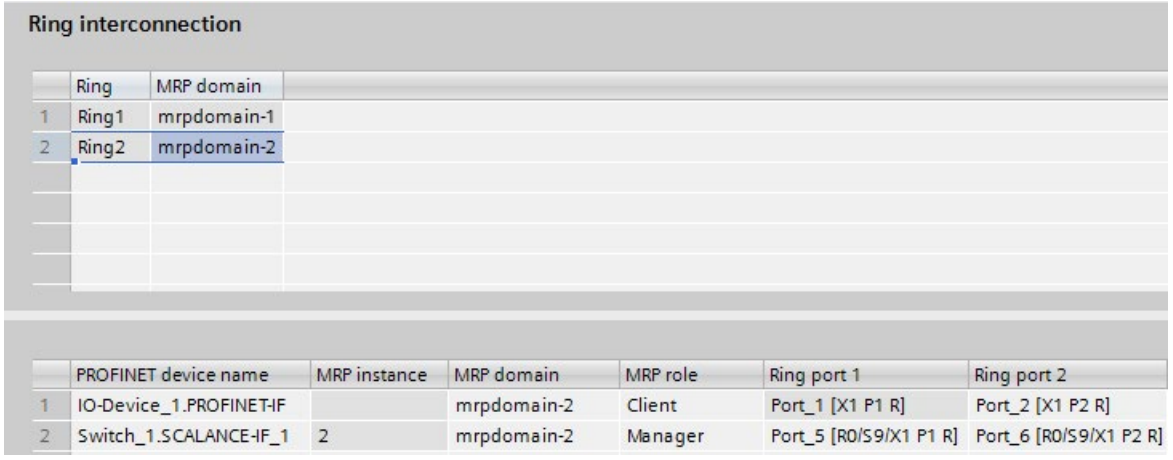


Figure 5-43 Ring 2

5.5 Real-time communication

5.5.1 Introduction

Properties

PROFINET IO is a scalable real-time communication system based on the Layer 2 protocol for Fast Ethernet. With the RT transmission method, two real-time-support performance levels are available for time-critical process data and IRT for high-accuracy and also isochronous processes .

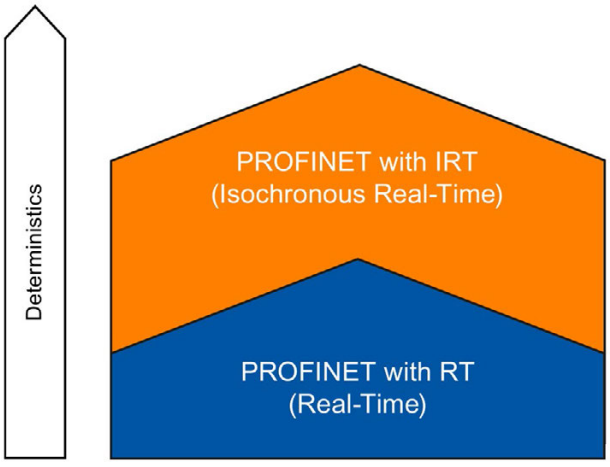


Figure 5-44 Real-time communication performance

Real-time communication and IT communication

Industrial communication, especially in the factory automation and process automation, requires a punctual and deterministic data transmission. This is why, for the cyclic exchange of time-critical IO user data, PROFINET IO does not use TCP/IP, it uses real-time communication (RT) or isochronous real-time communication (IRT) for the synchronized data exchange in reserved time intervals.

Fields of application of PROFINET with RT

PROFINET with RT is suited for:

- Time-critical applications in factory automation
- The implementation of large quantity structures in line process plants

Fields of application of PROFINET with IRT

PROFINET with IRT is particularly suitable for:

- Considerable deterministics with large quantity structures concerning the I/O user data communication (productive data)
- Considerable performance also with many devices concerning the I/O user data communication (productive data)
- Parallel transfer of productive and TCP/IP data via a cable, even with considerable data traffic whilst ensuring the forwarding of productive data by reserving the transmission bandwidth.

International standard IEC 61158

The communication procedures RT and IRT are standardized in the international standard IEC 61158.

5.5.2 RT

PROFINET IO with real-time communication (RT) is the ideal solution for integrating IO systems. This is a solution that also uses standard Ethernet in the devices and commercially available industrial switches as infrastructure components. A special hardware support is not required.

If you want to use PROFINET functions that provide an additional value, such as topology detection, diagnostics, device exchange without exchangeable medium/PG, you have to use switches that support the PROFINET standard according to the IEC 61158 standard. In the integrated switches of PROFINET devices and PROFINET switches (e.g., the SCALANCE product family), PROFINET functions in accordance with the PROFINET standard are implemented and can be used without restriction for integration in the PROFINET IO system (see also section Active network components (Page 28).

Real-time communication (RT)

PROFINET IO frames have priority over standard frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology. The data is transferred via prioritized Ethernet frames. With RT, you can achieve update times ≥ 250 µs with RT.

Switching mechanisms

Switches in SIMATIC meet the real-time requirements with two mechanisms on PROFINET: "Store and forward" and "Cut through".

Store and forward

In the Store and forward method, the switch stores the frames completely and places them in a queue. If the switch supports the international standard IEEE 802.1Q, then the data is sorted according to its priority in the queue. The frames are then forwarded selectively to the specific port that can access the addressed node (Store and forward).

Cut through

In the Cut through process the entire data package is not stored temporarily in a buffer, it is passed directly onto the target port as soon as the target address and the target port have been determined.

The times required by the data package to pass through the switch are then minimal and independent of the frame length. The data are only stored temporarily in accordance with the Store and forward process as per priority when the section between the target segment and the port of the next switch is occupied.

5.5.3 IRT

Isochronous real-time communication (IRT)

IRT is a synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can be transferred at reserved synchronized intervals, without being influenced also by higher other network loads (such as TCP/IP communication, or additional real-time communication).

Advantages

PROFINET with IRT is synchronized communication in reserved time intervals. With IRT you have the option to be able to control time-critical applications such as motion control via PROFINET. With IRT you use further advantages:

- High-precision deterministics allow highest control quality and thus, for example, exact positioning of axes
- Simple and flexible integration of PROFINET devices for real-time applications in existing company networks
- Shortest response times and highest deterministics by means of bandwidth reservation and thus also for applications that have to satisfy highest performance requirements (e.g., printing control/position control for presses, print-mark recognition with packaging machines)
- Secured standard communication parallel to real-time communication via the same transmission medium
- You can continue to use standard components for your PROFINET IO system outside of the sync domain

Properties of isochronous real-time

Topology configuration is a prerequisite for IRT.

In addition to the reserved bandwidth, the frames from defined transmission paths are exchanged for the further optimization of data transfers. For this, the topological information from the configuration is used for planning the communication. Transmission and reception points of every individual data frame at every communication node are thus guaranteed. This allows you to achieve optimal usage of the bandwidth and reach the best possible performance in the PROFINET IO system.

Use of IRT allows you to achieve update times with very high deterministics ≥ 125 µs and a jitter accuracy of the send clock < 1 µs. Isochronous applications are possible with IRT (see section Isochronous mode (Page 182)).

* The minimum update time depends on the CPU used. The update times supported by a CPU are listed in the technical specifications of the CPU manual.

Note

IWLAN and IRT

PROFINET devices that are connected to PROFINET IO via access points, do not support IRT.

Synchronization

The prerequisite for the IRTcommunication is a synchronization cycle for all PROFINET devices in a sync domain for distributing a mutual time basis. A synchronism of the transmission cycle of the PROFINET devices within a sync domain is achieved with this basic synchronization.

A sync master specifies the clock to which sync slaves are synchronized. An IO controller or an IO device can have the role of sync master. If the sync master fails, all IO devices with IRT will fail.

Sync master and sync slaves are always devices in a sync domain. Bandwidth is reserved within the sync domain for IRT communication. Real-time and non-real-time communication (TCP/IP communication) is possible outside of the reserved bandwidth.

Default sync domain

If you have created a PROFINET subnet, a special sync domain is automatically created, the default sync domain. All PROFINET devices configured for the PROFINET subnet automatically belong to this sync domain.

For additional information on creating sync domains, refer to the STEP 7 online help.

Time ranges of the communication cycle

The communication cycle is divided into three time ranges, which are shown in the following chart:

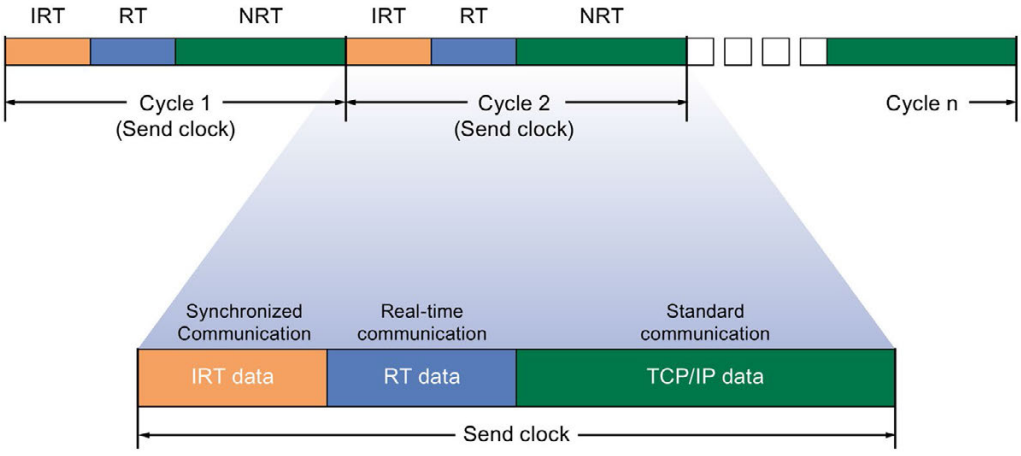


Figure 5-45 Reserving bandwidth

- IRT data (synchronized communication)

  This time range can be reserved in specific steps, depending on the send clock. Only IRT data is transmitted during this time range.

- RT data (real-time communication)

  The cyclic RT data is transferred in this time range. RT data is prioritized over "normal" TCP/IP data. TCP/IP data or Ethernet frames can have a priority of between 1 and 7. RT data have the Priority 6.

- TCP/IP data (standard communication)

  Standard communication (e.g., TCP/IP) is transmitted in the remaining interval of the communication cycle.

In STEP 7, you can set the ratio of the bandwidth usage of cyclic IO data to standard communication. For information on how to set the bandwidth usage, refer to the section Setting the bandwidth usage for the send clock (Page 166)

5.5.4 Comparison of RT and IRT

The most important differences between RT and IRT

Table 5- 2 Comparison between RT and IRT

Property	RT	IRT
Transmission method	Prioritizing the RT frames through Ethernet priority (VLAN tag)	Path-based switching on the basis of a communication path plan; no transmission of TCP/IP frames in the time range with IRT communication.
Determinism	Variance of the duration of transmission by the shared use of the transmission bandwidth with other protocols (e.g., TCP/IP)	Exact, planned transmission, transmission and reception times are guaranteed for all topologies.
Hardware support through special Ethernet controllers is required	Not required	Required
Isochronous application	-	Yes
Starting time of the isochronous application	-	The point in time for the reception of the data is planned exactly. Application can be started synchronized to the cycle.

5.5.5 Configuring PROFINET IO with IRT

Introduction

If you want to configure a PROFINET IO system with IRT, you have to configure the PROFINET IO devices. These PROFINET devices must support IRT. Set which device acts as the sync master and synchronizes the other devices. This is done by configuring a sync domain with a sync master and at least one sync slave.

Requirement

- There is an IO system with an IO controller and at least one IO device.
- You have configured the topology for the IO system.
- The devices support IRT.

Procedure

Proceed as follows to enable an existing IO system for the use of IRT:

1. Select the PROFINET interface of the IO controller.
2. In the Inspector window, navigate to "Advanced options > Real time settings > Synchronization".

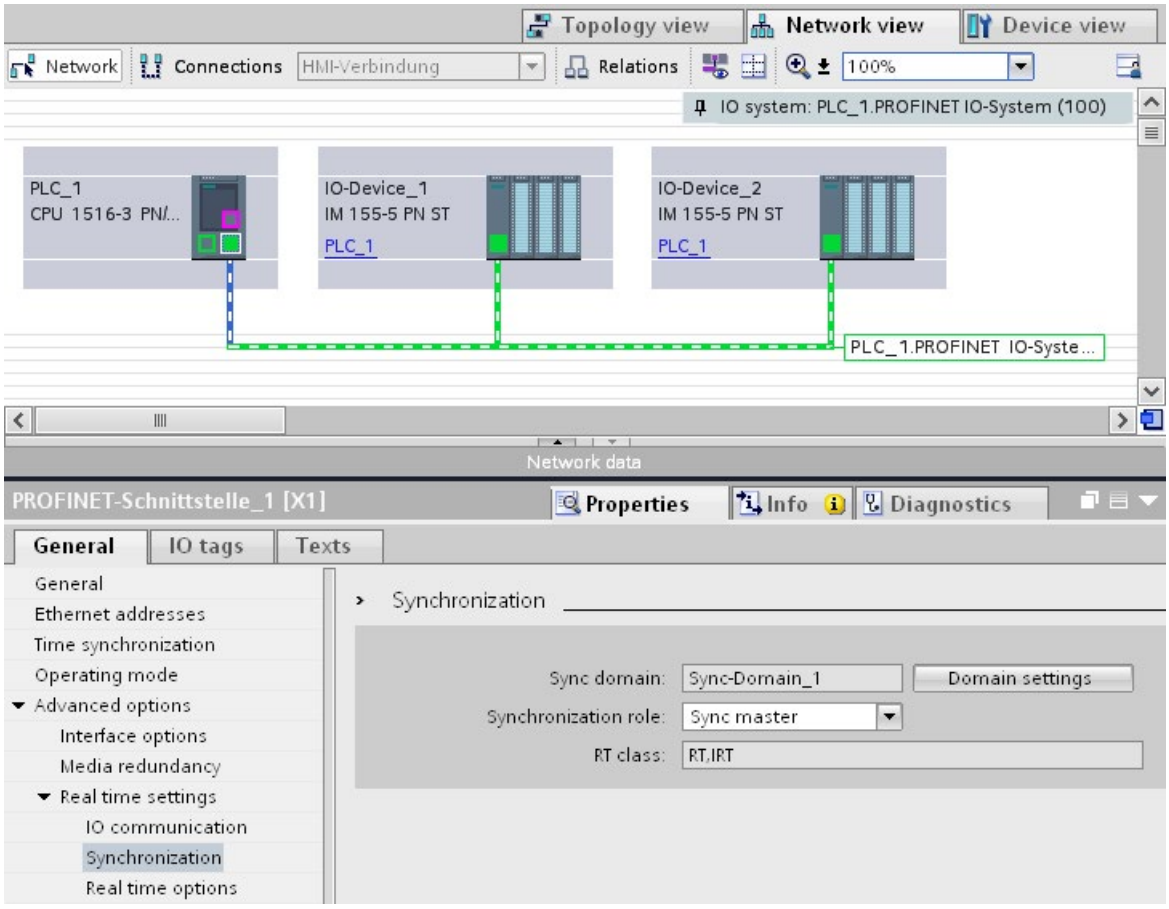


Figure 5-46 IRT configuring sync master

3. Assign the IO controller the role of sync master under "Synchronization role".
4. Select the PROFINET interfaces of an associated IO device.

5. In the Inspector window, navigate to "Advanced options > Real time settings > Synchronization".

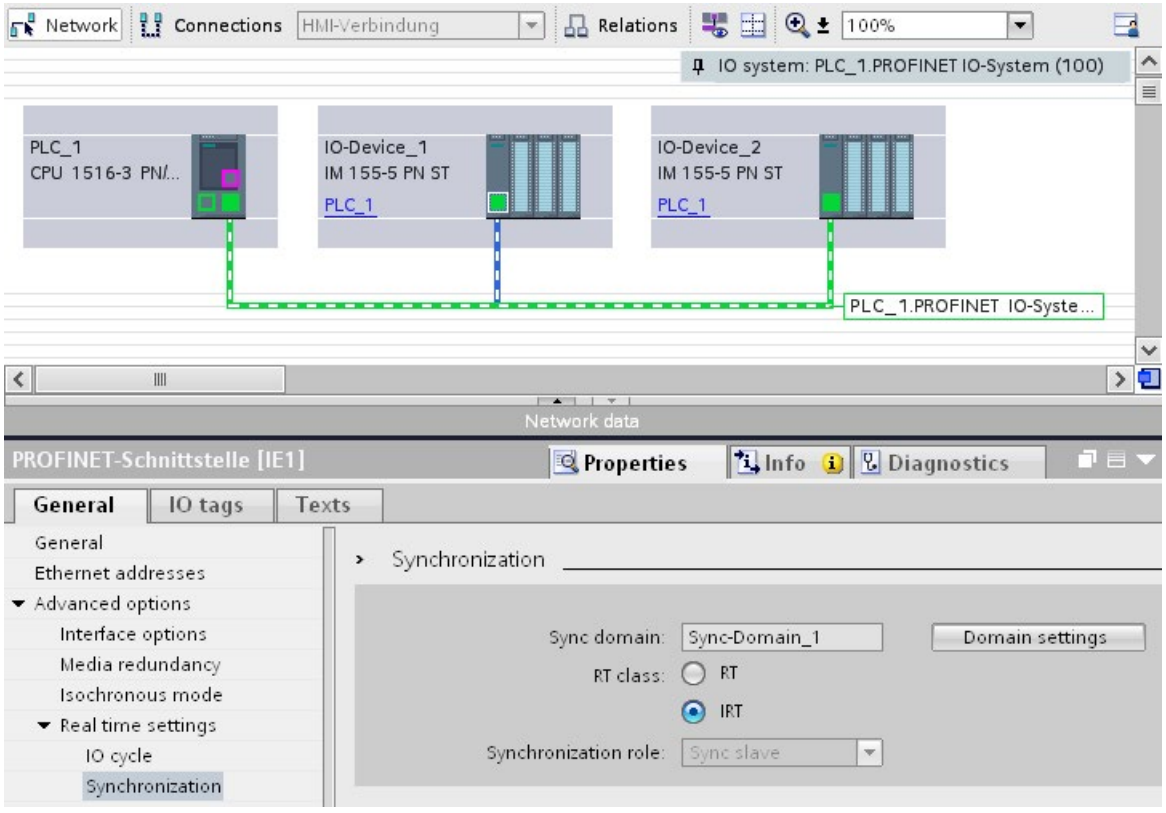


Figure 5-47 IRT configuring sync slave

6. Activate the RT class "IRT". The IO device will then automatically be assigned the synchronization role "sync slave".
7. You can check and correct your settings at any time using the "Domain settings" button.

Or

1. Highlight the PROFINET IO system in the network view.
2. Click on the PROFINET IO system.

3. Navigate to the device of the required sync domain in the Inspector window.

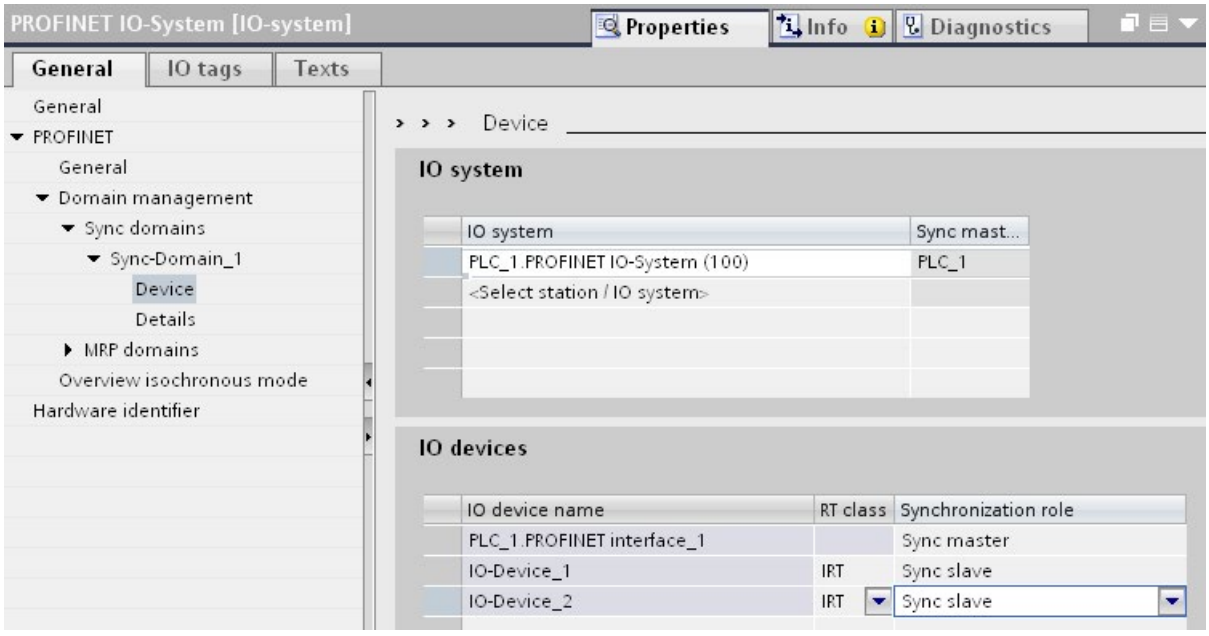


Figure 5-48 IRT configuring sync domain

4. Enter all necessary settings in the tables:
   - Select an IO system.
   - Set the synchronization role "sync master" for the IO controller.
   - Set the RT class for the IO devices to "IRT". The IO devices will then automatically be assigned the synchronization role "sync slave".

You can now load the configuration to the relevant devices with PROFINET IRT.

5.5.6 Setting the bandwidth usage for the send clock

Bandwidth level

For PROFINET IO with IRT, you can specify the maximum portion of the send cycle that you want to use for cyclic IO communication.

You have the following setting options for the bandwidth usage in STEP 7.

- Maximum 25% cyclic IO data. Focus on non-cyclic data.
- Maximum 37.5% cyclic IO data. Focus on non-cyclic data.
- Maximum 50% cyclic IO data. Balanced proportion.
- Maximum 90% cyclic IO data. Focus on cyclic IO data. (Requirement: The "Make 'high performance' possible" option is activated)

Setting the bandwidth usage

To set the bandwidth usage for a PROFINET IO system in STEP 7, follow these steps:

1. Select your IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain" > "Details".
3. Select the desired level of bandwidth usage from the "Bandwidth use" drop-drop down list box.

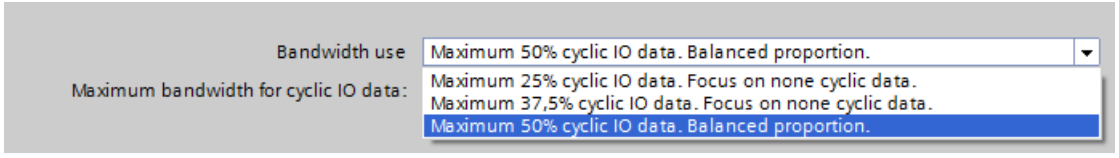


Figure 5-49 Setting the bandwidth usage

For information on how to set the bandwidth usage for IRT with maximum performance, refer to the section Configuration of IRT with high performance (Page 177)

5.5.7 Setup recommendations for optimizing PROFINET

Optimizing PROFINET with RT

PROFINET provides you with high-performance communication on all levels.

The following figures shows an example of an optimized PROFINET topology.

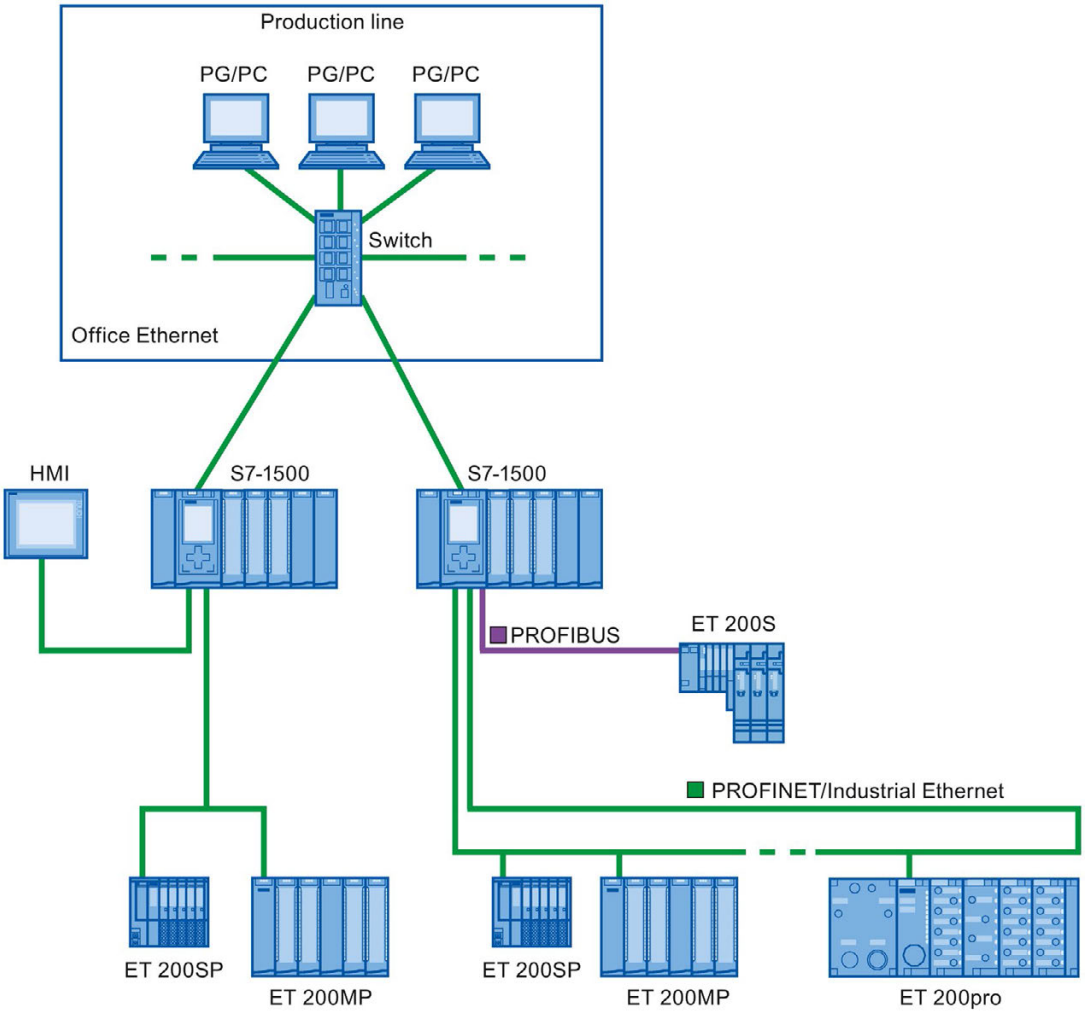


Figure 5-50 Optimized PROFINET topology

When setting up your PN network topology, take care that the various automation applications are distributed among separate network branches so that a sufficient bandwidth reserve will be available for future expansions.

- If you integrate standard Ethernet devices into the network topology or use standard Ethernet communication, take into account the network load caused by standard Ethernet and adapt the network topology as appropriate (max. bandwidth 100 Mbps).
- For communication with higher-level networks with a high data volume, use the most direct paths possible to the higher-level network infrastructure.

Also observe the Installation Guideline (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/) of the PROFIBUS User Organization.

Setting up PROFINET with IRT

Keep in mind the following rules for setting up and operating a PROFINET IO system in IRT mode. These rules will ensure best possible operation of your PROFINET IO system.

- When using IRT, you must configure the topology. This will enable exact calculation of the update time, bandwidth, and other parameters.
- If you would like to use multiple sync domains, configure a sync boundary for the port which is currently connected to the PROFINET device of another sync domain.
- In a sync domain, you can only configure one sync master at a time.
- A PROFINET IO system may only be part of a single sync domain.
- If you configure PROFINET devices in a sync domain and want to synchronize with IRT, the PROFINET devices concerned must support IRT communication.
- If possible, use the same PROFINET device as the PROFINET IO controller and sync master.
- If only some of the PROFINET devices in a PROFINET IO system are synchronized, please keep in mind the following: Assign PROFINET devices that are not participating in the IRT communication to the RT class "RT" and the synchronization role "unsynchronized" in the sync domain.

Applications for CPU with multiple PROFINET IO interfaces

- Connecting machines: Your configuration contains machines located on separate IO lines. You can perform real-time communication between the CPUs over PROFINET IO interface X2. Use the I-device or shared I-device function for this purpose.
  The figure below shows an example configuration for two machines connected over the X2 interface with an I-device relationship.

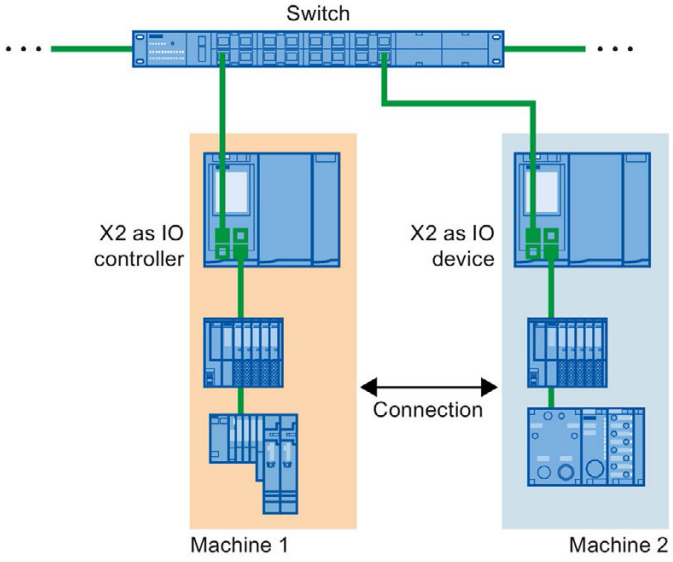


Figure 5-51 I-device connection over 2nd PNIO interface

- Distribution by automation tasks:
  - For automation tasks with high performance and deterministic requirements, use PROFINET with IRT over the X1 interface.
  - For other tasks that you can implement with RT, use the X2 interface.

If you use interface X2 as the PROFINET IO interface for one of the following CPUs, this can affect performance:

- CPU 1515(F)-2 PN
- CPU 1515T-2 PN
- CPU 1516(F)-3 PN/DP
- CPU 1516(F)pro-2 PN

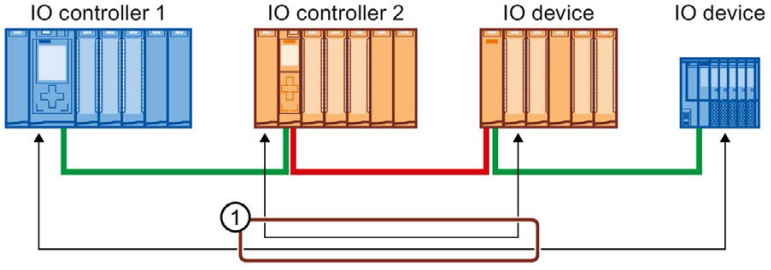
You can find additional information in the section PROFINET interface (Page 23) and in the Cycle and Response Times (https://support.industry.siemens.com/cs/ww/en/view/59193558) function manual.

Topological overlap of IO systems in multi-controller applications

In a configuration with multiple IO controllers, shared paths are subject to the combined network loads of all connected PROFINET IO systems.

To avoid high communication loads in multi-controller applications, observe the following recommendations:

- Avoid paths that are shared by multiple IO systems.
  The figure below shows a configuration with two PROFINET IO systems that use the same paths.



① Shared path

Figure 5-52 Multi-controller application with shared path

In the figure below, the two PROFINET IO systems do not use shared paths.

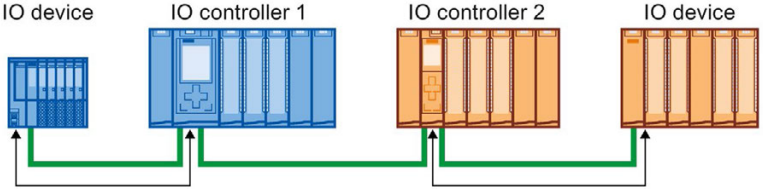


Figure 5-53 Multi-controller application with separate paths

- If separation is not possible: Increase the update time for the affected IO devices.

Installation guidelines of the PROFIBUS user organization

The installation guidelines can be found on the Internet (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/).

5.5.8 Limitation of the data infeed into the network

Limiting the data infeed into the network on PROFINET interfaces

The "Limit data infeed into the network" function limits the network load of standard Ethernet communication which is fed into the network by the interface to a maximum value. This does not apply to cyclic real-time communication (RT/IRT).

In a PROFINET IO system, critical network loads can occur quickly with standard Ethernet communication. All devices in a PROFINET IO system should support the "limitation of the data infeed into the network".

If you use devices that feed a lot of "standard Ethernet communication" into the PROFINET IO system, you should adapt the topology, if necessary.

Depending on the interface, you can activate or deactivate the "Limit data infeed into the network" function. If you use the X1 interface of an S7-1500 CPU as the IO controller or I-device, the "Limit data infeed into the network" function is always enabled. Example: If you are not using the X1 interface of an S7-1500 CPU as IO controller or I-device, you can enable or disable the function.

Uses of the limitation of the data infeed to the network

- Division of the bandwidth for standard Ethernet communication between devices:
  In PROFINET networks cyclic real-time communication and standard Ethernet communication share the same network. This means that only a limited bandwidth remains for standard Ethernet communication. The limitation of the data infeed ensures that the remaining bandwidth for standard Ethernet communication is not used just by one device, but is divided between several devices.
- Smoothing peaks in the data infeed:
  The limitation of the data infeed smooths peak loads of standard Ethernet communication (for example, from Open User Communication, access by the Web server).
- Limiting problems in the data infeed:
  If applications in a device generate too much data, this data is not forwarded to the PROFINET network. Negative effects (for example data loss, communication breakdown) remain limited to the device and its communications partner. Other nodes are not disturbed.

Setting limitation of the data infeed into the network for a CPU

To set the limitation of the data infeed into the network, follow these steps:

1. In the network view of STEP 7, select the interface of the CPU.
2. In the Inspector window, go to "Properties" > "General" > "Advanced options" > "Interface options".
3. Select or clear the "Limit data infeed into the network" check box.

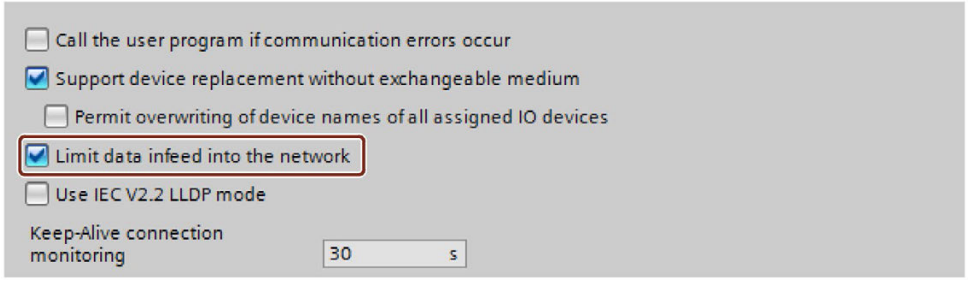


Figure 5-54 Limit data infeed into the network

5.6 PROFINET with performance upgrade

Performance upgrade

The performance upgrade implements the application class "High Performance" of the PROFINET specification V2.3.

The performance upgrade provides a series of measures that lead to the following improvements for PROFINET with IRT:

- Reduction of runtime delays in the IO devices
- Increase in the bandwidth for cyclic IO data
- Reduction of the bandwidth used for PROFINET frames
- Reduction of the send clocks

The improvements achieved with the performance upgrade mean that you can operate your PROFINET IO system with more devices with the same send clock or the same number of devices with a shorter send clock.

With PROFINET, it was previously possible to reach a send clock of 250 µs.

With the performance upgrade, it is now possible to achieve isochronous send clocks of up to 125 µs with the fast forwarding, dynamic frame packing and fragmentation procedures, depending on the performance capability of the CPU (see Technical Specifications in the device manuals). With short send clocks, standard communication remains possible.

The performance upgrade will help you to implement applications with high speed and send clock requirements.

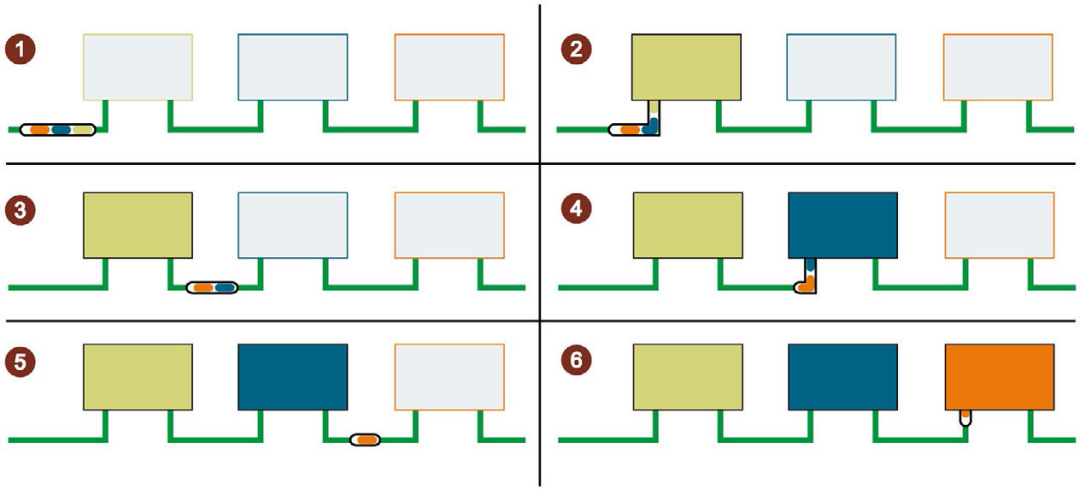
5.6.1 Dynamic frame packing

Dynamic frame packing

Previously, individual PROFINET IO frames were sent for every PROFINET IO device.

The performance upgrade uses the dynamic frame packing procedure that is based on the summation frame method. With the summation frame method, a frame contains the user data for neighboring devices on a line. With Dynamic Frame Packing, every IO device takes its data from the frame and forwards the rest. The frame is shortened from IO device to IO device. Dynamic frame packing improves the use of the bandwidth in a line topology.

The following figure shows how Dynamic Frame Packing works based on the example of a frame containing the user data for 3 IO devices.



① The PROFINET IO frame contains the user data for all 3 IO devices (green, blue and orange).
② The PROFINET IO frame reaches the first IO device. The IO device takes its user data (green) from the frame and forwards the remaining frame.
③ The PROFINET IO frame contains the user data for two IO devices (blue and orange).
④ The PROFINET IO frame reaches the second IO device. The IO device takes its user data (blue) from the frame and forwards the remaining frame.
⑤ The PROFINET IO frame contains the user data for one IO device (orange).
⑥ The PROFINET IO frame reaches the last IO device. The IO device saves the entire frame including user data (orange).

Figure 5-55 Dynamic Frame Packing (DFP)

DFP groups

Dynamic frame packing automatically groups IO devices that support the performance upgrade into DFP groups. To be grouped together in a DFP group. the IO devices must be located one after the other in a line and must have the same update time and watchdog time. As soon as a maximum frame size for the DFP group is exceeded or a maximum number of members for a DFP group is reached, Dynamic Frame Packing automatically opens a new DFP group.

STEP 7 shows the DFP groups in "Domain management" > "Sync domains" > "Name of the sync domain" > "Device" in the "IO devices" box.

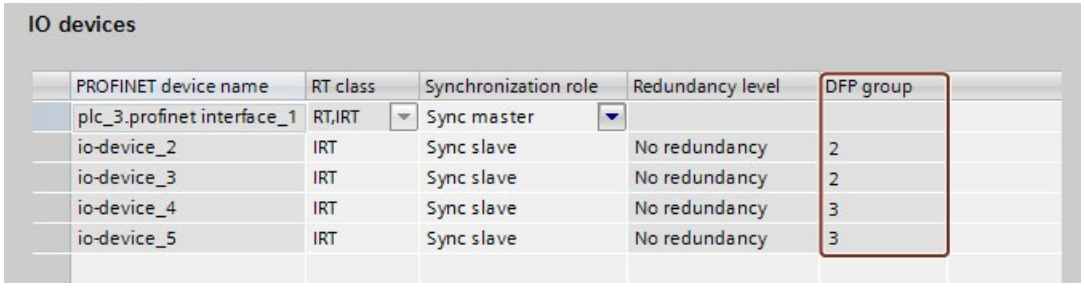


Figure 5-56 Display of the DFP groups in STEP 7

Note

Dynamic frame packing with high watchdog times

If you set the parameter "Accepted update cycles without IO data" higher than 31, Dynamic Frame Packing does not place this IO device in a DFP group.

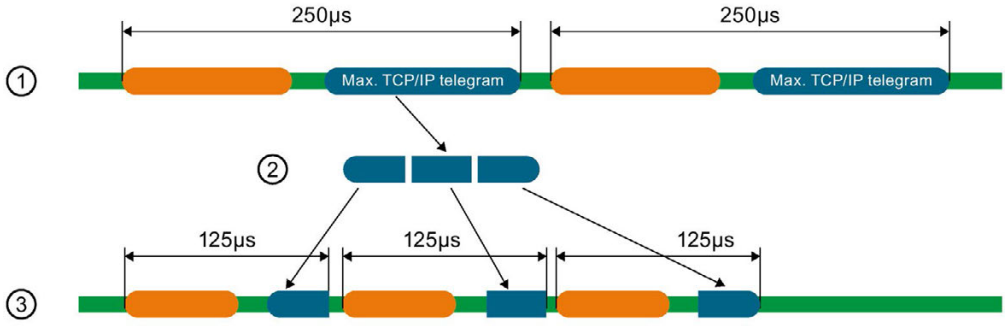
5.6.2 Fragmentation

The transfer of a complete standard Ethernet frame with TCP/IP data takes up to 125 µs. This means that the cycle time for PROFINET IO data cannot be reduced by any desired amount.

The performance upgrade uses the fragmentation procedure, which breaks down TCP/IP frames into sub-frames. These frame segments are transferred to the target device over multiple send clocks; there they are reassembled to the original TCP/IP frame.

Fragmentation is a requirement for cycle times lower than 250 µs. In these short send clocks, you can use more bandwidth for cyclic IO data, since the fragments of the standard Ethernet frames use significantly less bandwidth than a complete standard Ethernet frame.

The following figure shows how fragmentation works.



① A standard Ethernet frame with TCP/IP data is up to 125 µs.
② During fragmentation, the standard Ethernet frame is divided into frame segments.
③ The frame segments are divided into multiple short send clocks.

Figure 5-57 Fragmentation

Note

The PROFINET IO interface of the IO controller supports fragmentation if all the ports except one are deactivated.

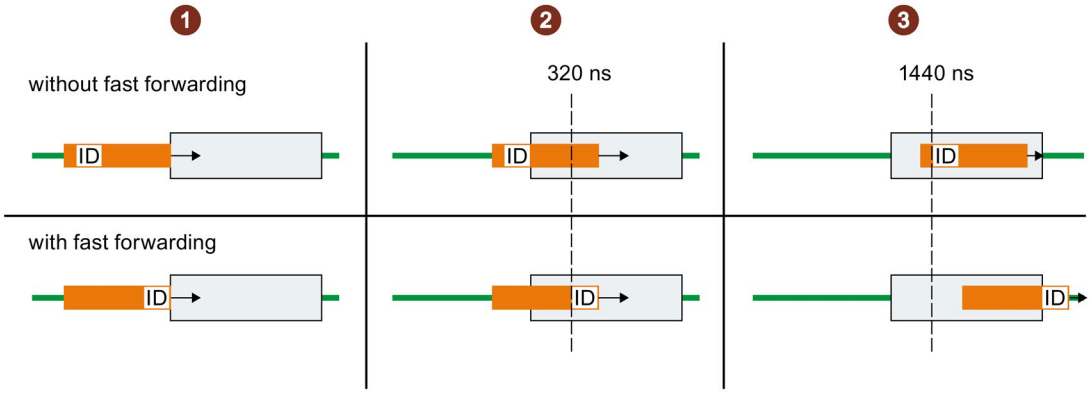
5.6.3 Fast forwarding

To be able to decide whether a frame should be forwarded or used, a PROFINET IO device requires the frame ID. It previously took 1440 ns until the frame ID was present in the IO device.

The performance upgrade uses the fast forwarding procedure in which the frame ID is located nearer the front of the frame. The throughput time in the device is reduced to 320 ns.

With fast forwarding, the throughput time of the frame is reduced in your PROFINET IO system. This results in decisive performance advantages, particularly in line, ring and tree topologies.

The figure below compares the throughput of a PROFINET IO frame in an IO device with and without fast forwarding.



① Start:

- Both PROFINET frames reach the IO device.
  The IO devices start to check the frames for the frame ID

② After 320 ns:

- Without fast forwarding: The IO device is still checking the PROFINET frame for the frame ID.
- With fast forwarding: The IO device receives the frame ID from the PROFINET frame and forwards the frame.

③ After 1440 ns:

- Without fast forwarding: The IO device receives the frame ID from the PROFINET frame and forwards the frame.
- The PROFINET frame with fast forwarding is "ahead" of the PROFINET frame without fast forwarding.

Figure 5-58 Fast forwarding

5.6.4 Configuration of IRT with high performance

High-end applications with IO communication require excellent performance in IO processing, for example in the control of wind turbines (converter control).

To use IRT communication with the highest performance in your PROFINET IO system, enable the option "Make 'high performance' possible".

When you enable the "Make 'high performance' possible" option, this has the following effects:

- You can set send clocks of 187.5 µs and 125 µs (CPU 1518) or 187.5 (CPU 1517), see Technical Specifications in the CPU device manuals.
- You can set more bandwidth use for cyclic IO data.
- You can use the option "Allows the use of 'fast forwarding'".

Requirements

- S7-1500 CPU as of firmware version V2.0

Enable the "Make 'high performance' possible" option.

Follow these steps to activate the "Make 'high performance' possible" option:

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Enable the "Make 'high performance' possible" option.

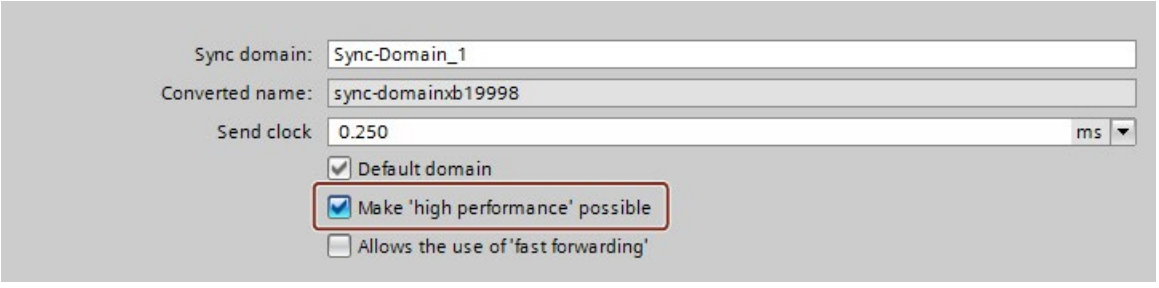


Figure 5-59 Activating high performance

Using more bandwidth for cyclic IO data

Requirement: The "Make 'high performance' possible" option is enabled.

To set more bandwidth for cyclic IO data for your PROFINET IO system, follow these steps:

1. Select your IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain" > "Details".
3. In the drop-down list, select "Maximum 90% cyclic IO data. Focus on cyclic IO data".

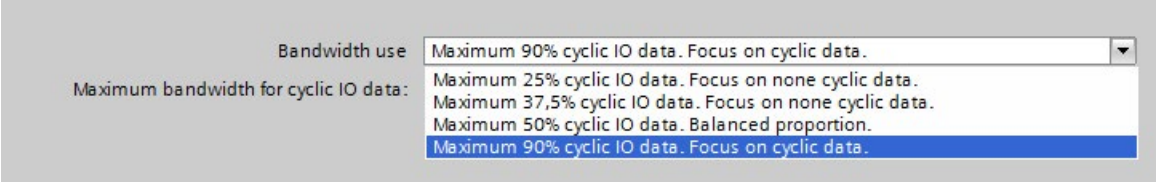


Figure 5-60 Using more bandwidth for cyclic IO data

Note

Bandwidth usage in isochronous mode

If you operate your PROFINET IO system in isochronous mode, avoid using the setting for the bandwidth usage "Maximum 90% cyclic IO data. Focus on cyclic IO data."

Setting low send clocks (CPU 1518-4 PN/DP)

Requirement: The "Make 'high performance' possible" option is enabled.

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Select the send clock for "Send clock" in the drop-down list.

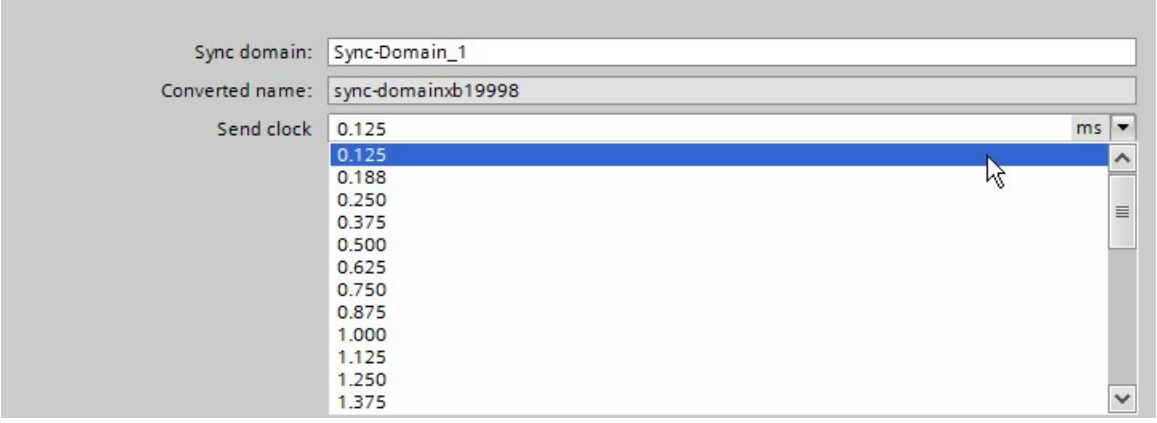


Figure 5-61 Setting low send clocks

Requirements for the fragmentation process (CPU 1518-4 PN/DP)

If you use the following combinations for send clock and bandwidth settings, the devices in the IO system use the fragmentation process.

- Send clock cycle 125 µs: Always fragmentation irrespective of the bandwidth setting.
- Send clock cycle 187.5 µs: Fragmentation with the bandwidth settings "Maximum 50% cyclic IO data. Balanced proportion." and "Maximum 90% cyclic IO data. Focus on cyclic IO data."

The PROFINET IO interface of the controller supports fragmentation if all the ports except one are deactivated.

Optimizing port settings for low send clocks

You can further optimize the bandwidth use in your PROFINET IO system by using cables with a short cable length (< 20 m) or a short signal delay (max. 0.12 µs) between the devices.

To configure cables with a shorter length or signal delay in STEP 7, follow these steps:

1. Select the port in the topology view of STEP 7.
2. Navigate in the Inspector window to "Port interconnection" in the "Partner port" box.
3. Select the option "Cable length" or "Signal delay:".
4. Select the cable length or enter the signal delay.

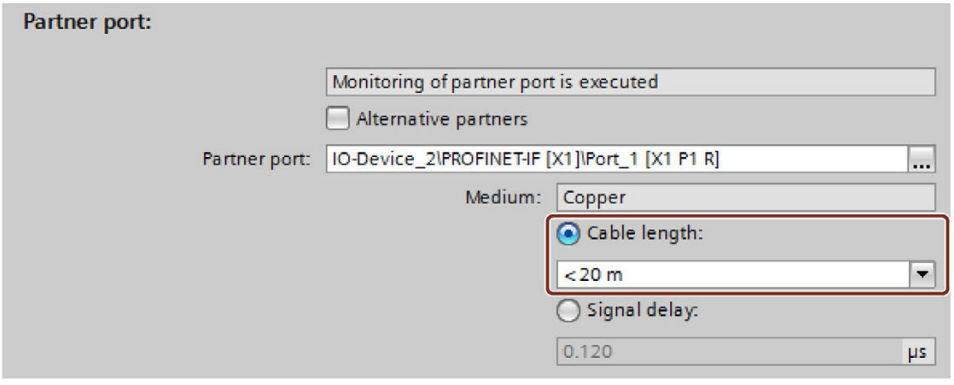


Figure 5-62 Optimizing port settings for low send clocks

Allowing fast forwarding

Requirements:

- The PROFINET IO device has to support the fast forwarding process so that the process can be used by the device.
- The "Make 'high performance' possible" option is enabled.
- The PROFINET IO interface supports fast forwarding if all the ports except one are deactivated.

Follow these steps to allow fast forwarding:

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Enable the "Allows the use of 'fast forwarding'" option.

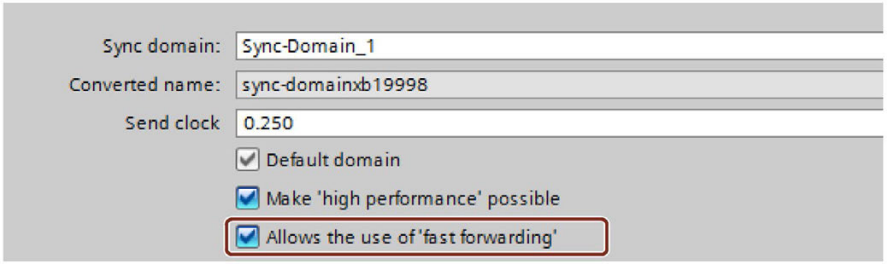


Figure 5-63 Allowing fast forwarding

Note

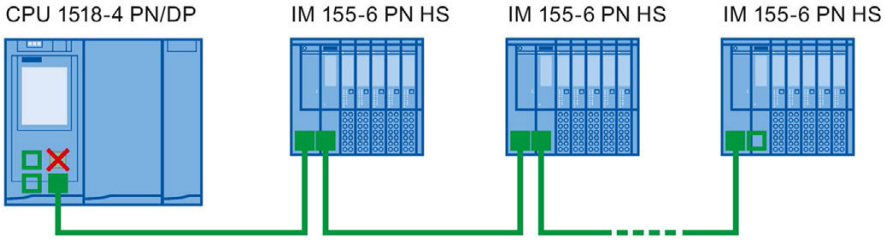
Fast forwarding and IPv6

The operation of fast forwarding in combination with IPv6 is not supported.

As soon as an IO device in the subnet uses an IPv6 address, you must not activate "fast forwarding".

5.6.5 Sample configuration for IRT with high performance

The figure below shows an example configuration with which you can achieve maximum performance.



Port 1 of the X1 interface of the CPU is deactivated.

Port 2 of the X1 interface and the ports of the interface modules on the bus use the following setting: Medium copper, cable length < 20 m or signal delay max. 0.12µs

A programming device connection to the CPU can be established via the interfaces X2 and X3 of the CPU or via the free port at the end of the line.

Figure 5-64 Example configuration for IRT with high performance

Use the following settings for the Sync domain:

- Enable the "Make 'high performance' possible" option.
- Set the send clock to 125 µs.
- Enable the "Allows the use of ‘fast forwarding'" option.

Standard Ethernet communication for IRT with high performance

Standard Ethernet communication is still possible even in a PROFINET IO system with high performance. Keep in mind that you first arrange the IRT nodes, as seen from the IO controller, and arrange the standard Ethernet nodes at the end of the line.

With a large volume of data through standard Ethernet communication, it makes sense to reduce the load on your network by separating standard Ethernet communication and cyclic real-time communication. Example: Use the interface X1 for the PROFINET IO communication and a different interface for the standard Ethernet communication.

5.7 Isochronous mode

5.7.1 What is isochronous mode?

Objectives of isochronous operation

Assuming public transport were to operate at maximum speed while reducing stop times at the passenger terminals to absolute minimum, the last thing many potential passengers would notice of the departing contraption are its red tail lights. The overall travel time is, however, decided by the train, bus or underground-railway clock, because well adjusted timing is essential to a good service. This also applies to distributed automation engineering. Not only fast cycles but also the adaptation and synchronization of the individual cycles result in optimum throughput.

Just-In-Time

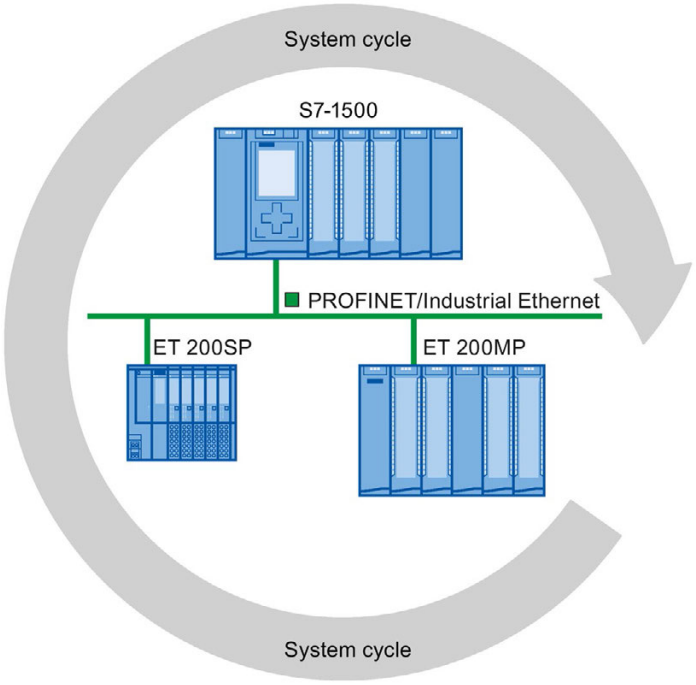


Figure 5-65 System cycle

The high speed and reliable reaction time of a system operating in isochronous mode is based on the fact that all data are provided just-in-time. The constant bus cycle time PROFINET IO cycle beats the time here.

Advantages of isochronous mode

The use of isochronous mode allows high-precision control.

- Optimized control
- Determinism
- Consistent (simultaneous) reading in of input data
- Consistent (simultaneous) output of output data

5.7.2 Use of isochronous mode

With the "Isochronous mode" system property, measured values and process data can be acquired in a fixed system clock. The signal processing up to the switching-through to the "output terminal" occurs within the same system clock. Isochronous mode thus contributes to high-quality control and hence to greater manufacturing precision. With isochronous mode, the possible fluctuations of process response times are drastically reduced. The time-assured processing can be utilized to improve machine cycle times.

In principle, isochronous mode is worthwhile whenever measured values must be acquired synchronously, movements must be coordinated, and process responses must be defined and simultaneously executed, as in the following example. There are thus numerous areas in which isochronous mode can be used.

5.7.3 Isochronous applications

Example: Isochronous measurement at several measuring points

Quality assurance requires precise measurement of dimensions within a camshaft production process.

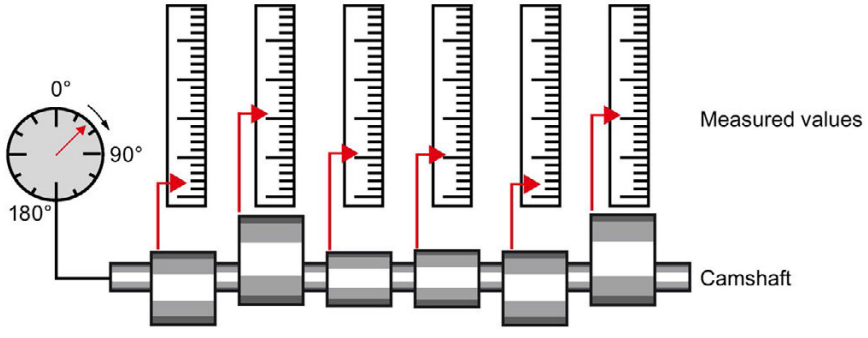


Figure 5-66 Measuring of camshafts

Isochronous workflow

When the isochronous mode property of the system is used, the measured value acquisition is clocked and occurs simultaneously at the various measuring points. The time required for measurement is reduced. Resultant workflow:

- Continuous machining of the camshaft
- Synchronous measurement of the camshaft positions and gradients within a continuous rotation.
- Machining of the next camshaft

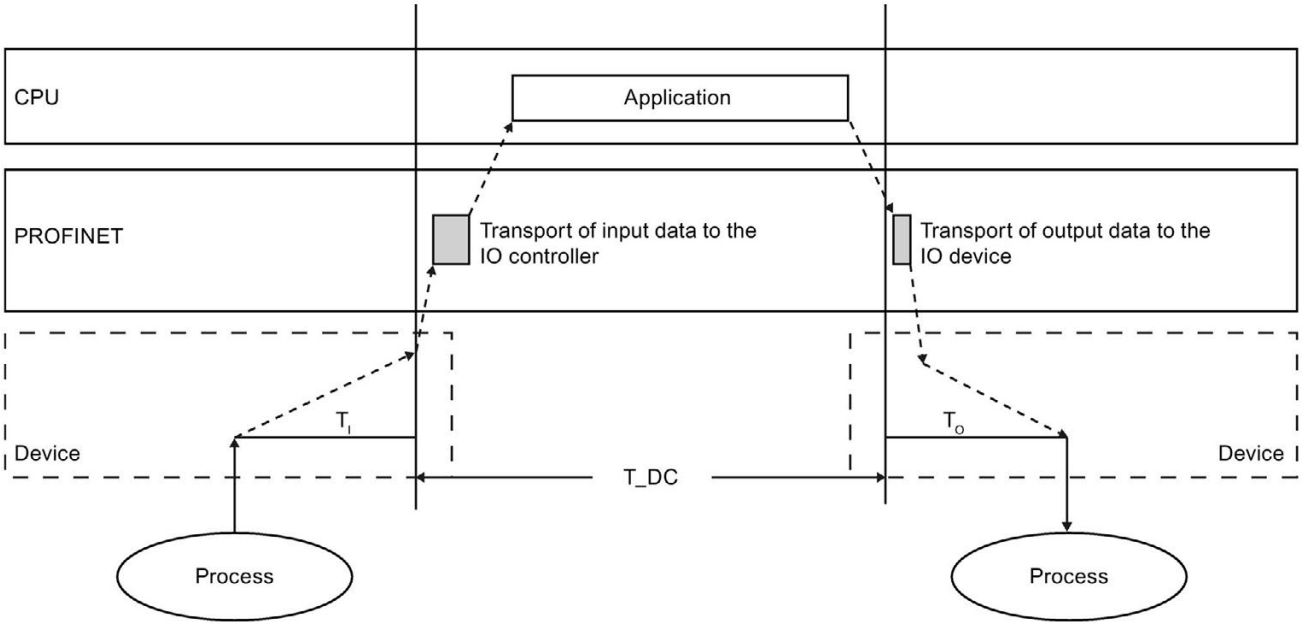
All camshaft positions and the corresponding measured values (red) are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

5.7.4 Time sequence of synchronization

From reading-in of input data to outputting of output data

The basic time sequence of all components involved in synchronization is explained in the following:

- Reading-in of input data in isochronous mode
- Transport of input data to the IO controller (CPU) via the PROFINET subnet
- Further processing in the isochronous application of the CPU
- Transport of output data to the outputting IO device via the PROFINET subnet
- Outputting of output data in isochronous mode



T_DC Data cycle (Time_DataCycle)

T_I Time for reading in the input data

T_O Time for outputting the output data

Figure 5-67 Time sequence of synchronization

The start of the I/O read cycle is advanced by the amount of a bias time T_I in order to make all input data available for transfer on the PROFINET IO line at the start of the next PROFINET IO cycle. T_I is the "flashlight" for the inputs; at this instant all synchronized inputs are read in. T_I is necessary in order to compensate for analog-to-digital conversion, backplane bus times, and the like. The bias time T_I can be configured by STEP 7 or by the user. We recommend automatically assigning the bias time T_I of STEP 7.

The PROFINET IO line transports the input data to the IO controller. The application can be started synchronized to the cycle, i.e., the isochronous mode interrupt OB is called after a parameterizable delay time. The user program in the isochronous mode interrupt OB decides the process reaction and provides the output data in time for the start of the next data cycle. The length of the data cycle is always configured by the user.

T_O is the compensation arising from the backplane bus and the digital-to-analog conversion within the IO device. T_O is the "flashlight" for the outputs; at this instant the synchronized outputs are output. The time T_O can be configured by STEP 7or by the user. We recommend automatically assigning the bias time T_o of STEP 7.

Isochronous mode and non isochronous mode distributed I/O

It is possible to combine isochronous mode distributed I/O with non isochronous mode distributed I/O on one IO controller.

5.7.5 Basics of Programming

Programming in the isochronous mode interrupt OBs

The isochronous part of the program is always programmed in the isochronous mode interrupt OBs OB 61 to OB 64. As the isochronous mode interrupts are processed with high priority, only the time-sensitive elements of the program should be processed in OB 6x. The isochronous mode interrupt is called with a configured delay time.

Accessing isochronous I/O by calling system functions

The isochronous I/O are updated exclusively by calling the "SYNC_PI" and "SYNC_PO" instructions and therefore in the corresponding process image partition.

Note

To prevent inconsistent data from being returned to OB6x, you should avoid using the "DPRD_DAT" and "DPWR_DAT" instructions (direct data access) in the isochronous mode OB.

Direct access to the I/O areas returns current values of the process that do not, however, necessarily match the values supplied by "SYNC_PI" and "SYNC_PO".

The "SYNC_PI" and "SYNC_PO" instructions can update the process image partition only within the permitted execution window. The execution window for the possible call of the "SYNC_PI" and "SYNC_PO" instructions stretches from the end of the cyclical data exchange on the PROFINET IO until the point in time before the end of T_DC at which the outputs can still be copied on time. The data exchange must be started within this time window. If the "SYNC_PI" and "SYNC_PO" instructions are not processed within the execution window, the system functions will indicate this with a corresponding error message. An image in which the execution window and the corresponding times are displayed can be found in the next section.

Program execution models

Depending on the order of the "SYNC_PI" and "SYNC_PO instructions in OB6x and the application cycle factor used, the program execution can be divided into two basic models:

- **IPO** model (read **I**nputs - **P**rocessing - write **O**utputs), CACF = 1
- **IPO** model (read **I**nputs - **P**rocessing - write **O**utputs), CACF > 1

5.7.6 Program processing according to the IPO model with application cycle = 1

Characteristics of the IPO-model with application cycle factor = 1

The IPO model with application cycle factor = 1 is characterized by the fact that the execution of the I/O data is complete within one system clock cycle T_DC. The shortest response times are achieved with this model.

IPO model with application cycle factor = 1

With the IPO model with application cycle factor = 1, there is a constant execution time from the "input terminal" to the "output terminal" of T_I + T_DC + T_O. T_I + 2×T_DC + T_O can be guaranteed for the process response time.

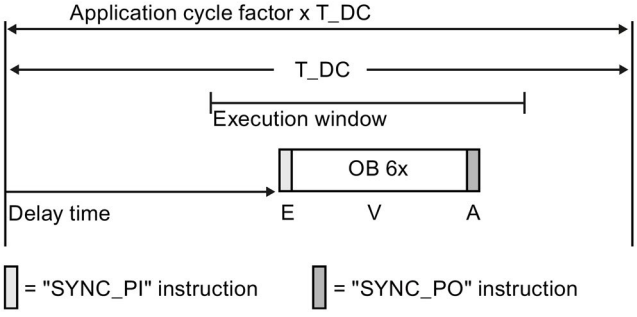


Figure 5-68 Program execution according to the IPO model with application cycle = 1

The figure shows the IPO model with the application cycle factor = 1 from acquisition through processing on the CPU to output of the process values. STEP 7 calculates the delay time or you can enter it yourself (see section Setting the application cycle and delay time (Page 192)). During this time, the read input data and the written output data is on its way on PROFINET IO. The delay time is set as a default to the start of the execution window.

The isochronous user program in OB 6x begins with the "SYNC_PI" instruction and ends with the "SYNC_PO" instruction.

The "SYNC_PI" and "SYNC_PO" instructions may only be processed within the execution window. The processing of the user program must be completed within the data cycle T_DC.

5.7.7 Program execution according to the IPO model with application cycle > 1

Characteristics of the IPO-model with application cycle factor > 1

The IPO model with application cycle factor > 1 is an IPO model over multiple data cycles T_DC. In this case, it is an IPO model with an output delayed by one application cycle (OB6x). The input and processing take place in the same application clock cycle. Output is performed at the start of the next application clock cycle, directly before the next input.

You call the "SYNC_PI" and "SYNC_PO" instructions in the execution window of the first data cycle T_DC of the application clock cycle (only available there with application cycle factor > 1.) The other user program execution in OB 6x then occurs after "SYNC_PO" and extends into the next data cycle or over the following data cycles T_DC.

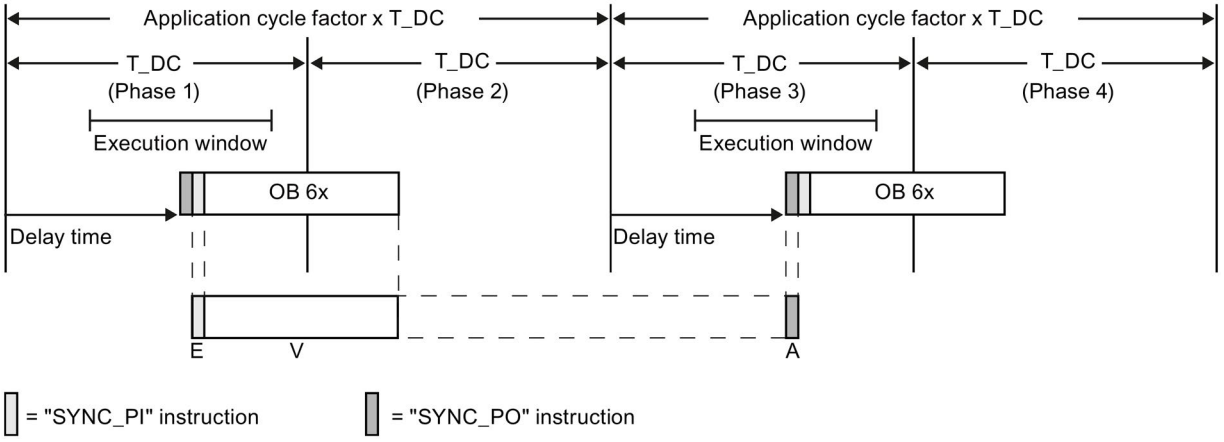


Figure 5-69 Program execution according to the IPO model with application cycle factor > 1

The figure shows the signals of the IPO model with application cycle factor = 2 over time from the acquisition through the processing on the IO controller to the output of the process values. STEP 7 calculates the delay time T_M. During this time, the read input data and the written output data is on its way on PROFINET IO.

The IPO model with application cycle factor > 1 is particularly ideal for large IO infrastructures with a comprehensive user program in the OB6x. With this model, longer calculation times are possible when executing the input data and obtaining the corresponding output data.

With the IPO model with application cycle factor > 1, there is a constant execution time from the "input terminal" to the "output terminal" of T_I + (application cycle factor + 1) x T_DC + T_O. T_I + (2 x application cycle factor + 1) x T_DC + T_O can be guaranteed for the process response time.

5.7.8 Configuring isochronous mode

Introduction

The configuring of isochronous mode for a module is described as IO device in the following based on the ET 200MP distributed I/O system. The procedure described also applies to other distributed I/O systems (e.g., ET 200S or ET 200SP).

The IO controller is an S7-1500 CPU.

Requirements

- The STEP 7 network view is open.
- A S7-1500 CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An interface module IM 155-5 PN HF (ET 200MP) has been placed and networked with the CPU.
- All requirements for an IRT configuration are met, namely:
  - The ports of the CPU and the interface module are interconnected.
  - The RT class of the interface module is set to "IRT" (area "Advanced options > Real time settings > Synchronization").
  - You have assigned the "sync master" and "sync slave" roles.

Procedure

To create an isochronous connection between the I/O and user program, follow these steps:

1. Select the "IM 155-5 PN HF" in the network view of STEP 7 and switch to the device view.
2. Insert an IO module that can be operated in isochronous mode (module with the extension "HF").
3. Go to the "I/O addresses" area in the Inspector window of the selected I/O module.

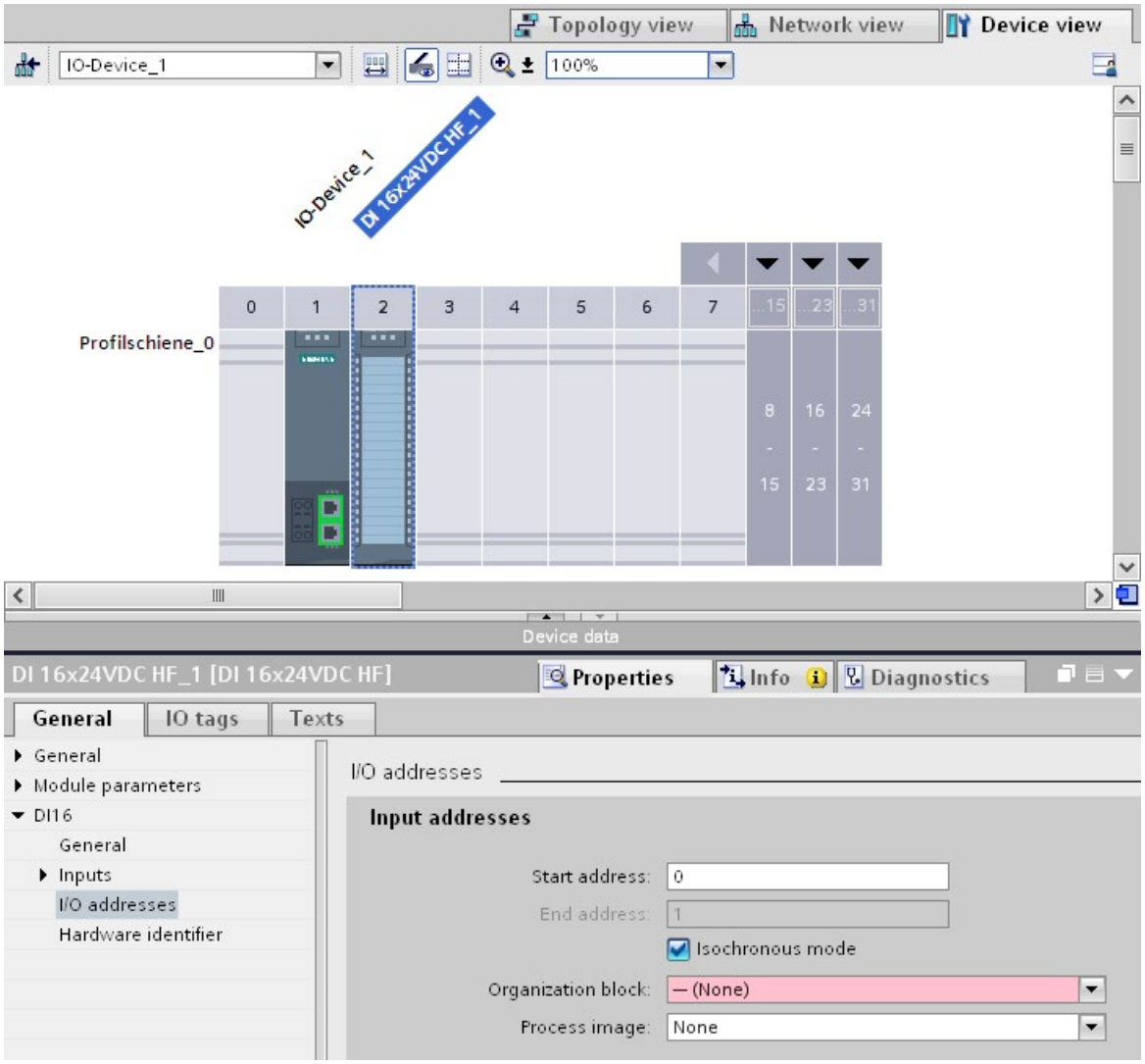


Figure 5-70 Configuring isochronous mode in STEP 7

4. Make the following settings in the I/O addresses area:
   - Select the "Isochronous mode" option.
   - Select a process image partition, e.g., process image partition 1.
   - Click on the "Assigned organization block" in the drop-down list and click the "Add object" button, or select an already existing OB.

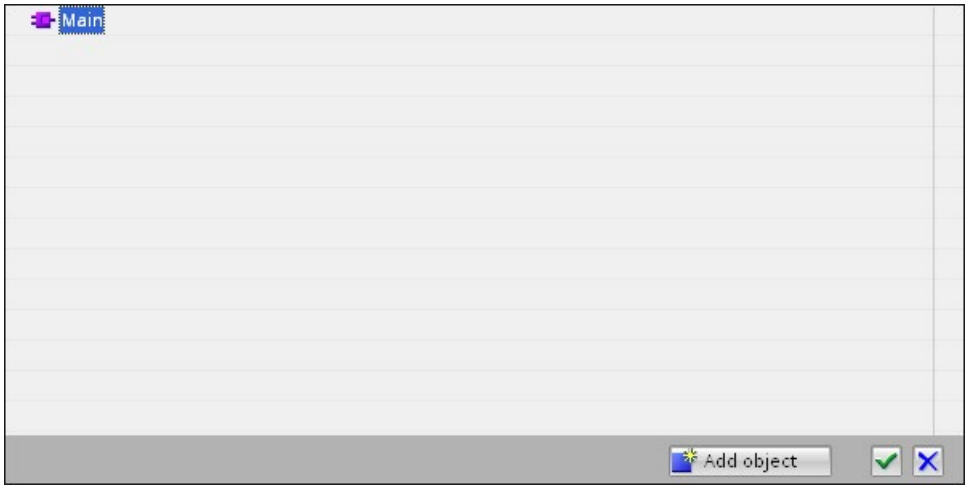


Figure 5-71 Creating the organization block for programming isochronous mode

A dialog box for selecting organization blocks opens.

   - Select the "Synchronous Cycle" OB and confirm the selection with "OK".

     In the case of automatic number assignment, OB 61 will be generated and opened. The "Isochronous mode" area is selected in the Inspector window, and you can continue directly with the setting of the application cycle and delay time and start the programming of the OB in the instruction section.

5. Add other IO devices as required in the network view and adapt the configuration and the isochronous mode settings.
6. To retrieve information about calculated bandwidths or to adapt the send clock, select the subnet and navigate to the corresponding area of the domain management in the Inspector window.

Programming isochronous mode

The user program must be set up accordingly in order to operate your plant in isochronous mode. To do this, you must create an isochronous mode interrupt OB (OB 6x) in an I/O module (see above). You access the isochronous I/O via a process image partition, i.e., the addresses of isochronous modules must be in a process image partition. You have to program accesses to the isochronous IO with the instructions SYNC_PI and SYNC_PO in the isochronous mode interrupt OB.

With an application cycle = 1 you call the SYNC_PI instruction at the start of the isochronous mode interrupt OB, provided you have selected the automatic setting for the delay time. You call the instruction SYNC_PO at the end of the OB 6x.

With an application cycle > 1 you first call the SYNC_PO instruction at the start of the isochronous mode interrupt OB, then the SYNC_PI instruction and subsequently the actual user program.

5.7.9 Setting the application cycle and delay time

Requirement

- You have created an isochronous mode configuration in STEP 7.
- You have created an isochronous mode interrupt OB.
- The isochronous mode interrupt OB is open.

Setting the application cycle and delay time

To set the application cycle for your isochronous mode application, follow these steps:

1. Open the "Properties" dialog associated with the relevant isochronous mode interrupt OB.
2. In the area navigation, click the "Isochronous mode" group .
3. Set the application cycle in "Application cycle (ms)". Open the drop-down list box and select the application cycle. The drop-down list box offers multiples of the PROFINET send cycle clock as possible values for the application cycle. The PROFINET send cycle clock is set to 2 ms in the following figure.

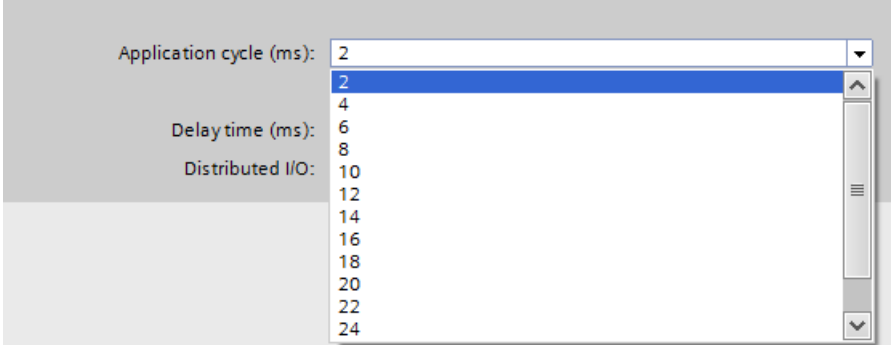


Figure 5-72 Setting the application cycle

Setting the delay time

STEP 7 sets the delay time automatically to the start of the execution window by default. As a result, the isochronous mode update of the process image partition automatically falls within the execution window of the application cycle.

You can also set the delay time manually. A shorter delay time enables you to increase the processing time for your user program in the isochronous mode interrupt OB. If a manual setting is made, note that you must call the "SYNC_PI" and "SYNC_PO" instructions in the execution window of the application cycle.

To set the delay time for your isochronous mode application, follow these steps:

1. Open the "Properties" dialog associated with the relevant isochronous mode interrupt OB.
2. In the area navigation, click the "Isochronous mode" group .
3. Clear the "Automatic setting" check box.
4. Enter your desired delay time in "Delay time (ms)".

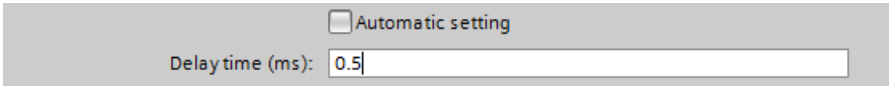


Figure 5-73 Setting the delay time

5.8 Device replacement without exchangeable medium

Definition

IO devices which have no slot for exchangeable medium (e.g. ET 200SP, ET 200MP) or IO devices which support the PROFINET functionality "Device replacement without exchangeable medium/PG" can be replaced without having an exchangeable medium with saved device names inserted and without having to assign the device name with the PG. The new IO device is given a device name by the IO controller and not by the exchangeable medium or the PG.

To assign the device name, the IO controller uses the configured topology and the neighborhood relations established from the IO devices.

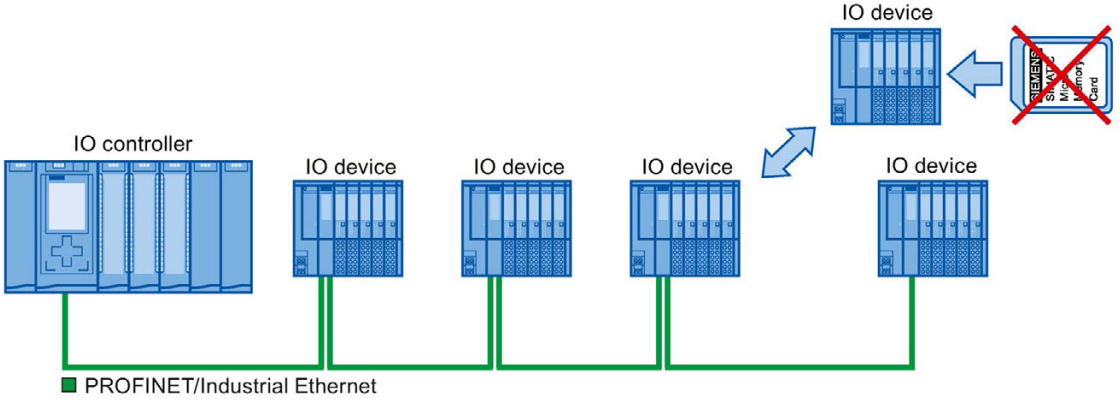


Figure 5-74 Device replacement without exchangeable medium

Note

When you exchange a device, make sure that the PROFINET cable is again inserted into the correct port, as it is configured in STEP 7.

Otherwise, the system will not run.

Advantages

With the Device replacement without exchangeable medium/PG PROFINET functionality, you can profit from the following advantages:

- After the replacement of the IO device, it automatically obtains its device name from the IO controller. You no longer have to assign device names with the PG or exchangeable medium.
- You can save on the storage medium for the IO device that replaces the removed one.
- Simple device name allocation with series machines that have the same configuration and set topology. It is no longer necessary to assign device names via exchangeable medium/PG.

Which devices support device replacement without exchangeable medium?

An overview of the devices that support the "Device replacement without exchangeable medium" function is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/36752540).

5.8.1 Device replacement without exchangeable medium/PG function

Neighborhood

Neighborhood is the physical relationship between two ports of adjacent PROFINET devices. A PROFINET device is connected in this case through one of its ports over a physical Ethernet line to a specific port of the second PROFINET device in close proximity (neighbors).

Both terminal devices, for example, IO controllers and IO devices with a port, and network components, for example, switches, IO controllers and IO devices with multiple ports, are considered PROFINET devices.

Failure and replacement of an IO device

The following example describes device replacement without exchangeable medium in the case of failure of an IO device.

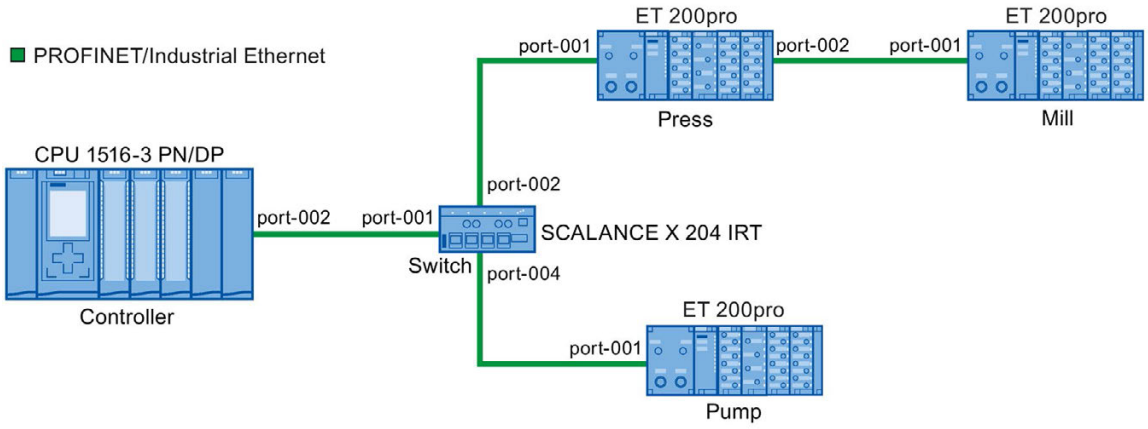


Figure 5-75 Example configuration of device replacement without exchangeable medium

For the device replacement, the following information is available to the IO controller:

PROFINET device	Device alias
Controller	"port-001.Switch"
Switch	"port-002.Controller", "port-001.Press", "port-001.Pump"
Press	"port-002.Switch", "port-001.Mill"
Mill	"port-002.Press"
Pump	"port-004.Switch"

The IO device with the device name "Mill" fails in this example:

Requirement

The PROFINET device replacing the removed one has no device name.

Principles of name assignment

The failure of the "Mill" IO device is considered here.

1. The IO controller queries the device name of the replaced IO device.
2. The IO controller detects that the IO device with the device alias "port-002.Press" does not have a device name.
3. The IO controller assigns the device name "Mill" to the replaced IO device via the device alias "port-002.Press" of the failed IO devices.

Note

If you insert a device with the Device replacement without exchangeable medium/PG PROFINET functionality at a different location than the configuration, a different device name is then assigned to the device.

Reset a wrongly inserted device to delivery state before you use it again.

5.8.2 Replacing an IO device without exchangeable medium

Introduction

Replacement of IO devices is sometimes frequently required in automation systems. The IO devices are generally assigned a device name by either inserting an exchangeable medium or via the programming device. The CPU identifies the IO device by using these device names.

Under certain circumstances, replacing an IO device can be done without inserting an exchangeable medium or without the PG.

Requirements

- The topology of the PROFINET IO system with the respective IO devices must be configured.

  By configuring the topology, the neighbor relationships of all the PROFINET devices located in the PROFINET IO system are announced to the PROFINET IO system or the IO controller. From the neighbor relationships specified by the set topology and the actual neighbor relationships established by the real PROFINET devices, the IO controller can identify the replaced IO device without a name and assign to it the configured name and the IP address and then again list it in the user data traffic.

- The affected IO devices in the automation system must support device replacement without exchangeable medium.

  If the individual IO devices in the automation system do not support device replacement without exchangeable medium, a corresponding alarm is output for the IO device.

Note

Use only new IO devices as replacements or restore configured IO devices to their delivery state.

Activating/deactivating device replacement without exchangeable medium

The "Device replacement without exchangeable medium" function is activated in the IO controller by default.

To deactivate device replacement without exchangeable medium, follow these steps:

1. In the device or network view of the STEP 7, select the PROFINET interface in the corresponding IO controller.
2. In the interface properties under "Advanced options > Interface options", clear the "Support device replacement without exchangeable medium" check box.

To reactivate device replacement without exchangeable medium, you must select the "Support device replacement without exchangeable medium" check box again.

5.8.3 Permit overwriting of PROFINET device name

With the option "Permit overwriting of PROFINET device names of all assigned IO devices", you can overwrite PROFINET device names of IO devices during startup of the CPU. This option reduces the effort during automatic commissioning, for example, when replacing a device.

Requirements

- IO controller supports the "Permit overwriting of device names of all assigned IO devices" option, for example CPU 1215C DC/DC/DC as of firmware version 4.0

How the "Permit overwriting of PROFINET device names of all assigned IO devices" option works

The IO controller (CPU) can overwrite the PROFINET device names of IO devices in the IO system when the "Permit overwriting of PROFINET device names of all assigned IO devices" option is enabled.

Multiple use IO systems can only be operated when this option is enabled. The IO controller checks prior to overwriting if the type of the IO device matches the configured type.

⚠ WARNING

Wrong PROFINET device name

When the "Permit overwriting of PROFINET device names of all assigned IO devices" option is enabled, incorrectly connected devices can be assigned an incorrect PROFINET device name from the configuration.

Depending on the connected I/O, there is risk of death, severe injuries or damage caused by malfunctions.

To rule out any danger, check whether the suitable replacement device has been connected in case of a device replacement and whether the port interconnection matches the configured preset topology.

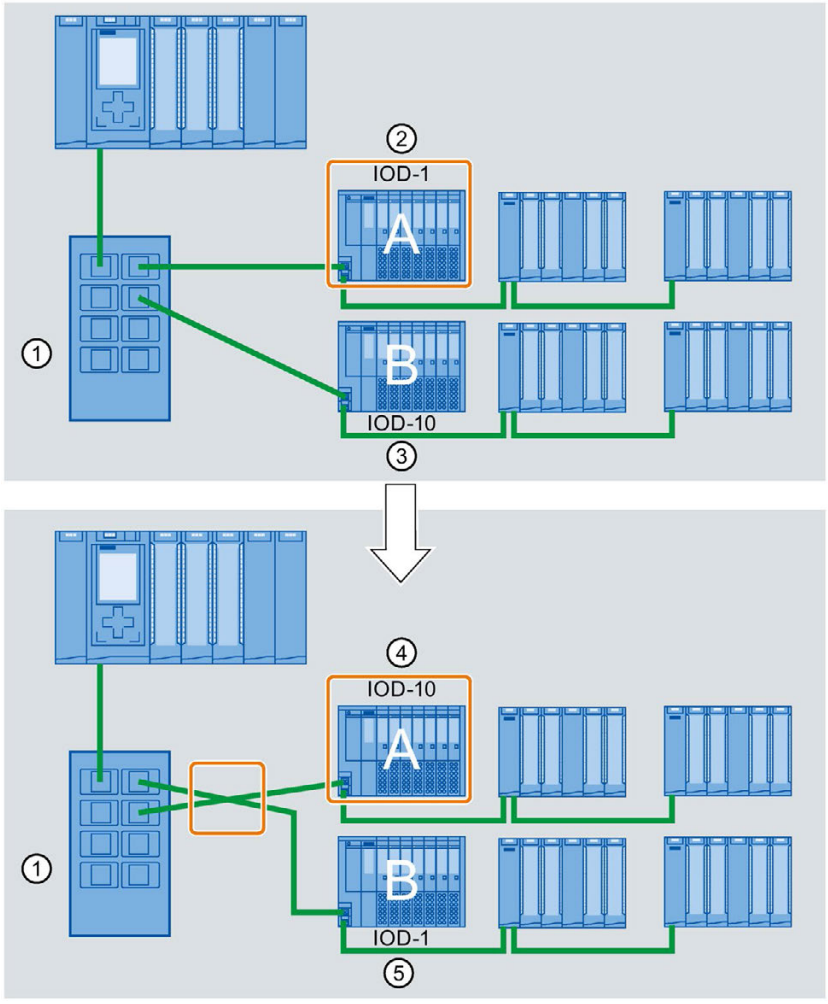
If the option is not selected, the IO controller cannot overwrite the device names of the IO devices. In this case, you must manually assign the PROFINET device name on the IO device if the PROFINET device name changes in the configuration or when a device is replaced, or delete the device names of the IO devices prior to an automatic commissioning.

Typical source of danger

When replacing an IO device ("standard case"), it is almost guaranteed that the replaced device will be connected according to the configured port interconnection.

The figure below shows a scenario whereby the connections of two identical PROFINET cables are swapped at two switch ports. Because the IO controller assigns the device names according to the preset topology, the incorrect connection of the devices has serious effects on the naming.

Due to the control of different actuators, the plant could become hazardous in this case.



① Switch with connected PROFINET cables
② Device A, device name "IOD-1": controls motor 1
③ Device B, device name "IOD-10": controls motor 10
④ Device A controls motor 10!
⑤ Device B controls motor 1!

Procedure

Proceed as follows to change the "Permit overwriting of PROFINET device names of all assigned IO devices" option:

1. Select the PROFINET interface of the CPU for which you want to change the option in the network view or in the device view.
2. Select the area "Advanced options", section "Interface options".
3. Change the option.

5.9 Standard machine projects

Introduction

Standard machine projects are STEP 7 projects that use a set of innovative functions allowing simple configuration and commissioning of flexible automation solutions for standard machines or for machines with a modular structure.

A hardware configuration consisting of an IO controller and any number of connected IO devices represents a "PROFINET IO system master". This master is configured with a maximum configuration based on a template from which various options can be derived for different standard machines, for example with different configuration variants of the IO system.

Greater flexibility at all levels

Standard machine projects have the following central characteristics:

- Different variants of a standard machine can be loaded from precisely one project with an engineered maximum configuration (IO system options). The standard machine project covers all variants (options) of the IO system.
- An IO system option can be integrated in an existing network locally using simple tools.

Flexibility is provided in more ways than one:

- With suitable configuration, adaptation of the IP address parameters of the IO controller is possible locally using simple tools. This allows a standard machine to be integrated in different plants with little effort or to be included in a network several times.
  IO systems with this property are known as **multiple use IO systems**.
- With suitable configuration and programming, different setups of IO system options can be operated locally that differ in terms of the selection of IO devices used or in terms of the arrangement of the IO devices.
  Since the specific configuration of the IO system is controlled by the user program, this is known as **configuration control for IO systems**.
- Independently of the functions described above, with suitable configuration and programming, you can use different station options of central devices or distributed I/O devices in one project. The devices can be different in terms of the selection and arrangement of the modules.
  Since the concrete configuration of the station is controlled by the user program, this is also known as **configuration control**.

Additional information

For more information on multiple use IO systems, refer to section Multiple use IO systems (Page 200).

For more information on the configuration control for IO systems, refer to section Configuration control for IO systems (Page 209).

For more information on configuration control, refer to the system manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792).

5.9.1 Multiple use IO systems

5.9.1.1 What you should know about multiple use IO systems

Multiple use automation solutions

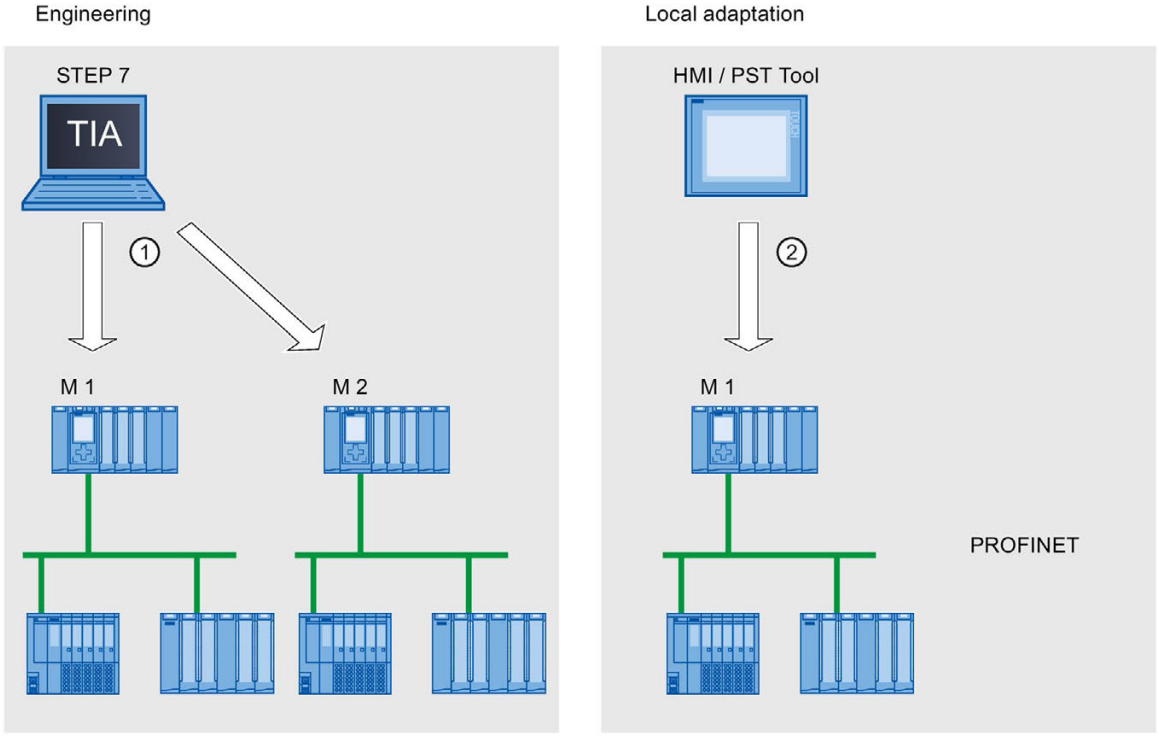
For a flexible reusable automation solution as is the case with series machines, the following use cases are typical:

- The machine (and therefore also the PROFINET IO system) is used more than once by the customers.
- The machine is used in different plants by various customers.

For this to be possible, the automation solution must meet the following requirements:

- A project (configuration and program) can be loaded on various machines of the same type without changes.
- Only a few easy adaptations need to be performed locally to integrate the machine into an existing network infrastructure.

The following figure shows how an automation solution with a multiple use IO system is loaded on different automation systems and then one automation system is adapted to the existing network infrastructure locally.



① Load configuration with multiple use IO system

② Set IP address and device name locally on the IO controller

Figure 5-76 "Multiple use IO system" principle

Principle

The automation components for a machine include a PROFINET IO system, consisting of an IO controller (PROFINET interface of a CPU) and the IO devices assigned to it.

With the "Multiple use IO system" setting for the IO system, you turn a STEP 7 project into a "Standard machine project".

The "Multiple use IO system" setting triggers various settings and checks of the configuration by STEP 7. The settings ensure that the IO system is self-contained and there are no dependencies on components outside the IO system.

Requirements

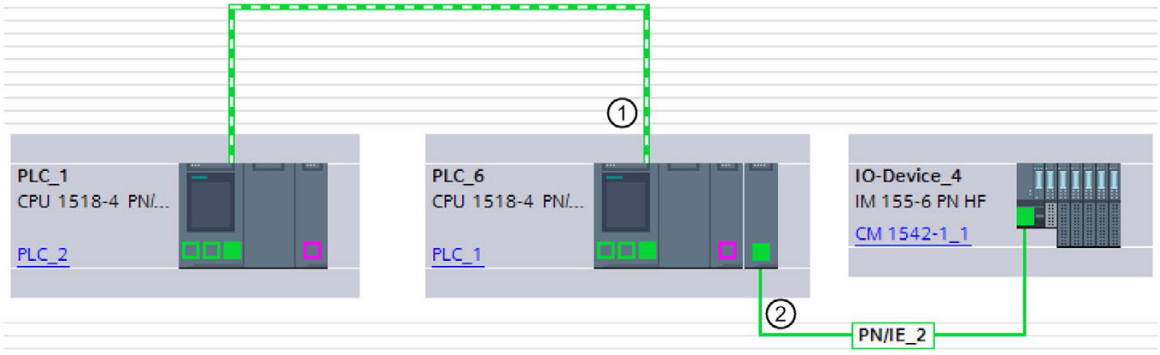
- STEP 7 as of V13
- The IO controller supports the "Multiple use IO system" function, for example a CPU 1512SP-1 PN as of firmware version 1.6.

Rules

The following rules apply to a multiple use IO system:

- No IO device can be configured as shared device.
- The ports of the devices must be interconnected.
  Devices for which no port interconnection is configured, for example, interface module IM 154-6 IWLAN (ET 200pro PN), cannot be operated with STEP 7 V13 as IO devices on a multiple use IO system.
- If an IO device in a multiple use IO system is an I-device (CPU as an "intelligent" IO device):
  - If the I-device has a lower-level IO system, this I-device cannot be connected to the same PROFINET interface as the higher-level IO controller.

    Note: If the I-device is configured using a PROFINET GSD, STEP 7 cannot check for compliance with this rule. In this case, you are responsible for ensuring compliance with the rule.



① I-device in multiple use IO system. The PROFINET interface is operated as IO device. No other IO system is connected here.

② A lower-level IO system on the I-device is connected to another PROFINET interface.

Figure 5-77 Example configuration for "Multiple use IO system" with I-device

  - The PROFINET interface of the I-device must be set to "Parameter assignment of PN interface by higher-level controller".
- If MRP (Media Redundancy Protocol) is configured:
  - All IO devices on the multiple use IO system must belong to the same MRP domain.
- If IRT (Isochronous Real Time) is configured:
  - All IO devices in multiple use IO systems must belong to the same sync domain.
  - The sync domain must not include any other IO devices.
- IE/PB Links cannot be operated as an IO device in a multiple use IO system with STEP 7 V13.

Configuration

You specify whether or not a configuration can be used multiple times in the properties of the IO system.

All other parameter settings for the configured devices are then set automatically by STEP 7 and checked during compilation.

Boundary conditions

To prevent a standard machine project from having dependencies on other devices outside of the machine, observe the following:

- A standard machine project consists of an IO controller and the corresponding IO devices. You should therefore configure only one CPU as IO controller and the corresponding IO devices in the standard machine project.
- Do not use connection configured at both ends for the communication. Instead, use only a connection configured at one end or unspecified connections if necessary.

  Background: To configure the communication in a STEP 7 project, it is always possible to set the IP address parameters in the project. For multiple use IO systems, however, this strategy is not possible since the IP address parameters of the IO controller and the assigned IO devices are assigned locally. At the time of the configuration, the IP address parameters are therefore unknown.

  If you nevertheless want to configure communication with devices on PROFINET, for example with a central coordinator, you can only use communications mechanisms that allow dynamic assignment of the IP address parameters in the user program.

  Example: Open User Communication

  If, for example, the device is configured as an active end point (initiator of the connection), the IP address parameters can be stored, for example, in a data block. You then supply the data block with the currently valid IP address parameters during commissioning. For this dynamic type of IP address parameter assignment, there is no system support; in other words, if you change the configuration of the system, the IP address parameters are not automatically adapted.

  You will find a description of handling instructions for Open User Communication under this keyword in the STEP 7 online help.

5.9.1.2 Configuring multiple use IO systems

Requirements

- STEP 7 as of V13
- The IO controller supports the "Multiple use IO system" function, for example a CPU 1512SP-1 PN as of firmware version 1.6.

Procedure

The configuration of a series machine using an S7-1500-CPU as an example is described below.

To create a standard machine project, follow these steps:

1. Create a project.
2. Configure a CPU as the IO controller, for example a CPU 1518-4 PN/DP as of firmware version 1.5.
3. Configure the required IO devices and assign the IO devices to the IO controller.
4. Configure the port interconnection between the devices.
5. Select the IO system so that you can edit the properties in the inspector window.
6. Select the "Multiple use IO system" check box in the "General" area of the inspector window.

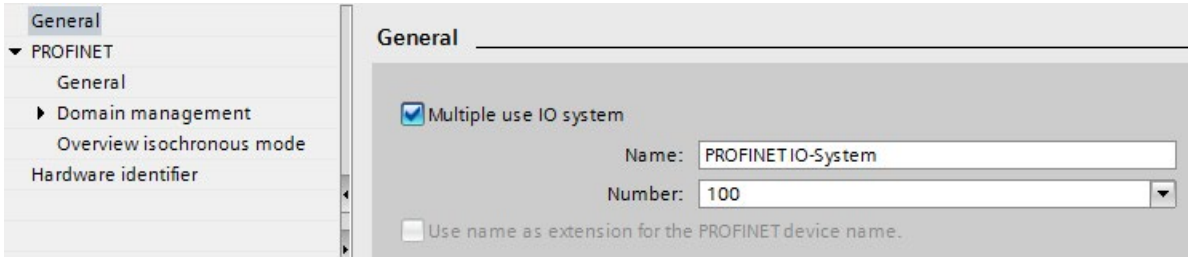


Figure 5-78 Activate "Multiple use IO system"

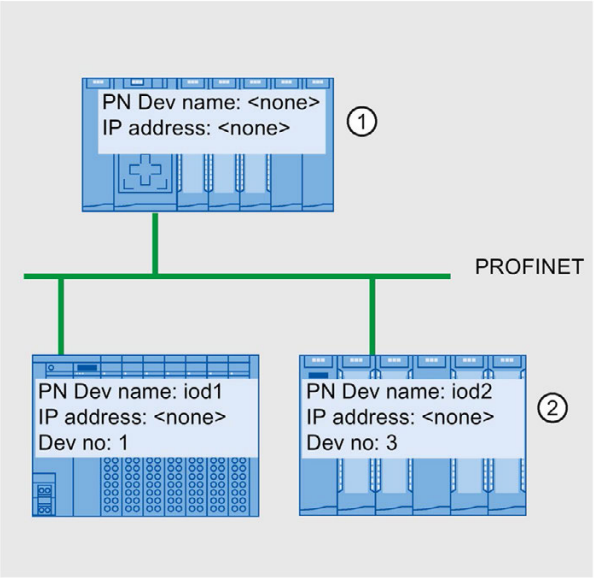
Result: The following settings are made by STEP 7:

- The device name of the IO controller (CPU) in the standard machine project is set to "PROFINET device name is set directly at the device". The IO controller (CPU) has no PROFINET device name initially.
- The IP protocol of the IO controller (CPU) is set to "IP address is set directly at the device". The CPU has no IP address initially.
- The "Support device replacement without exchangeable medium" option is selected automatically. This option enables automatic commissioning. A commissioning engineer does not have to assign device names to the IO devices locally. The IO controller assigns the device name and IP address to the IO devices based on the preset topology and other settings during startup.
- The device name of the IO devices is set to "Generate PROFINET device name automatically" (from the configured name of the IO device).
- The IP protocol of the IO devices is set to "IP address is set by the IO controller during runtime". The IO devices have no IP address initially. If an IO device is not a typical distributed I/O system (e.g., ET 200 systems), but rather another device such as an HMI device, change the option to "IP address is set directly at the device"; see below.
- The device number for the IO devices is automatically assigned and is used locally for making the IP address unique.

The option "Permit overwriting of PROFINET device name" must be selected (CPU parameters, properties of the PROFINET interface, Ethernet addresses area) so that the IO controller can adapt the device name later at the operator.

This option is disabled by default.

The following figure shows the above-described settings for the IP address and PROFINET device name.



① After the configuration is loaded from the standard machine project, the IO controller has no device name and no IP address.

② Following loading, the IO devices have a device name and a device number but no IP address.

Figure 5-79 Settings for the IP address and the PROFINET device name

How an IO device obtains an IP address locally

Below, you will find an explanation of the "IP address is set by the IO controller during runtime" and "IP address is set directly at the device" options, which can generally be configured for a multiple use IO system.

If you have set the "Multiple use IO system" option for the IO system, STEP 7 automatically sets the "IP address is set by the IO controller during runtime" option for the IO devices.

In this case, the IO controller assigns the IO device an IP address that results from the locally assigned IP address of the IO controller (see next section). This option is appropriate if the IO device is a field device, e.g., ET 200MP, ET 200SP, ET 200AL, or another distributed I/O system.

If the IO device is not a "standard" field device, for example, an HMI device for a Windows operating system, the "IP address is set by the IO controller during runtime" option described above does not work. In this case, choose the "IP address is set directly at the device" option. You must then assign the IP address to the device locally and take steps to ensure that this address is suitable for the IP addresses of the other IO devices and the IP address of the IO controller.

5.9.1.3 Adapt multiple use IO systems locally

A few steps are needed to adapt the machine that was loaded with the standard machine project.

Only the device name and IP address of the IO controller must be adapted locally. The device names and IP addresses of the IO devices result from these adaptations. In this example, the effects of local settings are described for two specific machine modules.

The local settings are possible, for example, with the CPU display and commissioning tools such as Primary Setup Tool (PST) or PRONETA. You do not need a programming device with STEP 7 to make these settings, even though it is possible to do so.

Requirements

- The machine was loaded with a standard machine project (see Configuring multiple use IO systems (Page 204)).
- The display is ready for operation and the desired tool for assigning the IP address and device name is available (e.g., PST Tool, STEP 7).
- The ports of the IO controller and IO devices are interconnected according to the configuration.

Procedure

Observe the boundary conditions and instructions for commissioning an S7-1500. For more information on commissioning an S7-1500 CPU, refer to the system manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792).

To adapt a standard machine locally, follow these steps:

1. Integrate the machine into the network.
2. Connect the device for assigning the IP address and device name to the CPU, for example a PG/PC with the appropriate software.
3. Assign the desired device name and IP address to the IO controller.
4. Start up the CPU.

The IO controller then assigns the adapted PROFINET device name and a unique IP address to the IO devices.

The following rules apply to the assignment:

- The device names of the IO devices are formed by chaining together the following name components, separated by a period:

  <configured name of the IO device from the standard machine project>.<name of the associated IO controller set on the device>

- The IP addresses of the IO devices result from the locally configured IP address of the associated IO controller and the device number (sum).

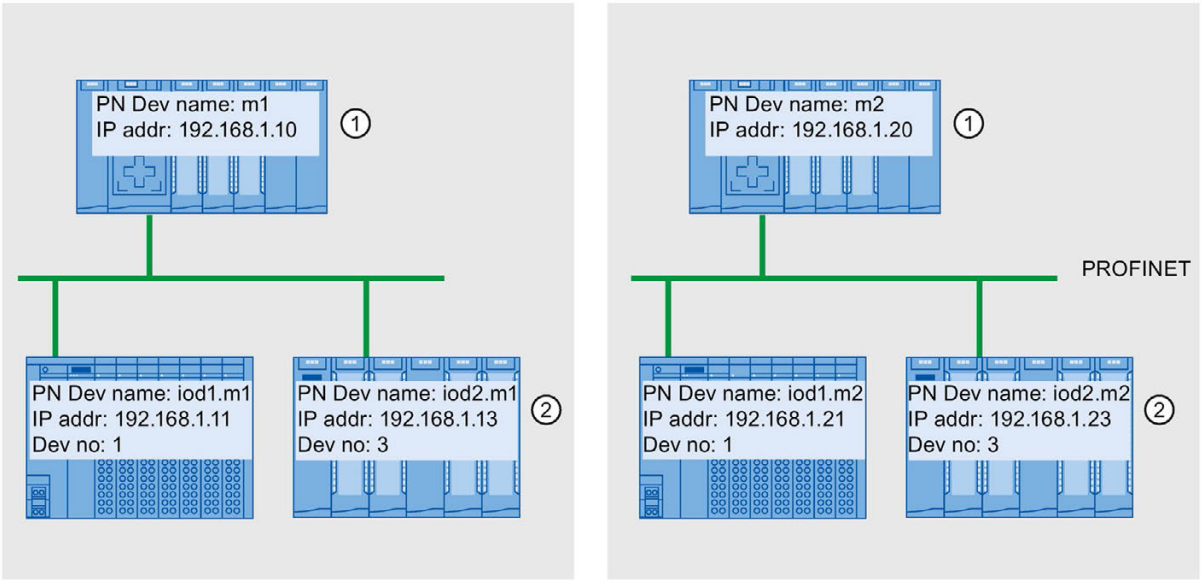
Note

Make sure that duplicate IP addresses cannot be created on the subnet during the assignment. The IO controller does not assign a new IP address in this case.

In the following figure, the device name "m1" and the IP address 192.168.1.10 have been assigned to the IO controller of the first machine.

The device name "m2" and the IP address 192.168.1.20 has been assigned for the second machine.

Refer to the figure for the resulting device names and IP addresses.



① Set device name and IP address on the IO controller

② After startup, the IO devices have an updated device name (<configured device name>.<device name of IO controller>) and an adapted IP address (= <IP address of IO controller> + <device number>)

Figure 5-80 Example of the assignment of IP addresses and device names at "Multiple use IO system"

See also

Configuring multiple use IO systems (Page 204)

5.9.2 Configuration control for IO systems

5.9.2.1 Information about configuration control of IO systems

Configuration control of IO systems makes it possible to generate several concrete versions of a standard machine from a standard machine project.

You are given the flexibility to vary the configuration of an IO system for a specific application as long as the real configuration can be derived from the set configuration. The configured configuration therefore represents the superset of all real configurations that can be derived from it.

The following figure shows an example of how two IO systems with a different number of IO devices arise from one standard machine project.

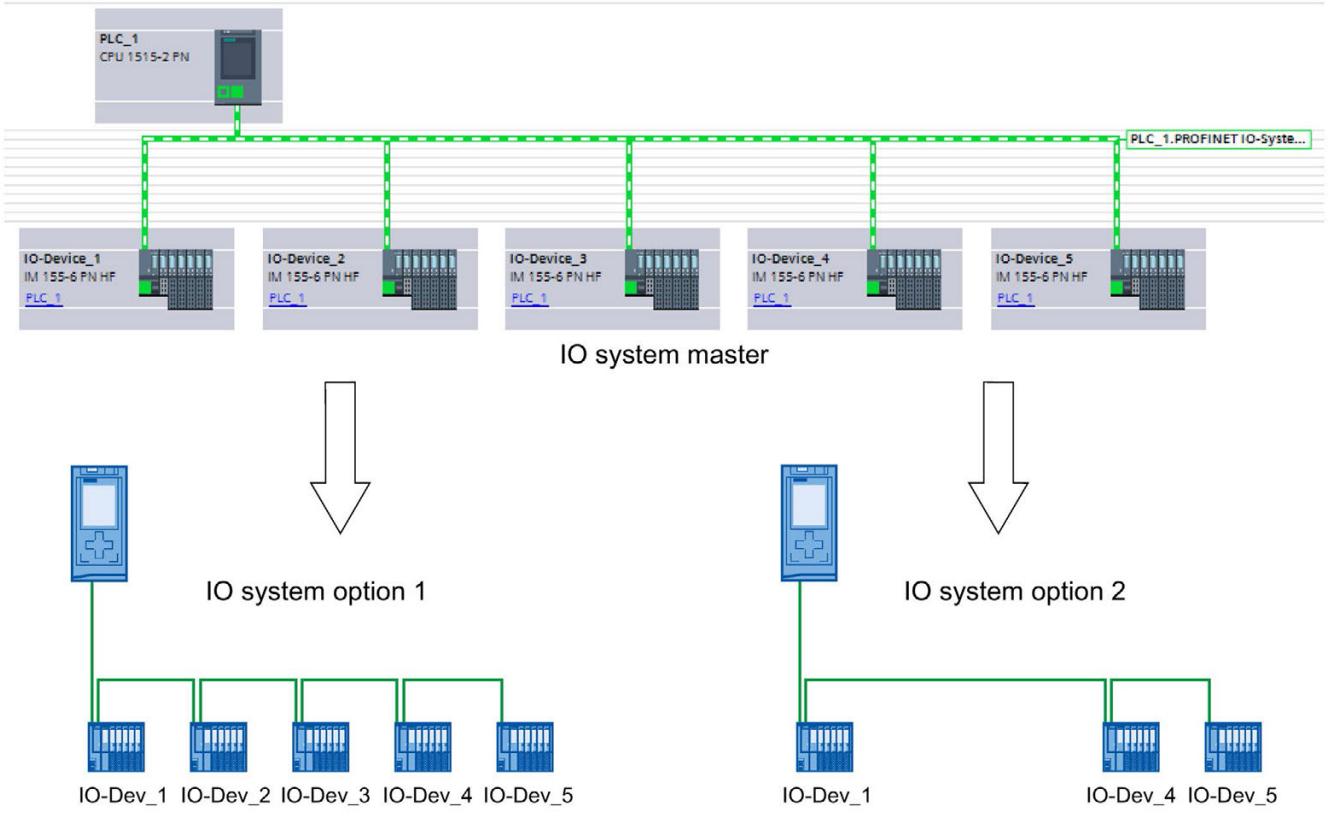


Figure 5-81 Example of configuration control for PROFINET IO systems

In the following sections, you find a description of how to configure and program a PROFINET IO system to commission, for example, a standard machine on-site without using configuration software.

Concept

The principle of configuration control is already known at the device level for the flexible use of submodules/modules ("option handling"). Different configurations can be derived from one engineering project both for central as well as for distributed I/O.

With S7-1500 CPUs as of firmware version V1.7, this principle can also be applied at the IO system level. You have the option of omitting, adding or changing the order of stations (IO devices) of a PROFINET IO system in a specific plant.

Configuration control for devices and configuration control for IO systems can be combined; the functions are independent of each other.

It is possible to operate variants deviating from a maximum configuration of an IO system. In a standard machine project, you can prepare a kit of IO devices which can be flexibly customized for various configurations using configuration control.

The following variations are available:

- Variation of the number of IO devices involved

  You include optional IO devices for the configuration control in the configuration by transferring a suitable data record with the required configuration in the user program.

- Variation of the order of IO devices involved

  You adapt the port interconnection of the IO devices to the topology being used by transferring a suitable data record with the required topology in the user program.

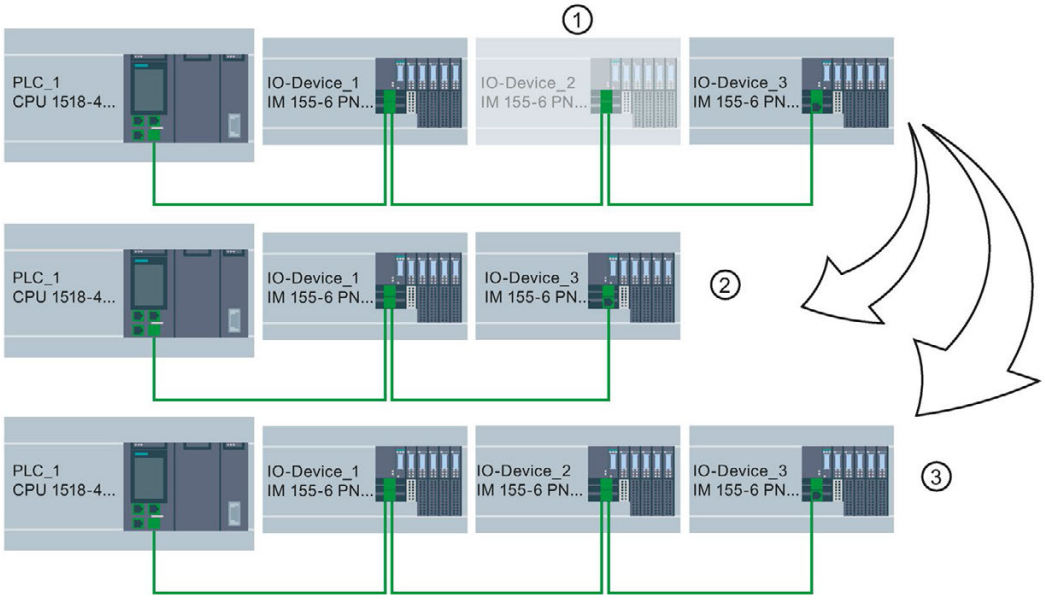
The following figure shows how you serve two different configurations with an IO device marked as optional in the network view of STEP 7.

- Configuration without the optional IO device:

  In this case, you use the instruction "ReconfigIOSystem" to transfer a data record to the PROFINET interface containing the information that no optional IO device is to be included in the configuration.

- Configuration with the optional IO device:

In this case, you use the instruction "ReconfigIOSystem" to transfer a data record to the PROFINET interface adding the optional IO device to the configuration.



① Determined through parameter assignment: IO Device_2 is optional IO device
② Configuration without the optional IO device
③ Configuration with the optional IO device

Figure 5-82 Example configuration with "Optional IO device" and the associated configuration options

Summary: The procedure in principle

The following phases are distinguished when it comes to the implementation of a standard machine concept:

1. Engineering phase: Creating a standard machine project and loading into specific machine or plant:
   - Completely configuring all IO devices (options) ever required in a specific machine or plant
   - Configuring as optional those IO devices that will be omitted in specific machines or plants
   - Configuring the interconnection of ports with respect to various arrangements of IO devices
   - Preparing user program (see Configuring flexible order of IO devices (Page 219)) with the possibility of selecting on-site the actually existing configuration via switch or HMI device
2. Commissioning phase: Preparing specific machine or plant for operation:
   - Integrating machine or plant in the on-site network (see Adapt multiple use IO systems locally (Page 207))
   - Selecting the currently existing configuration of the IO system via configured option

5.9.2.2 Configuring IO devices as optional

Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516-3 PN/DP as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- The rules (Page 225) for the establishment and operation of a standard machine project have been considered.

Procedure

To configure an IO device as optional IO device, proceed as follows:

1. Create a project.
2. Configure an S7-1500 CPU firmware version V1.7 or higher as IO controller.
3. Configure the required IO devices and assign the IO devices to the IO controller.
4. Configure the port interconnection between the devices.

Note

A port interconnection between the devices of the IO system is mandatory for IO systems to be customized with the user program. Otherwise, no order would be defined for the interconnected IO devices. The following settings are possible for the partner port:

- Specific partner port of an IO device (selection via the "Partner port" drop-down list in the port properties or interconnection with drag-and-drop in the topology view)
- "Setting partner port by user program" (selection via the "Partner port" drop-down list in the port properties).

5. Select the IO device you want to mark as optional.
6. Select the area "PROFINET interface [X1]" > Advanced options".
7. Enable the "Optional IO device" option.
8. Repeat steps 5 to 7 for all IO devices to be configured as optional.
9. Load the configuration onto the CPU.

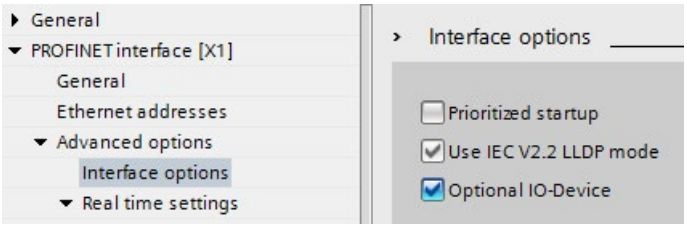


Figure 5-83 Configure the IO device as an optional IO device

Result: Once this configuration is loaded, the system behavior is as follows:

- The CPU is prepared for the configuration control of the IO system.
- All IO devices are disabled.
- Irrespective of whether you customize the configuration with the user program (adding optional IO devices) or make no changes to the loaded configuration: You must call the instruction "ReconfigIOSystem" in the user program and notify the current configuration to the system!

  The system will not be operational without calling the instruction "ReconfigIOSystem".

  For further information on the proceeding see Enabling optional IO devices in the program (Page 213).

Fast parameter assignment in the "IO communication" table

You can also specify whether or not an IO device is optional in the "IO communication" tab.

In an additional "Optional IO device" column, a selectable check box is available for each IO device that indicates whether or not an IO device is optional. Here, you can adjust the setting centrally.

5.9.2.3 Enabling optional IO devices in the program

Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516-3 PN/DP as of firmware version 1.7
- STEP 7 V13 SP1
- At least one IO device was configured as optional IO device.
- The rules (Page 225) for the establishment and operation of a standard machine project have been considered.

Procedure

Observe the information on and rules for commissioning in the documentation for SIMATIC S7-1500, for the ET 200SP CPUs and for the CPU 1516pro-2 PN.

The following description of the proceeding only includes steps required to understand the program-controlled activation of an optional IO device.

To activate or deactivate IO devices, follow these steps:

1. Create a data record "CTRLREC" for the instruction "ReconfigIOSystem". You can find information on the structure of the data record in the STEP 7 online help.

2. Call the instruction "ReconfigIOSystem" and select MODE 1 to deactivate all IO devices.

   If you set the CPU to STOP or POWER OFF state in order to modify the plant in this status (for example to add an optional IO device), explicit deactivation using "ReconfigIOSystem" with mode 1 is not necessary. In this case, i.e. following a STOP-RUN transition and following a POWER-OFF > POWER-ON transition, all IO devices are deactivated automatically.

3. When you have brought the plant to a safe status that allows restructuring without any danger:

   Put the plant together according to your intended application. Add the required optional IO devices at the points at which you planned this in the configuration (observe the order!) or remove optional IO devices that you no longer require.

4. Network the IO devices.

5. Startup the S7-1500 system and call again the instruction "ReconfigIOSystem". Select MODE 2 to transfer the data record CTRLREC.

6. Following successful transfer of the data record, call again the instruction "ReconfigIOSystem". Select MODE 3 to activate all IO devices forming part of the current configuration.

   Result: The CPU **activates** the following IO devices:

   – All IO devices that you have not set as optional IO devices.

   – All optional IO devices listed in the control data record (CTRLREC).

   The following IO devices remain **disabled**:

   – Docking units (IO devices changing during operation).

   – Optional IO devices that are not listed in the control data record.

Note

Call the instruction "ReconfigIOSystem" for all values of the parameter MODE with the same control data record (CTRLREC)!

If you use different data records for the values of the MODE parameter, this results in an inconsistent customization of the configuration and thus to rather incomprehensible error messages.

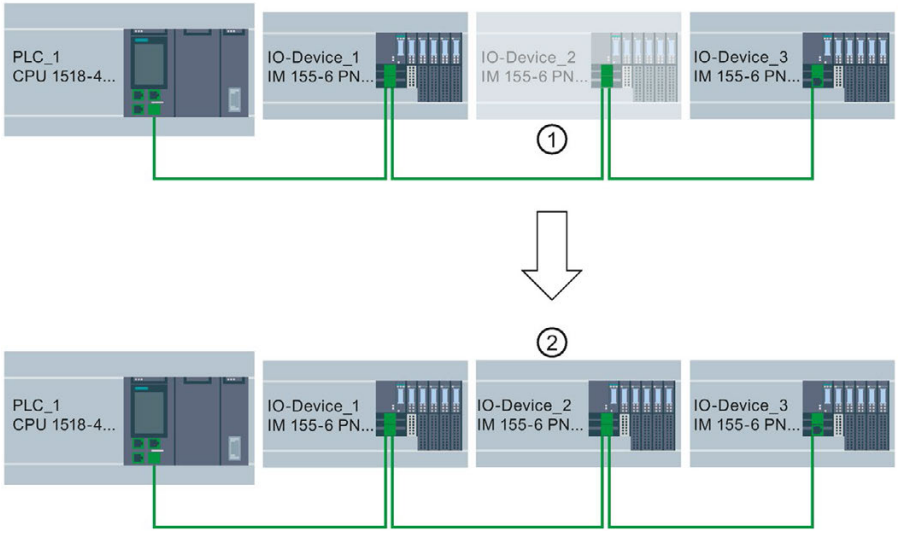
Example: Data record structure for the activation of an IO device

The IO device "IO-Device_2" is to be activated as the only IO device in the user program.

To do this, you only require the hardware identifier of "IO-Device_2".

Recommendation: Use the system constants of the hardware identifiers instead of the absolute values as shown in this example. With this procedure, the content of the DB is not influenced by changes to the hardware identifiers as the result of changes to the configuration.

The data record is to be stored in a data block and to be transmitted to the PROFINET interface of the IO controller in the user program using the instruction "ReconfigIOSystem".



① IO device_2 is configured as optional IO device.

② Once the data record is transmitted and the configuration is activated using the instruction "ReconfigIOSystem" IO device_2 is included in the configuration and participates in the data exchange with the IO controller.

Figure 5-84 Example: Activating an optional IO device

Creating data block

In this example, the control data record is created in a data block. The data block is structured as follows:

Line 2: Array definition: Array of type Word with 4 elements. Array of Word is permitted as the data type.

Line 3: Version of the data record (currently: V1.0).

Line 4: Number of optional IO devices to be activated (here: 1).

Line 5: List of the hardware identifiers of the IO devices, inserted here as system constants.

Line 6: Number of port interconnections that are set in the user program (here: 0).

Line 7: Additional data records (optional)

myCTRLREC

	Name	Data type	Start value	Comment
1	Static			
2	ArrMachineConfig0	Array[0..3] of Word		Array for one optional IO device
3	ArrMachineConfig0[0]	Word	16#0100	
4	ArrMachineConfig0[1]	Word	16#0001	
5	ArrMachineConfig0[2]	Word	"IO-Device_2~IODevice"	
6	ArrMachineConfig0[3]	Word	16#0000	
7	ArrMachineConfig1	Array[0..8] of Word		

Figure 5-85 Data block with control records

Parameter MODE of instruction "ReconfigIOSystem"

You control how the "ReconfigIOSystem" instruction works with the MODE parameter.

The following values are possible for the MODE input parameter:

MODE	Description
1	All IO devices of the IO system can be disabled by calling the instruction with MODE 1. The "ReconfigIOSystem" instruction uses the "D_ACT_DP" instruction internally. "ReconfigIOSystem" returns errors that are detected by D_ACT_DP in the following output parameters: • STATUS (error code) • ERR_INFO (hardware identifier of the IO device causing the error). In STATUS and ERR_INFO, the CPU enters the last determined error/HW identifier and in so doing overwrites an existing error code. For this reason, additional errors can be present besides the entered error.
2	For controlling the actual configuration of the IO system, the instruction transfers the data record to the PROFINET interface, which is addressed with LADDR block parameter (HW identifier of the PROFINET interface).
3	All non-optional IO devices in the IO system and optional IO devices that are listed in the control data record CTRLREC are enabled. The optional IO devices that are **not** listed in the CTRLREC data record remain disabled. If IO devices that are part of docking units (alternating IO devices in operation) are listed in the CTRLREC control data record, the PN IO system reacts as follows: • IO devices of the docking units remain disabled when ReconfigIOSystem is called with MODE 3. This reaction corresponds to the reaction of a configuration without configuration-controlled IO devices. IO devices of docking units are disabled by default and must be enabled in the user program. For more information on docking units, refer to the section Docking systems (Page 229).

Rules for the call sequence of "ReconfigIOSystem"

- Always supply the instruction "ReconfigIOSystem" with the same control data record (CTRLREC input parameter)!
- Call sequence following POWER OFF -> POWER ON transition:
  - ReconfigIOSystem call with MODE 1 (optional).
  - ReconfigIOSystem call with MODE 2 (mandatory, even without previous reconfiguration!).
  - ReconfigIOSystem call with MODE 3 (mandatory).
- Call sequence following STOP > RUN transition:
  - ReconfigIOSystem call with MODE 1 (optional).
  - ReconfigIOSystem call with MODE 2 (mandatory, even when configuration was modified in STOP state). Otherwise not required).
  - ReconfigIOSystem call with MODE 3 (mandatory).
- Call sequence for reconfiguration in RUN state:
  - ReconfigIOSystem call with MODE 1 (mandatory).
  - ReconfigIOSystem call with MODE 2 (mandatory).
  - ReconfigIOSystem call with MODE 3 (mandatory).

Explanations and recommendations concerning the rules

- If you do not list an IO device to be configured as optional IO device in the control data record or data block resp. this IO device does not form part of the configuration and does not take part in data exchange with the CPU.
- If you do not activate any optional IO device at all and work with the loaded configuration without reconfiguration, you still have to follow the proceeding described in the above section and transmit the control data record to the CPU.

  The control data record has the simple structure with the following tags:
  - Version (High Byte =1, Low Byte = 0)
  - Number of optional devices to be activated = 0
  - Number of port interconnections that are set in the user program = 0
- Following a STOP > RUN transition and following a POWER-OFF > POWER-ON transition, all IO devices are deactivated automatically. For this reason, no ReconfigIOSystem call with MODE 1 is required for configuration control to function properly.

  If you use your project as a universally valid sample for programming the configuration control, we still recommend to perform the ReconfigIOSystem call with MODE 1 prior to any reconfiguration. This way, the sample can also be used for reconfigurations in RUN mode.

- Commissioning extensive I/O systems (more than 8 optional IO devices) while using IRT at the same time:

  To keep the startup times short when activating the optional IO devices (ReconfigIOSystem, mode 3), note the following tip: Check the device numbers of the IO devices. The device numbers should follow the topological interconnection starting at the IO controller in ascending order. The further an IO device is from the IO controller topologically, in other words the more IO devices there are between the IO controller and the IO device in question, the higher the device number should be.

  You set the device numbers in the "Ethernet addresses - PROFINET" area in the Inspector window with the PROFINET interface selected.

  Example of the assignment of device numbers with a linear topology:

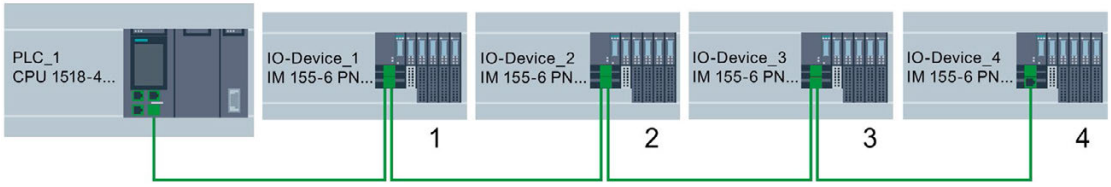


Figure 5-86 Example: Device numbers in a line topology

- The CPU processes the instruction "ReconfigIOSystem" to transfer the control data record asynchronously.

  For this reason, you must call "ReconfigIOSystem" in a loop repeatedly when calling the instruction in the startup program until the output parameter "BUSY" or "DONE" indicate that the data record has been transferred.

  Tip: To program the loop, use the SCL programming language with the instruction REPEAT ... UNTIL.

```
REPEAT

    "ReconfigIOSystem"(REQ := "start_config_ctrl",

                MODE := 1,

                LADDR := 64,

                CTRLREC := "myCTRLREC".ArrMachineConfig0,

                DONE => "conf_DONE",

                BUSY => "conf_BUSY",

                ERROR => "conf_ERROR",

                STATUS => "conf_STATUS");

UNTIL NOT "conf_BUSY"

END_REPEAT;
```

Additional information

For information on the basic structure of the data record and on using the instruction "ReconfigIOSystem" see the STEP 7 online help.

See also

Configuring IO devices as optional (Page 212)

5.9.2.4 Configuring flexible order of IO devices

The following section shows how you can create the conditions required to change the order of IO devices in a PROFINET IO system.

This function is also supported with optional IO devices. For simplicity, a maximum configuration without optional IO devices is shown below.

Concept

A typical application for a standard machine project consists of composing an entire plant from a set of various plant units which only differ with respect to the different arrangement of the units, e.g. in the case of transport systems. Each plant unit consists of a functional unit of mechanics (rails or conveyor belts) and electrics (power supply, IO device with IO modules, sensors, actuators, motors, PROFINET port for data exchange with central control ...).

The following figure shows how, simply by exchanging two rail segments, a new transport system is created that is adapted with an upstream points to the local conditions.

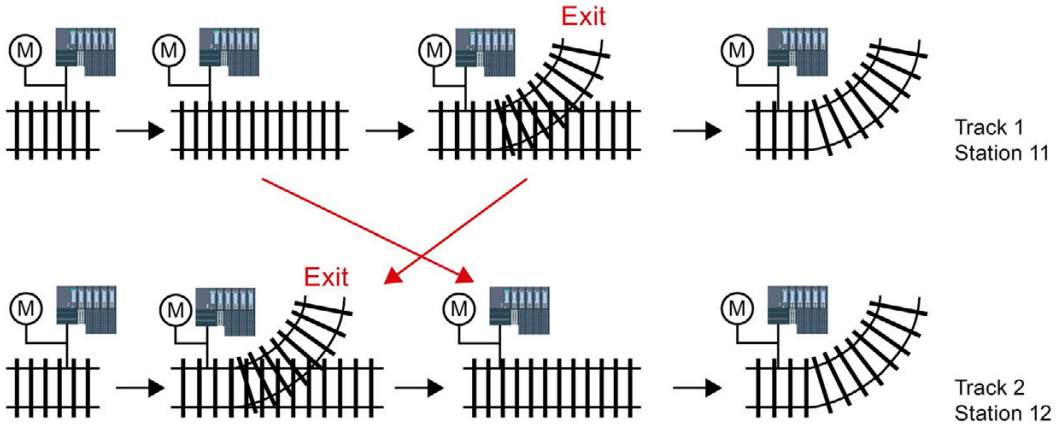


Figure 5-87 Example: Changing the arrangement of IO devices

From the automation viewpoint, no change in the project is required for the flexible adjustment of the PROFINET configuration.

The order of the IO devices is determined by the port interconnection. For each IO device, you define in the port properties the partner port and thus the neighboring device connected at the respective local port. If the partner port is to be defined by the user program, the option "Partner set by user program" is to be selected as partner port.

The figure below shows the initial configuration of the transport system shown above, which is to permit the order of the connected IO devices to be changed via the user program. In the example, the order of IO-Device_2 and IO-Device_3 is to be controlled via the user program.

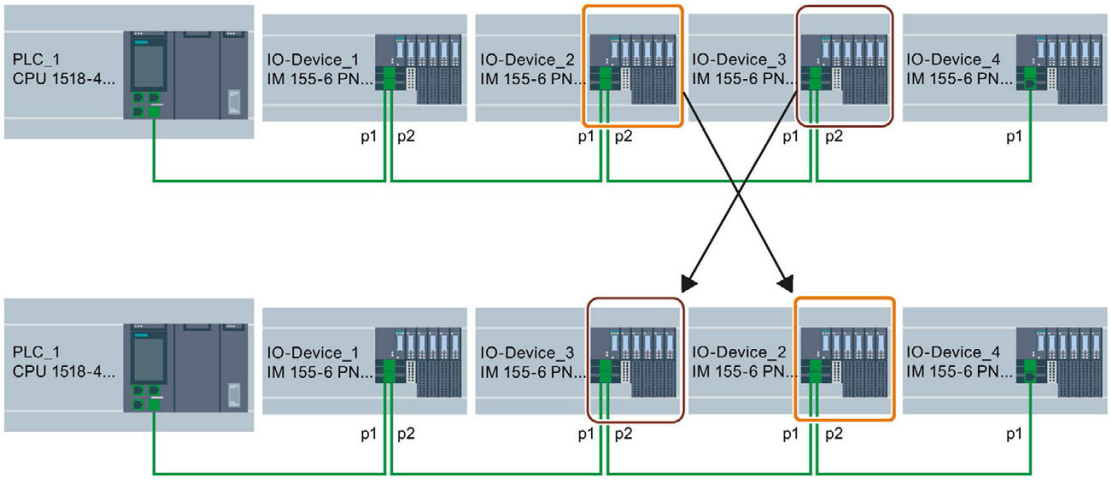


Figure 5-88 Example configuration: Configuring flexible order of IO devices

To determine how the partner port settings are to be selected, you must note for each device and each port of a device which partner can be interconnected.

- If the partner is always the same in the different configurations provided, you select the partner port for this partner.
- If the partners vary in the different configurations, you select "Setting partner by user program".

For the example in the figure above, the following port settings result:

Device	Local port	Partner port setting	Explanation
PLC_1	p1	p1 (IO device_1)	Partner of PLC_1 at port 1 is IO device_1 (always)
IO device_1	p1	p1 (PLC_1)	Partner of IO device_1 at port 1 is PLC_1 (always)
IO device_1	p2	Partner is set by user program	Partner of IO device_1 at port 2 is either IO device_2 or IO device_3 => Setting partner by user program
IO device_2	p1	Partner is set by user program	Partner of IO device_2 at port 1 is either IO device_1 or IO device_3 => Setting partner by user program
IO device_2	p2	Partner is set by user program	Partner of IO device_2 at port 2 is either IO device_3 or IO device_4 => Setting partner by user program
IO device_3	p1	Partner is set by user program	Partner of IO device_3 at port 1 is either IO device_2 or IO device_1 => Setting partner by user program
IO device_3	p2	Partner is set by user program	Partner of IO device_3 at port 2 is either IO device_4 or IO device_2 => Setting partner by user program
IO device_4	p1	Partner is set by user program	Partner of IO device_4 at port 1 is either IO device_3 or IO device_2 => Setting partner by user program
IO device_4	p2	Any partner	No partner planned at port 2

Requirements

- IO controller supports configuration control for IO systems, for example CPU 1515-2 PN as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- The rules (Page 225) for the establishment and operation of a standard machine project have been considered.

Procedure

To set the partner port for a program controlled interconnection, proceed as follows:

1. Select the PROFINET interface of the device (IO controller or IO device) whose port you want to set.
2. In the properties of the PROFINET interface, select the area "Port interconnection" (Extended options > Port [...] > Port interconnection).
3. From the drop-down list, select "Setting partner by user program" as partner port.
4. Repeat steps 1 to 3 for each port to be interconnected via the user program.

See also

Customizing arrangement of IO devices in the program (Page 222)

5.9.2.5 Customizing arrangement of IO devices in the program

Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516pro-2 PN as of firmware version 1.7 as an IO controller
- STEP 7 V13 SP1
- At least one partner port was configured as "Partner set by user program".
- The rules (Page 225) for the establishment and operation of a standard machine project have been considered.

Procedure

The proceedings corresponds to the proceeding for activating optional IO devices.

Only the structure of the data record must be extended for the program-controlled assignment of the ports. The extension is described in the following sections.

Example: Data record structure for the assignment of partner ports

For the data record structure, you need the HW identifications of the ports.

The data record is to be stored in a data block and to be transmitted to the PROFINET interface of the IO controller in the user program using the instruction "ReconfigIOSystem".

As the input parameter RECORD of the instruction "ReconfigIOSystem" is of the VARIANT data type, you first have to create a data type for the data block.

In the following sections, you find a description of the structure of the PLC data type as well as of the structure of the data block based on this type.

Selecting derived configuration

For the following selected configuration it is shown below what the data record must look like so that the IO devices are interconnected in the planned order by the user program.

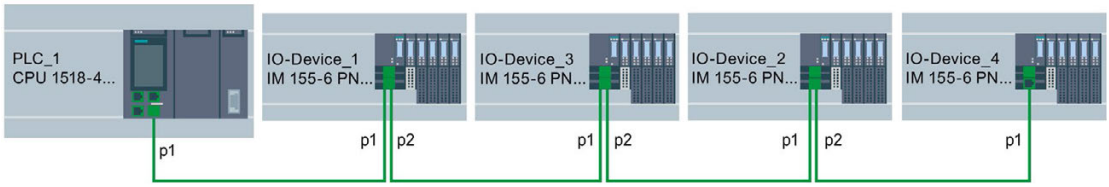


Figure 5-89 Example configuration: Customizing arrangement of IO devices in the user program

This example is based on the flexible configuration from the previous section (Page 219) with the settings for the respective partner ports described there.

The partner ports in the specific derived configuration have been defined so that it is possible to name the HW identifications of the ports involved.

The following table only contains those devices whose ports can be defined by the user program. Only these devices are relevant for the data record structure.

Device	Local port	Partner port setting	Partner port of the selected configuration
IO device_1	p2 = Port 2 HW identifier: 251	Partner is set by user program	Port 1 of IO device_3 HW identifier: 261
IO device_2	p1 = Port 1 HW identifier: 281	Partner is set by user program	Port 2 of IO device_3 HW identifier: 291
IO device_2	p2 = Port 2 HW identifier: 311	Partner is set by user program	Port 1 of IO device_4 HW identifier: 321

Creating data block

For the derived configuration, the structure of the data block "DB-IO-SYSTEM-Port-Interconnections" is explained as an example.

This data block is used when calling the instruction "ReconfigIOSystem" at input parameter "CTRLREC".

Instead of the absolute values for the hardware identifiers of the ports, the system constants of the hardware identifiers are used here.

The data block is structured as follows:

Line 2: Declaration of an Array of Word (only this data type is possible).

Line 3: Version of the control data record: V1.0.

Line 4: Number of optional IO devices: 0.

Line 5: Number of specified port interconnections: 3.

Line 6: Port interconnection 1, local port.

Line 7: Port interconnection 1, partner port.

Line 8: Port interconnection 2, local port.

Line 9: Port interconnection 2, partner port

Line 10: Port interconnection 3, local port.

Line 11: Port interconnection 3, partner port.

IO-SYSTEM-Port-Interconnections

		Name	Datentyp	Startwert	Kommentar
1		Static			
2		ArrMachineConfig	Array[0..8] of Word		data record for port interconn settings
3		ArrMachineConfig[0]	Word	16#0100	
4		ArrMachineConfig[1]	Word	16#0000	
5		ArrMachineConfig[2]	Word	16#0003	
6		ArrMachineConfig[3]	Word	"IO_device_1~PROFINET_interface~Port_2"	
7		ArrMachineConfig[4]	Word	"IO_device_3~PROFINET_interface~Port_1"	
8		ArrMachineConfig[5]	Word	"IO_device_2~PROFINET_interface~Port_1"	
9		ArrMachineConfig[6]	Word	"IO_device_3~PROFINET_interface~Port_2"	
10		ArrMachineConfig[7]	Word	"IO_device_2~PROFINET_interface~Port_2"	
11		ArrMachineConfig[8]	Word	"IO_device_4~PROFINET_interface~Port_1"	

Figure 5-90 Data block with data record for port interconnections

Interconnection not listed in data block

If the partner port was configured as "Setting partner by user program" in the port properties and this port is not listed in the data record or data block resp., then the CPU sets this port to the setting "any partner". If no data record is transmitted at all, the CPU sets this "any partner" setting for all program-controlled assignments.

Additional information

For information on the basic structure of the data record and on using the instruction "ReconfigIOSystem" see the STEP 7 online help.

5.9.2.6 System behavior and rules

Below, you find a description of how an IO system whose configuration is controlled by the user program behaves in operation.

In addition, rules and restrictions are listed here which must be considered when configuring the maximum structure of the configuration in a standard machine project.

System behavior

- System diagnostics:

  If an optional IO device is deactivated, the IO device is displayed as "deactivated" from the system diagnostics viewpoint (online view or Online & Diagnostics).

- Topology view:

  Offline view: As configured. No interconnection is shown for ports with partner ports configured as "Setting partner by user program".

  Online view: Ports and interconnections with deactivated IO devices are shown in a different shade of green as error-free ports and interconnections of activated IO devices.

- Representation in the Web server:

  The names of devices are shown as configured (Properties > General > Project information).

  The assigned PROFINET device name for the CPU is shown on the "Communication" website, at the "Parameter" tab.

  IP address parameters: Currently assigned IP address parameters are shown on the site "Module state".

  Topology: The current topology resulting from any customizations via user program is shown in the Web server. IO devices configured as optional are shown as "deactivated" IO devices in the Web server.

Rules

The rules for standard machine projects as described here (Page 200) apply.

For configuration-controlled IO systems, the following additional rules apply:

- When configuring MRP (Media Redundancy Protocol):

  The ports configured as ring ports must not be interlinked via user program.

  However, devices with ring ports (devices of an MRP domain) can be optional IO devices.

- When configuring docking stations (= IO devices changing during operation):

  Neither the docking station nor the first IO device of a docking unit may be optional IO devices.

  The ports of the docking units must not be interlinked via user program.

- When configuring IRT:

  The order of synchronized IO devices ("IRT devices") must be defined by the configuration and must not be changed in the different variants of a standard machine. For this reason, the ports of the IRT devices must not be interlinked via user program.

  However, you have the possibility to configure IRT devices primarily as optional IO devices.

  You also have the option to interconnect, by user program, RT devices that are, for example, separated from this line by a switchport (see figure).

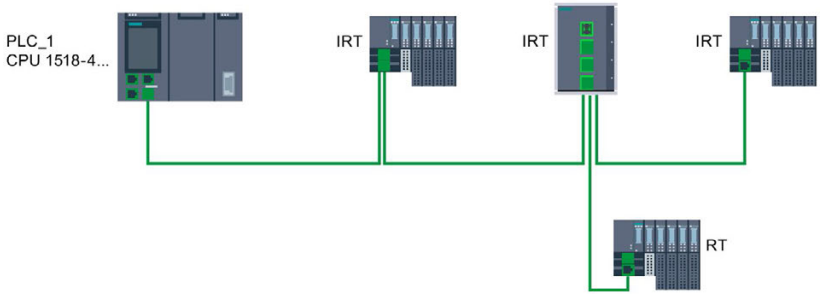


Figure 5-91 Example: Configuration control for IO systems with separated RT device

5.10 Saving energy with PROFIenergy

Saving energy with PROFIenergy

PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. Through this, the process should only be provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.

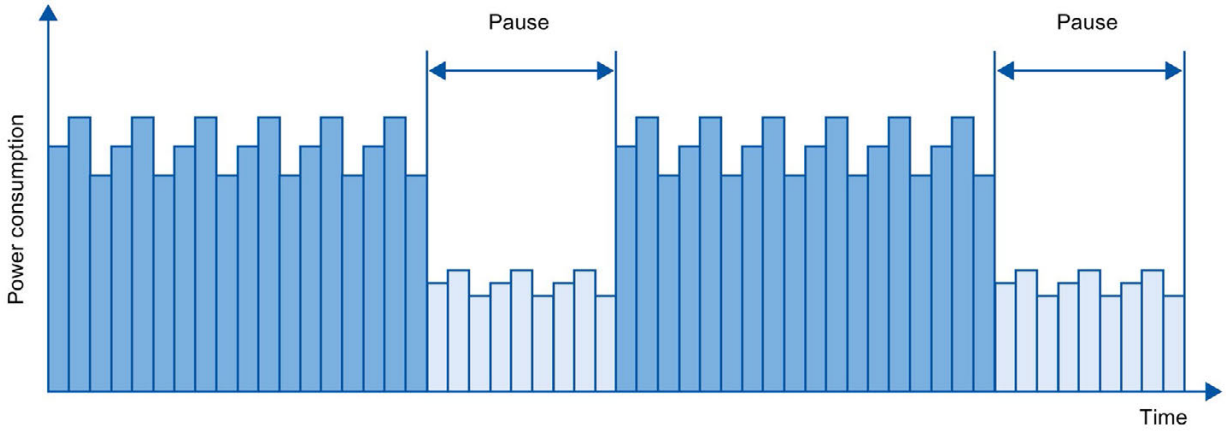


Figure 5-92 Energy savings during pauses with PROFIenergy

Basic information

In order to use the PROFIenergy functionality, the existing IO controller has to be "upgraded" to a so-called "PROFIenergy controller" by means of a function block in the PROFINET IO system and at least one PROFIenergy-capable IO device ("PROFIenergy device") has to exist. The PROFIenergy commands (for example to start or end a pause) are sent by the "PROFIenergy controller" to the individual "PROFIenergy devices". Each "PROFIenergy device" decides individually how it responds to the PROFIenergy command (response is device- and manufacturer-specific).

No additional hardware is needed; the PROFIenergy commands are directly interpreted by the PROFINET devices.

Principle of operation

At the beginning and end of pauses, the system manager enables or disables the pause function of the system; then the IO controller sends the PROFIenergy command "Start_Pause"/"End_Pause" to the PROFINET devices. The device interprets the contents of the PROFIenergy command and switches off or back on.

Through other PROFIenergy functions, device information can be accessed during pauses. The user can use this information in order to optimally time the transfer of the "Start_Pause"/"End_Pause" command.

PROFIenergy instructions for IO controllers

Two instructions are needed for controlling and monitoring the PROFIenergy functions.

The instruction PE_START_END allows you to easily activate and deactivate the idle state of PROFINET devices. This occurs by means of an incoming edge or outgoing edge. The instruction PE_START_END provides a simple interface for implementing the PROFIenergy commands Start_Pause and End_Pause.

The instruction PE_CMD allows you to transmit all PROFIenergy commands, including Start_Pause and End_Pause. The other commands can be used, for example, to query the current status of the PROFINET device or the behavior during the pauses. The instruction PE_CMD is a convenient means for handling all PROFIenergy functions.

PROFIenergy instruction for I-devices

The instruction PE_I_DEV allows you to also implement PROFIenergy on I-devices. The instruction receives PROFIenergy commands on the I-device and forwards these to the user program for execution. After executing the command, the user program calls the PE_I_DEV instruction again in order to send the acknowledgment to the IO controller. For these replies, each command offers you a helper instruction that supplies the reply data to the instruction.

The instructions can be found in the "Instructions" task card of the STEP 7 program editor.

Configuration and programming

The functions can be comfortably integrated into existing systems. No configuration is required for the use of PROFIenergy. However, amendments to the user program are required:

- Before the "Start_Pause" command, you must ensure that your system is brought into a condition that is suitable for a pause.
- A sequential control system for the beginning of the pause of the devices and for the punctual restarting of the device on break must be programmed (depending on the required startup times that the respective PROFINET device demands).
- The error messages of the PE_CMD instruction must be evaluated, and the required reaction must be programmed (for example, cancellation or continuation of further commands on lower-level PROFINET devices).

Note

In the case of the ET 200S distributed I/O system, you have to configure the application of PROFIenergy in STEP 7. You configure PROFIenergy by selecting the "Use energy saving for this potential group" check box in the PM-E DC24V/8A RO power module.

If you want to use PROFIenergy for an I-device, you have to configure this in STEP 7. Information about configuring PROFIenergy for an I-device is available in the section Configuring PROFIenergy with I-devices (Page 118).

Application examples

- SIMATIC S7 library for simple configuration of PROFIenergy.
  The application example is available here
  (https://support.industry.siemens.com/cs/ww/en/view/109478388).
- Application guide for implementation of shutdown concepts with PROFIenergy.
  The application example is available here
  (https://support.industry.siemens.com/cs/ww/en/view/96837137).
- Saving energy with SIMATIC S7 PROFIenergy with I-device
  The application example is available here
  (https://support.industry.siemens.com/cs/ww/en/view/41986454).

5.11 Docking systems

Using alternating IO devices ("alternating partners") during operation in a docking station

The following figure shows an automation cell with a docking station and several docking units.

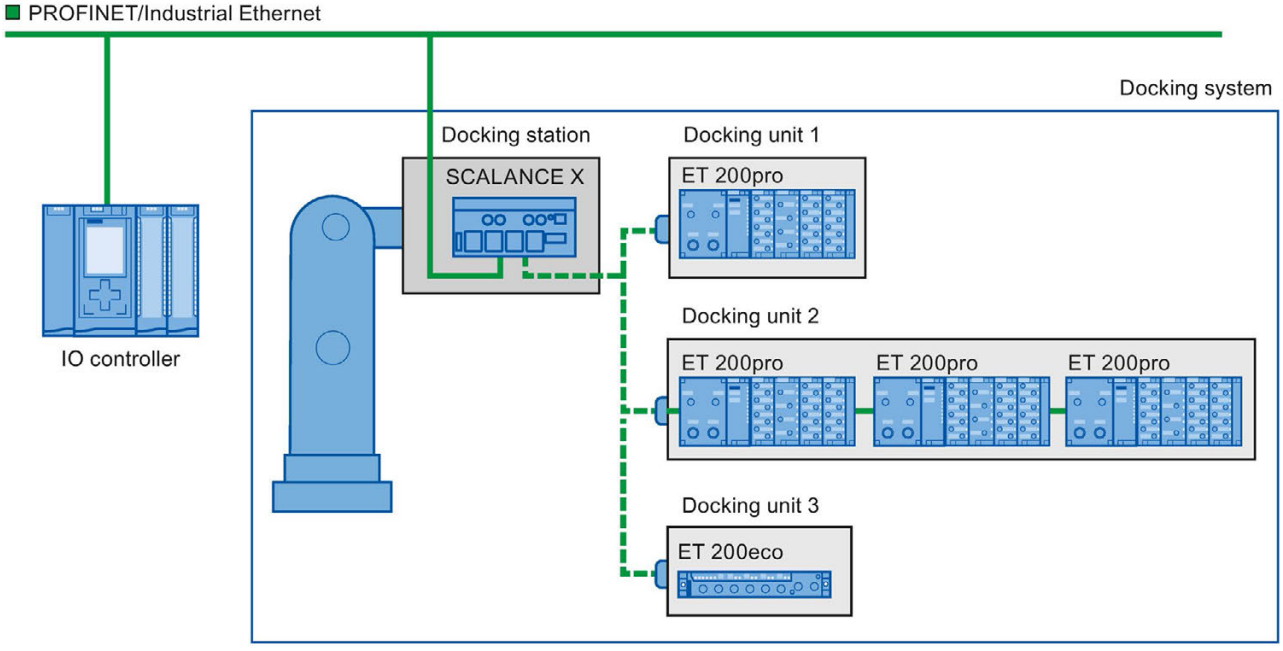


Figure 5-93 Alternating IO devices (partner ports) in a docking system

Area of application for alternating IO devices during operation

You can use the PROFINET function "Alternating IO devices during operation" ("alternating partners"), for the tool changeover for robots, for example. Typical tools include:

- Welding guns
- Positioning tools for manufacturing parts

Requirements for interconnecting alternating partner ports during operation

You can interconnect IO devices with alternating partner ports during operation in the following situations:

- The alternating IO device (docking unit) has no IRT communication configured.
- The PROFINET interface is connected to the Ethernet subnet.
- The PROFINET devices support topology configuration.
- The IO controller, the alternating IO devices (docking unit) and the switch (docking station) on which the alternating IO devices are to be operated support this feature.

Note

Unique IP address

Each docking unit of a docking system must be configured with a unique IP address in a shared project and operated on the same IO controller as all other docking units of the system.

Applicative conditions

The following points should be observed when implementing a docking system with alternating IO devices during operation:

- The IO devices of all docking units must be deactivated by default in the configuration.
- At any time, only one docking unit can be active, i.e., only the IO devices of one docking unit can be activated. All IO devices of other docking units must be deactivated or become deactivated before the IO devices of a docking unit can be activated. You activate an IO device with the "D_ACT_DP" instruction.
- A physical connection to this docking unit and its IO devices must be created in order to activate a docking unit. The IO devices are then switched on (power on). At the same time, all the IO devices of this docking unit must be activated in the user program with the "D_ACT_DP" instruction.

Note

Automatic deactivation in "Startup" mode of the CPU

If the CPU is in "Startup" mode, IO devices of a docking system that alternate during operation are deactivated automatically.

- After the feedback "IO device activated", you can access the IO device by means of direct I/O access.
- Call the "D_ACT_DP" instruction to activate and deactivate the IO device as close as possible to the start of the OB 1 cycle.

Note

Number of alternating IO devices during operation ("alternating partner port") - number of docking units

If you wish to achieve the shortest possible tool changeover times, you must observe the following points that are dependent on the CPU or the CP that is being used:

- Only those IO devices that have been configured with the PROFINET function "Prioritized startup" can start up in an optimized fashion. The number of IO devices with configuration for this PROFINET function is restricted.
- Only a limited number of IO devices can be activated at the same time. This number depends on the available "D_ACT_DP" resources. A docking unit should not contain more than the corresponding number of IO devices. If more IO devices are operated in a docking unit, the IO devices must be activated one after the other, which takes correspondingly longer.

Example: An S7-CPU 1516-3 PN/DP can operate a maximum of 32 IO devices with prioritized startup and can simultaneously activate 8 IO devices by means of "D_ACT_DP".

Therefore, for a scheduled optimum use, a docking unit should include no more than 8 IO devices and no more than 32 IO devices should be used in all the alternating docking units.

5.11.1 Configuring docking systems

Configuring docking systems

The possible connections to the individual IO devices must be configured in STEP 7.

Procedure in STEP 7

1. Configure your system as usual, but do not yet configure the topological interconnections of the individual PROFINET devices.
2. Navigate to the "Topology view" tab.
3. Select the port which you want to operate with alternating partners during operation.
4. Navigate to the "Properties" tab of the inspector window and select "Port interconnection" in the area navigation.
5. Under "Partner port", select the "Alternative partners" option.
6. Select the desired partner ports: To do this, click "<Add alternative partners... and choose a partner port. Repeat this process until all required partner ports are connected.

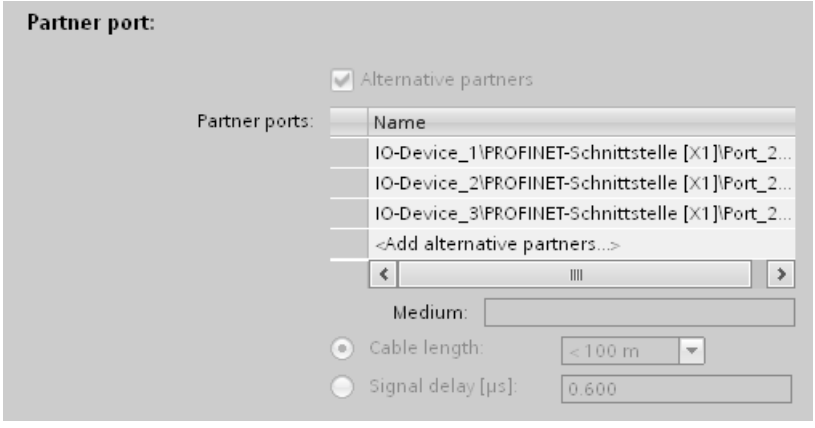


Figure 5-94 Configuring docking systems in STEP 7

Tip: You can also use drag-and-drop operation to connect alternative partner ports in the topology view.

Result

You have interconnected the respective port with one or more alternating IO devices. The connections with the individual alternating partner ports during operation are shown in the topology view by a green, dashed line.

Multiple IO devices as a docking unit ("Alternating partner port")

A docking unit may also consist of several IO devices connected in series. If you use IO devices connected in series as a docking unit, ensure that the topology of the IO devices is configured. A docking unit consisting of two IO devices connected in series (Tool_3_1 and Tool_3_2) is shown at the bottom right in the figure below.

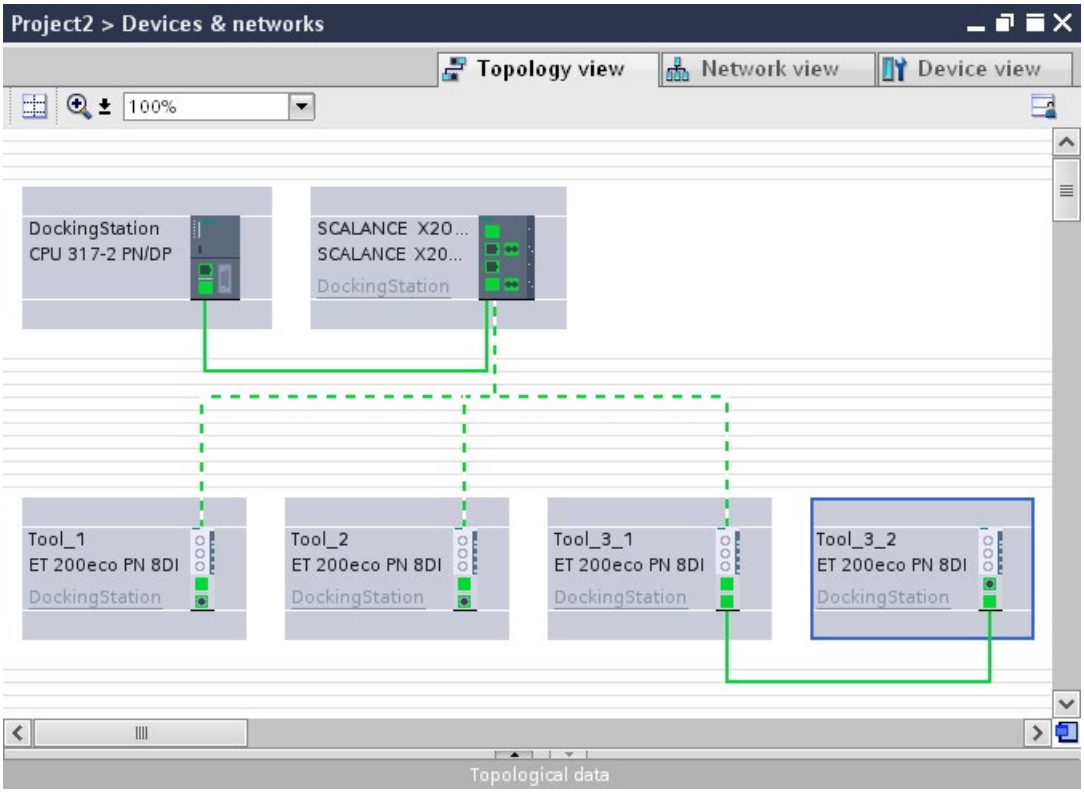


Figure 5-95 Docking system in the topology view of STEP 7

Restriction in the interconnection

The interconnection with a partner port is not possible in the following cases:

- The partner port does not have a suitable type of cable. In this case, a media convertor from the catalog must be inserted.
- The partner port is blocked (deactivated).
- The two ports that are to be interconnected belong to the same interface (it is only possible to interconnect the ports from different interfaces in a station).
- The two ports that are to be interconnected belong to different Ethernet subnets.

Deleting interconnections

Select the port of the alternating partner and remove the interconnection with the "Remove" button.

5.12 Accelerating startup

5.12.1 Options for accelerating the startup of IO devices

Reducing the startup time of IO devices

The time needed for the startup of IO devices depends on various factors and can be reduced in different ways.

You can achieve a significant reduction in the startup time using the "Prioritized startup" PROFINET function.

To further reduce the startup times, use the following measures in addition to the "Prioritized startup":

- Optimize the port settings
- Optimize the cabling of the ports
- Perform measures in the user program (for docking systems only)

These measures will accelerate the startup of IO devices even without "Prioritized startup". However, you can only achieve the fastest startup times of about 500 ms by combining all the measures with "Prioritized startup".

Note

Startup time up to 8 s

In the following situation, despite prioritized startup, a startup time of up to 8 s may occur:

On a docking point, multiple physical IO devices dock as an IO device with identical device names and identical IP configurations (for example, docking point for automatic transport system).

Dependencies

The length of the startup time for an IO device (distributed I/O) with the "Prioritized startup" PROFINET function depends on the following factors:

- IO devices (distributed I/O)
- IO structure of the IO device (distributed I/O)
- Modules of the IO device (distributed I/O)
- IO controller
- Switch
- Port setting
- Cabling
- Configured RT class of the IO device

Note

Startup time and RT class of the IO device

An IO device with IRT communication requires longer than an IO device with RT communication for the accelerated startup.

The longer startup for IRT is due to the necessity of synchronizing the IO device before the communication can be set up.

Note

IWLAN and prioritized startup

PROFINET devices which are connected via access points to PROFINET IO do not support the "Prioritized startup" PROFINET function.

5.12.2 Prioritized startup

Definition

Prioritized startup refers to the PROFINET function for accelerating the startup of IO devices in a PROFINET IO system with RT communication. It shortens the time that the respective configured IO devices require in order to reach the cyclic user data exchange in the following cases:

- After the power supply has returned
- After a station has returned
- After activation of IO devices

⚠ WARNING

Data exchange despite multiple use IP addresses/device names in PROFINET IO system

To achieve higher ramp-up times, the IO controller checks the uniqueness of device name of IP address parallel to the device ramp-up. In the case of incorrect or double assignment of device name or IP address, a short-time data exchange is possible until the IO controller reacts to the error. In this time the IO controller can exchange IO data with the false device.

During commissioning, ensure that no IP addresses / device names are assigned multiple times in the PROFINET IO system.

Advantages

The PROFINET functionality "prioritized startup" enables PROFINET IO applications in which machine parts or tools and their IO devices have been permanently replaced. Waiting times of several seconds between the scheduled processes of the restart are reduced to a minimum by this optimization. This accelerates the production process with alternating IO devices (PROFINET functionality "docking systems"), e.g. in tool changer applications, and enables a greater throughput in production.

The PROFINET functionality "prioritized startup" also offers a considerable increase in performance for applications where a quick startup time of the IO devices after "power on" or after station failure / station return is required, or when activating IO devices.

Area of application

You can use prioritized startup, for example, for changing tools for robots in the automotive industry. Typical tools are, for example:

- Welding guns
- Positioning tools for the manufacture of car body parts

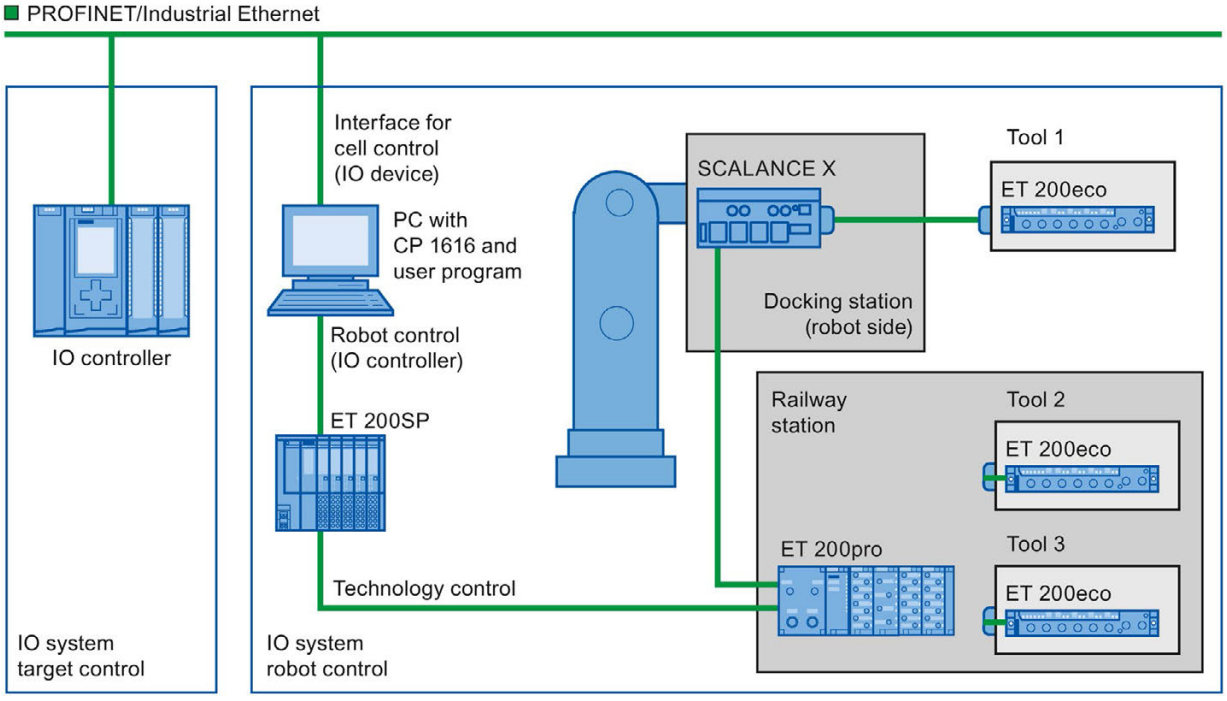


Figure 5-96 Example configuration of a tool changer: Tools 1-3 configured with "Prioritized startup".

5.12.3 Configuring prioritized startup

Requirements

You can enable the "Prioritized startup" PROFINET function for the IO devices (distributed I/O) only in the following cases:

- The IO controller used can prioritize selected IO devices during startup.
- The IO device used supports prioritization.

Procedure

1. Select the IO device in the network view or device view for which you wish to accelerate startup.
2. Open the IO device properties in the Inspector window.
3. Select "PROFINET interface > Advanced options > Interface options".
4. Select the "Prioritized startup" check box.

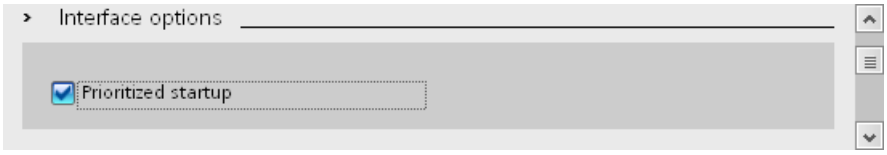


Figure 5-97 Configuring prioritized startup in STEP 7

5. Download the configuration to the IO controller.

Note

Prioritized startup after a startup for the first time

A prioritized startup of the IO device is always available to you after the first configuration of this IO device in the very first startup of the PROFINET IO system. Even in the case of spare parts or a reset to factory settings, the first startup is a standard startup for the respective configured IO devices.

Note

Number of IO devices (distributed I/O) with prioritized startup

You can only start up a maximum number of IO devices with the "Prioritized startup" PROFINET functionality within one PROFINET IO system. This maximum number depends on the IO controller used.

5.12.4 Optimize the port settings

Optimizing port settings on the IO device and IO controller

The transfer medium and the duplex option are checked during startup of the IO device in the case of copper cabling.

These checks require time, but with specific presets of these options you can save the time the check requires. Make certain that the settings made correspond to the actual conditions (using the correct cables).

Optimizing port settings for accelerated startup

To optimize port settings for accelerated startup, follow these steps:

1. Select the ports of the IO controller or the partner port of the corresponding IO device.
2. Navigate to "Port options > Connection" in the Inspector window. Select the setting "TP 100 Mbps full duplex" under "Transmission rate/duplex"
3. Clear the "Enable autonegotiation" check box.

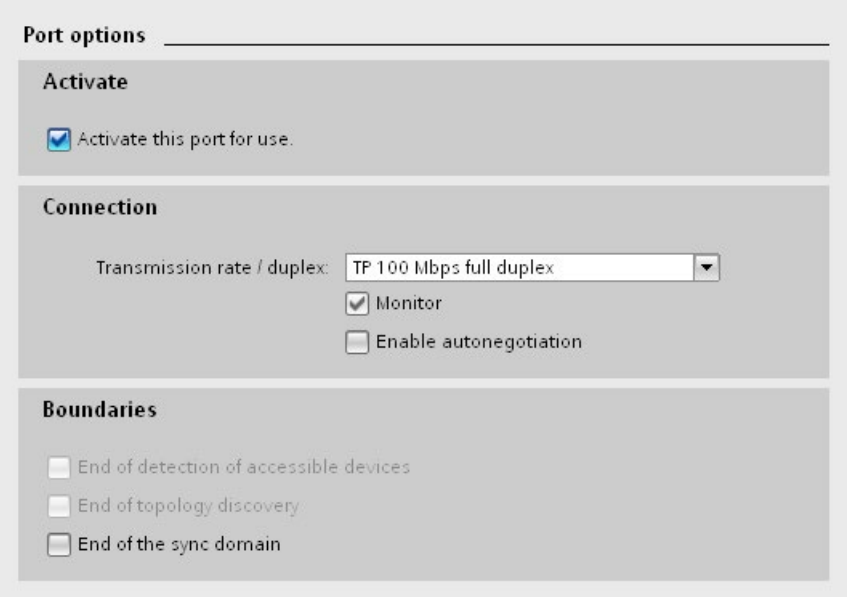


Figure 5-98 Optimizing port settings for accelerated startup in STEP 7

These settings are automatically applied during topology configuration for the partner port.

5.12.5 Optimize the cabling of the ports

Requirements

You have made the following settings for the port in question to reduce the startup time of the IO device:

- Fixed transmission rate
- Autonegotiation deactivated

The time for negotiating the transmission rate during startup is saved.

If you have disabled autonegotiation, you must observe the cabling rules.

Properties of ports

PROFINET devices have the following two types of ports:

Type of port	PROFINET devices
Switch port with crossed pin assignment	For IO devices: Port 2 For S7-CPUs with two ports: Ports 1 and 2
Terminal device port with normal pin assignment	For IO devices: Port 1 For S7-CPUs with one port: Port 1

Crossed pin assignment means that the pin assignment for the ports for sending and receiving between the respective PROFINET devices is inverted internally.

Validity of the cabling rules

The cabling rules described in the following paragraph apply exclusively for the situation in which you have specified a fixed port setting in STEP 7.

Rules for cabling

You can connect several IO devices in series using patch cables. To do this, connect port 2 of the IO device (distributed I/O) with port 1 of the next IO device. The following graphic provides an example with two IO devices.

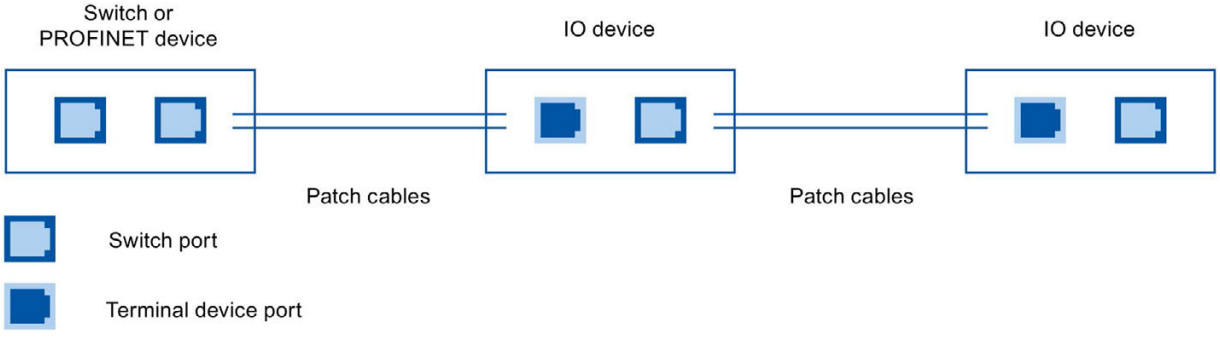


Figure 5-99 Optimized cabling for accelerated startup

5.12.6 Measures in the user program

Introduction

You can make certain changes in the user program to accelerate the startup for IO devices of docking systems that alternate during operation.

Making the required changes to the user program

To accelerate the startup by making changes to the user program, follow these steps:

1. Call the "D_ACT_DP" instruction to activate and deactivate the IO device at the start of the OB 1 cycle.

   If the IO device is replaced, the device that is no longer required must be deactivated and the new device must be activated.

2. If you control the "Power ON" command of the IO devices via the application, then start the activation of the IO devices via the corresponding call of the "D_ACT_DP" instruction as near to the same time as possible. The IO device has to be physically connected for this.

3. You access the IO device using direct access commands after the "D_ACT_DP" instruction has provided the feedback "IO device activated".

Glossary

API

API (**A**pplication **P**rocess **I**dentifier) is a parameter, the value of which specifies the IO data processing process (application).

The PROFINET standard IEC 61158 assigns profiles to specific APIs (PROFIdrive, PROFIsave), which are defined by the PROFINET user organization.

The standard API is 0.

Application

An application is a program that runs directly on the MS-DOS/Windows operating system. An application on the PG is STEP 7, for example.

AR

AR (**A**pplication **R**elation) is an addressing level for diagnostics data records.

Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Backplane bus

The backplane bus is a serial data bus for module intercommunication and the distribution of the necessary power to the modules. Bus connectors interconnect the modules.

Bus

A bus is a transfer medium that interconnects several devices. Data transmission can be performed electrically or via optical fibers, either in series or in parallel.

Communications Cycle and Reservation of Transmission Bandwidth

PROFINET IO is a scalable real-time communication system based on the Layer 2 protocol for Fast Ethernet. With the RT transmission method, two real-time-support performance levels are available for time-critical process data and IRT for high-accuracy and also isochronous processes .

Communications processor

Communication processors are modules used for point-to-point and bus connections.

Configuring

Selecting and putting together individual components of an automation system or installing necessary software and adapting it for a specific application (for example, by configuring the modules).

Consistent data

Data which belongs together in terms of content and must not be separated is known as consistent data.

For example, the values of analog modules must always be handled as a whole, that is, the value of an analog module must not be corrupted as a result of reading out at two different points in time.

CP

→ *Communications processor*

CPU

Central **P**rocessing **U**nit - Central module of the S7 automation system with a control and arithmetic unit, memory, operating system and interface for programming device.

DCP

DCP (**D**iscovery and Basic **C**onfiguration **P**rotocol). Enables the assignment of device parameters (for example, the IP address) using manufacturer-specific configuration/programming tools.

Default router

The default router is used when data has to be forwarded via TCP/IP to a partner located outside the local network.

Determinism

Determinism means that a system responds in a predictable (deterministic) manner.

Device

In the PROFINET environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, PLC, PC, hydraulic devices, pneumatic devices)
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

Device name (PROFINET device name)

In the PROFINET IO environment, the device name is a unique identifier for the PROFINET IO interface of a device.

Diagnostics

→ *System diagnostics*

Diagnostics buffer

The diagnostics buffer represents a backup memory in the CPU, used to store diagnostics events in their order of occurrence.

Diagnostics error interrupt

Modules capable of diagnostics operations report detected system errors to the CPU by means of diagnostics interrupts.

→ *See also CPU*

DP master

A master which behaves in accordance with EN 50170, Part 3, is known as a DP master.

→ *See also Master*

DP slave

A slave operated on PROFIBUS with PROFIBUS DP protocol and in accordance with EN 50170, Part 3 is referred to as DP slave.

→ *See also Slave*

DPV1

The designation DPV1 refers to the functional extension of acyclic services (to include new interrupts, for example) provided by the DP protocol. The DPV1 functionality is integrated in IEC 61158/EN 50170, Volume 2, PROFIBUS.

Duplex

Half duplex: One channel is available for alternating exchange of information.

Full duplex: Two channels are available for simultaneous exchange of information in both directions.

Ethernet

Ethernet is an international standard technology for local area networks (LAN) based on frames. It defines types of cables and signaling for the physical layer and packet formats and protocols for media access control.

GSD file

As a Generic Station Description, this file contains all properties of a PROFINET device that are necessary for its configuration in XML format.

I-device

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller, for example, as intelligent preprocessing unit of sub-processes. In its role as an IO device, the I-device is accordingly integrated into a "higher-level" IO controller.

Industrial Ethernet

Industrial Ethernet is a guideline for installing an Ethernet in an industrial environment. The biggest difference from standard Ethernet is the mechanical current carrying capacity and noise immunity of the individual components.

Interrupt

An interrupt is an event that causes the operating system of an S7-CPU to automatically call an assigned organization block (interrupt OB) in which the user can program the desired reaction.

Interrupt, diagnostics

→ *Diagnostics error interrupt*

IP address

To allow a PROFINET device to be addressed as a device on Industrial Ethernet, this device also requires an IP address that is unique within the network. Example: An IPv4 address consists of 4 decimal numbers with the value range 0 to 255. The decimal numbers are separated by periods.

The IP address is made up of the following components:

- Address of the network
- Address of the device (generally called the host or network node).

IRT

IRT is a synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can be transferred at reserved synchronized intervals, without being influenced also by higher other network loads (such as TCP/IP communication, or additional real-time communication).

LAN

Local **A**rea **N**etwork - a local network to which multiple computers within a company are connected. The LAN therefore has a limited geographical span and is only available to the company or institution.

Line depth

Designates the number of external switches or integrated switches interconnected in series.

MAC address

Worldwide unique device identification for all Ethernet devices. It is assigned by the manufacturer and has a 3-byte vendor ID and 3-byte device ID as a consecutive number.

Every PROFINET device is assigned a worldwide unique device identifier at the factory. This 6-byte long device identifier is the MAC address.

Maintenance Required / Maintenance Demanded

A "Maintenance required" system message can be defined for different wear parameters and an inspection of a component can be recommended, for example, when a certain number of operating hours has elapsed.

The "Maintenance demanded" alarm is sent when the part involved needs to be replaced within a foreseeable period.

(Example printer: The maintenance demanded alarm is sent when the ink/printer cartridges have to be replaced immediately.)

Master

Higher-level, active participant in the communication/on a PROFIBUS subnet. It has rights to access the bus (token), sends data and requests it.

Media redundancy

The so-called **M**edia **R**edundancy **P**rotocol (MRP) enables the configuration of redundant networks. Redundant transmission links (ring topology) ensure that an alternating communication path is made available if a transmission link fails. The PROFINET devices that are a part of this redundant network form an MRP domain.

Micro Memory Card (MMC)

Micro Memory Cards are memory media for CPUs and CPs. Their only difference to the SIMATIC memory card is the smaller size. S7-1500 and ET 200SP-CPUs use SIMATIC memory cards.

MPI

The multipoint interface (**M**ulti **P**oint **I**nterface,MPI) represents the programming device interface of SIMATIC S7. It enables multiple devices (programming devices, text-based displays, OPs) to be operated simultaneously by one or more CPUs. Each device is identified by its unique (MPI) address.

MRPD

MRPD (**M**edia **R**edundancy with **P**lanned **D**uplication of Frames) based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.

Network

A network consists of one or more interconnected subnets with any number of devices. Several networks can exist alongside each other.

OB

→ *Organization block*

OPC

OPC (OLE for Process Control) refers to a standard interface for communication in automation technology.

Operating mode

The SIMATIC S7 automation systems know the following operating states: STOP, STARTUP, RUN.

Organization block

Organization blocks (OBs) form the interface between the CPU operating system and the user program. The order in which the user program is executed is defined in the organization blocks.

Parameter

1. Tag of a STEP 7 code block:
2. Tag used to set one or several characteristics of a module

In delivery state, every module has practical basic settings, which can be modified by configuration in STEP 7.

There are static and dynamic parameters

PG

→ *Programming device*

PLC

→ *Programmable logic controller*

Prioritized startup

Prioritized startup denotes the PROFINET functionality for accelerating the startup of IO devices operated on a PROFINET IO system with RT and IRT communication. It reduces the time that the correspondingly configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the power supply has returned
- After a station has returned
- After activation of IO devices

Process image

The process image is part of CPU system memory. At the start of cyclic program execution, the signal states of the input modules are transferred to the process image of the inputs. At the end of cyclic program execution, the process image of the outputs is transferred to the output modules as signal state.

→ *See also System memory*

PROFIBUS

Process **Fi**eld **Bus** - European Fieldbus standard.

PROFIBUS device

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS485) or optical (polymer optical fiber, POF) interface.

PROFIBUS DP

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O (fast, real-time capable, cyclic data exchange). From the perspective of the user program, the distributed I/Os are addressed in exactly the same way as the centralized I/Os.

PROFIBUS Users Organization

Technical committee dedicated to the definition and development of the PROFIBUS and PROFINETstandard. Additional information can be found on the Internet.

PROFIenergy

Function for energy saving in the process, for example, during pause times by briefly switching off the entire system via standardized PROFIenergy commands.

PROFINET

Open component-based industrial communication system based on Ethernet for distributed automation systems. Communication technology promoted by the PROFIBUS Users Organization.

PROFINET device

A PROFINET device always has a PROFINET interface (electrical, optical, wireless). A lot of devices also have a PROFIBUS DP interface to connect PROFIBUS devices.

PROFINET IO

Communication concept for the realization of modular, distributed applications within the scope of PROFINET.

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps.

PROFINET IO Controller

Device used to address the connected IO devices. This means that the IO controller exchanges input and output signals with assigned field devices. The IO controller is often the controller on which the automation program runs.

PROFINET IO Device

A distributed field device that is assigned to one of the IO controllers (e.g. remote IO, valve terminals, frequency converters, switches)

PROFINET IO System

PROFINET IO controller with assigned PROFINET IO devices.

Programmable logic controller

Programmable logic controllers (PLCs) are electronic controllers whose function is stored as a program in the control unit. The structure and wiring of the device does not therefore depend on the controller's function. A programmable logic controller is structured like a computer. It consists of a CPU with memory, input/output modules and an internal bus system. The IOs and the programming language are oriented to the requirements of the control technology.

Programming device

Programming devices are essentially compact and portable PCs which are suitable for industrial applications. They are identified by a special hardware and software configuration for programmable logic controllers.

Proxy

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link, for example. The IE/PB Link PN IO then handles communication via PROFINET on behalf of the PROFIBUS components.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

Real-time

Real-time means that a system processes external events within a defined time.

Real-time communication

Group error for RT and IRT.

PROFINET uses its own real-time channel (RT) rather than TCP/IP for communication of time-critical IO user data.

Router

A router interconnects two subnets. A router works in a similar way to a switch. With a router, however, you can also specify which communication devices may communicate via the router and which may not. The communication devices on various sides of a router can only communicate with one another if you have explicitly enabled communication between these devices via the router. Real-time data cannot be exchanged beyond subnet boundaries.

RT

PROFINET IO with **R**eal **T**ime communication (RT) is the optimal transmission method for time-critical applications in factory automation. PROFINET IO frames are prioritized over standard frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology.

Security

Generic term for all the measures taken to protect against

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to the destruction of data

Send clock

Period between two consecutive intervals for IRT or RT communication. The send clock is the shortest possible transmit interval for exchanging data.

SIMATIC

The term denotes Siemens AG products and systems for industrial automation.

SIMATIC NET

Siemens Industrial Communication division for Networks and Network Components.

SIMATIC PC Station

A "PC station" is a PC with communication modules and software components within a SIMATIC automation solution.

SIMATIC Memory Card (SMC)

→ *Micro Memory Card (MMC)*

Slave

A slave can only exchange data after being requested to do so by the master.

→ See also DP slave

SNMP

The network management protocol SNMP (**S**imple **N**etwork **M**anagement **P**rotocol) uses the wireless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP agents collect the various network-specific information in the individual network nodes and stores it in a structured form in the MIB (**M**anagement **I**nformation **B**ase). This information allows a network management system to run detailed network diagnostics.

STEP 7

STEP 7 is an engineering system and contains programming software for the creation of user programs for SIMATIC S7 controllers.

Subnet

All the devices interconnected by switches are nodes of the same network or subnet. All the devices in a subnet can communicate directly with each other.

All devices in the same subnet have the same subnet mask.

A subnet is physically restricted by a router.

Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general, the following applies:

- The network address is obtained from the AND operation of the IP address and subnet mask.
- The device address is obtained from the AND NOT operation of the IP address and subnet mask.

Switch

Network components used to connect several terminal devices or network segments in a local network (LAN).

Sync domain

All PROFINET devices to be synchronized with IRT via PROFINET IO must belong to a sync domain.

The sync domain consists of exactly one sync master and at least one sync slave. An IO controller or switch generally handles the role of the sync master.

Non-synchronized PROFINET devices are not part of a sync domain.

System diagnostics

System diagnostics refers to the detection, evaluation, and signaling of errors that occur within the automation system, for example, programming errors or module failures. System errors can be indicated by LEDs or in STEP 7.

TCP/IP

The Ethernet itself is only a transport system for data - similar to a highway, which is a transport system for people and goods. The actual data transport is performed by so-called protocols - similar to cars and trucks, which transport people and goods on the highway.

The two basic protocols TCP (**T**ransmission **C**ontrol **P**rotocol) and IP (**I**nternet **P**rotocol) - TCP/IP for short - perform the following tasks:

1. The data is broken down into packets at the sender.
2. The packets are transported over the Ethernet to the correct recipient.
3. At the recipient, the packets are reassembled in the correct order.
4. Corrupt packets continue to be sent until they are received correctly.

Most higher-level protocols use TCP/IP to perform their duties. **H**yper **T**ext **T**ransfer **P**rotocol (HTTP), for example transfers documents written in **H**yper **T**ext **M**arkup **L**anguage (HTML) in the **W**orld **W**ide **W**eb (WWW). This technique is what enables you to view web pages in your Internet browser in the first place.

Topology

Structure of a network. Common structures include:

- Linear bus topology
- Ring topology
- Star topology
- Tree topology

Topology configuration

All the interconnected ports of the PROFINET devices in the STEP 7 project and their relationships to each other.

Twisted-pair

Fast Ethernet via twisted-pair cables is based on the IEEE 802.3u standard (100 Base-TX). The transmission medium is a shielded 2x2 twisted-pair cable with an impedance of 100 Ω (AWG 22). The transmission characteristics of this cable must meet the requirements of category 5.

The maximum length of the connection between the terminal and the network component must not exceed 100 m. The connectors are designed according to the 100Base-TX standard with the RJ45 connector system.

Update time

An IO device / IO controller in the PROFINET IO system is supplied cyclically with new data from the IO controller / IO device within this time interval. The update time can be configured separately for each IO device and determines the interval at which data is sent from the IO controller to the IO device (outputs) as well as from the IO device to the IO controller (inputs).

User program

In SIMATIC, we distinguish between the CPU operating system and user programs. The user program contains all instructions, declarations and data by which a plant or process can be controlled. The user program is assigned to a programmable module (for example, CPU, CM) and can be structured in smaller units.

WAN

A network that extends beyond LAN boundaries and enables, for example, intercontinental network communication. Legal rights do not belong to the user but to the provider of the communication network.

XML

XML (E**x**tensible **M**arkup **L**anguage) is a flexible, easy to understand and easy to learn data description language. Information is exchanged using readable XML documents. These include continuous text supplemented by structure information.

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SIEMENS

SIMATIC

PROFIBUS
PROFIBUS with STEP 7 V13

Function Manual

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12/2014

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

Trademarks

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the manual

This function manual provides an overview of the PROFIBUS communication system with SIMATIC STEP 7 V13.

STEP 7 V13 is integrated into the powerful graphic Totally Integrated Automation Portal (TIA Portal), the new integration platform for all automation software tools.

This function manual supports you in planning a PROFIBUS system. The manual is structured into the following subject areas:

- PROFIBUS basics
- PROFIBUS diagnostics
- PROFIBUS functions

Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Scope

This function manual is the basic documentation for all SIMATIC products from the PROFIBUS environment. The product documentation is based on this documentation.

The examples are based on the functionality of the S7-1500 automation system.

Changes compared to previous version

As compared to the previous version (version 07/2014), this manual contains the following amendments/changes:

- Extension of the documentation to STEP 7 (TIA Portal) V13 SP1
- Addition of the function Intelligent DP slaves (I-slaves)
- New guide

Conventions

STEP 7: We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This documentation contains figures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Additional support

You will find information about available technical support in the appendix Service & Support (Page 91).

The technical documentation for the individual SIMATIC products and systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

The online catalog and the ordering system are available on the Internet (http://mall.industry.siemens.com).

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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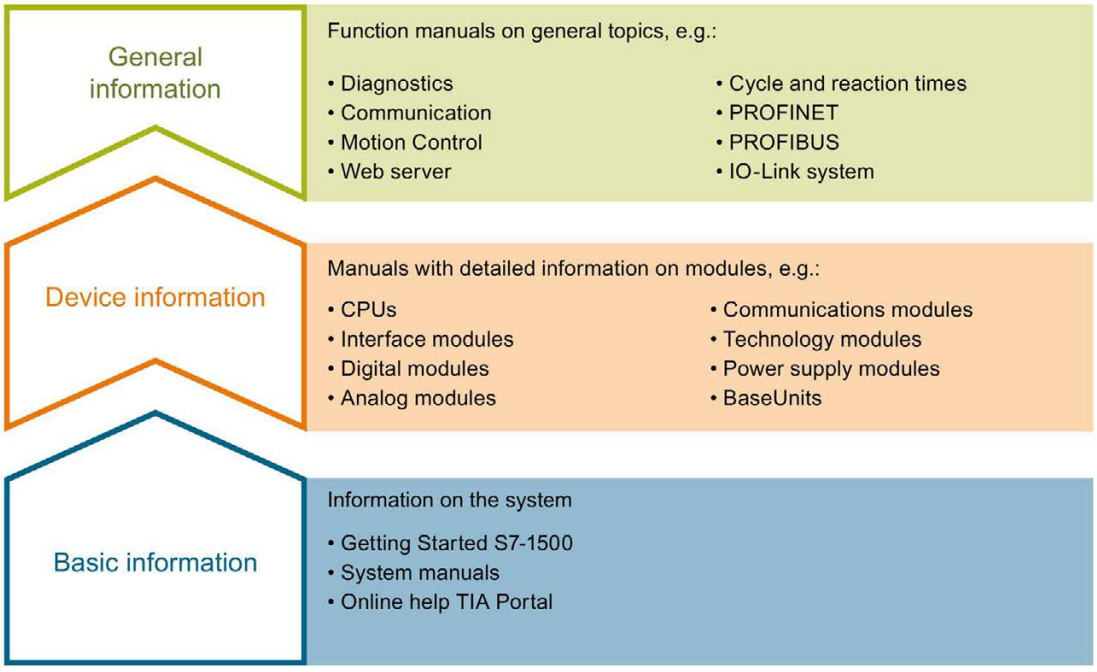
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP, ET 200SP and ET 200AL distributed I/O systems is divided into three areas. This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view/en/86140384)
- ET 200SP (http://support.automation.siemens.com/WW/view/en/84133942)
- ET 200AL (http://support.automation.siemens.com/WW/view/en/95242965)

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Description 2

2.1 Introduction to PROFIBUS

What is PROFIBUS?

PROFIBUS is a bus system that networks automation systems and field devices that are compatible with PROFIBUS. As communication medium for the field level, PROFIBUS is an important part of Totally Integrated Automation (TIA).

The different communication networks can be used independent of one another or they can be combined with each other.

PROFIBUS protocols

PROFIBUS DP (distributed I/O) is a communication network for the field level according to IEC 61158-2 / EN 61158-2 with the hybrid access protocols token bus and master-slave. The networking takes place by means of two-wire lines or fiber-optic cables. Data transmission rates of 9.6 kbps to 12 Mbps are possible.

PROFIBUS PA is the PROFIBUS for process automation (PA). It connects the PROFIBUS DP communication protocol with the MBP (Manchester Bus Powered) transmission technology to IEC 61158-2.

PROFIBUS PA networks can be designed based on shielded, twisted two-wire lines intrinsically safe and are therefore suitable for hazardous areas (Ex zones 0 and 1). The data transmission rate is 31.25 kbps.

2.1.1 Applications of PROFIBUS DP

Introduction

The efficiency of control systems is not determined by automation devices alone, but depends to a large extent on the overall configuration of an automation solution. This includes a powerful communication system in addition to plant visualization and operator control and monitoring.

The STEP 7 engineering tool supports you during the engineering and configuration of an automation solution.

Applications of PROFIBUS DP

The PROFIBUS network offers wireless connection of several controllers, components and subnets as electrical network, optical network or by using links. Sensors and actuators are controlled centrally by means of PROFIBUS DP.

The following figure shows connection options to PROFIBUS DP:

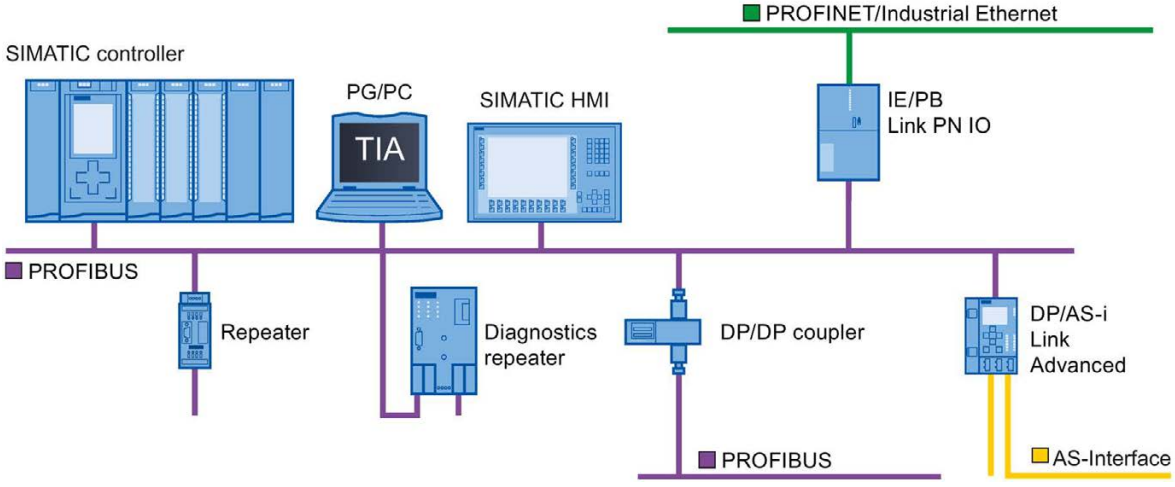


Figure 2-1 Connection options to PROFIBUS DP

Objectives of PROFIBUS DP

Distributed automation systems are increasingly used in production and process automation. This means a complex control task is divided up into smaller, more transparent subtasks with distributed control systems. This creates a high demand for communication between the distributed systems.

Distributed systems offer the following benefits:

- Independent and simultaneous commissioning of individual devices is possible
- Small, manageable programs
- Parallel processing due to distributed automation systems
- Reduced response times
- Higher-level structures can take on additional diagnostics and logging functions.
- Increased plant availability because the rest of the overall system can continue to work when a subordinate station fails.

2.1.2 PROFIBUS terminology

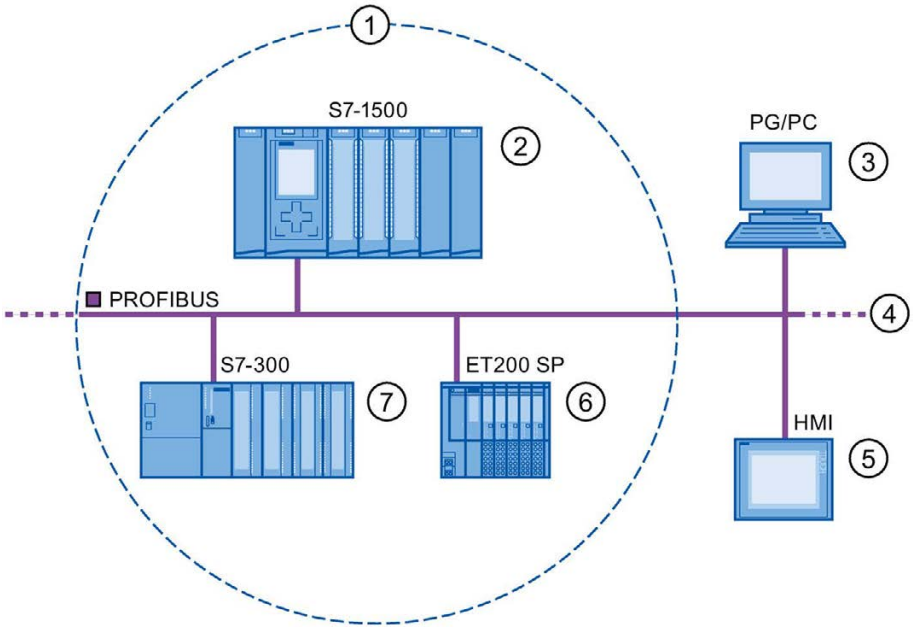
Definition: Devices in the PROFIBUS environment

In the PROFIBUS environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components (e.g., diagnostic repeater, optical link module)
- Gateways to AS interface or other fieldbus systems

Devices with PROFIBUS DP

The figure below shows the most important components with PROFIBUS DP. The table below lists the designations of the individual components.



Number	PROFIBUS	Note
①	DP master system	
②	DP master	Device used to address the connected DP slaves. The DP master exchanges input and output signals with field devices. The DP master is often the controller on which the automation program runs.
③	PG/PC	PG/PC/HMI device for commissioning and diagnostics DP master of class 2
④	PROFIBUS	Network infrastructure
⑤	HMI	Device for operating and monitoring functions
⑥	DP slave	Distributed field device assigned to the DP master, e.g., valve terminals, frequency converters.
⑦	I-slave	Intelligent DP slave

Figure 2-2 Devices with PROFIBUS

Overview of I/O communication

I/O communication is the reading or writing of inputs/outputs of the distributed I/O. The figure below gives you an overview of I/O communication using PROFIBUS DP:

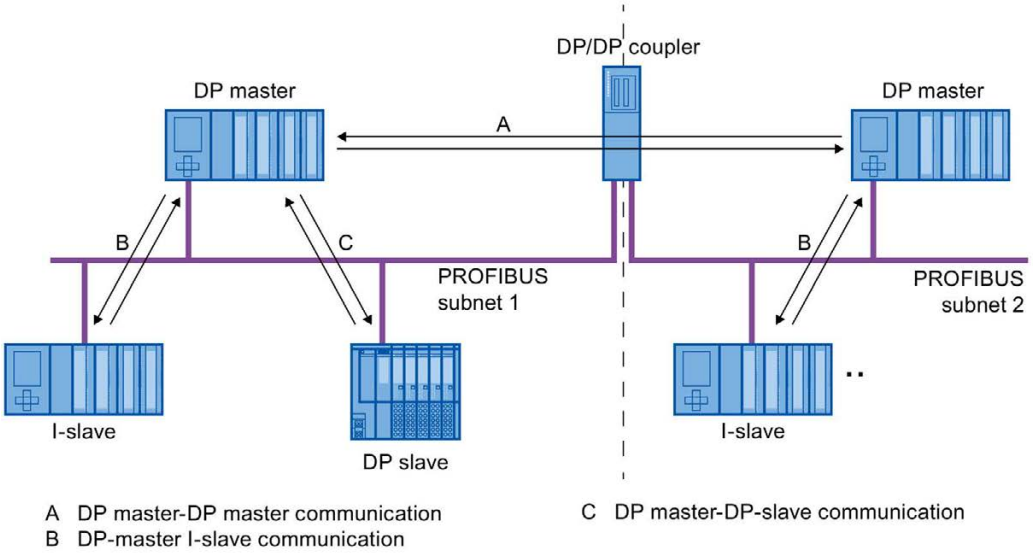


Figure 2-3 I/O communication using PROFIBUS DP

I/O communication is also available with the communication module (CM) or the interface module (IM) with integrated DP interface. These DP interfaces behave like integrated DP interfaces of the CPU.

I/O communication using PROFIBUS DP

Table 2- 1 I/O communication using PROFIBUS DP

Communication between …	Explanation
DP master and DP slave	The data exchange between a DP master and DP slaves with I/O modules takes place as follows: The DP master queries the DP slaves of its master system one after the other, receives input values from the DP slaves, and transmits output data to the DP slaves (master-slave principle).
DP master and I-slave	A fixed amount of data is transmitted cyclically between the user programs in CPUs of DP masters and I-slaves. The DP master does not access the I/O modules of the I-slave, but instead accesses configured address areas, called transfer areas, that can be inside or outside the process image of the I-slave CPU. If parts of the process image are used as transfer areas, these may not be used for actual I/O modules. Data transmission takes place with load and transfer operations using the process image or by direct access.
DP master and DP master	A fixed amount of data is transmitted cyclically between the user programs in CPUs of DP masters. A DP/DP coupler is required as additional hardware. The DP masters mutually access configured address areas, called transfer areas, inside or outside the process image of the CPUs. If parts of the process image are used as transfer areas, these may not be used for actual I/O modules. Data transmission takes place with load and transfer operations using the process image or by direct access.

Additional information

You can find additional information on the hardware configuration in the STEP 7 online help.

2.1.3 PROFIBUS DP interface

Properties

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS 485) interface or optical (Polymer Optical Fiber, POF) interface.

Table 2- 2 Properties of the PROFIBUS DP interface

Standard	PROFIBUS: IEC 61158/61784
Physical bus/media	PROFIBUS cables (twisted two-wire lines RS 485 or fiber-optic cables)
Transmission rate	9.6 kbps to 12 Mbps

Representation of the PROFIBUS DP interface in STEP 7

In the device view of STEP 7, the PROFIBUS DP interfaces for a DP master and a DP slave are highlighted by a purple rectangle:

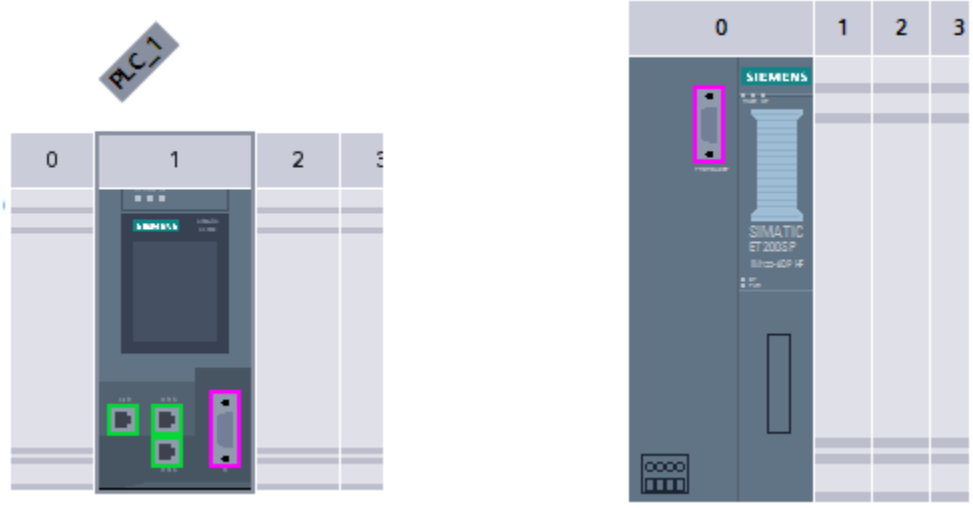


Figure 2-4 PROFIBUS DP interfaces

2.2 Structure of PROFIBUS networks

Contents of this chapter

The following chapter provides background information on building your communication network.

- Overview of the most important passive network components: These are network components that forward a signal without the possibility of actively influencing it, for example, cables, connectors.
- Overview of the most important active network components: These are network components that actively affect a signal, for example, repeaters, diagnostic repeaters.
- Overview of the most common network structures (topologies)

Physical connections of industrial networks

PROFIBUS devices can be networked in industrial plants in two different physical ways:

- By means of electrical signals via copper cables
- By means of optical signals via fiber-optic cables

Selection criteria for networking

The table below includes selection criteria for electrical and optical networking of PROFIBUS devices:

Table 2- 3 Selection criteria for electrical and optical networking

Criteria		Electrical PROFIBUS	Optical network with OLM	Optical network with OBT
Transmission medium	Shielded two-wire line	●	–	–
	POF	–	●	●
	PCF	–	●	●
	Glass	–	●	–
Distances	Max. network span	PROFIBUS DP: 9.6 km PROFIBUS PA: 1.9 km	90 km	9.6 km
	Between two devices	up to 1 km 1)	up to 15 km 2)	up to 300 m 2)
Topology	Bus	●	–	–
	Linear	–	●	●
	Tree	●	●	●
	Ring	–	●	●
Transmission protocols		DP, PA	DP, PA	DP
Connection of devices by means of	OLM	–	●	–
	Integrated interfaces	●	–	●
	Bus terminal	●	–	●
	Bus connector	●	–	–
Electrical network segments can be connected		●	●	–

● Suitable

– Not relevant for this application

1) Depending on data rate and type of service used

2) Depending on cable type used

Installation guideline for PROFIBUS networks

A PROFIBUS segment must be terminated at the start and end; passively with a connector or actively with a bus terminating resistor.

The same principles apply to the installation of a PROFIBUS network as described in the SIMATIC NET PROFIBUS networks (http://support.automation.siemens.com/WW/view/en/35222591) manual.

2.2.1 Passive network components for RS 485 networks

2.2.1.1 RS 485 cables

Introduction

The following applies to all RS 485 cables for PROFIBUS from Siemens:

- Their double shielding makes them especially suited for laying in industrial environments with electromagnetic interference.
- A continuous grounding concept can be implemented by means of the outer shield of the bus cable and the ground terminals of the bus terminals.
- The imprinted meter marking makes it easier to determine the length (accuracy ±5%).

RS 485 cables for PROFIBUS

SIMATIC NET PROFIBUS cables are available in different versions which allow optimum adaptation to different areas of application:

- FC Standard Cable GP (bus cable for fixed laying inside buildings)
- FC Standard Cable IS GP (bus cable for hazardous area)
- FC-FRNC Cable GP (bus cable with halogen-free protective jacket for use inside buildings)
- FC Food Cable (bus cable with PE jacket for use in the food and beverage industry)
- FC Robust Cable (bus cable with PUR jacket for environments subject to chemical and mechanical stress)
- FC Ground Cable (ground cable with PE jacket)
- PROFIBUS FC Trailing Cable (trailing cable for tow chains)
- PROFIBUS Festoon Cable (bus cable for festoon mounting)
- PROFIBUS Torsion Cable (torsion-free bus cable for networking movable plant parts, for example, robots)
- PROFIBUS FC Flexible Cable (bus cable for machine parts that are moved infrequently or cabinet doors)
- SIENOPYR-FR ship cable (for permanent laying on ships and off-shore units in all rooms and on open deck)
- PROFIBUS Hybrid Standard Cable (hybrid cable with 2 power wires (1.5 mm^2) for data and power supply of the ET 200pro)
- PROFIBUS Hybrid Robust Cable (trailable hybrid cable with 2 power wires (1.5 mm^2) for data and power supply of the ET 200pro)

Maximum cable lengths

When using copper cables, the maximum size of a PROFIBUS segment depends on the transmission rate.

If these lengths are not sufficient for your application, you can expand the network by using repeaters. You can achieve a maximum size by cascading up to nine repeaters.

Table 2- 4 Maximum cable lengths

Transmission rate	Maximum cable length of a bus segment	Maximum distance between two stations
9.6 to 187.5 kbps	1000 m	10000 m
500 kbps	400 m	4000 m
1.5 Mbps	200 m	2000 m
3 to 12 Mbps	100 m	1000 m

2.2.1.2 PROFIBUS FastConnect system

PROFIBUS FastConnect (FC)

PROFIBUS FastConnect is a system for fast and easy fabrication of PROFIBUS copper cables.

The system consists of three components:

- FastConnect bus cables for quick mounting
- FastConnect stripping tool
- FastConnect bus connector for PROFIBUS with insulation displacement method

FastConnect bus cables and stripping tool

The special design of the FastConnect bus cables allows for the use of the FastConnect stripping tool to accurately strip away the protective jacket and the braided shield in one step. The connection of the prepared cables takes place in the FastConnect bus connectors using the insulation displacement method.

All PROFIBUS FastConnect bus cables can also be connected to the conventional bus connectors with screw-type terminals.

Area of application

You need FastConnect bus connectors for PROFIBUS for the following applications:

- Connect devices with an electrical 9-pin D-Sub interface to IEC 61158-2 directly with SIMATIC NET PROFIBUS cables.
- Connect electrical segments or individual devices to the Optical Link Module (OLM) and Optical Bus Terminal (OBT).
- Connect devices or programming devices to the repeater.

Versions

The FastConnect bus connector in degree of protection IP20 is available in the following versions:

- with integrated terminating resistor and isolating function
- with or without PG socket
- with a cable outlet of 35°, 90° or 180°
- with device category 3G suitable for zone 2 hazardous area

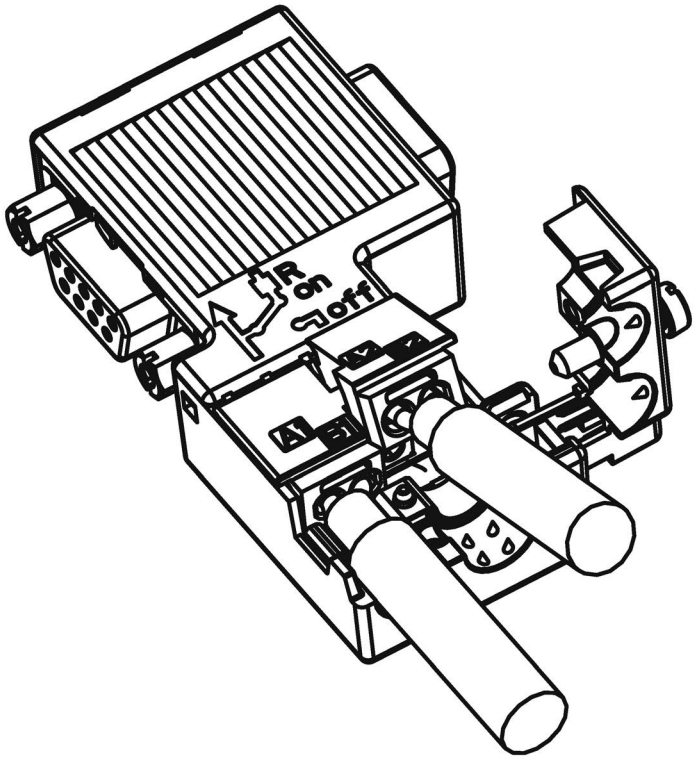


Figure 2-5 Example for PROFIBUS FastConnect bus connector with PG socket, cable outlet 90°

Additional information

For additional information on the available components visit the Siemens Mall (http://mall.industry.siemens.com).

2.2.1.3 PROFIBUS bus connector

Area of application

You need PROFIBUS bus connectors for the following applications:

- Connect devices with a 9-pin D-Sub interface to IEC 61158-2 directly with the SIMATIC NET PROFIBUS cables.
- Connect electrical segments or individual devices to the Optical Link Module (OLM) and Optical Bus Terminal (OBT).
- Connect devices or programming devices to the repeater.

Versions

The PROFIBUS bus connector in degree of protection IP20 is available in the following versions:

- with integrated terminating resistor and isolating function
- with or without PG socket
- with a cable outlet of 35°, 90° or 180°
- with device category 3G suitable for zone 2 hazardous area

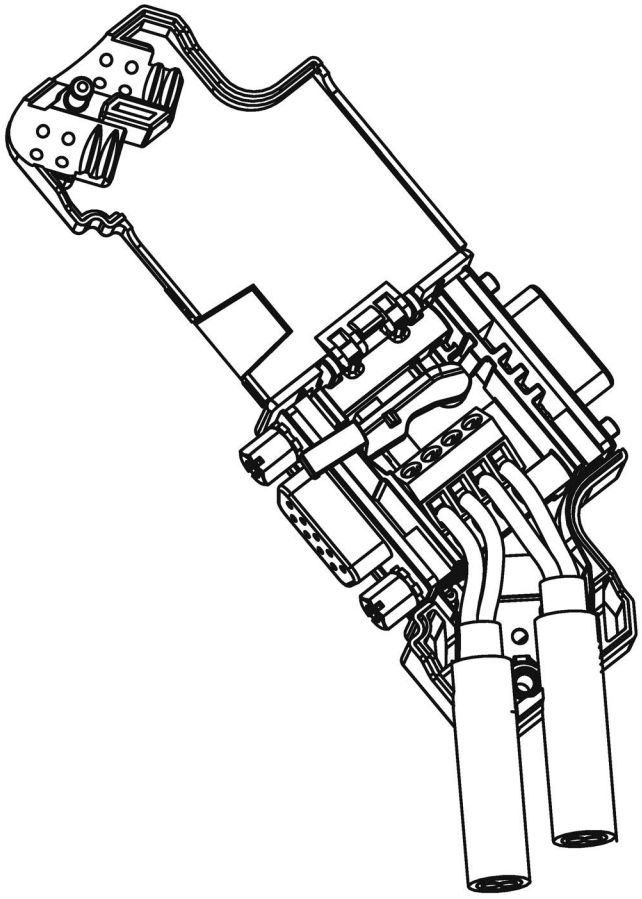


Figure 2-6 Example for PROFIBUS bus connector with PG socket, cable outlet 35°

Additional information

For additional information on the available components visit the Siemens Mall (http://mall.industry.siemens.com).

2.2.1.4 M12 bus connector

Area of application

Devices with an electrical M12 interface can use the M12 bus connector for SIMATIC NET PROFIBUS for direct connection with the SIMATIC NET PROFIBUS cables.

The M12 bus connector in degree of protection IP65 is available in the following versions:

- with screw-type terminals
- with insulation displacement termination
- with a cable outlet of 180°

2.2.1.5 Bus terminals for RS 485 networks

Bus terminal RS 485 and bus terminal M12

A bus terminal is used for the connection of an individual PROFIBUS station with RS485 interface to the PROFIBUS bus cable.

Bus terminals in degree of protection IP20 are available in the following versions:

- Bus terminal RS 485 with or without PG interface, transmission rate 9.6 kbps to 1.5 Mbps, integrated terminating resistor combination (connectible), with 1.5 m and 3 m connecting cable
- Bus terminal M12, transmission rate 9.6 kbps to 12 Mbps, integrated terminating resistor combination with isolating function, with 1.5 m connecting cable

2.2.1.6 M12 bus terminating resistor

Terminating segment with terminating resistor

If there is a station with M12 connection system at the beginning or end of a PROFIBUS segment, you need an M12 bus terminating resistor.

The M12 PROFIBUS connection of a device consists of an M12 socket for the infeed and an M12 male connector to loop-through the bus signal.

This means you need one bus terminating resistor with male contacts (6GK1905-0EC00) and with female contacts (6GK1905-0ED00) for each M12 bus cable.

2.2.2 Passive components for optical networks

2.2.2.1 Fiber-optic cables

Types of fiber-optic cables

Data transmission with fiber-optic cables takes place through modulation of electromagnetic waves in the range of visible and invisible light. These cables are made of high-quality plastic fibers and glass fibers:

- Plastic and PCF fiber-optic cables (Page 26)
- Glass fiber-optic cables (Page 27)

The different types of fiber-optic cables provide solutions matched to the operating and environmental conditions for the connection of components with each other.

Benefits

Fiber-optic cables offer the following benefits when compared with electrical cables:

- Galvanic isolation of the devices and segments
- No potential equalization currents
- No impact on transmission path through external electromagnetic interference
- No lightning protection elements required
- No noise radiation along the transmission route
- Low weight
- Depending on the type of fiber you can implement cable lengths up to few kilometers at even higher transmission rates.
- No dependency of the maximum permitted distances on the transmission rate

Additional information

Additional information of the properties and technical specifications of the passive components and connectors for fiber-optic cables is available in the PROFIBUS network manual (http://support.automation.siemens.com/WW/view/en/35222591).

2.2.2.2 Plastic and PCF fiber-optic cables

Plastic and PCF fiber-optic cables

Plastic (POF) and PCF fiber-optic cables are used for the connection of Optical Link modules with connections for plastic fiber-optic cables (OLM/P), Optical Bus Terminal (OBT) and devices with integrated optical interfaces. Under certain conditions, they are an inexpensive alternative to conventional glass fiber-optic cables.

Plastic Fiber Optic duplex core

The plastic fiber-optic duplex core is a flat dual core with PVC inner jacket without protective jacket. The cable can be easily assembled on-site.

The cable is intended for indoor applications with low mechanical loads or inside cabinets. For OLM connections and with integrated optical interfaces you cover a length of up to 50 m between two devices with this cable.

Plastic Fiber Optic standard cable

The plastic fiber optic standard cable consists of two plastic fibers with robust polyamide inner jacket surrounded by Kevlar tensile elements and a purple PVC protective jacket. The cable can be easily assembled on-site.

The robust round cable is suited for indoor applications. The maximum distance that can be covered is 80 m for OLM/P connections and 50 m with integrated optical interfaces and OBT.

PCF Standard Cable

The pre-assembled PCF Standard Cable consists of two PCF fibers surrounded by Kevlar tensile elements and a purple PVC protective jacket. It is always supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for indoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

PCF Standard Cable GP

The PCF Standard Cable GP consists of two PCF fibers surrounded by Aramid tensile elements and a green PVC protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

PCF Trailing Cable

The PCF Trailing Cable consists of two PCF fibers surrounded by Aramid tensile elements and a green PUR protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for moving indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

PCF Trailing Cable GP

The PCF Trailing Cable GP consists of two PCF fibers surrounded by Aramid tensile elements and a green PVC protective jacket. The cable is pre-assembled and can be ordered by the meter. It is supplied with a pulling aid installed on one end to pull in the cable channels.

The robust round cable is suited for moving indoor and outdoor applications with cable lengths up to 400 m (OLM) or 300 m (integrated optical interfaces, OBT) between two devices.

2.2.2.3 Glass fiber-optic cables

Glass fiber-optic cables

Glass fiber-optic cables are suitable for connection of optical interfaces that work in the wavelength range around 850 nm and around 1300 nm. They include two graded-index multimode fibers of the type 62.5/125 µm.

The glass fiber-optic cables are available in different versions which makes for an optimum adaptation to different areas of application:

- Fiber Optic standard cable
- INDOOR Fiber Optic indoor cable
- Flexible Fiber Optic trailing cable

Fiber Optic standard cable

The standard cable is the universal cable for indoor and outdoor use.

INDOOR Fiber Optic indoor cable

The indoor cable is intended for weather-proof indoor use. It is halogen-free, non-crush and flame-retardant.

Flexible Fiber Optic trailing cable

The trailing cable was designed for the special application of forced movement, for example, for constantly moved machine parts such as trailing chains. It is mechanically designed for 100,000 bending cycles by ±90° (with the specified minimum radius). Integrated dummy elements ensure a round cross-section of the cable. The trailing cable can be used indoors and outdoors.

Maximum distances between two optical link modules

The following distances may not be exceeded between two OLMs regardless of the optical power budget:

- OLM/P11, OLM/P12: 400 m
- OLM/G11, OLM/G12, OLM/G12-EEC: 3 km
- OLM/G11-1300, OLM/G12-1300: 15 km

Additional information

All operating instructions (http://support.automation.siemens.com/WW/view/en/10805951/133300) of the SIMATIC NET bus components include information on distances that can be covered with the SIMATIC NET glass fiber-optic cables. You can configure your optical network without any calculations using simple limits.

2.2.3 Active network components

2.2.3.1 Network components in electrical networks

Active network components

The following active network components are available for PROFIBUS in electrical networks:

- Repeater RS485
- Diagnostics repeater
- PROFIBUS Terminator
- DP/DP coupler
- IE/PB Link PN IO
- IWLAN/PB Link PN IO
- Active components for the connection of CAN
- Active components for the gateway between PROFIBUS and AS-Interface
  - DP/AS-i LINK Advanced
  - DP/AS-Interface Link 20E
  - DP/AS-i F-Link

RS485 repeater

The RS485 IP20 repeater connects two PROFIBUS bus segments in RS485 technology with up to 32 devices. It provides transmission rates from 9.6 kbps to 12 Mbps.

The RS485 repeater refreshes a signal regarding amplitude, signal width and edge steepness between two segments. It is used when more than 32 stations are connected to the bus or the maximum cable length of a segment is exceeded.

Bus segments can be operated ungrounded (galvanic isolation of segments) with an RS485 repeater.

Diagnostics repeater

The diagnostic repeater connects three PROFIBUS segments in RS485 technology, two of which are diagnostics-capable segments with 31 devices each. It is designed as DP slave to send diagnostics alarms to the DP master.

The diagnostic function provides the location and the cause of cable faults, such as wire break or missing terminating resistors. The fault location is indicated relative to the existing devices.

The diagnostics repeater refreshes a signal regarding amplitude, signal width and edge steepness between the segments. The cascading depth between any two PROFIBUS devices is limited to nine diagnostics repeaters.

PROFIBUS Terminator

The PROFIBUS Terminator forms an active bus termination. Bus devices can be switched off, removed or replaced without affecting data transmission. This is particularly true for bus devices on both ends of the bus cable at which terminating resistors must be connected or supplied. The PROFIBUS Terminator can be mounted on a standard mounting rail.

IE/PB Link PN for the connection of a PROFIBUS segment to an Industrial Ethernet network

The IE/PB Link PN IO as independent component provides the seamless transition between Industrial Ethernet and PROFIBUS. Through the use of IE/PB Link PN IO as substitute on the Ethernet, the existing PROFIBUS devices can continue to be used and can be integrated into a PROFINET application.

A PROFINET IO controller is required for this configuration. The IE/PB Link PN acts as master on the PROFIBUS end.

IWLAN/PB Link PN IO as gateway between LAN and PROFIBUS

PROFIBUS devices can be coupled to PROFINET IO by means of IWLAN/PB Link PN IO. This means you can integrate existing PROFIBUS configurations into PROFINET.

The IWLAN/PB Link PN IO supports the use of IWLAN and WLAN antennas for wireless data transmission, for example, in suspended monorail systems or conveyor systems. Because of the PROFINET support, the numerous PROFIBUS system services, for example, diagnostics by bus, can continue to be used.

A PROFINET IO controller is required for this configuration. The IWLAN/PB Link PN IO acts as master on the PROFIBUS end.

CANopen module for connection to CAN

You can use the CANopen module to easily connect CANopen applications to PROFIBUS.

Typical areas of application:

- Control of hydraulic valves/hydraulic axes in vehicles
- Control of motors in packaging machines and on conveyor belts
- Use in wind turbines for detection of angular encoders
- Detection of HMI devices on machines, e.g., joysticks
- Detection of measured data from displacement transducers, inclination sensors or angle encoders on tower cranes or gantry cranes

DP/DP coupler for connection of two PROFIBUS networks

The PROFIBUS DP/DP coupler is used to connect two PROFIBUS DP networks. Data (0 to 244 bytes) is transmitted from the DP master of the first network to the DP master of another network and vice versa.

The DP/DP coupler comes equipped with two independent DP interfaces that establish the connection to the two DP networks. There is one slave at each DP network. The data exchange between the two DP networks takes place by internal copying in the coupler.

DP/PA bus link for connection of PROFIBUS PA

The DP/PA bus link is the connection between PROFIBUS DP and PROFIBUS PA. This means it connects the process control systems with the field devices of the process automation.

The following components are available for a DP/PA bus link:

- DP/PA coupler Ex [ia]
- DP/PA coupler FDC 157-0
- Interface module IM 153-2 for establishing a DP/PA link.
- Active field distributor AFDiS for hazardous areas

Active components for the gateway between PROFIBUS and AS-Interface

- **DP/AS-i LINK Advanced**:

  The **DP/AS-i LINK Advanced** is PROFIBUS DPV1 slave (according to IEC 61158-2/EN 61158-2) and AS-Interface master (according to AS-Interface specification V3.0 according to EN 50295) and provides transparent data access to AS-Interface from PROFIBUS DP.

  PROFIBUS DP masters can cyclically exchange I/O data with the AS-Interface; DP masters with acyclic services can also make AS-Interface master calls. The **DP/AS-i LINK Advanced** is particularly suited for distributed configurations and for the connection of a subordinate AS-Interface network.

  The DP/AS-i LINK Advanced in the version as AS-Interface single master is completely sufficient for applications with typical configuration limits.

  For applications with high configuration limits, the DP/AS-i LINK Advanced is used as AS-Interface double master. In this case, the duplicate configuration limits can be used on two independently running AS-Interface strands.

- **DP/AS-Interface Link 20E:**

  The DP/AS-Interface Link 20E is PROFIBUS DP slave (in accordance with EN 61158) and AS-Interface master (in accordance with AS-Interface specification V3.0 according to EN 50295) and supports operation of the AS-Interface on PROFIBUS DP.

  Single PROFIBUS masters can cyclically exchange I/O data with the AS-Interface; masters with acyclic services can exchange I/O data and make master calls.

- **DP/AS-i F-Link:**

  The DP/AS-i F-Link is PROFIBUS DP-V1 slave (according to EN 61158) and AS-i master (according to AS-Interface specification V3.0 to EN 50295) and provides transparent data access to AS-Interface from PROFIBUS DP. The DP/AS-i F-Link is also the only AS-i master that can forward safety-oriented input data of ASIsafe slaves to a fail-safe CPU with PROFIBUS DP master by means of the PROFIsafe protocol. Additional safety cabling or monitoring is not required (in particular, no AS-Interface safety monitor). Depending on the slave type, you can transmit binary values or analog values. All slaves according to AS-Interface specification V2.0, V2.1 or V3.0 can be operated as AS-i slaves.

  As fully-featured AS-i master according to specification V3.0, you can use higher configuration limits on the AS-i network (496 inputs and outputs each, up to 62 digital or analog slaves).

Additional information

Information on the components is available in the Siemens Mall (http://mall.industry.siemens.com).

Additional information is available in these manuals:

- PROFIBUS Network Manual (http://support.automation.siemens.com/WW/view/en/35222591)
- Diagnostic repeater (http://support.automation.siemens.com/WW/view/en/7915183)
- DP/DP Coupler (http://support.automation.siemens.com/WW/view/en/1179382)
- SIMATIC NET Twisted-Pair and Fiber-Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)
- Basics on Setting up an Industrial Wireless LAN (http://support.automation.siemens.com/WW/view/en/9975764)
- SIMATIC bus links, DP/PA coupler, active field distributors, DP/PA Link and Y Link (http://support.automation.siemens.com/WW/view/en/1142696)
- Information on the CANopen module is available on the Internet (http://www.hms-networks.com/can-for-et200s).
- DP/AS-interface LINK Advanced (http://support.automation.siemens.com/WW/view/en/22502958/133300) manual
- DP/AS-i F-Link (http://support.automation.siemens.com/WW/view/en/24196041) manual

See also

Topology with RS485 repeater (Page 35)

OLM topology (Page 40)

WLAN topology (Page 40)

Connecting PROFIBUS to PROFINET (Page 41)

2.2.3.2 Network components in optical networks

Active network components

The following active network components are available for PROFIBUS in optical networks:

- Optical Link Module OLM
- Optical Bus Terminal OBT

Optical Link Module OLM

You can use the PROFIBUS Optical Link Modul OLM to install PROFIBUS networks in line, star structure and redundant ring structure.

The transmission rate of a fiber-optic cable line does not depend on the distance and can be 9.6 kbps to 12 Mbps.

Applications for OLM include, for example, plant buses on PROFIBUS base, networking across buildings using glass fiber-optic cables, mixed networks with electrical and optical segments, large networks (road tunnels, traffic guidance systems) and networks with high demands on availability (redundant ring networks).

Optical Link modules can be combined by means of an RS485 interface and individual devices or entire electrical segments can be integrated into the optical PROFIBUS network.

The following distances may not be exceeded between two OLMs regardless of the optical power budget:

- OLM/P11, OLM/P12: 400 m
- OLM/G11, OLM/G12, OLM/G12-EEC: 3 km
- OLM/G11-1300, OLM/G12-1300: 15 km

Optical Bus Terminal OBT (optical bus terminal)

The Optical Bus Terminal connects an individual PROFIBUS device without integrated optical interface or a PROFIBUS RS 485 segment with up to 31 devices to an optical PROFIBUS.

An individual PROFIBUS DP device is connected with its RS 485 interface by means of a PROFIBUS cable with integrated terminating resistor, for example, connecting cable 830-1T, to the RS 485 interface of the OBT. The OBT is integrated into the optical line by means of two optical interfaces.

The following optical transmission media can be connected to the OBT:

- Plastic fiber-optic cable up to 50 m single distance length. They can be assembled on-site with two 2x2 Simplex connectors.
- PCF fiber-optic cable up to 300 m single distance length. The cables are delivered pre-assembled.

Additional information

Information on the components is available in the Siemens Mall (http://mall.industry.siemens.com).

Additional information is available in these manuals:

- PROFIBUS network manual (http://support.automation.siemens.com/WW/view/en/35222591)
- SIMATIC NET PROFIBUS, Optical Link Module (http://support.automation.siemens.com/WW/view/de/56606534/0/en)
- SIMATC NET Twisted-Pair and Fiber-Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736)

2.2.4 Examples for topology

2.2.4.1 Topology with RS485 repeater

Configuration options with the RS485 repeater

You can operate the RS485 repeater in the following configurations:

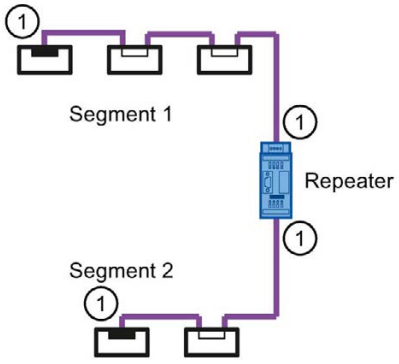


Figure 2-7 Segment 1 and segment 2 connected to RS485 repeater

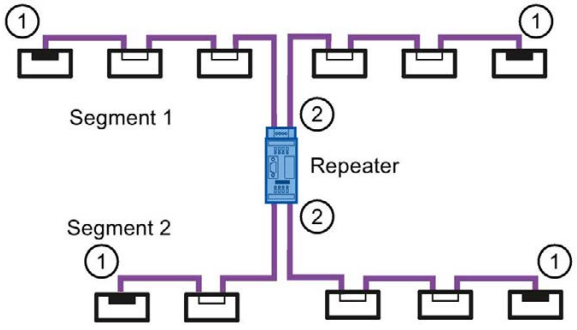


Figure 2-8 Segment 1 and segment 2 looped-through to RS485 repeater

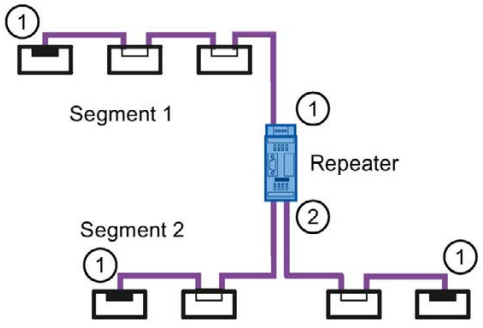


Figure 2-9 Segment 1 connected to RS485 repeater and segment 2 looped-through to RS485 repeater

① Connect terminating resistor

② Do not connect terminating resistor

Configuration example

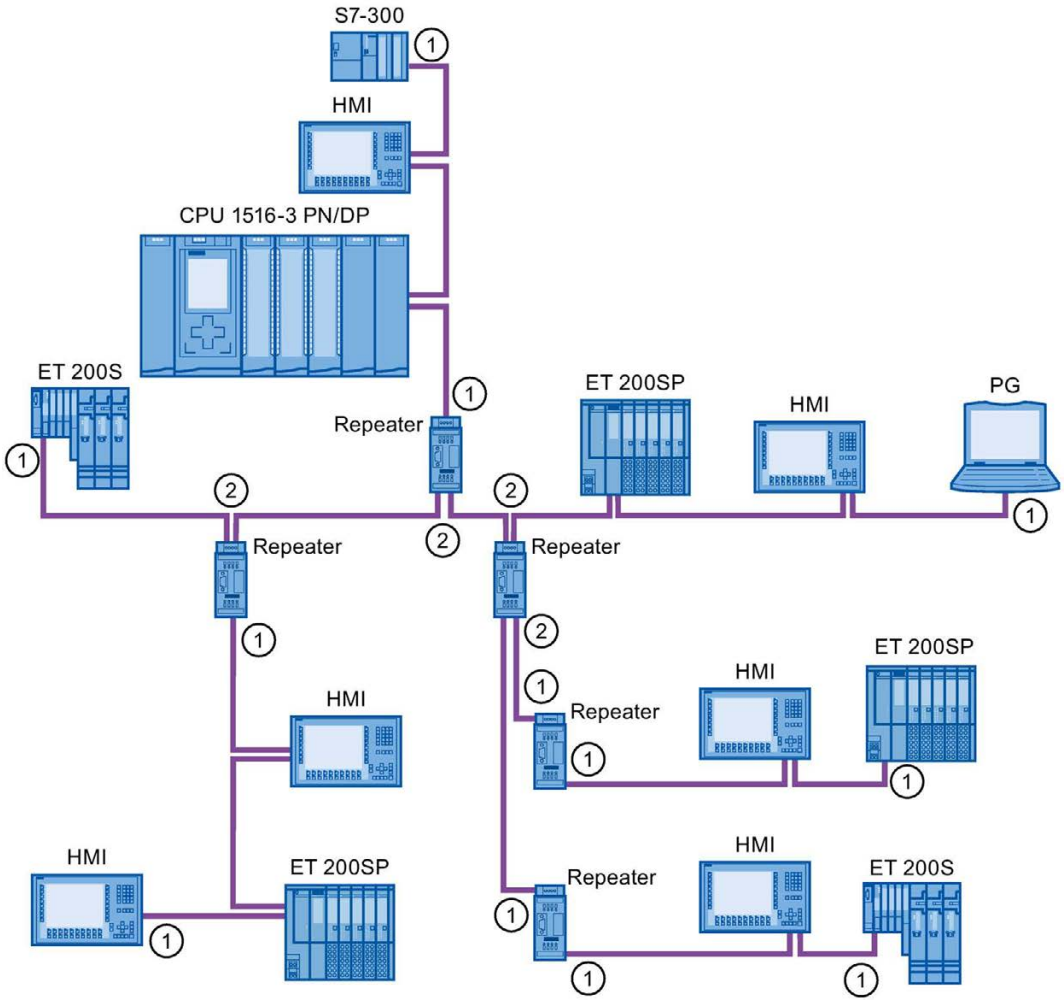


Figure 2-10 Configuration example with five RS485 repeaters

① Connect terminating resistor

② Do not connect terminating resistor

Maximum configuration

If you install a PROFIBUS network with RS485 repeaters, you may not connect more than nine RS485 repeaters in series.

2.2.4.2 Topology with diagnostic repeater

Diagnostic repeater with three segments

You may not exceed the maximum permitted cable length of 100 m per segment that can be monitored for the diagnostic repeater. The segments connected to DP2 and DP3 are diagnostics-capable. The cable length that can be monitored is limited for some cable types.

Maximum cascade depth

You can connect up to nine diagnostic repeaters in series between any two PROFIBUS stations.

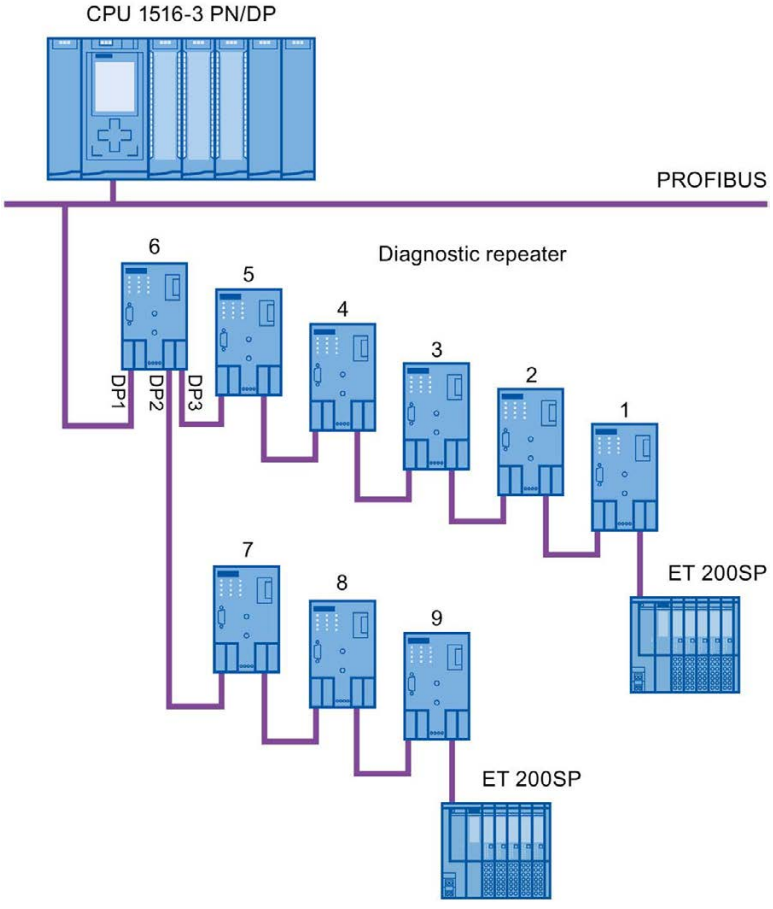


Figure 2-11 Schematic layout of a PROFIBUS network with maximum possible cascade depth at diagnostic repeaters

Example: Maximum cascade depth exceeded

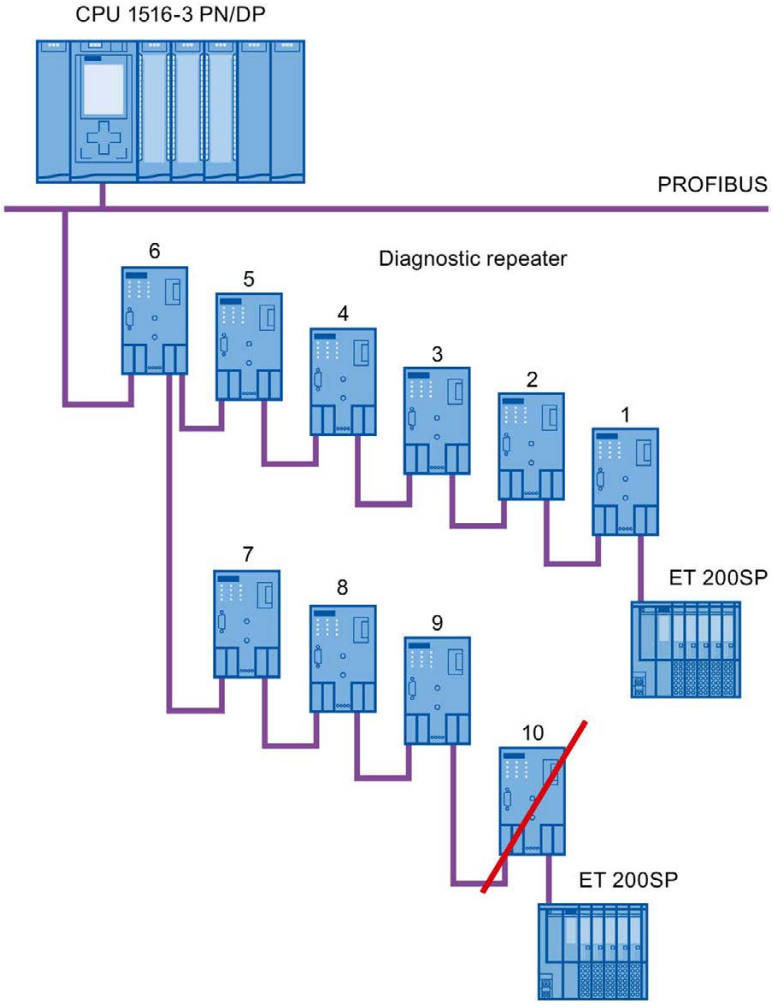


Figure 2-12 Maximum cascade depth exceeded

Layout with several segments

You can increase the number of used diagnostic repeaters by using several segments. The example shows a layout in which the maximum cascade depth is exceeded at two segments.

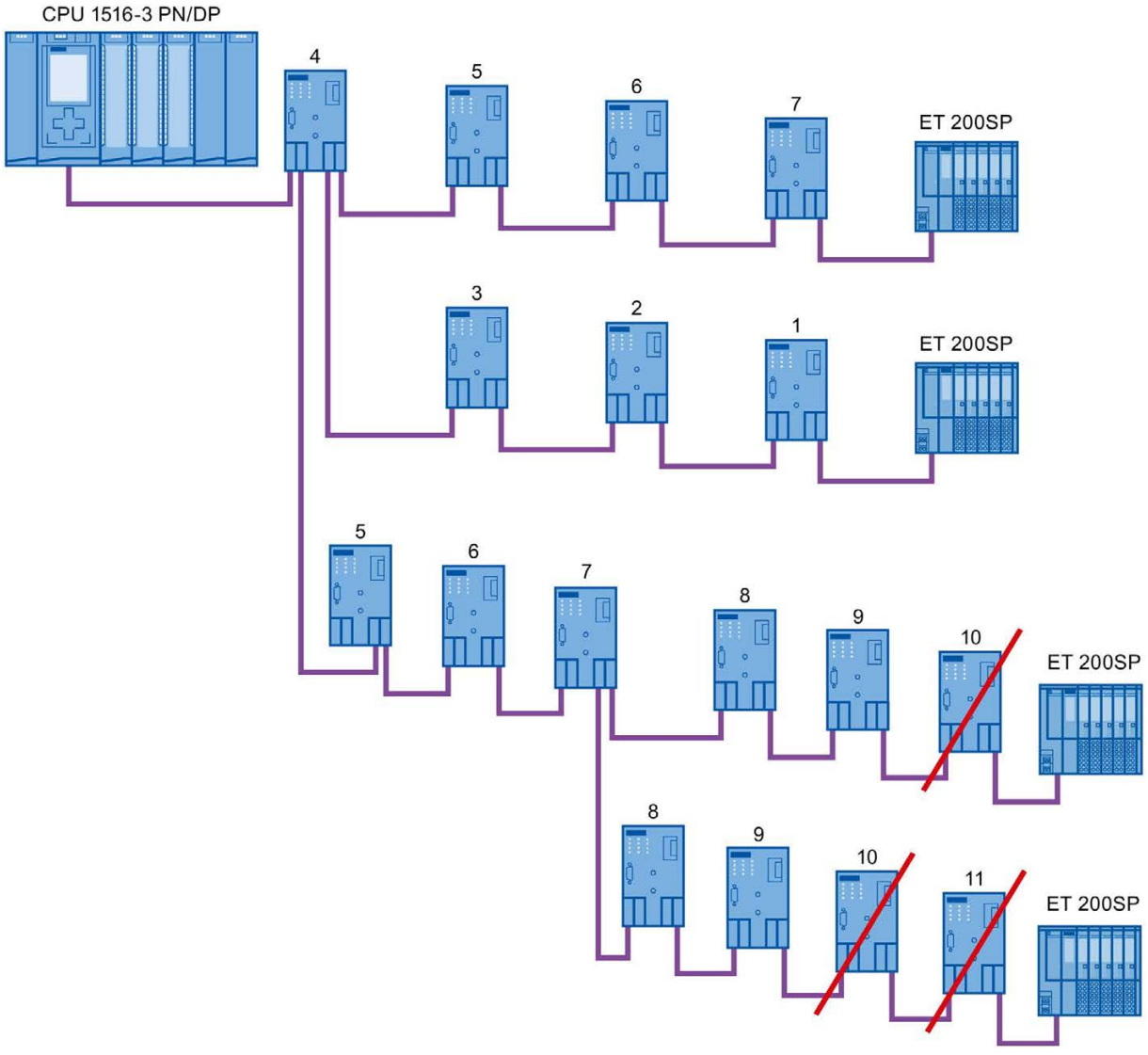


Figure 2-13 Layout with several segments, maximum cascade depth exceeded

Additional information

Additional information is available in the Diagnostic Repeater (http://support.automation.siemens.com/WW/view/en/7915183) manual.

2.2.4.3 OLM topology

Combination of electrical and optical networks with OLM

Additional distances can be covered by means of the Optical Link Module.

Because bus cables across several buildings are particularly vulnerable to damage caused by overvoltage (effect of lightning), the devices in the connected bus segment must be protected against overvoltage.

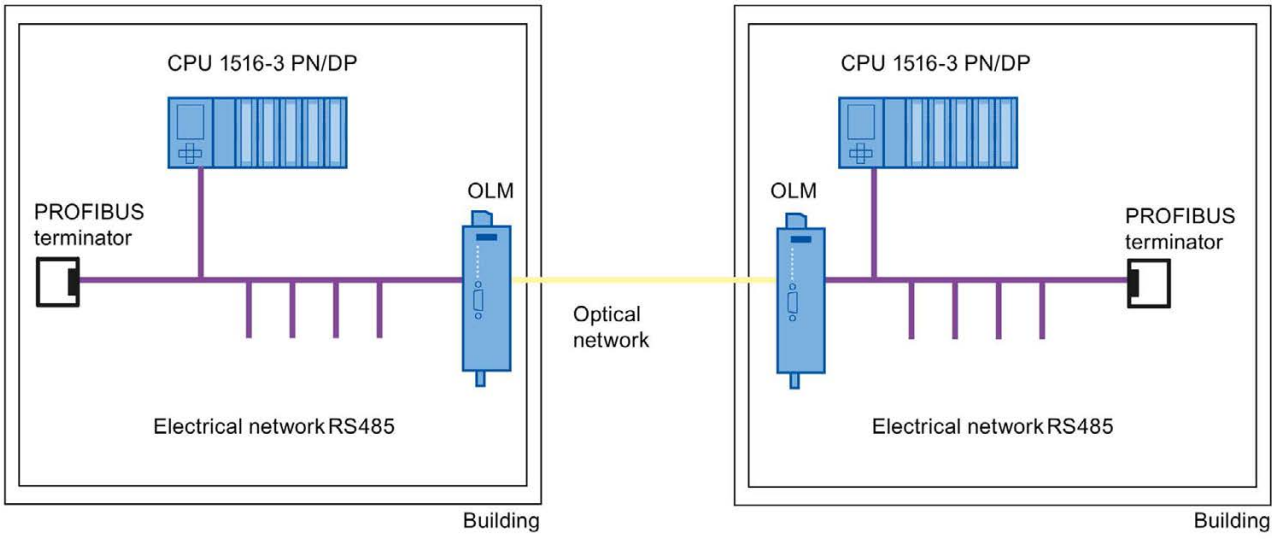


Figure 2-14 Combination of electrical and optical networks

2.2.4.4 WLAN topology

IWLAN/PB Link PN IO as gateway between Industrial Wireless LAN and PROFIBUS

The IWLAN/PB Link PN IO supports the use of IWLAN and WLAN antennas for wireless data transmission. This means the numerous PROFIBUS system services, for example, diagnostic by bus, can be used throughout.

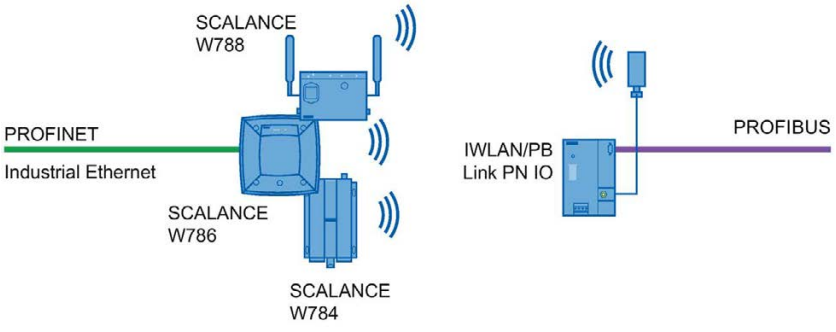


Figure 2-15 PROFIBUS and WLAN

2.2.4.5 Connecting PROFIBUS to PROFINET

PROFIBUS can be integrated in PROFINET. In this way, you can set up any hybrid systems consisting of fieldbus and Ethernet-based subsystems. This provides a continuous data exchange.

Coupling of PROFIBUS and PROFINET

With a proxy-capable PROFINET device that is equipped with a PROFIBUS interface in addition to a PROFINET interface, you can integrate existing PROFIBUS configurations into the PROFINET configuration.

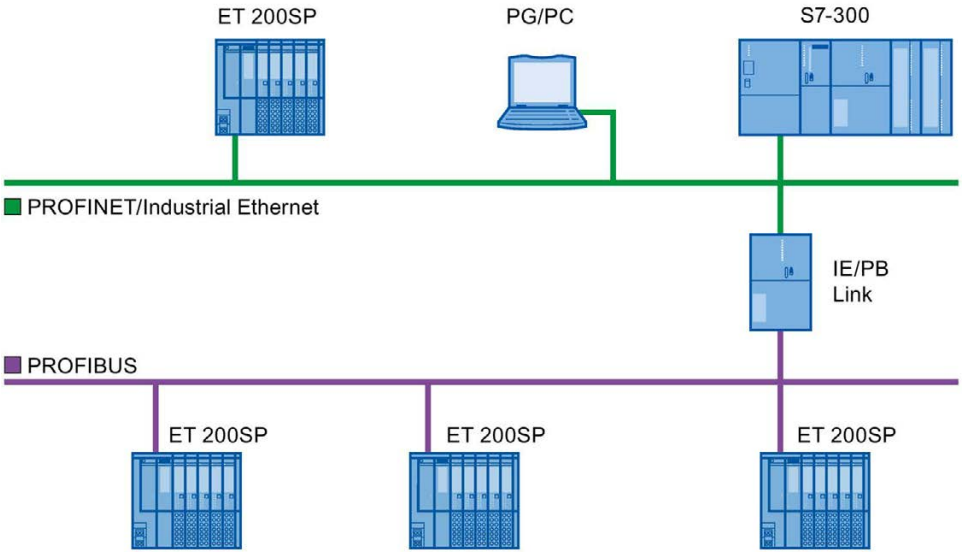


Figure 2-16 Connection of PROFIBUS and PROFINET with IE/PB link

PROFINET device with proxy functionality

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET, existing PROFIBUS systems can be integrated into the PROFINET communication with the aid of an IE/PB link. The IE/PB link PN IO then handles communication via PROFINET on behalf of the PROFIBUS components.

Parameter assignment/addressing 3

To set up an automation system, you will need to configure, assign parameters and link the individual hardware components. The work needed for this is undertaken in the STEP 7 device, topology and network view.

Configuration

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device or network view.

A PROFIBUS address is automatically assigned to each module. The addresses can be subsequently modified.

The CPU compares the preset configuration created in STEP 7 with the actual configuration of the plant. Errors can be detected and signaled immediately this way.

The exact procedure for configuring devices is described in detail in the STEP 7 online help.

Parameter assignment

"Parameter assignment" is understood to mean setting the properties of the components used. The settings for the hardware components and for data exchange are assigned, for example, activating diagnostics, input delay with DI.

The parameters are downloaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules can be replaced with ease because with SIMATIC CPUs the set parameters are automatically downloaded into the new module during each startup.

Adjusting the hardware to the project requirements

You need to adapt the hardware if you want to set up, expand or change an automation project. To do this, add hardware components to your layout, link them with existing components, and adapt the hardware properties to the tasks.

The properties of the automation systems and modules are preset so that in many cases you do not have to assign parameters again.

But parameter assignment is required in the following cases:

- You want to change the preset parameters of a module.
- You want to use special functions.
- You want to configure communication connections.

Basic procedure for creating a PROFIBUS DP system

- Configuration
  - Creating PROFIBUS devices and modules in STEP 7
  - Assigning the DP slave to a DP master (Page 43)
- Optional: Parameter assignment
  - Assigning the PROFIBUS address (Page 45)
  - Making network settings (Page 46)
  - Considering cable configuration (Page 49)
  - Considering additional network devices (Page 51)
  - Bus parameters – creating a user-defined profile (Page 52)
  - Configuring constant bus cycle time (Page 55)

3.1 Assigning the DP slave to a DP master

PROFIBUS DP system

A PROFIBUS DP system consists of a PROFIBUS DP master and its assigned PROFIBUS DP slaves. Once the devices have been placed in the network view or device view, STEP 7 assigns default parameter values to them. Initially, you only have to assign the DP slaves to one DP master.

Requirement

- The network view of STEP 7 is open.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- A DP slave has been placed (e.g., IM151-1 HF).

Procedure

To assign DP slaves to a DP master, follow these steps:

1. On the DP slave, use the left mouse button to click on the "Not assigned" link. The "Select DP master" menu opens.
2. Select the DP master in the menu to which you want to assign the DP slave.

   Result: A subnet with a DP system is created on the CPU. The CPU is now the PROFIBUS DP master. The DP slave is assigned to the DP master.
3. Repeat steps 1 and 2 for all other DP slaves that you want to assign to the DP master.

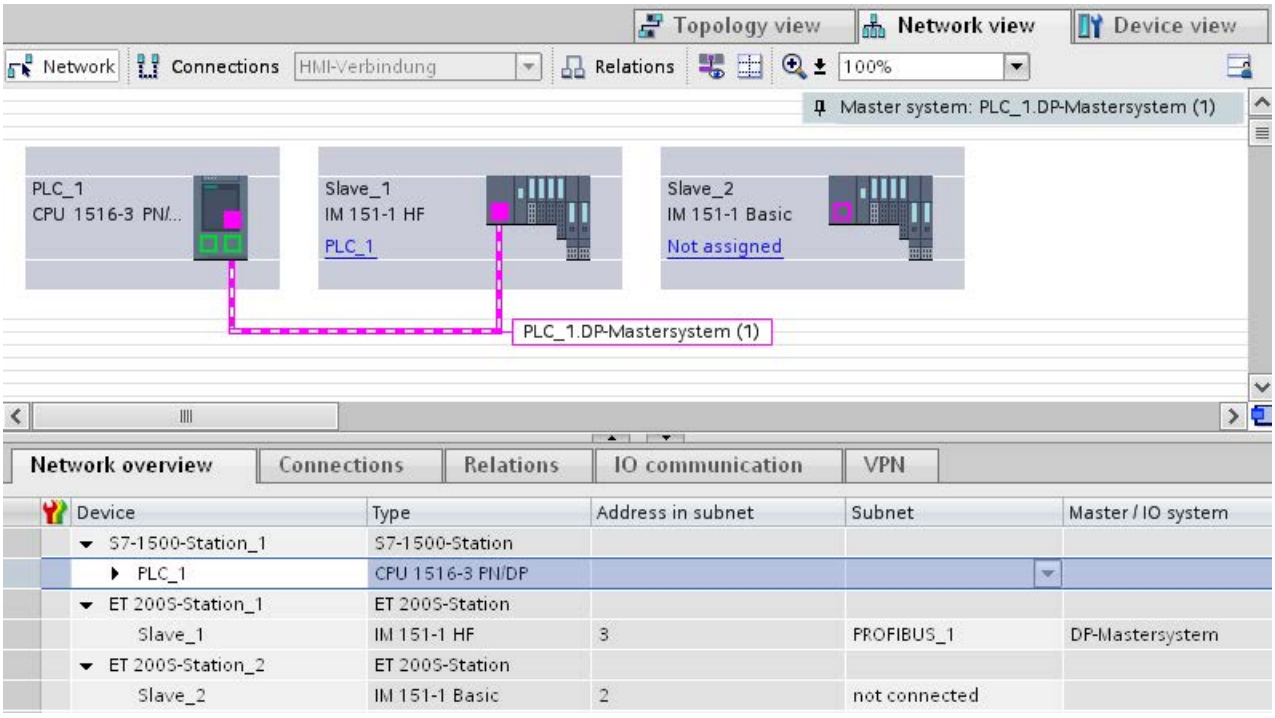


Figure 3-1 Assigning the DP slave to a DP master

Network overview

You can check the communication relationships of the activated interface in the network overview. The network overview is context-sensitive for selection in the network view:

- The selection of the CPU shows the DP communication of the CPU.
- The selection of the station shows the communication of the entire station.
- The selection of the interface shows the DP communication of the interface.

3.2 PROFIBUS address

Devices can be connected to the PROFIBUS subnet that communicate by means of configured connections or that are part of a PROFIBUS DP master system.

If the DP slave has already been assigned to a DP master, the PROFIBUS subnet to which the device is connected is automatically displayed under "Interface linked with".

In the Inspector window under "PROFIBUS", select the subnet to which the interface is linked or add a new subnet.

All devices of a subnet must have different PROFIBUS addresses.

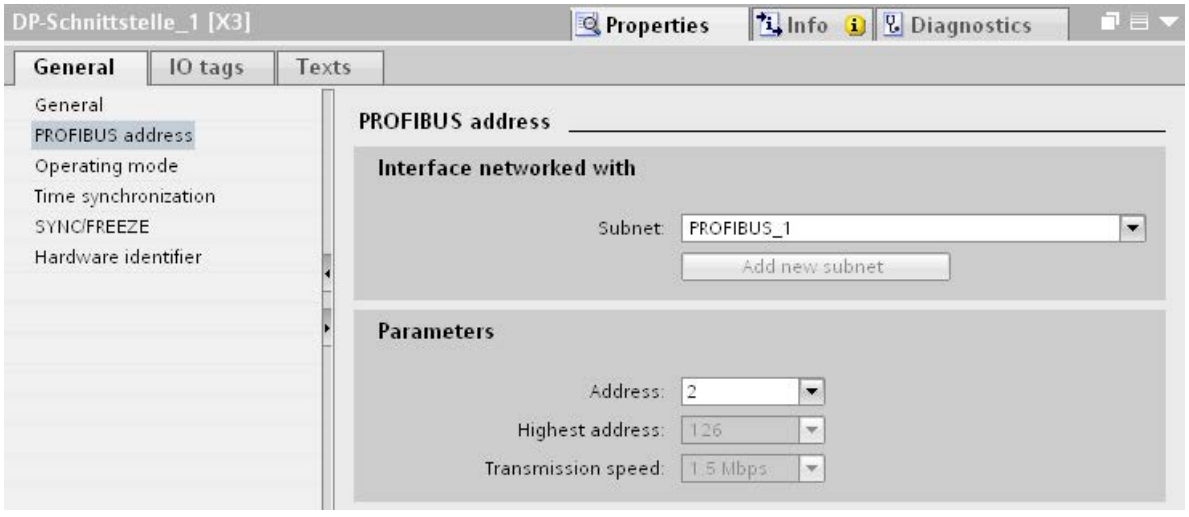


Figure 3-2 PROFIBUS address

Rules for address assignment

STEP 7 automatically assigns device addresses.

You can change the addresses if you observe the following points:

- Assign a unique PROFIBUS address to each device in the PROFIBUS network, each DP master and each DP slave in the PROFIBUS network.
- Depending on the DP slave, not all permitted PROFIBUS addresses are supported. For devices with BCD switches, it is often the case that only the PROFIBUS addresses 1 to 99 are supported.

Changing the PROFIBUS address

You change the PROFIBUS address under "Parameter".

3.3 Network settings

Highest PROFIBUS address (HSA)

Outputs the highest PROFIBUS address of an active device. PROFIBUS addresses greater than HSA are permitted for passive devices, but only up to 126.

Profile

Depending on the connected device types and the protocols used, different profiles are available on the PROFIBUS. The profiles differ with respect to their setting options and calculation of the bus parameters.

The PROFIBUS subnet will only work properly if the bus parameters of all devices have the same values.

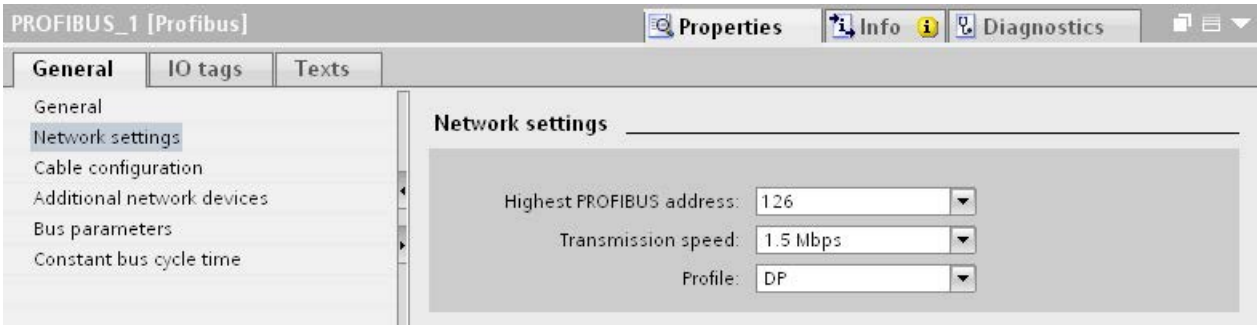


Figure 3-3 Network settings

Profiles and transmission rates

Table 3- 1 Profiles and transmission rates

Profiles	Supported transmission rates
DP	9.6 kbps to 12 Mbps
Standard	9.6 kbps to 12 Mbps
Universal (DP/FMS) (FMS is not supported)	9.6 kbps to 1.5 Mbps
User-defined	9.6 kbps to 12 Mbps

DP (recommended profile)

Select the "DP" profile if only devices meeting the requirements of the standard EN 61158-6-3 are connected to the PROFIBUS subnet. The setting of the bus parameters has been optimized for these devices. These include devices with DP master and DP slave interfaces of SIMATIC S7 as well as distributed I/O devices from third parties.

Note

Profile for constant bus cycle time and isochronous mode

DP is the recommended profile for the configuration of constant bus cycle time and isochronous mode.

Standard

Compared with the "DP" profile, the "Standard" profile gives you the option to take into consideration devices of another project or devices that have not been configured here for calculation of the bus parameters. The bus parameters are then calculated with a simple algorithm that was not optimized.

Universal (DP/FMS) (FMS is not supported)

Select the "Universal (DP/FMS)" profile if individual devices in the PROFIBUS subnet use the FMS service (e.g., CP 343-5, PROFIBUS FMS devices).

As with the "Standard" profile, here, too, you have the option to take additional devices into consideration for calculation of the bus parameters.

User-defined

The PROFIBUS subnet will only work properly if the parameters for the profile have been synchronized. Select the "User-defined" profile if none of the other profiles "match" for operation of a PROFIBUS device and if you have to adapt the bus parameters for your special layout.

You cannot configure all theoretically possible combinations with the user-defined profile either. The PROFIBUS standard prescribes some parameter limits depending on other parameters. It is, for example, not permitted that a responder responds (Min Tsdr) before the initiator is able to receive the frame (Trdy). These standard specifications are also checked in the "User-defined" profile.

Note

User-defined settings

Use user-defined settings only if you are familiar with the PROFIBUS parameters. It is usually better to work with the "DP" profile.

Contact Customer Support (Page 91) if you have any questions.

The bus parameters that were last valid on the PROFIBUS subnet are automatically set as user-defined. If the "DP" bus profile was valid for the subnet, for example, the bus parameters for "DP" are set in the "User-defined" bus profile. You can modify the parameters based on these settings.

The monitoring times are not automatically recalculated in the "User-defined settings" setting so that the uniformity of the set values is not changed without your knowledge, for example, to configure other configuration tools.

You can calculate the monitoring times Ttr and watchdog based on the parameters you have set. To do so, click on the "Recalculate" button.

See also

Additional network stations (Page 51)

3.4 Cable configuration

Considering cable configuration

Information on the cable configuration can be taken into consideration for calculation of the bus parameters. To do so, select the check box "Take into account the following cable configuration" in the properties of the PROFIBUS subnet.

The other information depends on the type of cable used.

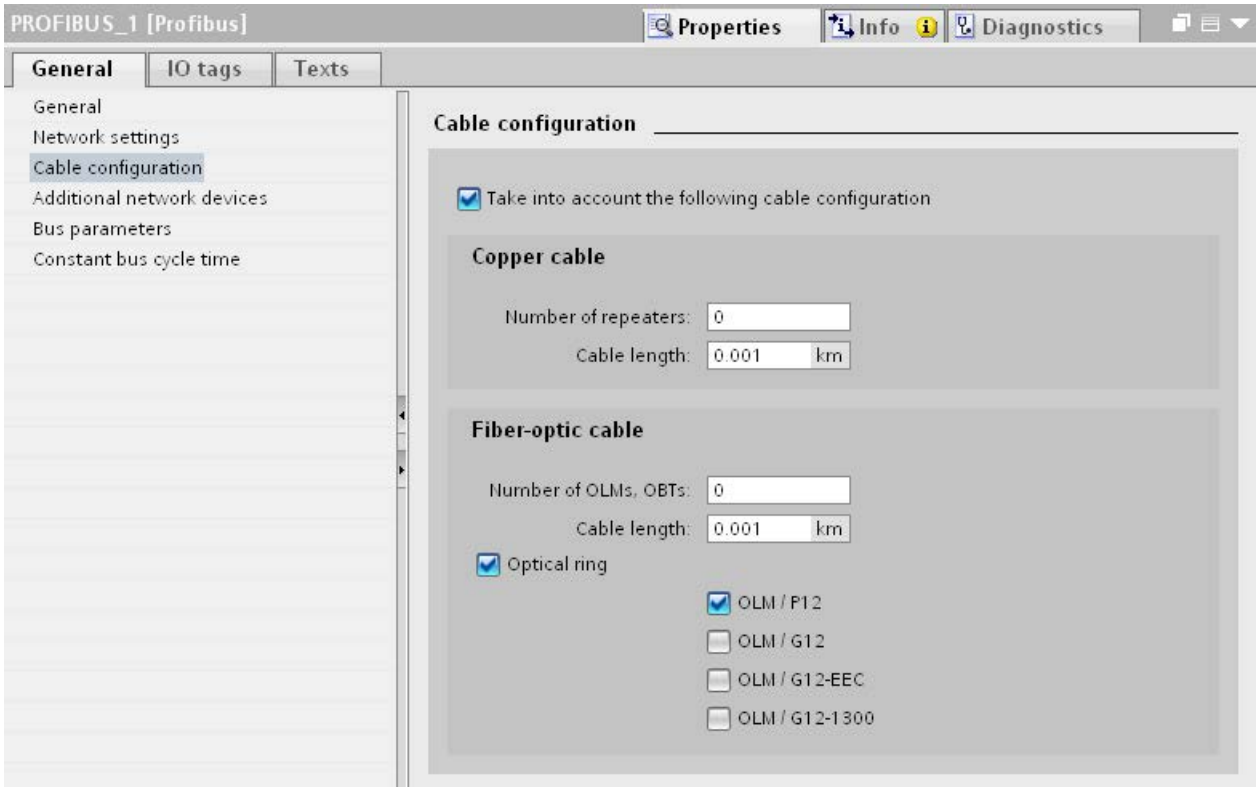


Figure 3-4 Cable configuration

Cable configuration: Fiber-optic cables/optical ring

The calculation depends on the used OLM types. Select the corresponding check box. Multiple selections are possible.

Adapting bus parameters in the optical ring

With the layout as ring, there is a kind of redundancy because you have the option to address all devices using the ring structure even if the connection between two devices is interrupted.

The following configuration conditions must be met in the optical ring:

- A free address below HSA (Highest Station Address)
- Increase of the retry value to at least 3

  (Network settings: user-defined profile)
- Checking and adapting of the slot time

  (Network settings: user-defined profile; bus parameters: Tslot parameter:

  You need short slot time values for OLM / P12, medium slot time values for OLM / G12 and OLM / G12-EEC and high slot time values for OLM / G12-1300. This results in a high performance for small networks and a medium to low performance with medium to large networks.

Additional information

Additional information on adaptation of the retry value and the slot time is available in the PROFIBUS Network Manual (http://support.automation.siemens.com/WW/view/en/35222591).

3.5 Additional network stations

Communication load - considering additional network stations

The bus parameters depend on the communication volume of the active network stations. There are differences between cyclical communication (DP) and connection-oriented, acyclical communication (S7 communication, Send/Receive (FDL)). Contrary to DP, the number and size of the communication jobs (communication load) depends on the user program. This means the communication load cannot always be determined automatically.

If you select the check box "Consider the following network stations", you can consider network stations in the calculation of the bus times that were not configured in the project.

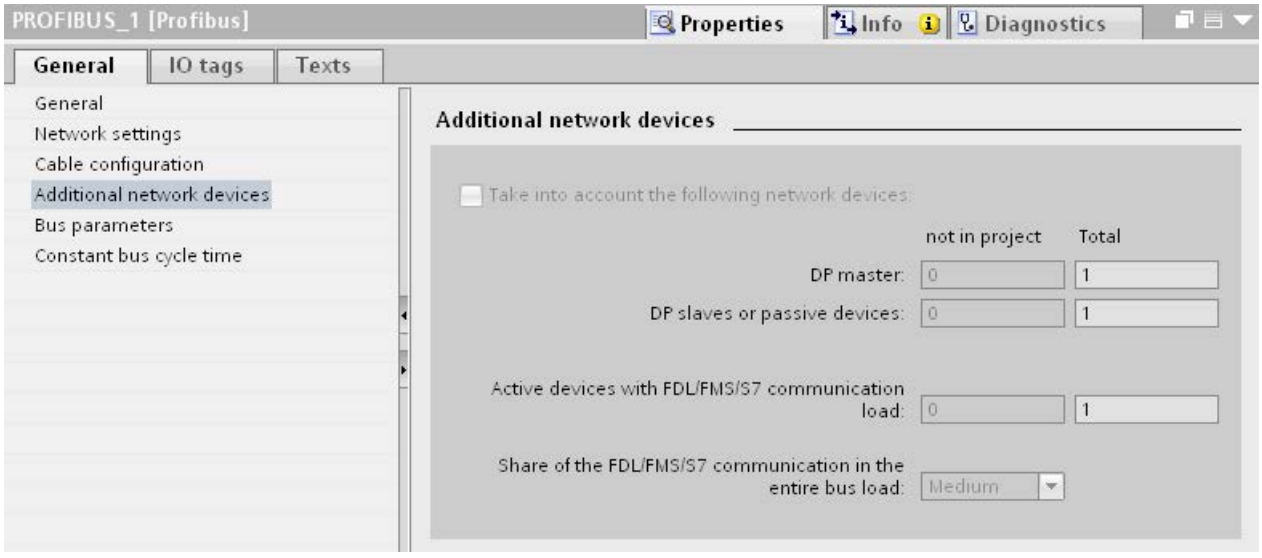


Figure 3-5 Additional network stations

Calculating the bus times

You can specify a network configuration in the parameter group "Additional network stations" for calculation of the bus times that deviates from the configured network configuration.

The network configuration is available for the following profiles:

- Standard
- Universal (DP/FMS)
- User-defined

Quantification of the communication load

The following settings are possible to take the communication load into consideration:

- Number of network stations that are not configured
- Information on the communication load from the user programs for FDL or S7 communication. You can choose from the following levels:
  - Low: Typical for DP, no larger data communication except DP.
  - Medium: Typical for mixed operation of DP and other communication services (e.g., S7 communication), if DP has high time requirements and with medium, acyclical communication volume.
  - High: For mixed operation of DP and other communication services (e.g., S7 communication), if DP has low time requirements and with high, acyclical communication volume.

3.6 Bus parameters

Introduction

Bus parameters control the transmission behavior on the bus. Each device on the bus must correspond with the bus parameters of other devices.

Note

The PROFIBUS subnet will only work properly if the parameters for the bus profile have been synchronized. Change the preset values only if you are familiar with the parameter assignment of the bus profile for PROFIBUS.

Cyclical distribution of the bus parameters

If the check box "Activate cyclical distribution of bus parameters" is selected under "Bus parameters" with the selected PROFIBUS subnet in the Inspector window, the bus parameters are sent cyclically during operation by the modules that support this function. This way you can, for example, connect a programming device to the PROFIBUS during operation.

Disable this function in the following cases:

- In constant bus cycle time mode to minimize the bus cycle.
- If third-party devices are connected in the PROFIBUS subnet whose protocol uses the DSAP 63 (Destination Service Access Point) for multicast.

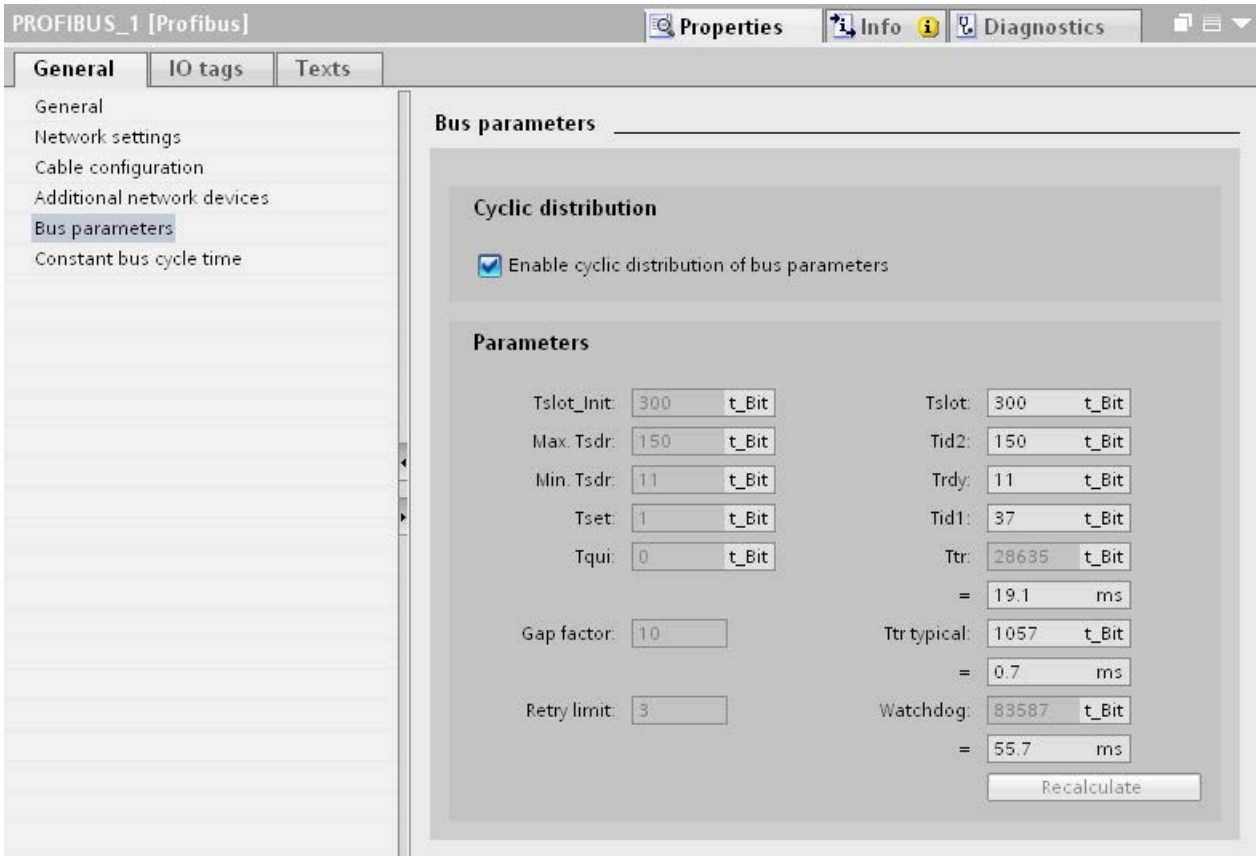


Figure 3-6 Bus parameters

Bus parameters for the bus profile of PROFIBUS subnets

Note

Display of offline values

The offline values of the bus parameters are always displayed even if they are connected online with the target system.

Table 3- 2 Bus parameters - value ranges

Bus parameters	Adjustable [1]	Limit values
Tslot_Init	Yes	Max. Tsdr + 15 <= Tslot_Init <= 16.383 t_Bit
Max. Tsdr	Yes	35 + 2*Tset + Tqui <= Max. Tsdr <= 1,023 t_Bit
Min. Tsdr	Yes	11 t_Bit <= Min. Tsdr <= MIN(255 t_Bit, ... Max. Tsdr - 1, 34 + 2*Tset + Tqui)
Tset	Yes	1 t_bit <= Tset <= 494 t_bit
Tqui	Yes	0 t_bit <= Tqui <= MIN(31 t_bit, Min. Tsdr - 1)
GAP factor	Yes	1 <= GAP factor <= 100
Retry limit	Yes	1 <= Retry limit <= 15
Tslot (slot time)	No	-
Tid2	No	Tid2 = Max. Tsdr
Trdy	No	Trdy = Min. Tsdr
Tid1	No	Tid1 = 35 + 2*Tset + Tqui
Ttr (Target Rotation Time)	Yes	256 t_Bit <= Ttr <= 16,777,960 t_bit
Ttr typical	No	This time is for information only and is not transmitted to the devices.
Watchdog		10 ms <= Watchdog <= 650 s

[1] depending on bus profile

User-defined bus profile

Use the following settings to create a user-defined bus profile:

- minimum Target Rotation Time (Ttr) = 5000x HSA (highest PROFIBUS address of an active device)
- minimum watchdog (Watchdog) = 6250x HSA

Recalculate

Use the button "Recalculate" to recalculate the parameters.

3.7 Constant bus cycle time

Constant bus cycle time

The DP master addresses its assigned DP slaves cyclically. S7 communication may cause the intervals to vary. You can enable a "bus cycle with constant bus cycle time" to achieve identical intervals. This ensures data transmission at the same (constant bus cycle time) intervals.

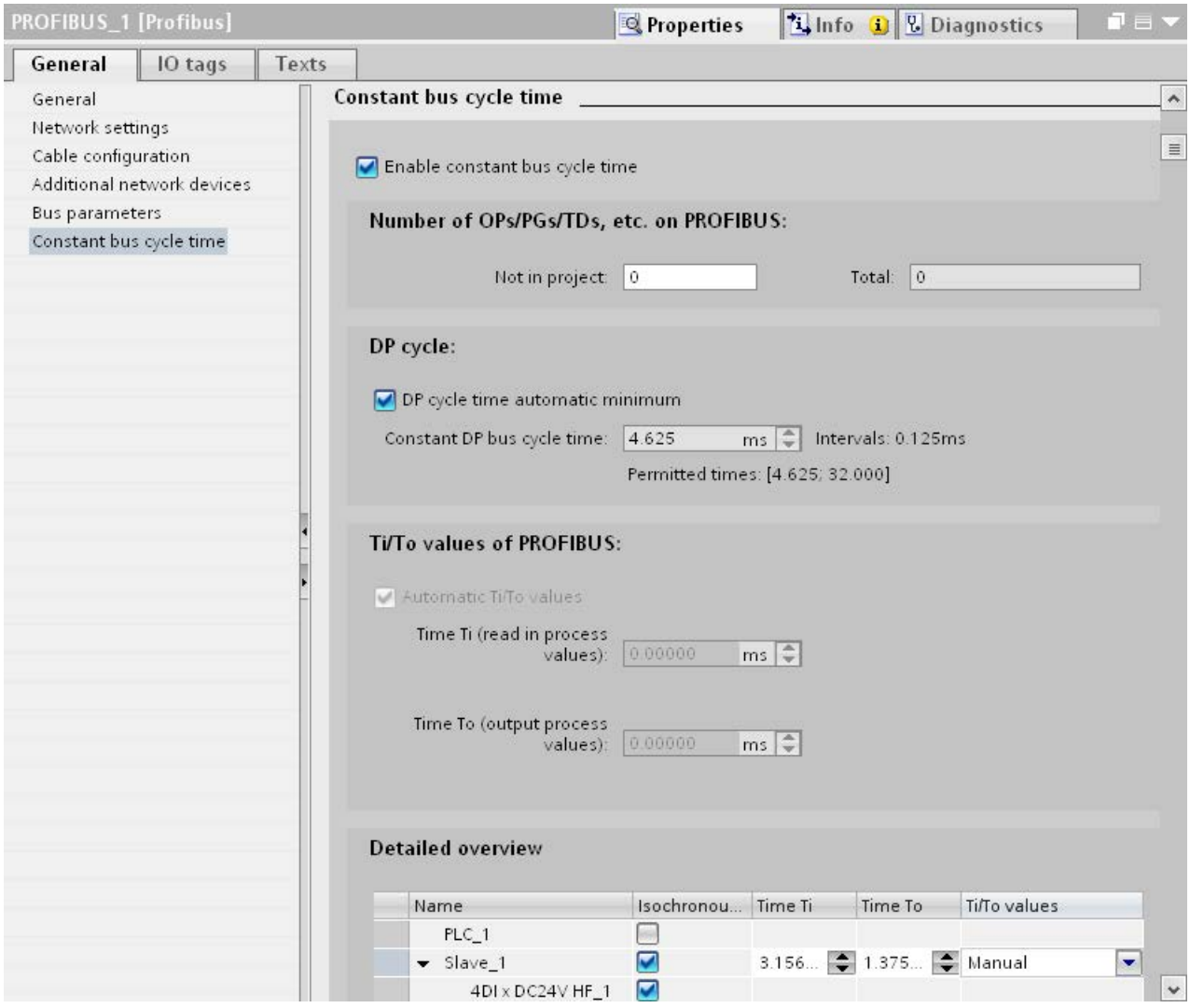


Figure 3-7 Enabling a bus cycle with constant bus cycle time

Number of OPs/PGs/TDs at the PROFIBUS

Here you enter the number of devices that are not configured.

Increasing DP cycle time manually

The following situation can occur especially with very short DP cycle times:
The runtime of the user program is greater than the shortest cycle (see Technical specifications of the CPU, section "Isochronous mode"). You have to manually increase the automatically calculated DP cycle time in this case.

See also

Configuring isochronous mode (Page 67)

Diagnostics 4

4.1 Overview

Diagnostics options

In case of an error you can determine the current status of your automation system and react specifically by using the event-related diagnostics and the evaluation of interrupts.

You can use the following options for diagnostics of the PROFIBUS components:

- Determine the status of the system using the Lifelist in STEP 7.
- Evaluate the module status, error and message texts by using the display of the S7-1500 CPU.
- Run cable diagnostics during operation by means of the diagnostics repeater.
- Evaluate the diagnostics and interrupt behavior in isochronous mode. (Page 70)
- Determine status information for fault localization and fault rectification by using the DP/PA coupler FDC 157-0 configured as PROFIBUS diagnostics slave.

Additional information

Additional information on diagnostics is available in these manuals:

- In the Diagnostics repeater for PROFIBUS-DP (http://support.automation.siemens.com/WW/view/en/7915183) manual for diagnostics with STEP 7, diagnostics in the user program, monitoring function isochronous PROFIBUS, topology display in STEP 7.
- In the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual for diagnostics options that are available for the SIMATIC systems S7-1500, ET 200MP, ET 200SP and ET 200AL.
- In the PROFIBUS Network Manual (http://support.automation.siemens.com/WW/view/en/35222591) system manual for diagnostics of fiber-optic cables.
- In the DP/PA Coupler, Active Field Distributors, DP/PA Link and Y Link (http://support.automation.siemens.com/WW/view/en/1142696) operating instructions.
- In the Web Server (http://support.automation.siemens.com/WW/view/en/59193560) function manual for diagnostics options (based on the functionality of the CPU).

4.2 Diagnostics using the display of the S7-1500

Displays

Each CPU in the S7-1500 automation system has a front cover with a display and operating buttons. Control and status information is displayed in different menus on the display. You use the operating buttons to navigate through the menus.

The following states can be evaluated on the display:

- Module status for central and distributed modules
- Error and alarm texts (system diagnostics, user-defined alarms)

Module status

From the station overview you go to the module status for a distributed module via the module overview.

Figure 4-1 Example: Station overview, module overview, module status

Error and alarm texts

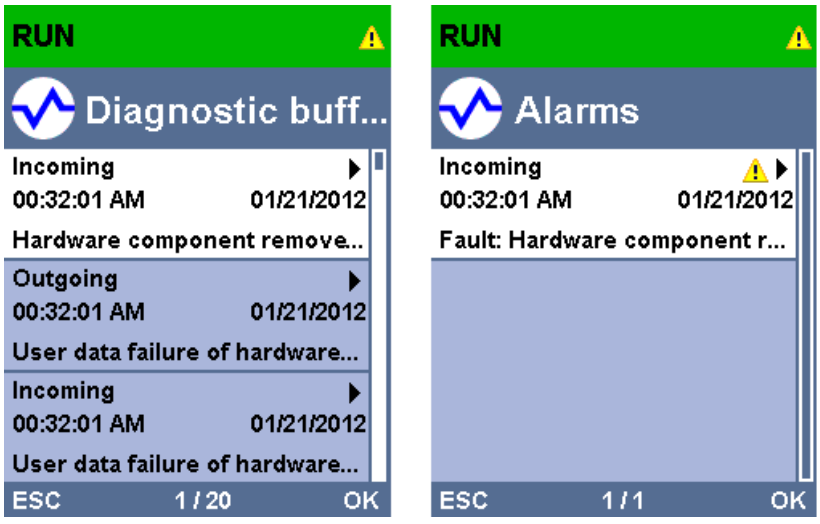


Figure 4-2 Example: Diagnostic buffer, alarms

Additional information

Additional information on the topic "Functions and operation of the display" is available in the documentation for the S7-1500 automation system on the Internet (http://support.automation.siemens.com/WW/view/en/59191792).

4.3 Diagnostics with the diagnostic repeater

Introduction

The diagnostic repeater is a repeater that can monitor two segments of a RS485-PROFIBUS subnet (copper cable) during operation and signal cable faults to the DP master by sending a diagnostic frame. Fault location and the cause of the fault can be displayed in plain text by means of STEP 7 as well as operator control and monitoring devices (SIMATIC HMI).

With its cable diagnostics during operation, the diagnostic repeater allows you to detect and localize cable faults early on. This means plant faults are detected early and plant downtimes can be prevented.

Diagnostic functions

- The diagnostic function provides the location and the cause of cable faults, such as wire break or missing terminating resistors. The fault location is specified relative to the devices present, for example "Break on signal line A and/or B".
- Reading out the saved diagnostic and statistical information.
- Monitoring of the isochronous PROFIBUS, e.g., violation of cycle time.
- Providing identification data.

Additional information

Additional information on diagnostics with STEP 7 and for reading out the diagnostics with the user program is available in the Diagnostic repeater for PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/7915183) manual.

4.4 I&M data (Identification and Maintenance)

Definition and properties

Identification and maintenance data (I&M) is information saved in a module to provide support when:

- Checking the plant configuration
- Locating hardware changes in a plant

Identification data (I data) is module information (some of which may be printed on the module housing) such as the order and serial number. I data is read-only, vendor-specific module information.

Maintenance data (M data) is system-specific information such as the installation location and date. M data is generated in the course of configuration and is written to the module memory.

The modules can be uniquely identified in online mode by means of the I&M data.

Additional information

Information if and to what extent a DP device supports I&M data is available in the respective device manual of the device.

Functions

5

5.1 Isochronous mode

5.1.1 What is isochronous mode?

Why isochronous mode?

Assuming public transport were to operate at maximum speed while reducing stop times at the passenger terminals to absolute minimum, the last thing many potential passengers would notice of the departing contraption are its red tail lights. The overall travel time is, however, decided by the train, bus or underground clock, because well adjusted timing is essential to a good service. This also applies to distributed automation engineering. Not only fast cycles but also the adaptation and synchronization of the individual cycles result in optimum throughput.

Just-In-Time

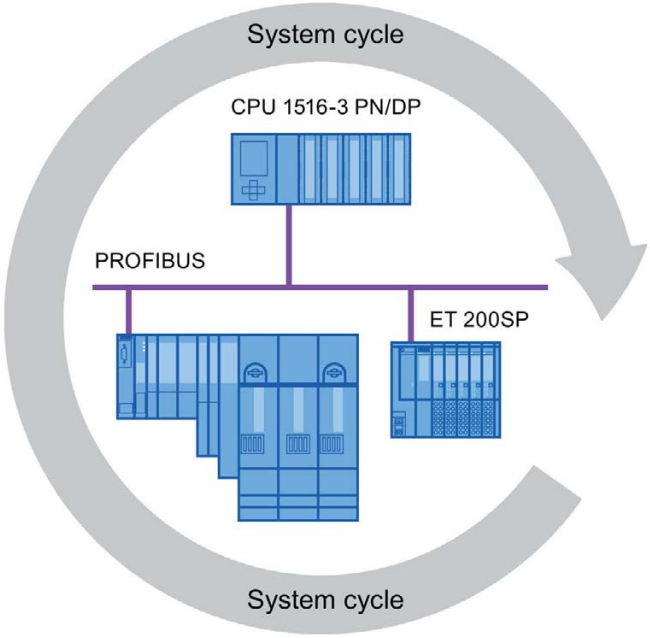


Figure 5-1 System cycle

The high speed and reliable reaction time of a system operating in isochronous mode is based on the fact that all data is provided just-in-time. The constant bus cycle time PROFIBUS DP cycle beats the time here.

Advantages of isochronous mode

The use of isochronous mode provides:

- Optimized controls
- Determinism
- Consistent (simultaneous) reading of input data
- Consistent (simultaneous) output of output data

5.1.2 Use of isochronous mode

The system property "isochronous mode" enables recording of measured values and process data in a defined system cycle. Signal processing takes place in the same system cycle all the way to switching to the "output terminal". This means isochronous mode improves the control quality and provides greater manufacturing precision. Isochronous mode drastically reduces the possible fluctuations of process response times. The time-assured processing can be used for a higher machine cycle.

Isochronous mode is basically always the choice when acquisition of measured values needs to be synchronized, movements need to be coordinated and process reactions need to be defined and take place simultaneously. This means the areas of applications for isochronous mode are manifold.

5.1.3 Isochronous applications

Example: Isochronous measurement at several measuring points

QC requires precise measurement of dimensions within a camshaft production process.

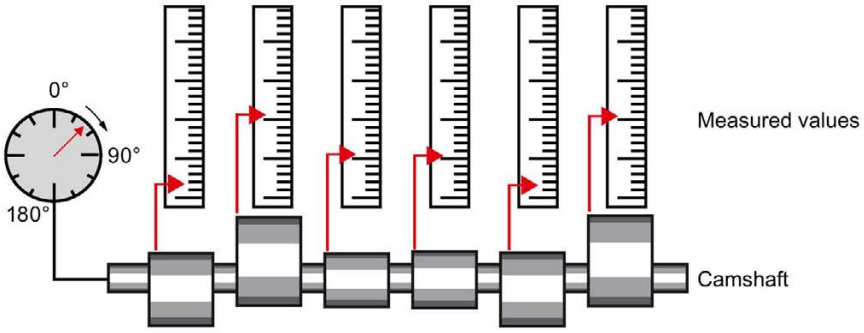


Figure 5-2 Measuring of camshafts

Isochronous workflow

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously and the time required for measurement is reduced. Resultant workflow:

- Continuous turning of the camshaft.
- During the continuous turning, measure the positions and cam excursion synchronously.
- Process the next camshaft.

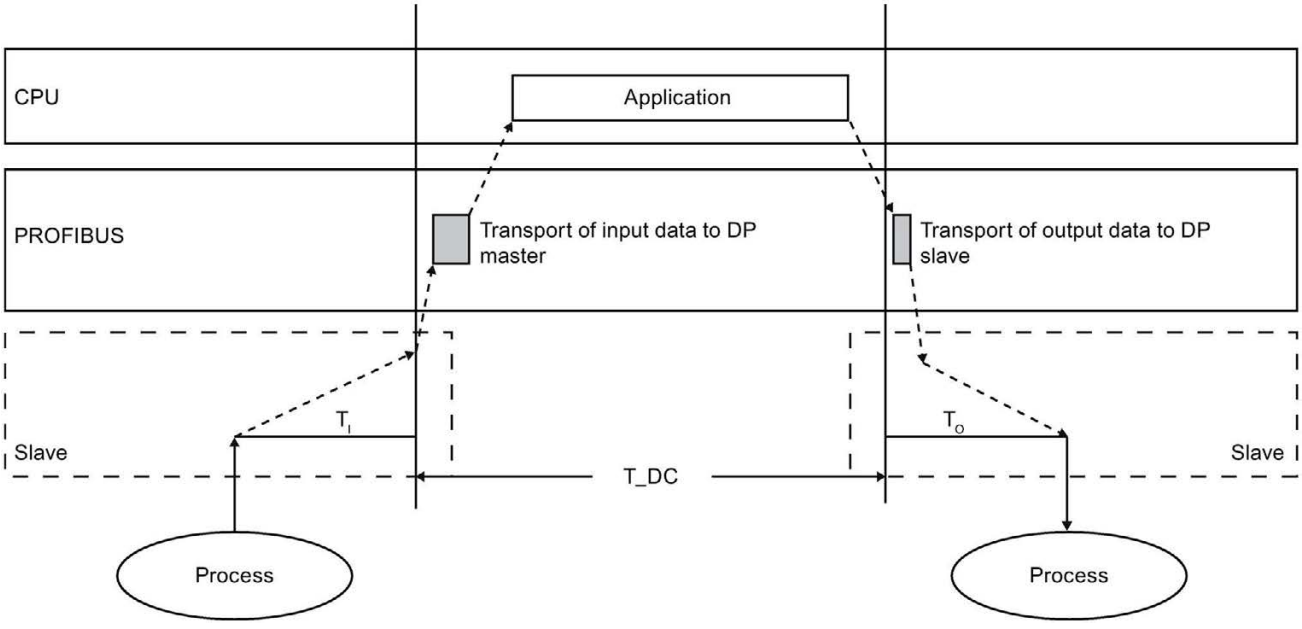
All camshaft positions and the corresponding measured values (red) are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

5.1.4 Sequence of synchronization

From reading of input data to output of output data

The sequence of all components involved in the synchronization is explained in the paragraphs below:

- Isochronous reading of input data
- Transport of input data by means of the PROFIBUS subnet to the DP master (CPU)
- Further processing in the isochronous application of the CPU
- Transport of output data by means of the PROFIBUS subnet to the output DP slave
- Isochronous output of output data



T_DC Date cycle

T_I Time for reading the input data

T_O Time for output of output data

Figure 5-3 Time sequence of synchronization

To ensure that all input data is ready for transportation via the PROFIBUS DP line when the next PROFIBUS DP cycle begins, the I/O read cycle has a lead time T_I so that it starts earlier. The T_I is the "flash gun" for all inputs. This T_I is necessary to compensate for analog to digital conversion, backplane bus times, etc. The lead time T_I can be configured by STEP 7 or by the user. We recommend that you have T_I assigned automatically by STEP 7 .

The PROFIBUS DP line transports the input data to the DP master. The synchronous cycle interrupt OB SynchronousCycle is called. The user program in the synchronous cycle interrupt OB decides the process reaction and provides the output data in time for the start of the next data cycle. The length of the data cycle is always configured by the user.

T_o is the compensation from the backplane bus and the digital to analog conversion within the slave. The T_o is the "flash gun" for all outputs. The time T_o can be configured by STEP 7 or by the user. We recommend that you have T_o assigned automatically by STEP 7.

Without isochronous mode, application, data transmission and field devices have their own, unsynchronized processing cycles; these result in a higher total cycle time with high jitter. With isochronous mode, application, data transmission and field device are synchronized resulting in a minimum total cycle with minimum jitter.

Isochronous mode and non isochronous mode distributed I/O

It is possible to combine isochronous mode distributed I/O with non isochronous mode distributed I/O on one DP master.

5.1.5 Requirements for configuration

Note the following requirements for configuration of isochronous mode:

- Isochronous mode cannot be used in optical PROFIBUS networks.
- Constant bus cycle time and isochronous mode are only possible with the bus profiles "DP" and "User-defined".
- Isochronous mode is only possible with the DP interfaces integrated in the CPU. Isochronous mode with CPs for PROFIBUS is not possible.
- Only the constant bus cycle time master is permitted as active station on the isochronous PROFIBUS DP. OPs and PGs (for example, PCs with PG functionality) influence the time behavior of the isochronous DP cycle and are therefore not permitted.
- Isochronous mode is not permitted across lines.
- Isochronous I/O can only be processed in process image partitions. Isochronous consistent data transmission is not possible without the use of process image partitions. The adherence to quantity structures is monitored because the number of slaves and bytes on the DP master system is limited for each process image partition.
- The addresses of isochronous modules must be located in a process image partition.
- Full isochronous mode from "terminal" to "terminal" is only possible if all components involved in the chain support the system property "isochronous mode".

  Make sure you look for the entry "Isochronous mode" or "Isochronous processing" in the information box of the module when you select it in the catalog.
- When you configure isochronous mode, you may not assign a SYNC/FREEZE group to the slave.

5.1.6 Configuring isochronous mode

Introduction

A SIMATIC automation solution can be connected to the isochronous PROFIBUS with the isochronous mode function. Isochronous mode guarantees the synchronous reading of input data, the processing and output of output data at the same (isochronous) intervals.

Basic procedure for configuration of isochronous mode

1. Setting the properties for isochronous mode on the DP slave:
   - Isochronous DP cycle
   - Isochronous mode of the modules
2. Setting the properties for isochronous mode on the modules:
   - Synchronous cycle interrupt (SynchronousCycle)
   - Process image partition
   - Input delay
3. Create user program with access to isochronous I/O

Requirement

- The network view in STEP 7 is open.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An interface module has been placed and networked with the CPU (e.g., IM 151-1 HF).
- I/O modules have been placed (e.g., 2DI x DC24V HF and 2DO x DC24V/0,5A HF).

Configuring isochronous mode on the DP slave

1. Select the DP slave in the network view and navigate to the "isochronous mode" area in the Inspector window.
2. Enable the option for synchronization to the DP cycle for the DP slave.

   Default: The DP slaves get the Ti/To values from the subnet which means the values are automatically the same for all DP slaves of the DP master system.
3. Enable the "Isochronous mode" option the the "Detail view" for all I/O modules you want to operate in isochronous mode.
4. Repeat steps 1 and 3 for all DP slaves that you want to operate in isochronous mode.

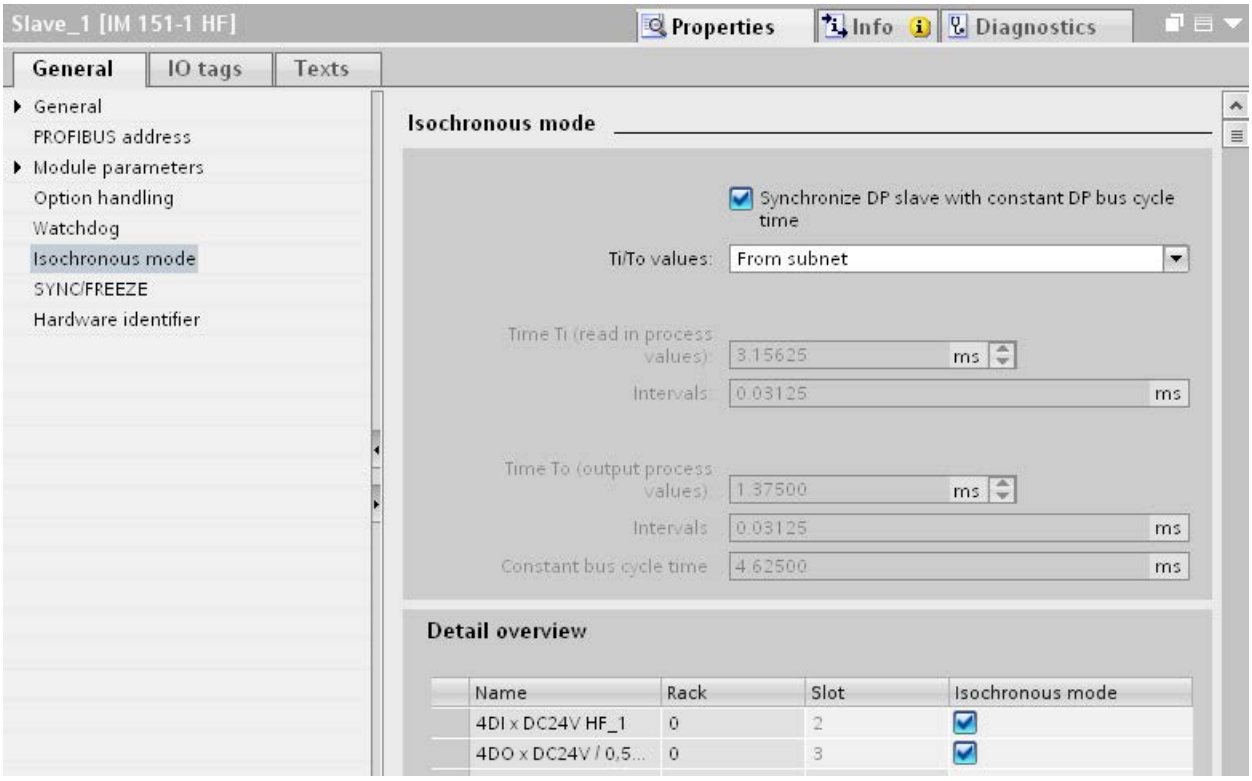


Figure 5-4 Configuring isochronous mode on the DP slave

Configuring synchronous cycle interrupt on the I/O module

1. Select an I/O module in the device view and navigate to the "I/O addresses" area in the Inspector window.
   – The option for isochronous mode is selected.
2. Select the synchronous cycle interrupt in the drop-down list.

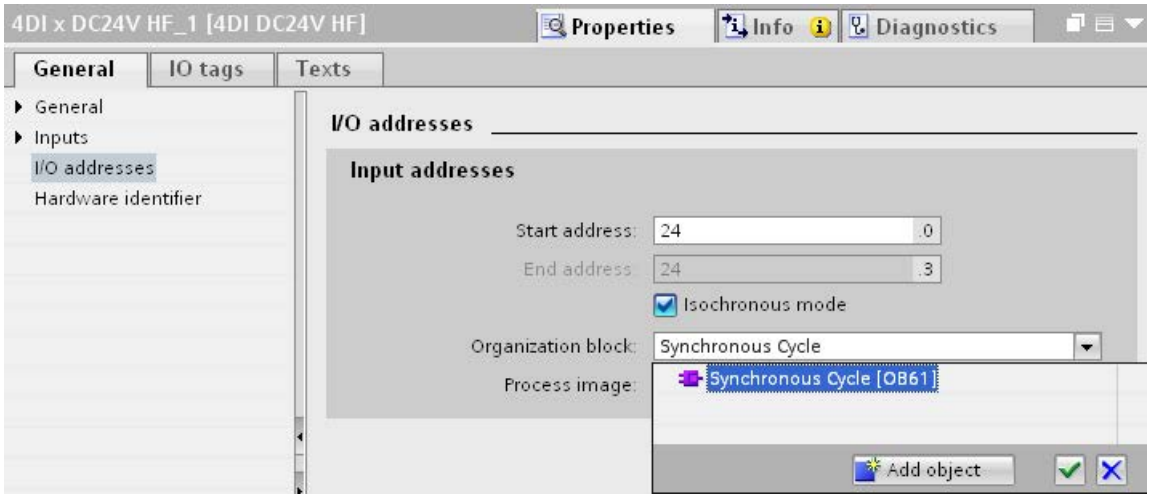


Figure 5-5 I/O addresses - creating the synchronous cycle interrupt OB

3. Assign the process image partition configured in the CPU.

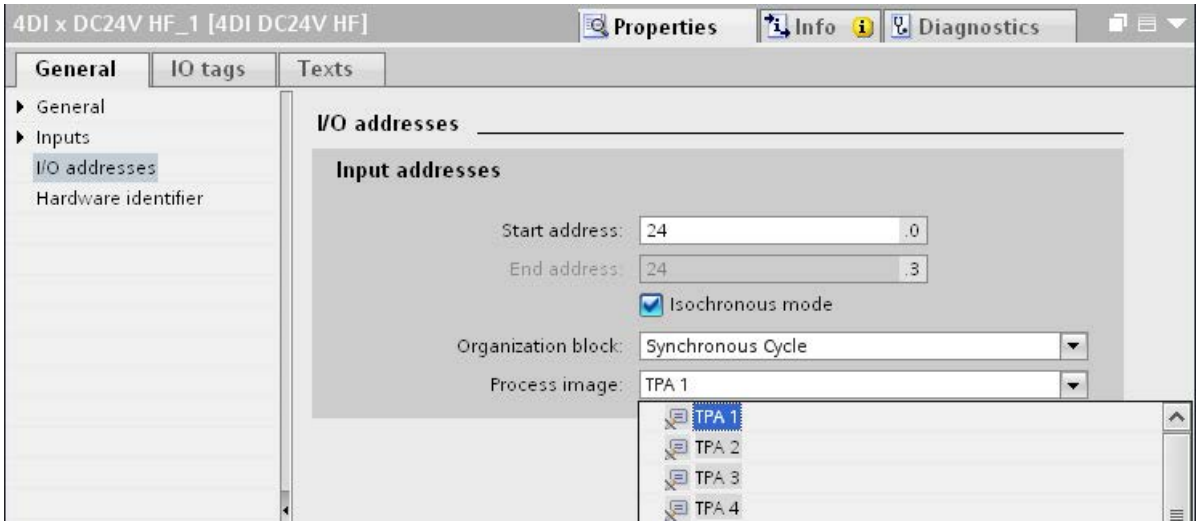


Figure 5-6 I/O addresses - assigning process image partitions

4. Repeat steps 1 and 3 for all I/O modules that you want to operate in isochronous mode.

Programming isochronous mode

To operate your plant in isochronous mode, the user program must be structured accordingly. This means you have to add a synchronous cycle interrupt in the STEP 7 project tree.

You access the isochronous I/O by means of a process image partition, which means the addresses of the isochronous modules must be located in a process image partition. You program access to isochronous I/O with the "SYNC_PI" instructions (updating the process image partitions of the inputs) and "SYNC_PO" (updating the process image partition of the outputs) in the synchronous cycle interrupt OB.

You call the "SYNC_PI" instruction at the start of the synchronous cycle interrupt OB, provided you have selected the automatic setting for the delay time. You call the "SYNC_PO" instruction at the end of the synchronous cycle interrupt OB.

5.1.7 Diagnostics and interrupt functions

The diagnostic and interrupt functions of STEP 7 are available for isochronous mode. These reduce downtimes and simplify localization and elimination of faults.

Events, causes of errors and remedies

Below, you will find the events for diagnostic and interrupt functions and remedies for the problem.

Table 5- 1 Events, causes of errors and remedies

Event	Cause of the error	Remedy
• Synchronous cycle interrupt OB is started with the input parameter EventCount > 0 (number of lost OB calls since last OB call) If configured: • Call of the time error OB • Diagnostic buffer entry "Buffer overflow for OB6x events"	The synchronous cycle interrupt OB takes too long.	• Shorten the synchronous cycle interrupt OB. • Increase the DP cycle. • Reduce the delay time setting (setting with isochronous mode at synchronous cycle interrupt OB).
Error (negative RetVals) when updating the isochronous process image partition with SYNC_PI / SYNC_PO: • Consistency warning • Update time is after / before the permitted access window.	SYNC_PI / SYNC_PO are not called in the permitted access window in the synchronous cycle interrupt OB, which means they are called or processed during the I/O data transfer on PROFIBUS.	• Increase the delay time. • Increase the DP cycle. • Adapt the program.
Error when updating the isochronous process image partition with SYNC_PI / SYNC_PO: • Access error	DP slave / module does not respond / is not available.	

5.1.8 Parameter settings for isochronous mode

Parameter changes as task of the field service technician

The task of a field service technician is to maintain the production process.

In this context the technician has to detect, localize and eliminate errors and performance losses of isochronous mode.

All parameters which influence isochronous mode can be checked and configured using the "Isochronous mode" dialog box.

Parameters should only be changed by experienced users or service technicians.

5.1.8.1 Viewing isochronous mode parameters

"Isochronous mode" dialog box

1. Select "Properties > Isochronous mode" in the Inspector window.

   The "isochronous mode" dialog box opens with an overview of parameters which influence isochronous mode.
   Information on the individual parameters is available under "Detail overview".

2. Compare the values shown with the values in the documentation, or with the value specified by a technician.

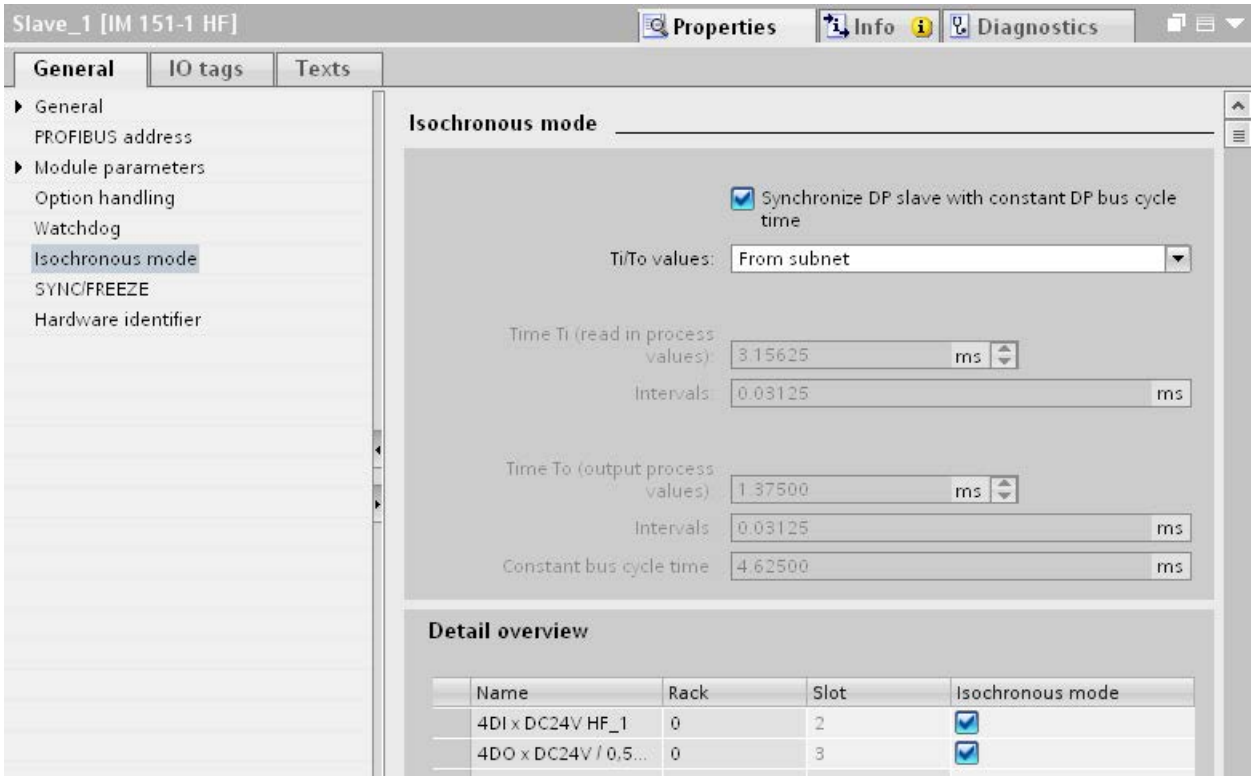


Figure 5-7 Viewing parameters for isochronous mode

5.1.8.2 Change parameters

Changing parameters for the DP master system

You can change the parameters for isochronous mode in the "Constant bus cycle time" dialog box.

1. Select the DP master system in the network view.
2. Select the section "Constant bus cycle time" in the Inspector window.
3. Change the parameters according to the received instructions.

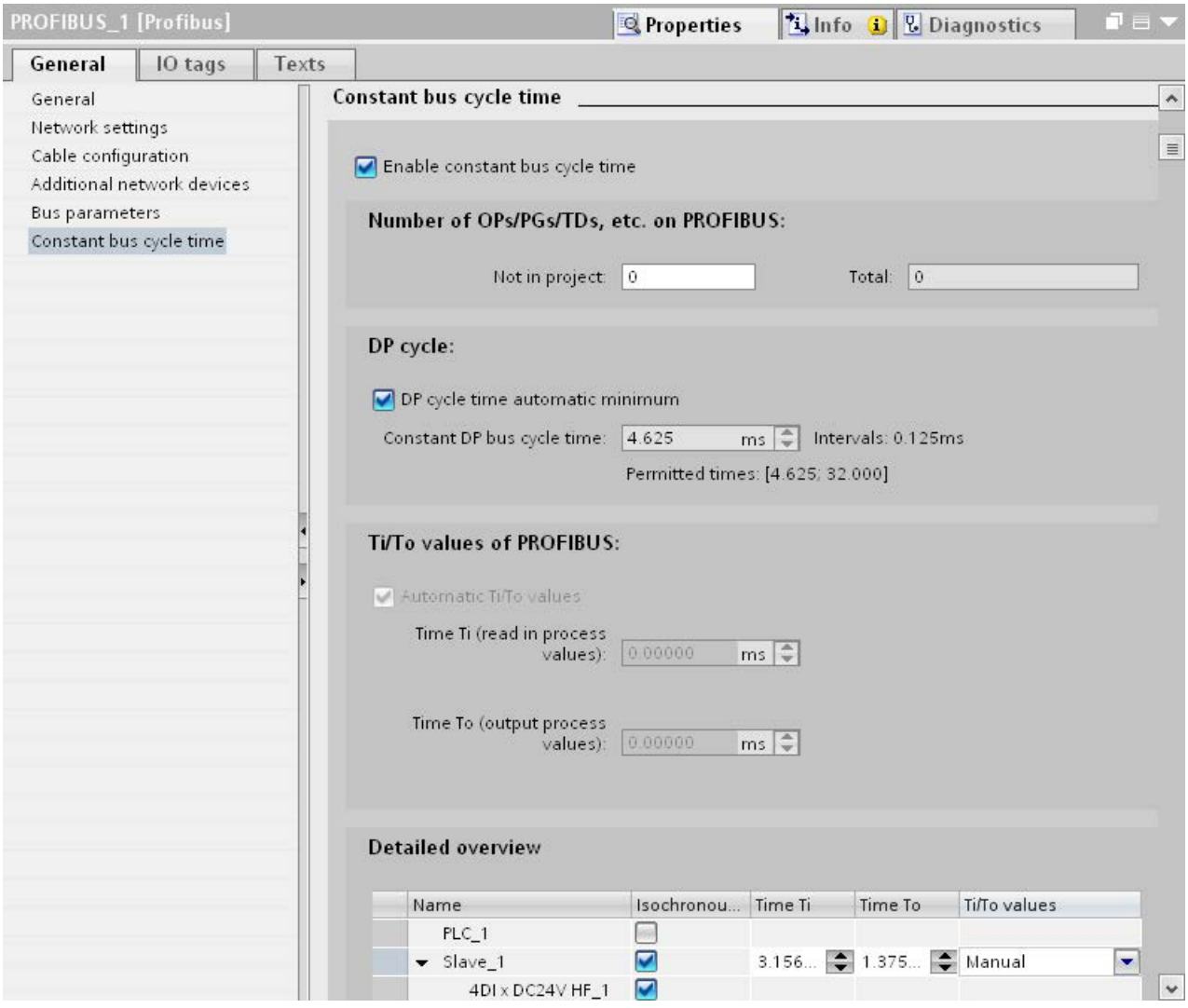


Figure 5-8 Changing parameters for the DP master system

Adapting the input delay

1. Select the input module in the device view.
2. Select the section "Inputs" in the Inspector window.
3. Adapt the input delay.

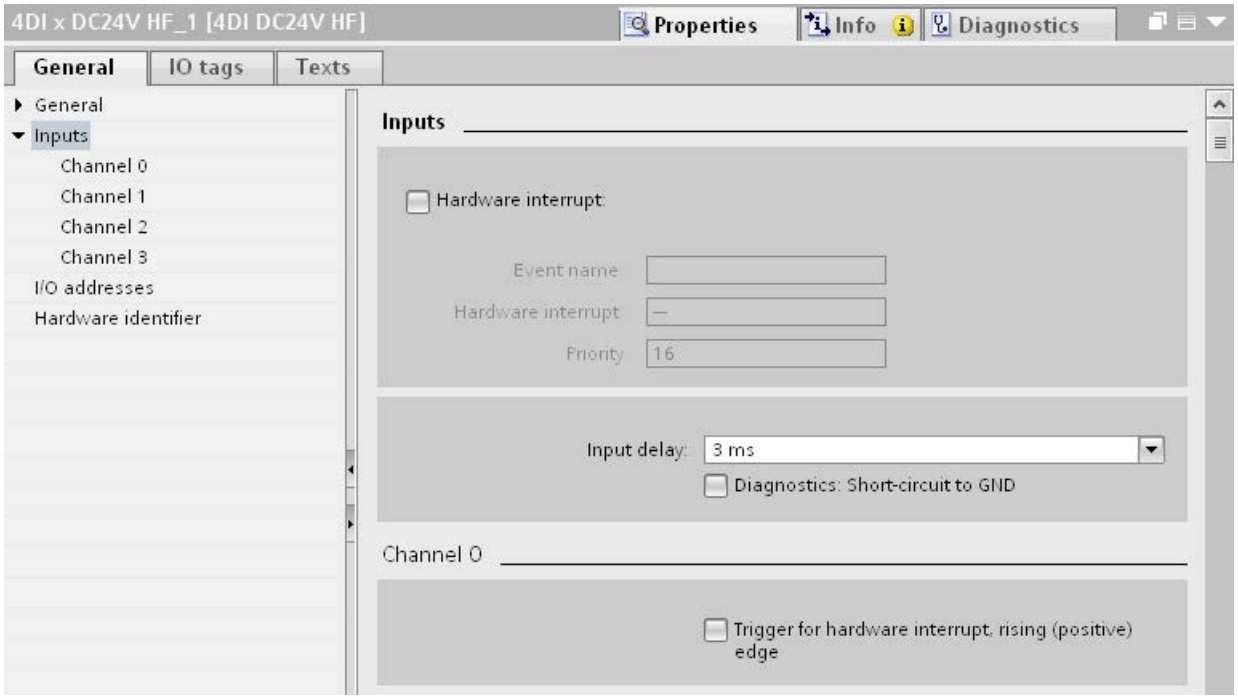


Figure 5-9 Adapting the input delay

Compile, load and save the changed configuration

1. Put the plant out of operation.
2. Select the CPU in the project navigator.
3. Select "Compile > Hardware" in the shortcut menu.
4. Select "Download to device" in the shortcut menu.
5. Save the project.

5.2 Acyclical data exchange

Additional functionality with DPV1 devices (DP master/DP slaves)

DP masters and DP slaves that support DPV1 have the following additional functions compared to the devices that support only DPV0:

- The acyclic data exchange between master and slave is supported.
- Interrupts can be set by a DPV1 slave which ensure handling of the interrupt-triggering event in the master CPU.

Acyclic data exchange

Read/write data record, for example, to change the parameters of a slave during operation. The data records of a module and the structure of these data records is available in the documentation for the respective module.

The table below contains the instructions with their functions for access to DPV1 slaves. Detailed information is available in the STEP 7 online help.

Table 5- 2 Instructions for access to DPV1 slaves

Instructions	Function (DPV1)
RDREC	Read data record
WRREC	Write data record
RALRM	Receive interrupt from a DP slave. (The instruction must be called in the OB that triggers the interrupt.)

5.3 SYNC/FREEZE groups

Assigning the SYNC/FREEZE group to the DP slave

A DP master with the corresponding functionality can send the control commands SYNC and/or FREEZE for synchronization of the DP slaves simultaneously to a group of DP slaves. You must assign SYNC/FREEZE groups to the DP slaves for this purpose.

Requirement: A DP master system has been created in the project.

Procedure

To assign a DP slave to a SYNC/FREEZE group, follow these steps:

1. Select the DP interface of the DP slave you want to assign to a group in the device view or network view.
2. Select the check boxes for the required SYNC/FREEZE groups under the group "SYNC/FREEZE" in the Inspector window.

   You can assign each DP slave to only one SYNC/FREEZE group.

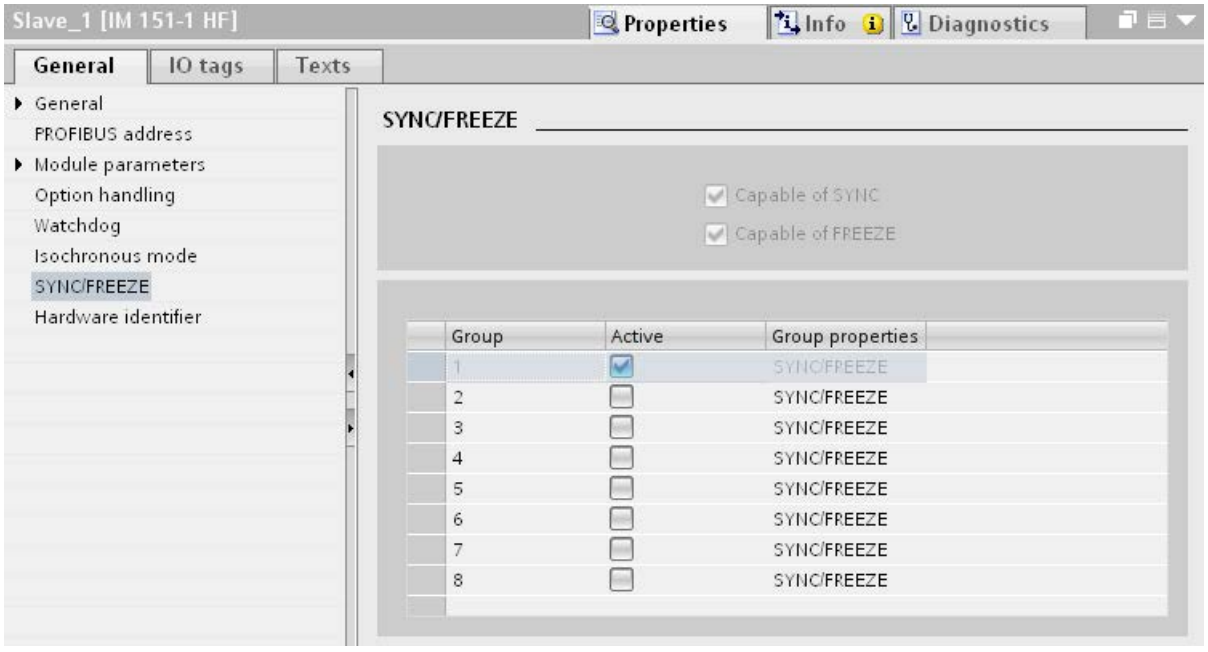


Figure 5-10 Assigning the DP slave to a SYNC/FREEZE group

Important information on the control commands SYNC and FREEZE

You can use the control commands SYNC and FREEZE in the DP master to synchronize the DP slaves event-controlled. The DP master sends the control commands simultaneously to a group of DP slaves in its master system. It does not take into consideration DP slaves that have failed or are currently sending diagnostic information.

Requirement for synchronization using control commands is that you have assigned the DP slaves to SYNC/FREEZE groups.

For a S7 CPU use the instruction DPSYC_FR (SFC 11) to synchronize the DP slaves.

When you select the DP master, you see a list of the eight SYNC/FREEZE groups under "Properties > DP interface > SYNC/FREEZE" in the Inspector window.

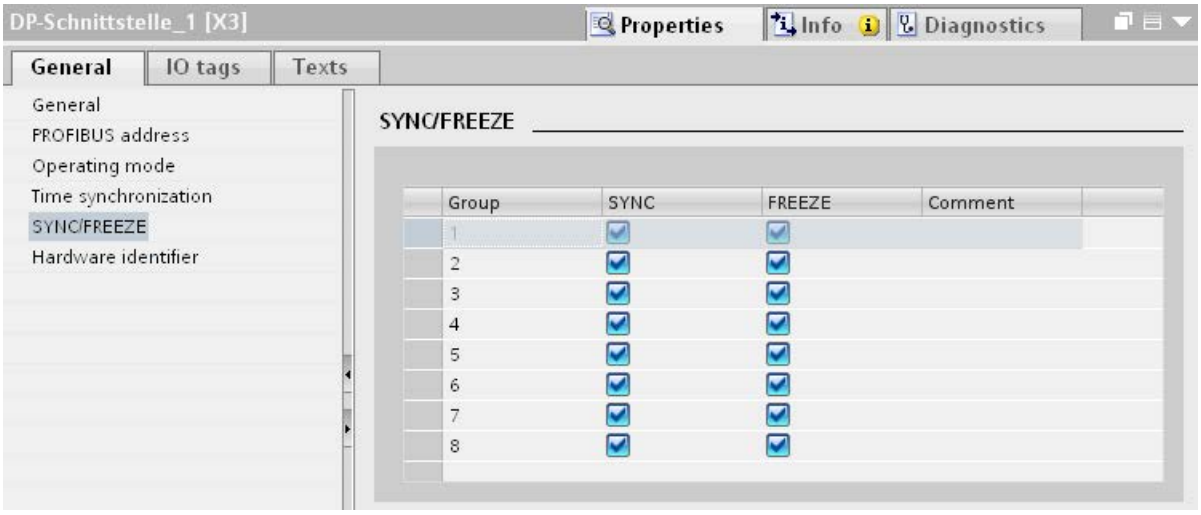


Figure 5-11 SYNC/FREEZE groups on DP master

SYNC control command

The DP master uses the SYNC control command to cause a group of DP slaves to freeze the states of their outputs to the current value.

The DP slaves save the output data of the DP master for the following frames. But the states of the DP slave outputs remain unchanged.

Only after each new SYNC control command does the DP slave set its outputs to the values that it has saved as the output data of the DP master.

The outputs are not updated cyclically again until the DP master has sent a UNSYNC control command.

FREEZE control command

After receiving the FREEZE control command from the DP master, the DP slaves of a group freeze the current status of their inputs. The DP slaves send these frozen input data to the DP master with the following cyclical frames.

The DP slaves freeze the current state of their inputs again after each new FREEZE control command.

The state of the DP slave inputs is only send to the DP master cyclically again when the DP master sends the UNFREEZE control command.

5.4 Interrupts

Interrupts and interrupt OBs for DPV1

Interrupts can be set by a DPV1 slave which ensure handling of the interrupt-triggering event in the master CPU. The interrupt data is evaluated in the CPU and the diagnostics buffer and the module state are updated even in the "STOP" operating mode. The OB is not processed in STOP.

The following DPV1 interrupts are supported:

- Status interrupt
- Update interrupt
- Vendor-specific interrupt

Detailed information is available in the descriptions on the OBs. You can use the corresponding OBs that are provided by the operating system of the S7 CPUs for diagnostic interrupts, hardware interrupts, and pull/plug interrupts.

OB 55 interrupt - Status interrupt

The status interrupt can be triggered when the operating mode of a device or module changes, for example, from RUN to STOP.

OB 56 interrupt - Update interrupt

An update interrupt can be triggered if the parameters of a slot were changed. This may be caused by local access or partner access to the parameters.

OB 57 interrupt - Vendor-specific interrupt

The event that triggers the vendor-specific interrupt can be specified by the manufacturer of a DPV1 slave.

Additional information

A detailed description of the events at which interrupts are triggered is available in the documentation of the respective manufacturer of the DPV1 slave.

5.5 Intelligent DP slaves (I-slaves)

5.5.1 I-slave functionality

I-slave functionality

The "I-slave" (intelligent DP slave) functionality of a CPU supports the exchange of data with a DP master and thus allows the CPU to be used, for example, as intelligent preprocessing unit of subprocesses. The I-slave is connected in its role as DP slave to a "higher-level" DP master.

The preprocessing is handled by the user program in the I-slave. The process values acquired by the I/O modules are preprocessed by the user program and made available to the DP master.

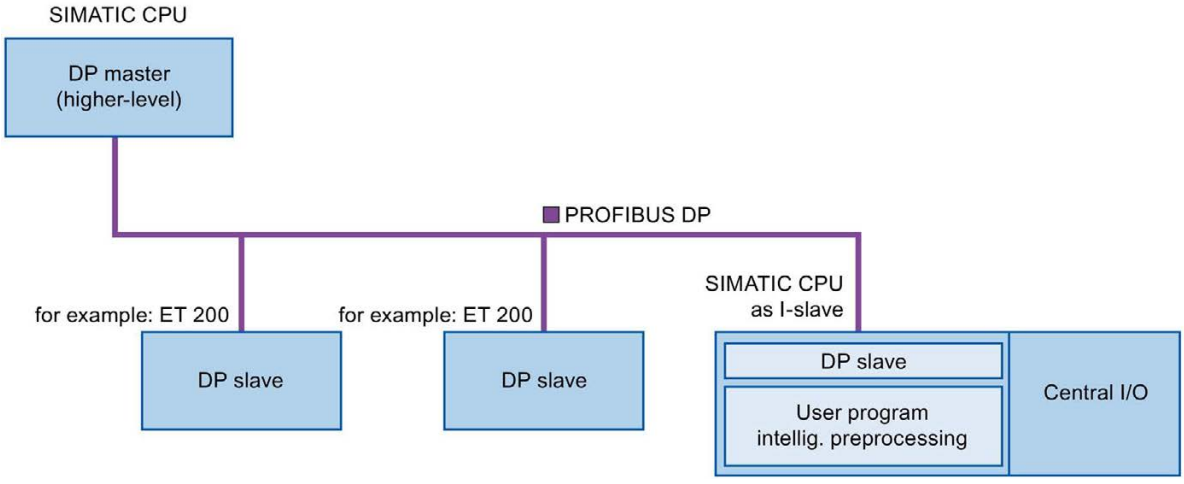


Figure 5-12 I-slave functionality

"I-slave" naming convention

In the remainder of this description, a CPU or a CP with I-slave functionality is simply called an "I-slave".

Advantages of configurations with I-slaves

The I-slave offers the following advantages:

- Simple coupling of CPUs with PROFIBUS interface
- Real-time communication between CPUs and PROFIBUS interface
- Distributed processing

  A complex automation task can be divided into smaller units/subprocesses. This results in manageable processes which lead to simplified subtasks.
- Relieving the DP master by distributing the computing capacity to I-devices
- Lower communication load by processing process data locally
- Separating subprocesses

  Complicated, widely distributed and extensive processes can be subdivided into several subprocesses with manageable interfaces by using I-slaves. These subprocesses can be stored in individual STEP 7 projects if necessary, which can later be merged to form one master project.
- Separating STEP 7 projects

  Creators and users of an I-device can have completely separated STEP 7 projects. The GSD file together with the configuration of the transfer areas of the I-slave form the interface between the STEP 7 projects. This allows coupling to standard DP masters via a standardized interface.
- Know-how protection

  Plant units can now only be delivered with a GSD file and the configuration of the transfer areas instead of with a STEP 7 project for the I-slave interface description. This means that you no longer have to disclose the user program know-how.

Difference: DP slave - I-slave

In the case of a DP slave, the DP master accesses the distributed inputs/outputs directly.

In the case of an I-slave, the DP master accesses a transfer area in the I/O address space of the preprocessing CPU instead of accessing the connected inputs/outputs of the I-slave. The user program running on the preprocessing CPU is responsible for ensuring data exchange between the operand area and inputs/outputs.

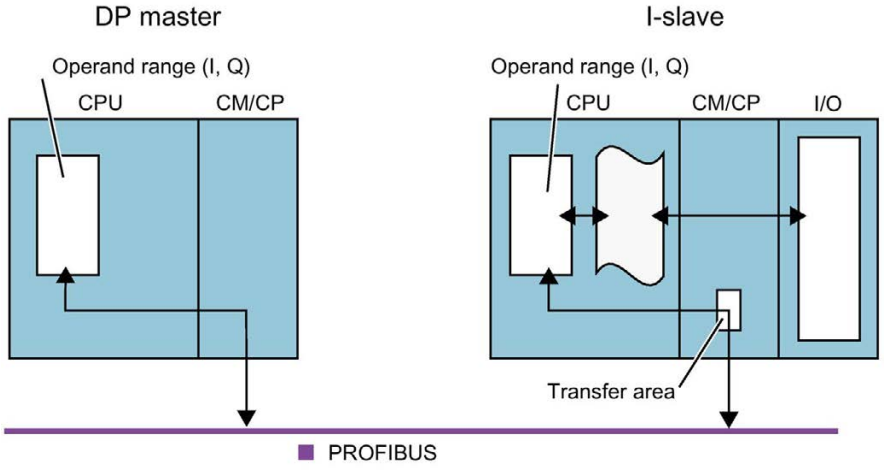


Figure 5-13 Data access to an I-slave

Note

DP master or DP slave

Note: The communication modules of the S7-1500 CPUs/ET 200SP CPUs, for example the CP 1542-5, support the operation as DP master or DP slave only as alternative.

Note

The I/O areas configured for data exchange between the DP master and DP slaves must not be used by I/O modules.

5.5.2 Data exchange with higher-level DP master

Introduction

The following section describes the data exchange between the I-slave and the higher-level DP master.

Transfer areas

Transfer areas are an interface to the user program of the I-slave CPU. Inputs are processed in the user program and outputs are the result of the processing in the user program.

The data for communication between DP master and I-slave is made available in the transfer areas. A transfer area contains an information unit that is exchanged consistently, in terms of bytes, words or overall, between DP master and I-slave. You can find more information on configuration and use of transfer areas in the section Configuring transfer areas (Page 84).

The following figure shows the data exchange between the I-slave and the higher-level DP master. The individual communication relations are explained below based on the numbers.

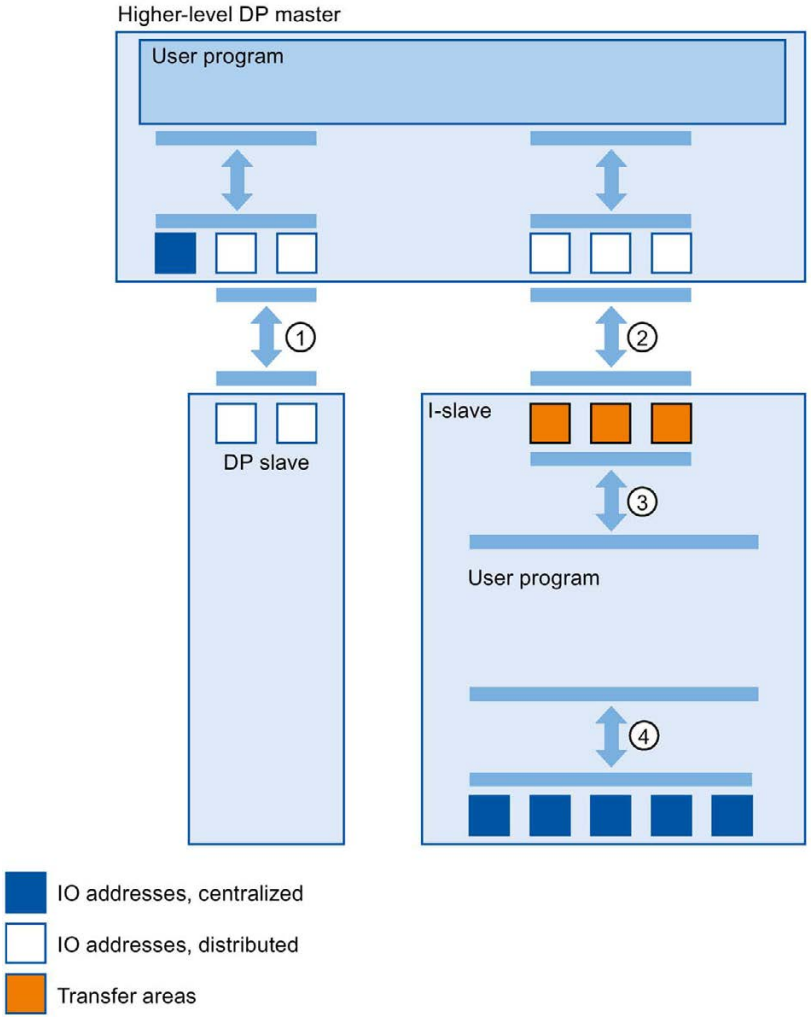


Figure 5-14 Data exchange with the DP master

① Data exchange between higher-level DP master and normal DP slave

In this way, the DP master and the DP slave exchange data through PROFIBUS.

② Data exchange between higher-level DP master and I-slave

In this way, the DP master and the slave exchange data through PROFIBUS.

The data exchange between a higher-level DP master and an I-slave is based on the conventional DP master/DP slave relationship.

For the higher-level DP master, the transfer areas of the I-slave represent submodules of a DP slave.

The output data of the DP master is the input data of the I-slave. Analogously, the input data of the DP master is the output data of the I-slave.

③ Transfer relationship between the user program and the transfer area

In this way, the user program and the transfer area exchange input and output data.

④ Data exchange between the user program and the I/O of the I-slave

In this way, the user program and the centralized I/O of the I-slave exchange input and output data.

5.5.3 Configuring an I-slave

Requirements for configuring an I-slave

The I-slave consists of:

- A CPU from S7-1500 and a communications module CM 1542-5/CP 1542-5 (STEP 7 as of V12)
- A CPU from ET 200SP and a communications module CM DP (STEP 7 as of V13 SP1)

Procedure for configuring an I-slave

This section shows how to configure an I-slave in STEP 7 based on the example of a CPU 1512SP-1 PN. The procedure for the CPUs from S7-1500 with CM 1542-5/CP 1542-5 and for the CPU 1510SP-1 PN with CM DP is the same.

To configure an I-slave, follow these steps:

1. Drag a CPU 1512SP-1 PN from the hardware catalog to the network view.
2. Open the device view of the CPU.
3. Double-click on the CM DP communications module in the hardware catalog. STEP 7 creates the CM DP in the device view.
4. Select the PROFIBUS interface of the CM DP communications module.
5. In the Inspector window in the area navigation, select the "Operating mode" entry and enable the "DP slave" check box.
6. Now you can select the DP master in the "Assigned DP Master" drop-down list.

   Once you have selected the DP master, the networking and the DP master system between both devices are displayed in the network view.

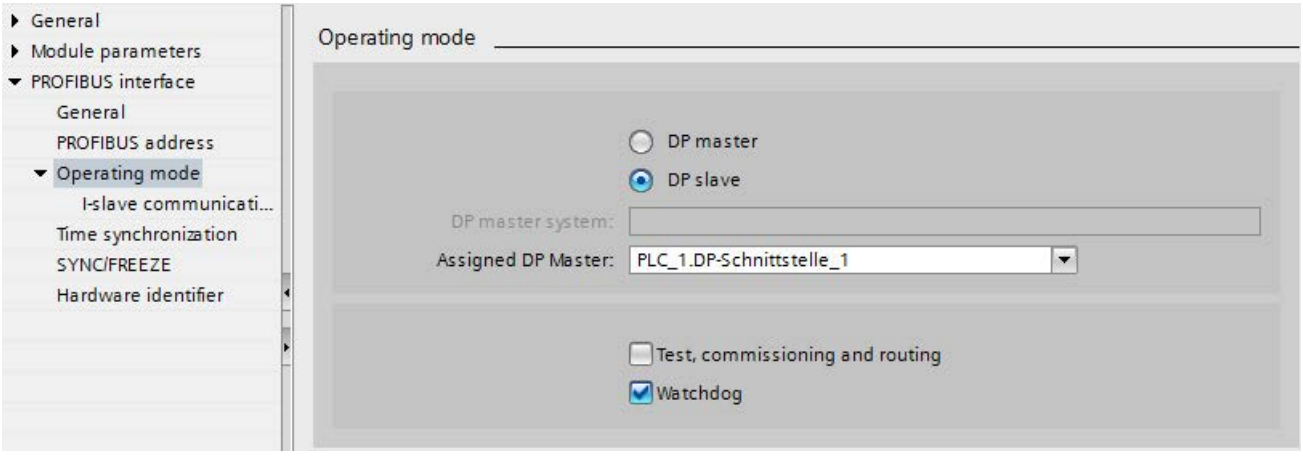


Figure 5-15 Configuring an I-slave

Note

Operation using a GSD file

If you operate an I-slave using a GSD file, you should not select the "Test, commissioning and routing" check box.

Create a DP subnet on the PROFIBUS interface of the I-slave.

Result

You have configured an I-slave.

5.5.4 Configuring transfer areas

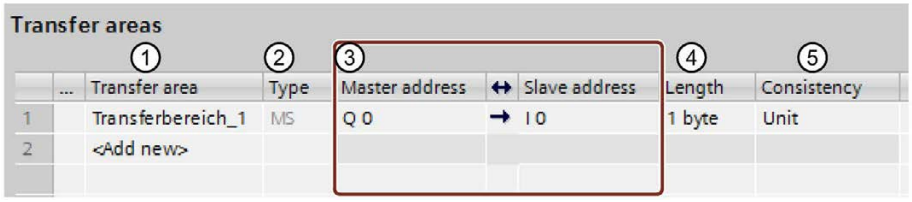
Requirements for configuring transfer areas

- You have configured an I-slave in STEP 7.
- You are in the device view of the I-device and have selected the PROFIBUS interface of the communications module.

Procedure for configuring transfer areas

To configure transfer areas for an I-slave in STEP 7, follow these steps:

1. In the area navigation, go to the section "Operating mode" > "I-slave communication" > "Transfer areas".
2. Create transfer areas. Set the properties of the created transfer areas.



① Click in the first cell of the "Transfer area" column. STEP 7 assigns a default name that you can change.

② Select the type of communication relation: Currently, you can only select MS for "master-slave communication relation".

③ STEP 7 assigns the addresses for the transfer area automatically. Correct the addresses if necessary.

④ Set the length of the transfer area. Specify the length of the transfer area in the cell in the following format: [1...64] Byte/Word.
Examples: "32 Byte", "64 Word"

⑤ Specify whether the transfer area is exchanged in units of bytes or words or consistently over the entire length between the DP master and I-slave.

Figure 5-16 Configuring transfer areas

A separate entry is created in the area navigation for each transfer area. If you select one of these entries, you can adjust the details of the transfer area, or correct them and comment on them.

5.5.5 Sample program

Introduction

This simple sample program shows how you use the transfer areas of an I-slave.

Requirement

You have configured an I-slave.

Task

The result of an "AND logic operation" of two inputs (preprocessing) in the I-slave is to be provided to the higher-level DP master. This result is to be assigned to a local output in the DP master (further processing).
Use a transfer area with the following addresses for this purpose:

- Address in the I-slave: Q568
- Address in the DP master: I68

Required steps

The following steps are necessary to solve the task:

1. Configuring the transfer area
2. Programming the I-slave
3. Programming the DP master

Configuring the transfer area

Configure a transfer area with the following properties in the I-slave:

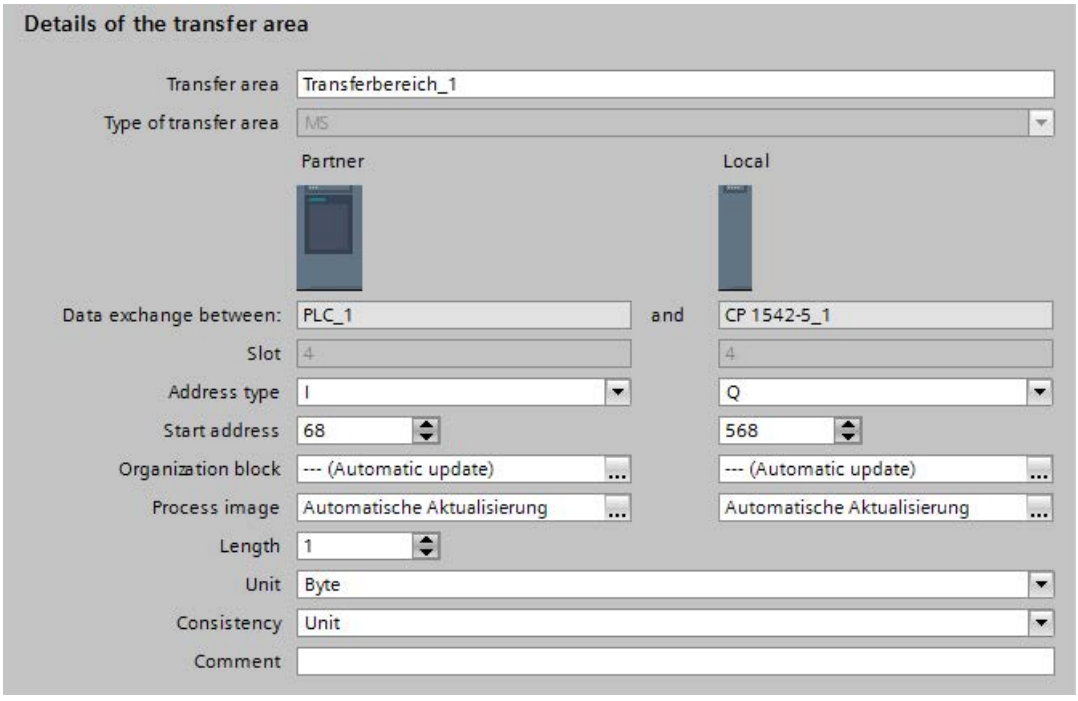


Figure 5-17 Transfer area, I-slave sample program

Programming the I-slave

To program the sample program for the I-slave, follow these steps:

1. Using the SCL programming language, create a new function with the name "preprocessing" in the project tree under "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "preprocessing", create the following tags:

Name	Data type	Input/output type
input 1	bool	Input
input 2	bool	Input
result	bool	Output

3. In the instruction window of the function "preprocessing", write the following program code:
   #result:=#input 1&#input 2;
4. Call the function "preprocessing" in a cycle OB, for example, in OB1.
5. Wire the function "preprocessing" in the cycle OB as follows:

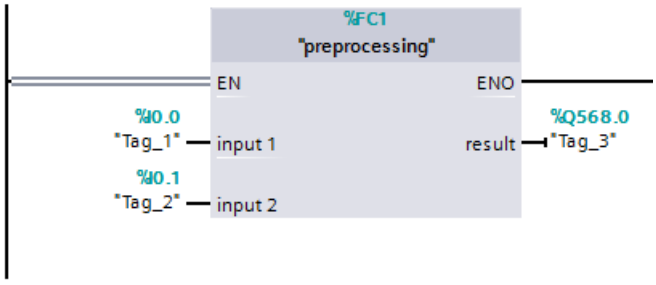


Figure 5-18 I-slave sample program

Programming the DP master

To program the sample program for the DP master, follow these steps:

1. Using the SCL programming language, create a new function with the name "further processing" in the project tree under "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "further processing", create the following tags:

Name	Data type	Input/output type
result	bool	Input
output	bool	Output

3. In the instruction window of the function "further processing", write the following program code:
   #output:=#result;
4. Call the function "further processing" in a cycle OB, for example, in OB1.
5. Wire the function "further processing" in the cycle OB as follows:

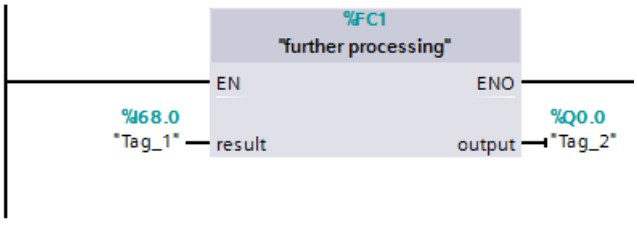


Figure 5-19 DP master sample program

Result

You mastered the task successfully.

5.5.6 Diagnostics and interrupt behavior

Diagnostics and interrupt behavior

S7 CPUs have numerous diagnostics and interrupt functions that can, for example, report errors/faults or failures of underlying DP systems. These diagnostics alarms reduce downtimes and simplify localization and elimination of problems.

Diagnostics options in the higher-level DP master and in the I-slave

The following diagnostics mechanisms are available to the higher-level DP master and the I-slave:

- OB 82 (diagnostic interrupt)

  When the I-slave changes mode, the DP master calls OB 82 (diagnostic interrupt).

  When the DP master changes mode, the I-slave calls OB 82 (diagnostic interrupt).

- OB 86 (rack failure)

  If the bus connection to the I-slave is interrupted, the DP master calls OB 86 (rack failure).

  If the bus connection to the DP master is interrupted, the I-slave calls OB 86 (rack failure).

- OB 122 (I/O access error)

  If you have not set the attribute "Handle errors within block" for OB 122, the following applies:

  – If the bus connection to the I-slave is interrupted, the DP master calls OB 122 (I/O access error) if there is direct access to the relevant transfer areas.

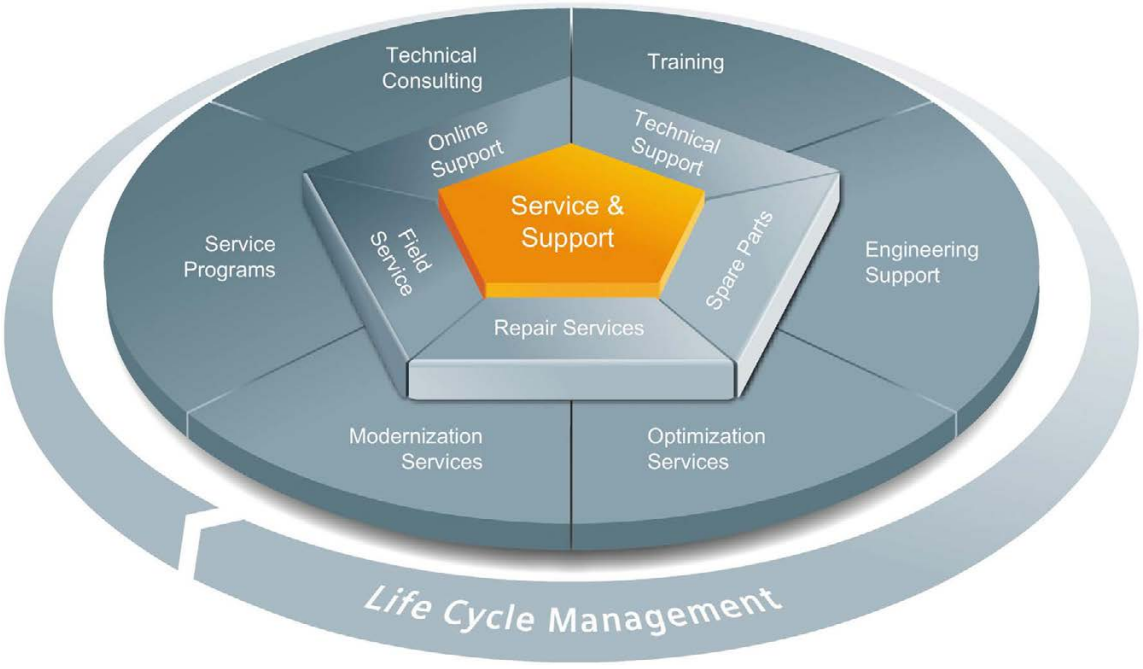
  – If the bus connection to the DP master is interrupted, the I-slave calls OB 122 (I/O access error) if there is direct access to the relevant transfer areas.

Reaction of the transfer areas to mode changes

Table 5- 3 Reaction of the transfer areas to mode changes

DP master	I-slave	Reaction of DP master input transfer areas	Reaction of I-slave input transfer areas
RUN→STOP	RUN	No updating of the process image	The input transfer areas retain their current values. (no access error)
STOP→RUN	RUN	The input transfer areas are updated by the cyclic user program via the process image.	The input transfer areas are updated via the process image.
RUN	RUN→STOP	The I-slave sets the input transfer areas on the DP master to "0".	No updating of the process image
RUN	STOP→RUN	The I-slave sets the input transfer areas on the DP master to "0". After the startup program of the I-slave, the input transfer areas of the DP master are updated via the process image.	Prior to processing of the startup program, the input transfer areas are updated via the process image.

Service & Support



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Glossary

Automation system

Programmable logic controller for the open-loop and closed-loop control of process chains of the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Bus

A common transfer route to which all nodes are connected; it has two defined ends.

In the case of PROFIBUS, the bus is a two-wire line or a fiber-optic cable.

Bus connector

Physical connection between the node and bus cable.

Bus system

All stations physically connected to a bus cable form a bus system.

Device

In the PROFIBUS environment, "device" is the generic term for:

- Automation systems (for example, PLC, PC)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components
- Gateways to AS interface or other fieldbus systems

Device that can send, receive or amplify data via the bus, for example, a DP slave by means of PROFIBUS DP.

Device

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- Automation systems (for example, PLC, PC)
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- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components
- Gateways to AS interface or other fieldbus systems

Device that can send, receive or amplify data via the bus, for example, a DP slave by means of PROFIBUS DP.

Diagnostics

Monitoring functions for the recognition, localization, classification, display and further evaluation of errors, faults and alarms. They run automatically during plant operation. This increases the availability of systems/plants by reducing commissioning times and downtimes.

DP master

CPU or device that conducts the communication with the DP slaves according to a defined algorithm. To do this, the DP master uses the functions for communication with the DP slaves which are defined by PROFIBUS DP. It acts according to standard EN 50170, Part 3.

→ *Master*

DP slave

Slave in the distributed I/O that is operated on the PROFIBUS with PROFIBUS DP protocol and acts according to standard EN 50170, Part 3. The DP slave is addressed by the DP master and provides it with specified functions (I/O data, diagnostics, etc.).

→ *Slave*

DPV1

The designation DPV1 refers to the functional extension of acyclic services (to include new interrupts, for example) provided by the DP protocol. The DPV1 functionality is integrated in IEC 61158/EN 50170, Volume 2, PROFIBUS.

FDL

Fieldbus Data Link (bus access protocol). Step 2 with PROFIBUS.

HMI device

Human Machine Interface, device for visualization and control of automation processes.

HSA

Highest Station Address. A bus parameter for PROFIBUS. Outputs the highest PROFIBUS address of an active device. PROFIBUS addresses greater than HSA are permitted for passive devices, up to 126.

Industrial Ethernet

Guideline for setting up Ethernet in an industrial environment. The main difference to the standard Ethernet is the mechanical current carrying capacity and interference immunity of the individual components.

I-slave

The "I-slave" functionality of a CPU supports the exchange of data with a DP master and can thus be used, for example, as intelligent preprocessing unit of partial processes. The I-slave is connected in its role as DP slave to a "higher-level" DP master.

Master

A master device that is in possession of the token can send data to other devices and request data from them (= active device).

PCF

Polymer Cladded Fiber (plastic-covered glass fiber)

POF

Polymer Optical Fiber (plastic fiber-optic cable made of light-conducting plastics)

Process image

Address area in the system memory of the DP master. At the start of the cyclic program the signal states of the input modules are transmitted to the process image of the inputs. And the end of cyclic program execution, the process image of the outputs is transmitted to the DP slave as signal state.

PROFIBUS

PROcess FIeld BUS, in IEC 61158-2 as "Type 3" standardized, bit-serial fieldbus system. The standard specifies functional, electrical and mechanical properties.

PROFIBUS is a bus system that networks automation systems and field devices compatible with PROFIBUS at the cell and field level. PROFIBUS is available with the protocols DP (= distributed I/O), FMS (= fieldbus message specification) or PA (process automation).

PROFIBUS address

Unique identification of a device connected to PROFIBUS. The PROFIBUS address is transmitted in the frame for addressing a device. A PC or programming device has the PROFIBUS address "0". DP masters and DP slaves have a PROFIBUS address in the range from 1 to 125.

PROFIBUS device

A PROFIBUS device has at least one PROFIBUS interface with an electrical (RS 485) or optical (Polymer Optical Fiber, POF) interface.

PROFIBUS DP

A PROFIBUS with DP protocol that complies with EN 50170. DP stands for distributed I/O (fast, real-time capable, cyclic data exchange). From the perspective of the user program, the distributed I/Os are addressed in exactly the same way as the centralized I/Os.

PROFINET

Open component-based industrial communication system based on Ethernet for distributed automation systems. Communication technology promoted by the PROFIBUS Users Organization.

RS 485

Asynchronous data transmission process for PROFIBUS DP to ANSI TIA/EIA-RS485-A.

RS 485 repeater

Equipment for amplifying bus signals and for coupling segments over long distances.

Segment

The bus line between two terminating resistors forms a bus segment.

A bus segment can contain up to 32 bus nodes. Segments can be coupled, for example, by means of RS 485 repeaters or diagnostics repeaters.

Slave

Distributed device in a fieldbus system that may exchange data with a master after being requested to do so by the master. Slaves are all DP slaves, for example, such asET 200SP, ET 200MP, ET 200AL.

Standard mounting rail

Standardized metal profile to EN 50022.

The standard mounting rail is used for quick snap-on installation of network components, such as OLM, repeaters, etc.

Subnet

Part of a network whose parameters must be synchronized with the devices (e.g., with PROFIBUS). A subnet includes the bus components and all connected stations.

SynchronousCycle

Name for synchronous cycle interrupt OB in STEP 7.

Target-Rotation-Time (Ttr)

Bus parameter for PROFIBUS. The token is the send permission for a device on PROFIBUS. A device compares a token rotation time it has measured with the Target-Rotation-Time and controls the sending of frames with high priority or low priority based on this comparison.

Terminating resistor

Component that terminates the ends of a data transmission line to prevent reflections in the transmission medium.

Terminator

Terminating resistor of bus segments with transmission rates of 9.6 kbps to 12 Mbps. The power supply is separate from the bus nodes.

TIA Portal

Totally Integrated Automation Portal

Topology

Structure of a network. Common structures are line topology, ring topology, star topology and tree topology.

Transmission rate

Specifies the number of bits transmitted per second.

Watchdog

Mechanism for monitoring the readiness for operation.

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SIMATIC

S7-1500, ET 200MP, ET 200SP

CM PtP - Configurations for point-to-point connections

Function manual

Edition 09/2016

siemens.com

SIEMENS

SIMATIC

S7-1500 / ET 200MP / ET 200SP CM PtP - Configurations for point-to-point connections

Function Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

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indicates that minor personal injury can result if proper precautions are not taken.

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indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation provides important information on configuring and commissioning the point-to-point communication modules for the S7-1500 (ET 200MP) and ET 200SP.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Validity of the documentation

This documentation is valid for all point-to-point communication modules of the S7-1500 (ET 200MP) and the ET 200SP when used with STEP 7 (TIA Portal) V12 and higher.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 as well as for interface modules of distributed I/O systems, such as the IM 155-5.

Please also observe notes labeled as follows:

Note

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Recycling and disposal

The products can be recycled due to their low pollutant content. For environmentally compliant recycling and disposal of your old device, please contact a company certified for the disposal of electronic waste.

Additional assistance

- Information on the offers of our Technical Support are available in the appendix Service & Support (Page 197).
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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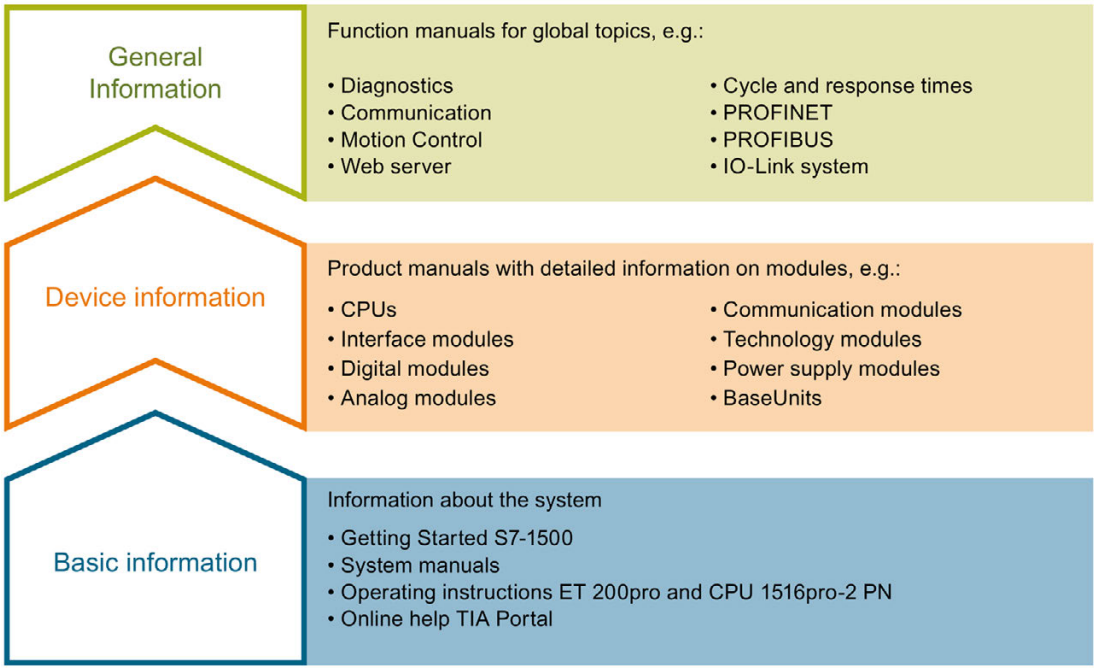
Guide to documentation

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

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In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU

- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Introduction

2

2.1 Overview of the communication modules

Automation systems encompass a wide range of components. These also include communication modules. A simple possibility of data exchange is provided by serial communication via point-to-point connections.

Customizing to a wide range of communication partners is possible by setting the communication parameters at a lower layer of the OSI layer model (see section Transmission security (Page 18)).

Communication through point-to-point connection with S7-1500, ET 200MP and ET 200SP takes place exclusively by means of communication modules (CM) with serial interfaces.

SIMATIC S7 offers a number of modules that provide the physical interface and fundamental protocol mechanisms for this purpose.

- RS232: An interface that can coordinate the communication between the partners through additional accompanying signals.
- RS422/RS485: An interface that allows longer lines through the use of differential voltages as transmission technology and also enables structures with more than 2 devices through a bus structure (RS485).

Instructions that carry out the coordination between the CPU and CM (Communication Module) are available to transfer data from the CPU to the respective modules. They inform the user program about a successful transfer or the receipt of new data (in systems without a SIMATIC CPU users have to program the function of these instructions themselves).

The function and use of the PtP communication modules is described in this function manual.

Overview of components and order numbers

Tabular overview of communication modules and their application suitability

Communication module	S7-1500	ET 200MP	ET 200SP	Article number
CM PtP RS232 BA [1)]	X	X	-	6ES7540-1AD00-0AA0
CM PtP RS422/485 BA	X	X	-	6ES7540-1AB00-0AA0
CM PtP RS232 HF [2)]	X	X	-	6ES7541-1AD00-0AB0
CM PtP RS422/485 HF	X	X	-	6ES7541-1AB00-0AB0
CM PtP (ET 200SP)	-	-	X	6ES7137-6AA00-0BA0

1) BA = Basic

2) HF = High Feature

Overview of components and interfaces

Tabular overview of communication modules and their functions.

Communication module	Interface	Protocols					Connection technology	
		Freeport	3964(R)	Modbus Master	Modbus Slave	USS-Master	D-Sub 9-pin	D-Sub 15-pin
CM PtP RS232 BA	RS232	X	X	-	-	X	X	-
CM PtP RS422/485 BA	RS422	X	X	-	-	X	-	X
	RS485	X	-	-	-	X	-	X
CM PtP RS232 HF	RS232	X	X	X	X	X	X	-
CM PtP RS422/485 HF	RS422	X	X	X	X	X	-	X
	RS485	X	-	X	X	X	-	X
CM PtP (ET 200SP)	RS232	X	X	X	X	X	ET 200SP BaseUnit [1]	
	RS422 [2]	X	X	X	X	X		
	RS485	X	-	X	X	X		

1) BaseUnit with terminals instead of D-Sub; assignment depending on physical transmission properties

2) The CM PtP communication module can also be used for multipoint connection in RS422 mode

Overview of components and data transmission rates

The communication modules can send and receive data with different data transmission rates. The table below shows the assignment to the individual communication modules.

Communication module	Data transmission rate in bps										
	300	600	1200	2400	4800	9600	19200	38400	57600	76800	115200
CM PtP RS232 BA	X	X	X	X	X	X	X	-	-	-	-
CM PtP RS422/485 BA	X	X	X	X	X	X	X	-	-	-	-
CM PtP RS232 HF	X	X	X	X	X	X	X	X	X	X	X
CM PtP RS422/485 HF	X	X	X	X	X	X	X	X	X	X	X
CM PtP (ET 200SP)	X	X	X	X	X	X	X	X	X	X	X

Overview of components and receive buffer size

Each communication module has a buffer to temporarily store received frames. The table below shows the assignment of the maximum size of an individual frame as well as the size of the memory for the individual communication modules.

Module	Receive buffer size KB	Max. frame length KB	Bufferable frames
CM PtP RS232 BA	2	1	255
CM PtP RS422/485 BA	2	1	255
CM PtP RS232 HF	8	4	255
CM PtP RS422/485 HF	8	4	255
CM PtP (ET 200SP)	4	2	255

Accompanying signals and data flow control

- Software data flow control with XON/XOFF

  The Freeport protocol supports data flow control with XON/XOFF via the RS232 and RS422 interfaces.

- Hardware data flow control with RTS/CTS

  The Freeport protocol supports data flow control with RTS/CTS via the RS232 interface.

- Automatic operation of accompanying signals

  The RS232 accompanying signals can be controlled with the Freeport, Modbus master and Modbus slave protocols by means of the RS232 interface. (Only available if hardware data flow control is not activated.)

Protocols of the communication modules

You may set up a communication connection with different protocols, depending on the communication modules used:

- Freeport: Transmission of ASCII character strings without specified protocol format
- 3964(R): Communication between programmable logic controllers (master/master communication)
- Modbus RTU: Communication between programmable logic controllers (master/slave communication) The communication module can be the master as well as the slave.
- USS: Communication between a programmable logic controller and a drive (master/slave communication) Communication is tailored to the drive technology requirements. The communication module can only be master.

2.2 Overview of the processing steps

Point-to-point connection

The system provides various networking options for the exchange of data between two or more communication partners. The simplest form of data interchange is via a point-to-point connection between two communication partners.

The communication module (CM) forms the interface between a programmable logic controller and a communication partner. Data is sent in serial mode via point-to-point connection with the communication module.

Configuring / parameter assignment

Configuring the communication module includes the arrangement of the communication module in the device configuration of STEP 7 (TIA Portal) as well as the settings of the specific protocol parameters in the properties dialog of the communication module (static configuration).

Programming

Programming includes the program-specific connection of the communication module to the corresponding CPU by means of the user program. You program the communication module with STEP 7 (TIA Portal).

Communication between CPU, communication module and a communication partner takes place through instructions (Page 66). A number of instructions are available for the S7-1500 and S7-1200 automation systems. You can use these instructions to initiate and control communication in the user program as well as influence the configuration for runtime (dynamic configuration).

For more information, please refer to Overview of instructions (Page 15) and the STEP 7 (TIA Portal) online help.

2.3 Overview of instructions

Note

CPU quantity structures

The point-to-point instructions communicate with the communication modules by reading or writing data records.
When using the instructions, you should therefore check the configuration limits of the CPU for reading and writing data records.
If multiple instructions need to read or write data records simultaneously on a CPU, there may need to be a gap between the calls of each instruction by the user program.

Overview of the instructions

The communication protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules.

The instructions form the software interface between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place across several cycles.

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor. They apply to all listed communication modules if they support the required function.

Table 2- 1 Instructions for PtP

Instruction	Meaning
Send_P2P (Page 84)	The instruction Send_P2P allows you to send data to a communication partner.
Receive_P2P (Page 88)	The instruction Receive_P2P allows you to receive data from a communication partner.
Receive_Reset (Page 90)	The instruction Receive_Reset allows you to clear the receive buffer of the communication module.
Port_Config (Page 71)	The instruction Port_Config allows you to dynamically assign basic interface parameters.
Send_Config (Page 74)	The instruction Send_Config (send configuration) allows you to dynamically assign serial send parameters of a port.
Receive_Config (Page 76)	The instruction Receive_Config (receive configuration) allows you to dynamically assign serial receive parameters of a port.
P3964_Config (Page 82)	The instruction P3964_Config (protocol configuration) allows you to dynamically configure the parameters of the 3964(R) procedure.
Signal_Get (Page 91)	The instruction Signal_Get allows you to read the RS232 accompanying signals.
Signal_Set (Page 93)	The instruction Signal_Set allows you to set the RS232 accompanying signals.
Get_Features (Page 95)	The instruction Get_Features allows you to read the extended functions supported by the communication module.
Set_Features (Page 96)	The instruction Set_Features allows you to activate the extended functions supported by the communication module.

Table 2- 2 Instructions for Modbus

Instruction	Meaning
Modbus_Master (Page 120)	The Modbus_Master instruction allows you to communicate as Modbus master by means of the PtP port.
Modbus_Slave (Page 127)	The Modbus_Slave instruction allows you to communicate as Modbus slave by means of the PtP port.
Modbus_Comm_Load (Page 115)	The Modbus_Comm_Load instruction allows you to configure the port of the communication module for Modbus RTU.

Table 2- 3 Instructions for USS

Instruction	Meaning
USS_Port_Scan (Page 163)	The instruction USS_Port_Scan allows you to communicate by means of the USS network.
USS_Drive_Control (Page 167)	The instruction USS_Drive_Control allows you to swap data with the drive.
USS_Read_Param (Page 171)	The instruction USS_Read_Param allows you to read parameters from the drive.
USS_Write_Param (Page 173)	The instruction USS_Write_Param allows you to change parameters in the drive.

Basics of serial communication 3

3.1 Serial data transmission

During serial data transmission, the individual bits of a character of information to be transmitted are sent successively in a defined sequence.

Bidirectional data traffic - operating mode

In the context of bidirectional data traffic, we distinguish between two operating modes for the communication module:

- Half-duplex operation

  The data is exchanged between the communication partners in both directions alternately. In half-duplex operation one communication partner is sending and the other communication partner is receiving at the same time. In the process one line is alternately used for sending or receiving.

- Full-duplex operation

  The data is exchanged between one or more communication partners in both directions simultaneously, which means you can send and receive data at the same time. This process requires one line for sending and one line for receiving.

Asynchronous data transmission

Serial data transmission is performed asynchronously with communication modules. The so-called time base synchronism (a fixed timing code used in the transmission of a fixed character string) is only upheld during transmission of a character. Each character to be sent is preceded by a synchronization impulse, also called start bit. The length of the start-bit transmission determines the clock pulse. The end of character transmission is formed by one or two stop bits.

Declarations

In addition to start and stop bits, additional declarations must be made between the sending and receiving partners before serial transmission can take place. These include:

- Data transmission rate
- Frame start and end criteria (e.g., character delay time)
- Parity
- Number of data bits (7 or 8 bits/characters)
- Number of stop bits (1 or 2)

3.2 Transmission security

Transmission security plays an important role in the transmission of data and in the selection of the transmission procedure. Generally speaking, the more layers of the reference model are applied, the higher the transmission security.

Classification of existing protocols

The figure below illustrates how the protocols of the communication module fit into the reference model.

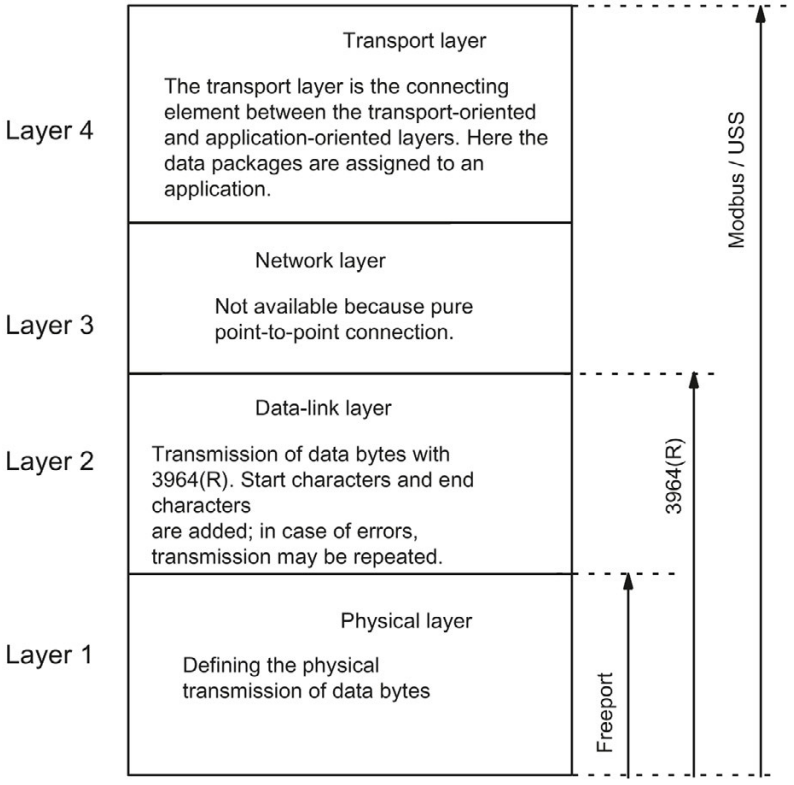


Figure 3-1 Classification of the existing protocols of the communication module in the reference model

Transmission security with Freeport

Transmission security when using Freeport:

- When data is sent with Freeport, there are no data security measures other than the use of a parity bit. This means data transmission with Freeport is very efficient, but data security is not guaranteed. A certain degree of data security can be achieved through parameter assignment of the frame start and frame end conditions.
- Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, there is no guarantee that these errors are still detected.
- To increase transmission security, you can, for example, implement a checksum, a frame length specification, or configurable end conditions. These measures must be implemented by the user.
- A further increase in data security can be achieved by means of acknowledgment frames in response to send or receive frames. This is the case with high-grade protocols for data communication (ISO 7-layer reference model).

Transmission security with 3964(R)

The parity bit is used to increase data security; depending on the configuration, it completes the number of data bits to be transmitted to form an even or odd number.

Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, these errors can no longer be reliably detected.

If parity is set to "none", no parity bit is transmitted. This setup reduces transmission security.

Two different procedures for data transmission can be used, either with or without a block check character:

- Data transmission without block check character: **3964**

  Transmission security is achieved by means of a specified frame structure, frame breakdown, and frame repetitions.

- Data transmission with block check character: **3964R**

  The high degree of transmission security is achieved by means of a specified frame structure and breakdown, frame repetitions, as well as inclusion of a block check character (BCC).

In this manual, the term 3964(R) is used when descriptions and notes refer to both data transmission modes.

Transmission integrity for Modbus and USS

The parity bit is used to increase transmission security; depending on the configuration, it completes the number of data bits to be transmitted to form an even or odd number.

Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, this error can no longer be clearly detected.

If parity is set to "none", no parity bit is transmitted. This setup reduces transmission security.

The CRC (cyclic redundancy check) is additionally used with Modbus. With this method additional redundancy in the form of a so-called CRC value is added for each data block of the user data before data transmission. This is a check value calculated by using a specific procedure that can be used to detect any errors that may occur during transmission.

A BCC (block check character) is additionally used with USS. The block check character is formed during the receipt and is compared with the received BCC after the entire frame has been read in. If these two characters do not match, the frame is not evaluated. (If a character is incorrectly transmitted, an error is reliably detected. If an even number of characters are incorrectly transmitted, an error can no longer be reliably detected.)

3.3 RS232 mode

The following communication modules support RS232 mode:

- CM PtP RS232 BA
- CM PtP RS232 HF
- CM PtP (ET 200SP)

In RS232 mode, data is sent via two lines. A separate line is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

RS232 signals

In addition to the TXD (interface transmits; Transmitted Data), RXD (interface receives; Received Data) and GND (Ground; isolated) signals, the communication module provides the following RS232 signals when using RS232 hardware:

DCD	(input)	Data Carrier detect; Carrier signal when connecting a modem. The communication partner signals that it recognizes incoming data.
DTR	(output)	Data terminal ready; DTR set to "ON": Communication module switched on, ready for operation DTR set to "OFF": Communication module not switched on, not ready for operation

DSR	(input)	Data set ready; DSR set to "ON": Communication partner signals readiness for operation DSR set to "OFF": Communication partner not switched on, not ready for operation
RTS	(output)	Request to send; RTS set to "ON": Communication module ready to send; signals to the communication partner that there is data ready to send RTS set to "OFF": Communication module not ready to send
CTS	(input)	Clear to send; Communication partner can receive data from the communication module (response to RTS = ON of the communication module) CTS set to "ON": Signals readiness to receive to the communication partner CTS set to "OFF": Signals "Not ready to receive" to the communication partner
RI	(input)	Ring Indicator; Incoming call when connecting a modem

After power on of the communication module, the output signals are in the OFF state (inactive).

You configure the operation of the DTR/DSR and RTS/CTS control signals in the user interface of the communication module.

The RS232 signals cannot be influenced in case of:

- configured data flow control "Hardware RTS always switched"

  (corresponds to automatic operation of the accompanying signals)
- configured data flow control "Hardware RTS always ON"

  (corresponds to hardware flow control with RTS/CTS)
- configured data flow control "Hardware RTS always ON, ignore DTR/DSR"

For more information, refer to chapter Handshake procedure (Page 23).

3.4 RS422 mode

The following communication modules support RS422 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS422 mode, data is transmitted via two line pairs (four-wire operation). A separate line pair is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

All communication partners must be capable of simultaneous operation of a sender and receiver unit.

The data can be exchanged simultaneously between one or several communication partners. In RS422 multipoint mode, only one slave may send data at any given time.

Interface operating modes

The following table is a summary of the interface operating modes for the various communication modules and protocols.

The communication module can be used in the following topologies in RS422 mode:

- Link between two devices: Point-to-point connection
- Link between several devices: Multipoint connection
  (only available with CM PtP (ET 200SP))

Operating mode	Description
Full duplex (RS422) four-wire operation (point-to-point connection)	Both devices have the same priority in this operating mode.
Full duplex (RS422) four-wire operation (multipoint master)	The communication module can be used as multipoint master.
Full duplex (RS422) four-wire operation (multipoint slave)	The communication module can be used as multipoint slave.

The following applies for a multipoint master/slave topology in RS422 mode:

- The master's sender is interconnected with the receivers of all slaves.
- The slaves' senders are interconnected with the master's receiver.
- Only the receiver of the master and the receiver of one slave have a default setting. All other slaves operate without default settings.

3.5 RS485 mode

The following communication modules support RS485 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS485 mode, data is transmitted via one line pair (two-wire operation). The line pair is available alternately for the send and receive directions. It is possible to either send or receive (half duplex). On completion of a send operation, operation is immediately switched to receive mode (ready to receive). Send mode is reset again as soon as a new send job is received.

RS485 mode

The following table is a summary of the interface operating modes for the various communication modules and protocols.

Operating mode	Description
Half duplex (RS485) two-wire operation	Operating mode for point-to-point connection or multipoint connection (multipoint) in two-wire operation. The communication module can be the master as well as the slave.

If you operate the Freeport in RS485 mode (half duplex, two-wire operation), you must make provisions in the user program to ensure that only one device sends data at any given time. If more than one device sends data at the same time, the frames are corrupted.

Modbus automatically ensures that only one device is sending.

Changeover times for RS485 communication module in half duplex mode

A maximum time of 0.1 ms is set for the changeover between sending and receiving.

3.6 Handshake procedure

Introduction

Handshaking controls the data flow between two communication partners. The use of the handshaking method prevents data loss during transmission if the devices are operating at different speeds.

We can basically distinguish between the following methods:

Table 3- 1 Overview of methods and interfaces

Method	RS232	RS422	RS485
Software data flow control XON/XOFF	X	X	-
Hardware data flow control (RTS/CTS)	X	-	-
Automatic operation of accompanying signals	X	-	-

Software data flow control

Software data flow control is implemented as follows on the communication module:

- XON/XOFF
  - As soon as the communication module has been set to the "XON/XOFF" operating mode by means of parameter assignment, it sends the XON character, thereby allowing the communication partner to send data.
  - On reaching the configured maximum number of frames, or 16 characters ahead of receive buffer overflow, the communication module sends the XOFF character,

thereby requesting that the communication partners stop sending. If the communication partner nonetheless continues to send data, an error message is generated if the receive buffer overflows. Data received in the last frame is discarded.

– As soon as a frame has been fetched by the CPU and the receive buffer is ready to receive data again, the communication module sends the XON character.
– If the communication module receives the XOFF character during sending, it cancels the current send operation until it receives a XON again from its communication partner. If no XON is received within a specific configurable time, send operation is canceled and a corresponding error message is output.

Note

You can configure the characters for XON and XOFF (any ASCII character).

During parameter assignment of the XON/XOFF software data flow control, user data may not contain any of the configured XON or XOFF characters.

Hardware data flow control

Note

The DTR/DSR signals do not have to be wired for "Hardware RTS always ON, ignore DTR/DSR" parameter assignment.

If "Hardware RTS always ON" is configured, it is imperative that you fully wire the interface signals used. Make sure that the local RTS (out) is connected with the CTS (in) of the communication partner and the local CTS is connected with the RTS of the communication partner. Accordingly, the local DTR must be connected with the DSR of the communication partner and the local DSR with the DTR of the communication partner.

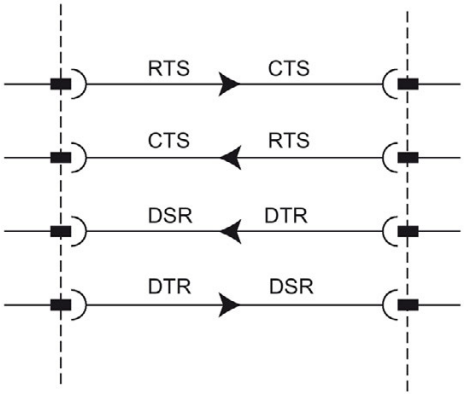


Figure 3-2 Wiring of the interface signals

- **Hardware RTS always ON, ignore DTR/DSR**
  - As soon as the communication module has been set to an operating mode with "Hardware RTS always ON" through parameter assignment, it outputs the RTS = ON signal to the communication partner to indicate its ready state.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
- **Hardware RTS always ON**

  The "Hardware RTS always ON" mode corresponds to the "Hardware RTS always ON, ignore DTR/DSR" mode. However, you also need to wire DTR and DSR.
  - As soon as the communication module has been set set to an operating mode with "Hardware RTS always ON" through parameter assignment, it sets DTR = ON and RTS = ON to signal its general ready state to the communication partner.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
  - A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

Automatic operation of accompanying signals

- **Hardware RTS always switched**

  "Hardware RTS always switched" is implemented as follows on the communication module:

  – As soon as the communication module is set to the operating mode with "Hardware RTS always switched" through parameter assignment, it sets the line RTS to OFF and DTR to ON (communication module ready for operation).

    It is not possible to send frames until the DSR line is set to ON. No data is sent via the RS232C interface as long as DSR is set to OFF. A send job is canceled and a corresponding error message is generated.

  – When a send job is pending, RTS is set to ON and the configured RTS ON delay starts. On expiration of the data output time, the system checks whether the communication partner has set CTS to ON. If so, the data is sent via the RS232 interface.

  – If the CTS line is not set to ON within the RTS ON delay, or if CTS changes to OFF during transmission, the send job is aborted and an error message is generated.

  – Once the data has been sent and the configured clear RTS OFF delay has elapsed, the RTS line is set to OFF. The system does not wait for CTS to change to OFF.

  – It is always possible to receive data via the RS232 interface. There will be no reaction if there is a danger of the receive buffer of the communication module overflowing.

  – A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

  Note

  Set the "RTS ON delay" in such a way that the communication partner is able to enter the ready to receive state before the time elapses.

  Set the "RTS OFF delay" in such a way that the communication partner is able to receive the last characters of the frame completely before RTS is set to OFF and the send request is canceled.

  Note

  When automatic operation of the RS232 signals is configured, RTS and DTR cannot be controlled by means of the corresponding instruction!

Time diagram

The figure below shows the chronological sequence of a send job with configured data flow control "Hardware RTS always switched":

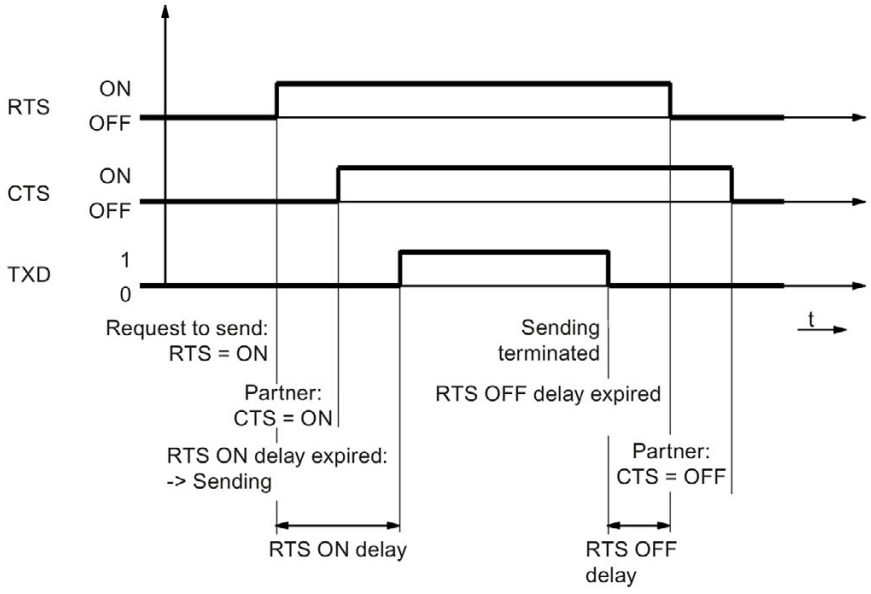


Figure 3-3 Time diagram for Hardware RTS always switched

Additional information

Note

Operation of DTR/DSR or RTS/CTS is accepted by the communication module with the following settings:

- Hardware RTS always ON, ignore DTR/DSR
- Hardware RTS always ON
- Hardware RTS always switched

Configuring / parameter assignment 4

4.1 Configuring / parameter assignment of a communication module

The following sections contain explanations on the following protocols and their parameters:

- Communication using Freeport (Page 29)
- Communication using 3964(R) (Page 38)
- Communication through Modbus RTU (Page 44)
- Communication using USS (Page 52)

This information is required to carry out the parameter assignment and subsequently programming of the communication in accordance with the used protocol.

Configuration and parameter assignment are carried out in the device view of STEP 7 (TIA Portal) and in the properties dialog of the communication module. Some configurations can also be changed during runtime by means of the corresponding "Config" instructions (Port_Config, Send_Config, Receive_Config, P3964_Config).

Procedure for setting up point-to-point communication

The procedure does not depend on the communication module used.

1. Configure an S7-1500 design with CPU and communication module in the device view of the STEP 7 (TIA Portal) hardware editor.
2. You assign the parameters of the communication module interface (protocol, protocol parameters, addresses) in the "General" area of the "Properties" tab.

4.2 Communication using Freeport

4.2.1 Procedure for establishing a serial connection with Freeport

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communication module into the hardware configuration.
2. Set the communication parameters according to the link partner:

   For example, transmission speed, character frame, frame start and frame end

   These parameters are transferred to the CM PtP communication module every time the CPU is started.

Procedure - Programming

1. Create the data structure that is to include the data to be transferred.

Sending data

1. Insert the instructions from the PtP Communication library: Send_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   - HWID from the system tags at the PORT input
   - Data structure with the data to be sent at the BUFFER input

   Note: During operation, each positive edge at the REQ input will send the specified data area once. The block must be called until DONE indicates that the data was transferred to the module.

   In case of an error, setting ERROR once and displaying the corresponding information in STATUS indicates that the data was not transferred.

Receiving data:

1. Insert the instructions from the PtP Communication library: Receive_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   – HWID from the system tags at the PORT input
   – Data structure for storage of received data at the BUFFER input

   Note: A high level at the NDR output during operation indicates that new data was received and stored in the specified data area. The block must be called until NDR=TRUE. The received data can then be analyzed and the RECEIVE_P2P can be called again.

Optional additions

- Instructions that end in _Config can be used optionally to change the parameters of the hardware configuration during operation of the user program. The changes are not saved in the hardware configuration. They are overwritten at the next restart.
- The instructions Signal_Set and Signal_Get can be used to control the RS232 accompanying signals individually if automatic operation is not a suitable option.

4.2.2 Data transmission with Freeport

Introduction

Freeport is a freely programmable frame-based protocol that is also known as ASCII protocol.

The Freeport protocol controls data transmission by means of a point-to-point connection between the communication module and a communication partner. The Freeport protocol contains the physical layer (Layer 1).

The Freeport protocol supports sending and receiving of messages with any structure (all characters from 00H through FFH (for character frames with 8 data bits) or from 00H through 7FH (for character frames with 7 data bits)).

The frame start and end criteria must be configured both for the send and the receive direction. The start and end criteria can be configured differently.

Instructions are available for communication with a communication partner (see Overview of point-to-point programming (Page 57)).

4.2.3 Sending data with Freeport

Specifying settings for sending

To send a message, the partner must be informed of the start and end of the message. These settings can be set fixed in the hardware configuration or be adjusted during runtime by using the instruction Send_CFG. You can select one of the following options or also combine them:

- Send break before frame start

  You can specify that an additional Break is sent at the beginning of each message transmission on expiration of the RTS ON delay time.
  The duration of the "Break" is specified in bit times.

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- Send idle line

  You can specify that an additional "Idle Line" signal is output at the start of each message transmission.
  The duration of the "Idle Line" is specified in bit times.

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- RTS ON delay

  You can configure the time that has to expire after the RTS (Request to send) before the actual data transmission starts (RS232 only).

- RTS OFF delay

  You can configure the time that has to expire after transmission has been completed before the RTS signal is deactivated (RS232 only).

- Send up to and including the end delimiter

  You can configure the number of end delimiters (1 or 2) and their value.

  All data up to the end delimiter(s) is sent, independent of the selected frame length. The end delimiter must be included in the data to be sent. Data is sent only up to and including the delimiter, even if the specified data length is longer.

- Number of appended characters

  Input of the number of appended characters. Sending takes place up to the configured length. The end delimiter(s) is/are appended automatically. Depending on the number of end delimiters, one to five characters more than the number specified at the instruction are sent to the partner.

Note

If you combine "Send break before frame start", "Send idle line" and "RTS ON delay", these are processed in the order "RTS ON delay", "Send break before frame start" and "Send idle line".

4.2.4 Receiving data with Freeport

Specifying the message start

For data transmission with Freeport, you can choose between several different start criteria. The start criterion defines when a frame starts. Once a criterion that indicates the start of the message is met, the data stream is scanned for message end criteria. Here you select the settings that correspond to the properties of the sending communication partner.

Two different methods are available for detecting the message start:

- **Start on any character**

  Any character can be used to define the start of the message (default).

  This means that the first character sent at the start of communication, or after the frame end has been detected, will be identified as the first character of a message.

- **Start on special condition**

  The start of the message is detected based on the following specified conditions.

  – **After detection of a line break**

    The frame start is not accepted unless a break has been received beforehand, in other words, it is compulsory for the partner to send a break before sending a frame.

  – **After detection of an idle line**

    The frame start is not accepted until the configured idle line duration has expired. This procedure requires a minimum interval between two frames.

  – **After receipt of a start character**

    The frame start is detected when the configured start character is identified.

  – **After detection of one or several start sequences**

    The frame start is detected when the configured string with a length of up to five characters is identified. You can configure up to 4 start sequences. The start sequences that are up to 5 characters long can also contain "don't care characters".

Example:

Table 4- 1 Configured start conditions

Start condition	1. character	2. character	3. character	4. character	5. character
1	0x68	xx	xx	0x68	xx
2	0x10	0xaa	xx	xx	xx
3	0xdc	0xaa	xx	xx	xx
4	0xe5	xx	xx	xx	xx
:					

The following message has been received: 68 10 aa 68 bb 10 aa 16

The evaluation of the start criteria begins with the receipt of the first character 0x68.
The 2nd and 3rd characters are free.
When the 4th character (second 0x68) is received, the first start condition is met and further evaluation of the message begins.

Specifying the message end

You can choose from several different end criteria for data transmission using the Freeport protocol. The end criterion defines the point at which a frame has been received completely.

Configurable end criteria are:

- **Recognize message end by message timeout**
- **Recognize message end by response timeout**
- **After character delay time elapses (default)**
- **After receipt of a fixed frame length**
- **After receipt of a maximum number of characters**
- **Read message length from message**
- **After receipt of an end sequence**

Message timeout

When data is received, the end of frame is detected on expiration of the configured time for transferring a frame. Time measurement starts after the start criterion has been met.

Response timeout

The response time is used to monitor the response behavior of the communication partner. If a valid frame start is not recognized after the completion of a send job, the send job is acknowledged with a corresponding message.

The actual end criterion has to be configured additionally.

Expiration of character delay time

When data is received, the frame end is detected when the configured maximum time between successive characters is exceeded (character delay time). The value is specified in bit times.

In this case, the character delay time must be set in such a way as to ensure that it expires between two consecutive frames. However, it should be of sufficient length to exclude incorrect identification of the end of the frame whenever the communication partner performs a transmission pause within a frame.

Fixed frame length

When data is received, the end of the frame is identified after the configured frame length has been reached.

An error message is output and the frame is discarded if the character delay time expires (if activated) before the fixed frame length has been reached.

Please note the following if the frame length of the received characters does not match the fixed configured frame length:

- All characters received after the fixed configured frame length has been reached will be discarded until a new start criterion is detected.
- An error message is output and the frame is discarded if another (activated) end criterion is met before the fixed frame length has been reached.

Maximum number of characters

When receiving data, the end of the frame is recognized after the declared number of characters have arrived.

This setting can be combined with the "Character delay time" settings. The frame received is also assessed as free of error if another end condition occurs, regardless of whether the maximum number of characters has been reached.

Please note the following if the frame length of the received characters does not match the configured maximum frame length:

- All characters received after the configured maximum number of characters has been reached will be discarded until a new start criterion (e.g. "Idle Line") is detected.
- If a different (activated) end criterion is met before the configured maximum number of characters has been reached, this "frame part" is assessed as a valid frame and the partner waits for a new start criterion. All characters received prior to fulfillment of a new start criterion are discarded.

Note

If no further end criterion is activated, the fixed frame length and maximum number of characters will respond in the same way.

Message length in the message

When data is received, the frame end is detected when the frame length sent with the received frame has been reached.

The following parameters define the characters to be used for evaluation of the message length:

- **Offset of length field in message**

  In the message, the value defines the position of the character that is to be used to determine the message length.

  You can set values from 0 to 4095 characters, depending on the buffer size.

- **Size of length field**

  This value specifies the number of characters as of the first evaluation position to be used to determine the message length.

  You can set values of 1, 2 and 4 characters.

- **Number of characters not counted in length specification**

  Number of characters appended to the frame without counting towards the frame length. This value defines the number of bytes at the end of the frame which should not be included in the evaluation of the message length.

  You can set values from 0 to 255 characters.

Example:

Parameter assignments for "Message length in the message"

Offset of length field in message:	3. byte ("2" has to be configured as offset)
Size of length field:	1 byte
Number of characters not counted in length specification:	3 bytes

Message					Number of characters not counted in length specification		
Start character	Address	Length field			Checksum	End delimiter	
Byte 1	Byte 2	Byte 3	Byte ...	Byte X	Byte X+1	Byte X+2	Byte X+3

End sequence

When data is received, the end of the frame is identified when the configured end sequence (max. 5 characters) is received. The end sequence which is up to 5 characters long can also contain "don't care characters". The received data is applied by the CPU, including the end sequence.

If you are working with the end sequence, transmission is not code-transparent and you must exclude the presence of end code in the user data.

Note

Frame end sequence

If there is only one end delimiter, the entry **must** take place in the 5th line.

If there are two end delimiters, the entries **must** take place in the 4th and 5th line (no gaps).

The same applies to the use of additional characters.

4.2.5 Code transparency

Code transparency

Code-transparent means that any character combinations can occur in the user data without the end criterion being recognized.

The code transparency of the procedure depends on the selection of the configured end criterion and flow control:

- With specified end sequence or using XON/XOFF flow control
  - Not code-transparent
- End criterion character delay time, fixed frame length, maximum frame length, message timeout, or response timeout and message length in the message
  - Code-transparent

4.2.6 Receive buffer

Receive buffer of the module

The communication modules have a receive buffer that stores the received frames temporarily until they are transmitted to the CPU. The receive buffer is implemented as a ring buffer, which means the frames are transmitted to the CPU in the order in which they were received until the receive buffer is full. If additional frames are received once the buffer is full, the oldest frame is overwritten. If "Prevent overwriting" was configured, a corresponding message is generated when the receive buffer is full. All further frames are rejected until the receive buffer is ready to receive new ones.

During the parameter assignment, you can specify whether the receive buffer should be deleted during startup. You can also specify the range of values (1 to 255) for the number of buffered receive frames.

The receive buffer of the module may have a size of up to 8 KB, depending on the communication module used (see chapter Introduction (Page 12)). The frame has a maximum length of 4 KB. This means that each communication module is capable of buffering at least two frames.

If you always want to transfer the last frame received to the CPU, you must set the value "1" for the number of buffered frames and deactivate overwrite protection.

Note

If continuous reading of the received data in the user program is interrupted for a certain time, you may find when the receive data is requested again, that the communication module first sends older frames before the CPU receives the most recent one. At the time of interruption, the old frame had already been transmitted from the receive buffer of the communication module and prepared for transmission to the CPU.

4.3 Communication using 3964(R)

4.3.1 Procedure for establishing a serial connection with 3964(R)

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communication module into the hardware configuration.
2. Set the communication parameters according to the link partner:

   For example, transmission speed, character frame, frame start and frame end

   These parameters are transferred to the CM PtP communication module every time the CPU is started.

Procedure - Programming

1. Create the data structure that is to include the data to be transferred.

Sending data:

1. Insert the instructions from the PtP Communication library: Send_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   – HWID from the system tags at the PORT input
   – Data structure with the data to be sent at the BUFFER input

   Note: During operation, each positive edge at the REQ input will send the specified data area once. The block must be called until DONE indicates that the data was transferred to the module.

   In case of an error, setting ERROR once and displaying the corresponding information in STATUS indicates that the data was not transferred.

Receiving data:

1. Insert the instructions from the PtP Communication library: Receive_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   – HWID from the system tags at the PORT input
   – Data structure for storage of received data at the BUFFER input

   Note: A high level at the NDR output during operation indicates that new data was received and stored in the specified data area. The block must be called until NDR=TRUE. The received data can then be analyzed and the RECEIVE_P2P can be called again.

Optional additions

- Instructions that end in _Config can be used optionally to change the parameters of the hardware configuration during operation of the user program. The changes are not saved in the hardware configuration. They are overwritten at the next restart.
- The instructions Signal_Set and Signal_Get can be used to control the RS232 accompanying signals individually if automatic operation is not a suitable option.

4.3.2 Data transmission with 3964(R) procedure

Introduction

The 3964(R) procedure controls point-to-point data exchange between the communication module and a communication partner. and contains both the physical layer (layer 1) and the link layer (layer 2).

Instructions are available for communication with a communication partner (see Overview of point-to-point programming (Page 57)).

4.3.3 Control characters

Introduction

During data transmission, the 3964(R) procedure adds control characters to the information data (link layer). The communication partner can use these control characters to check whether it has received all data completely and without errors.

Control characters of the 3964(R) procedure

The 3964(R) procedure evaluates the following control characters:

STX	Start of Text	Beginning of the character string to be transmitted	02H
DLE	Data Link Escape	Data transmission changeover	10H
ETX	End of Text	End of the character string to be transmitted	03H
NAK	Negative Acknowledge	Negative acknowledgment	15H
BCC	Block Check Character (only with 3964R)	Block check character	

BCC is formed and monitored automatically in the communication module. The block check character is not transmitted as frame content to the CPU.

Note

If the DLE character is transmitted as an information character within a frame, it is sent twice (DLE duplication) to distinguish it from the DLE control character during connection establishment and termination. The receiver reverses the DLE duplication.

Priority

With the 3964(R) procedure, one communication partner must be assigned a higher and the other a lower priority. If both partners start to establish a connection at the same time, the partner having lower priority will cancel its send job.

4.3.4 Block check character

Block check character

With the 3964R transfer protocol, data security is enhanced by sending an additional block check character (BCC = Block Check Character).

The block check character is the even longitudinal parity (EXOR logic operation of all data bytes) of a sent or received block. Its calculation begins with the first byte of user data (first byte of the frame) after the connection establishment, and ends after the DLE ETX character at connection termination.

Note

With DLE duplication, the DLE character is included twice in the BCC calculation.

4.3.5 Sending data with 3964(R)

Connection establishment for sending

The 3964(R) procedure sends the STX control character to set up the connection. If the communication partner responds with the DLE character before the acknowledgment delay time expires, the procedure switches to send mode.

If the communication partner answers with NAK or any other character (except for DLE or STX), or the acknowledgment delay time expires without a response, the procedure tries to set up the connection again. After the configured number of unsuccessful setup attempts, the procedure cancels the connection setup and sends the NAK character to the communication partner. The communication module outputs a corresponding error message.

Sending data

If the connection is successfully established, the user data contained in the output buffer of the communication module is sent to the communication partner with the selected transmission parameters (a DLE recognized in the user data is doubled during the send job). The communication partner monitors the time intervals between the incoming characters. The interval between two characters must not exceed the character delay time. Monitoring of the character delay time starts immediately after the connection has been established.

If the communication partner sends the NAK character during an active send operation, the procedure cancels the block and repeats it as described above, beginning with connection establishment. If a different character is sent, the procedure first waits for the character delay time to expire and then sends the NAK character to set the communication partner to idle state. Then, the procedure restarts sending with the connection setup STX.

Connection termination during sending

Once the contents of the buffer have been sent, the procedure appends the DLE and ETX characters and (only with 3964R) the block checksum BCC as the end identifier, and then waits for an acknowledgment character. If the communication partner sends the DLE characters within the acknowledgment delay time, the data block has been received without errors. If the communication partner responds with NAK, any other character (except DLE), or with a corrupted character, or if the acknowledgment delay time expires without a response, the procedure restarts sending with the connection setup STX.

After the configured number of attempts to send, the procedure stops the process and sends an NAK to the communication partner. The communication module outputs a corresponding error message.

4.3.6 Receiving data with 3964(R)

Connection setup for receiving

In idle state, when there is no send job to be processed, the procedure waits for the communication partner to set up the connection.

A wait time is started (wait time = acknowledgment delay time - 10 ms, however, maximum of 400 ms) if no free receive buffer is available during the connection setup with STX. An error message is generated if no free receive buffer is available on expiration of this time. The procedure sends the NAK character and returns to the idle state. Otherwise, the procedure sends a DLE and receives the data as described above.

The acknowledgment delay time should be set to the same value at both communication partners.

If the procedure receives any character (except for STX or NAK) while in idle state, it waits for the character delay time (CDT) to expire and then sends the NAK character. The communication module outputs a corresponding error message.

Receiving data

After a successful connection establishment, the incoming receive characters are saved to the receive buffer. If two consecutive DLE characters are received, only one of these is saved to the receive buffer.

After connection has been established and after each receive character, the procedure waits for the next character during the character delay time. If this period expires before another character is received, an NAK is sent to the communication partner. The communication module outputs a corresponding error message. A retry is then expected.

If transmission errors occur during receiving (frame errors, parity errors, etc.), the procedure continues to receive data until the connection is terminated and then sends an NAK to the communication partner. A retry is then expected. If the block still cannot be received without errors after the specified number of transfer attempts, or if the communication partner does not start the retry within a block wait time of 4 seconds, the procedure cancels the receive operation. The communication module reports the first corrupted transfer and the final cancelation.

Connection setup for receiving

If the 3964 procedure detects a DLE ETX string, it terminates the receive operation and confirms a successfully received block by sending a DLE to the communication partner. In the case of a receive error, an NAK is sent to the communication partner. A retry is then expected.

The 3964R procedure terminates the receive operation after having detected the DLE ETX BCC string. It compares the received block check character BCC with the internally calculated longitudinal parity. If the BCC is correct and no other receive errors have occurred, the 3964R procedure sends a DLE and returns to the idle state. The communication module informs the control system that new receive data is available.

If the BCC is faulty or a different receive error occurs, an NAK is sent to the communication partner. A retry is then expected.

4.4 Communication through Modbus RTU

4.4.1 Procedure for establishing a serial connection with Modbus RTU

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communication module into the hardware configuration.
2. Select the Modbus RTU protocol.

   Note: With Modbus RTU, most communication parameters are set using the Modbus_Comm_Load instruction during CPU start.

Procedure - Programming

1. Create the data structure that is to include the data to be transferred.
2. Integrate the Modbus_Comm_Load instruction into the cyclic sequence for parameter assignment of the communication module.
3. Interconnect the HWID from the system tags at the PORT input.
4. Call the instruction until successful execution is displayed at the DONE output. Do not call the instruction again thereafter unless you want to change the communication parameters.

Operation as Modbus master:

1. Insert the Modbus_Master instruction from the MODBUS (RTU) library:
2. Interconnect the data structure with the data to be sent at the BUFFER input.
3. Interconnect the instance DB of the Modbus_Master instruction at the MB_DB input of the Modbus_Comm_Load.

   Note: During operation, each positive edge at the REQ input will process the specified job once. The block must be called until DONE indicates that the data was transferred to the module.

   In case of an error, setting ERROR once and displaying the corresponding information in STATUS indicates that the data was not transferred.

Operation as Modbus slave:

1. Insert the Modbus_Slave instruction from the MODBUS (RTU) library.
2. Interconnect the data structure with the Modbus hold registers.
3. Enter the Modbus slave address at the MB_ADDR input.
4. Interconnect the instance DB of the Modbus_Master instruction at the MB_DB input of the Modbus_Comm_Load.

   Note: A high level at the NDR output during operation indicates that new data was received and stored in the specified data area.

4.4.2 Overview of modbus communication

Modbus RTU communication

Modbus RTU (Remote Terminal Unit) is a standard protocol for communication in the network and uses the electrical RS232 or RS422/485 connection for serial data transmission between Modbus devices in the network.

Modbus RTU uses a master/slave network in which the entire communication is triggered by only one master device while the slaves can only respond to the request of the master. The master sends a request to a slave address and only this slave address responds to the command (exception: broadcast frames to slave address 0 which are not acknowledged by the slaves).

The procedure used is a code-transparent, asynchronous half-duplex procedure. Data transmission is carried out without handshake.

Position in the system environment

The following Modbus description refers to the use of the corresponding communication modules.

- CM PtP RS232 HF
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

Function of the coupling

With the corresponding communication modules and the related instructions, you can establish a communication connection between a remote Modbus control system and a SIMATIC S7.

The GOULD-MODBUS protocol in RTU format is used for transmission.

Function codes 01, 02, 03, 04, 05, 06, 08, 15 and 16 are used for communication between a communication module operated as a Modbus slave and a master system (see Function Codes (Page 50)).

If a SIMATIC S7 communication module is operated as a Modbus master, function codes 11 and 12 are also available.

SIMATIC S7 as a Modbus slave

The master has the initiative for transmission, the communication module works as a slave.

frame traffic from slave to slave is not possible.

The instruction Modbus_Slave makes the data available on a SIMATIC data area in accordance with the mapping specification or stores them.

SIMATIC S7 as a Modbus master

As master, the communication module initiates transmission and, after outputting a request frame, it waits for the configured response monitoring time for a response frame from the slave. If the slave does not respond, the master repeats the request in accordance with the configuration before it outputs an error message.

frame structure

The data exchange "Master-Slave" and/or "Slave-Master" begins with the **slave address**, followed by the **function code**. Then the data are transferred. The structure of the data field depends on the function code used. The CRC check is transmitted at the end of the frame.

ADDRESS	FUNCTION	DATA	CRC-CHECK
Byte/Word	Byte	n byte	2 byte

ADDRESS	Modbus slave address • Standard address: 1 to 247 (bytes) • Extended station address: 1 to 65535 (word)
FUNCTION	Modbus Function Codes (Page 50)
DATA	frame data: Management and net data depending on the function code
CRC-CHECK	frame checksum

Slave address

The slave address can be range from 1 to 247 (byte) or 1 to 65535 (word). The address is used to address a defined slave on the bus.

Broadcast Message

The master uses slave address 0 to address all slaves on the bus.

Broadcast messages are only permitted in conjunction with writing Function codes 05, 06, 15 and 16.

A broadcast message is not followed by a response frame from the slave.

Data Field DATA

The data field DATA is used to transfer the function code-specific data such as:

- Bytecount, Coil_Startaddress, Register_Startaddress; Number_of_Coils, Number_of_Registers, ...

  For details, see "Function Codes (Page 50)".

CRC-Check

The end of the frame is identified by means of the CRC 16 checksum consisting of 2 bytes. It is calculated by the following polynominal: $x^{16} + x^{15} + x^2 + 1$.

The low byte is transmitted first, followed by the high byte.

End of frame

The end of frame is recognized when no transmission takes place during the time period required for the transmission of three and a half characters (3.5 times character delay time) (see Modbus Protocol Reference Guide).

This end of frame TIME_OUT therefore depends on the data transmission rate and is indicated in bit times (35 bit times are fix coded internally; further bit times can be configured in addition at the instruction).

The Modbus frame received from the connection partner is evaluated and formally checked after the end of frame TIME_OUT is received.

Exception responses

On recognition of an error in the request frame from the master, for example, register address illegal, the slave sets the highest value bit in the function code of the response frame.

This step is followed by transmission of a byte exception code that describes the cause of the error.

A detailed description of the meaning of the above-mentioned parameters is available in the "GOULD MODICON Modbus Protocol" (not part of this documentation).

Exception code frame

The exception code frame from the slave has the following structure:

- for example, slave address 5, function code 5, exception code 2

Response frame from the slave EXCEPTION_CODE_xx:

05H	Slave address
85H	Function code
02H	Exception code (1...7)
xxH	CRC checksum "Low"
xxH	CRC checksum "High"

On receipt of an exception code frame by the driver, the current job is completed with error.

The following error codes are defined in accordance with the Modbus specification:

Error code	Meaning in accordance with Modbus specification	Cause - Short Description *
1	Illegal function	Illegal function code
2	Illegal data address	Slave has illegal data address
3	Illegal data value	Slave has illegal data value
4	Failure in Associated Device	Slave has internal error
5	Acknowledge	Function is carried out
6	Busy, Rejected message	Slave is not ready to receive
7	Negative acknowledgement	The function cannot be carried out.
* Check slave for further details.		

RS232 mode

The following communication modules support RS232 mode:

- CM PtP RS232 HF
- CM PtP (ET 200SP)

For more information on RS232 mode, see the chapter RS232 mode (Page 20).

For information on hardware data flow control and on automatic operation of the accompanying signals, refer to the Handshake procedure (Page 23) chapter.

RS422/485 mode

The following communication modules support RS422/485 mode:

- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

For more information on RS422/485 mode, see the chapters RS422 mode (Page 21) and RS485 mode (Page 22).

FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 68202723 (https://support.industry.siemens.com/cs/ww/en/view/68202723)
- Entry ID 58386780 (https://support.industry.siemens.com/cs/ww/en/view/58386780)

4.4.3 Function Codes

Used function codes

The function code defines the meaning of the frame. It also defines the structure of a frame.

The following function codes are supported by the communication module:

Function code	Function in accordance with MODBUS specification	Range
01	Read Coil Status	1 to 2000 bit/request
02	Read Input Status	1 to 2000 bit/request
03	Read Holding Registers	1 to 124/125 bit/request (124 at extended station address)
04	Read Input Registers	1 to 124/125 bit/request (124 at extended station address)
05	Force Single Coil	1 bit/request
06	Preset Single Register	1 word/request
08 *	Loop Back Test	Read slave status or reset event counter in the slave
11 *	Fetch Communications Event Counter (only master)	-
15	Force Multiple Coils	1 to 1968 bits/request
16	Preset Multiple Registers	1 to 123 bit/request

* Diagnostic information for slave communication

Modbus function code 00 sends a broadcast message to all slaves (without slave response).

Assignment of the Modbus addresses to the SIMATIC addresses

The table below shows the assignment of the Modbus addresses to the SIMATIC addresses.

Modbus				S7-1500	
FC [1]	Function	Declaration	Address area	Declaration	CPU address
01	Read bits	Output	1 - 9999	Process image of outputs	Q0.0 to Q1248.6
02	Read bits	Input	10001 - 19999	Process image of inputs	I0.0 - 1248.6
03 [2]	Read words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU
04	Read words	Input	30001 - 39999	Process image of inputs	IW0 to IW19996
05 [2]	Write bits	Output	1 - 9999	Process image of outputs	Q0.0 to Q1248.7
06	Write words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU

Modbus				S7-1500	
FC [1]	**Function**	**Declaration**	**Address area**	**Declaration**	**CPU address**
15	Write bits	Output	1 - 9999	Process image of outputs	Q0.0 to Q1248.6
16 [2]	Write words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU

1) FC = function code

2) The value of the HR_Start_Offset determines whether data areas or bit memory address areas can be addressed with the FCs 03, 05 and 16 in the SIMATIC CPU.

4.5 Communication using USS

4.5.1 Procedure for establishing a serial connection with Modbus USS

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communication module into the hardware configuration.
2. Select the Freeport protocol and set the communication parameters.

   Note: The USS functionality is implemented by the instructions.

Procedure - Programming

1. Insert the USS_Port_Scan instruction from the USS Communication library.
2. Interconnect the HWID from the system tags at the PORT input.
3. Insert the USS_Drive_Control instruction from the USS Communication library.
4. Interconnect the USS_DB data structure in the instance DB of the USS_Drive_Control instruction to the USS_DB input of the USS_Port_Scan instruction. The data structure contains the data to be transferred for all drives.
5. Insert an additional call of the USS_Drive_Control instruction for each additional axis that is to be connected via the USS interface.

   Use the same instance DB each time. The distinction takes place with the help of the USS address that you specify at the DRIVE input of the USS_Drive_Control instruction. This means you have access to the control and feedback data at the parameters of the respective call for each drive.

4.5.2 Overview of USS communication

Position in the system environment

The following USS description refers to the use of the corresponding communication modules.

- CM PtP RS232 BA
- CM PtP RS422/485 BA
- CM PtP RS232 HF
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

Introduction

The USS® protocol (Universal Serial Interface Protocol) is a basic serial data transmission protocol designed to meet the requirements of drive technology.

The USS protocol defines an access method based on the master-slave principle for communication via a serial bus. One master and up to 16 drives (slaves) can be connected to the bus. The individual drives are selected by the master using an address character in the frame. A drive can never send anything without first being initiated by the master. Therefore, direct data transmission between individual drives is not possible. Communication functions in half-duplex mode. The master function cannot be transferred.

Drive technology requires specific response times for the control tasks and therefore strict cyclical frame traffic:

The master continuously sends frames (job frames) to the drives and expects a response frame from each addressed drive.

A drive must send a response frame if

- it has a received a frame without errors and
- it was addressed in this frame.

A drive may not send if these conditions are not met or the drive was addressed in the broadcast.

The connection with the respective drives exists for the master once it receives a response frame from the drive after a specified processing time (response delay time).

frame structure

Each frame begins with a start character (STX), followed by the length specification (LGE) and the address byte (ADR). The data field comes after that. The frame ends with the block check character (BCC). The frame length includes the user data (quantity n), the address byte (ADR) and the data verification character (BCC).

STX	LGE	ADR	1	2	...	N	BCC

For single-word (16-bit) data, the high byte is sent first followed by the low byte. Correspondingly, with double-word data the high word is sent first, followed by the low word. The length of a frame is specified in bytes.

Data encryption

The data is encrypted as follows:

- STX: 1 byte, start of text, 02H
- LGE: 1 byte, contains the frame length as a binary number
- ADR: 1 byte, contains the slave address and frame type in binary code
- Data fields: One byte each, content depending on job
- BCC: 1 byte, block check character

Data transmission procedure

The master ensures cyclic data transmission in frames. The master addresses all slave devices one after another with a job frame. The nodes addressed respond with a response frame. In accordance with the master-slave procedure, the slave must send the response frame to the master after it has received the job frame. Only then can the master address the next slave.

Data field in the frame

The data field is divided into two areas: the parameter area (PKW) and the process data area (PZD).

STX	LGE	ADR	Parameter (PKW)	Process data (PZD)	BCC

- **Parameter area** (PKW)

  The PKW area handles parameter transmission between two communication partners (e.g., controller and drive). This involves, for example, reading and writing parameter values and reading parameter descriptions and the associated text. The PKW interface generally contains jobs for operation and display, maintenance and diagnostics.

- **Process data area** (PZD)

  The PZD area consists of signals that are required for automation:

  – Control words and setpoints from the master to the slave

  – Status words and actual values from the slave to the master

  The contents of the parameter area and process data area are defined by the slave drives.

  For additional information on this, refer to the drive documentation.

4.5.3 Overview of functions

Transmission sequence

The instructions process the data transmission cyclically with up to 16 drive slaves. Only one job is active for each drive at any one time.

Performance features:

- Creation of data storage areas for communication, depending on the bus configuration
- Execution and monitoring of PKW jobs
- Monitoring of the complete system and troubleshooting
- Communication with the CPU
- Access to the drive functions
- Reading the drive parameters
- Writing the drive parameters

Programming - communication using instructions 5

5.1 Overview of point-to-point programming

Data exchange using Freeport or 3964(R) communication

You must make the send data available in data blocks or in the bit memory address area in the user program of the corresponding CPU. A receive buffer is available in the communication module for the receive data. A corresponding data block is set up in the data block.

In the user program of the CPU, the following instructions carry out the data transfer between the CPU and the communication module.

- Send_P2P
- Receive_P2P

The receive buffer can be deleted with the instruction Receive_Reset.

Dynamic configuration by means of the user program

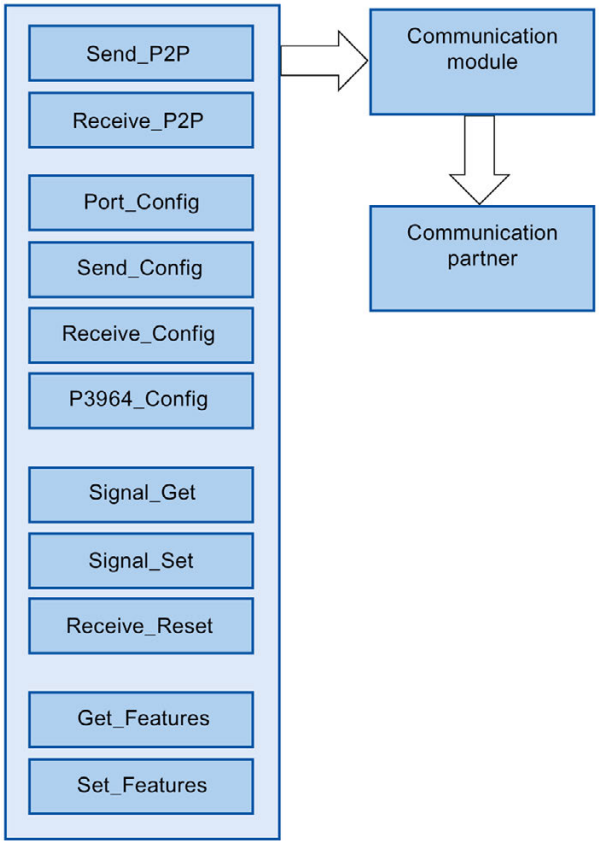
As an alternative to or in addition to the parameter assignment of the communication module interface described in section Configuring / parameter assignment of a communication module (Page 28), it may be advisable in certain application areas to set up the communication dynamically, i.e., program-controlled by a specific application.

All parameters assigned in the properties dialog of the communication module can also be changed during runtime by means of one of the following "Config" instructions:

Port_Config, Send_Config, Receive_Config, P3964_Config

Program calls for point-to-point communication - sequence

The figure below shows the function of the point-to-point instructions for communication between the user program and communication partner.



PtP instructions

Application	Instruction	Description
Data exchange between CPU, communication module and communication partner (communication)	Send_P2P (Page 84)	The instruction Send_P2P (send point-to-point data) can be used to send data to the communication partner. Call up the instruction Send_P2P to send data using the Freeport protocol. You have to call the instruction cyclically until you receive a corresponding acknowledgement at the output parameters of the instruction. Note: During parameter assignment of the XON/XOFF data flow control, user data may not contain any of the configured XON or XOFF characters. Default settings are DC1 = 11H for XON and DC3 = 13H for XOFF.
	Receive_P2P (Page 88)	The instruction Receive_P2P (receive point-to-point data) can be used to pick up the messages received in the communication module from a communication partner. Call the Receive_P2P instruction cyclically to receive data using the Freeport protocol. The instruction indicates at the NDR parameter if new received data is available. To signal the start and end of a message transmission, you need to define criteria in the Freeport protocol which identify the start and end of the message.
Deletion of the receive buffer	Receive_Reset (Page 90)	The instruction Receive_Reset (delete receive buffer) allows you to clear the receive buffer of the communication module.
Dynamic parameter assignment of the interface or the protocol (optional)	Port_Config (Page 71)	You can use the Port_Config instruction (port configuration) to configure basic interface parameters, such as the data transmission rate, parity and data flow control dynamically through your user program.
	Send_Config (Page 74)	With the instruction Send_Config(send configuration) you can configure serial send parameters, such as RTS ON delay / RTS OFF delay, dynamically for a point-to-point communication interface.
	Receive_Config (Page 76)	The instruction Receive_Config (receive parameter assignment) allows you to dynamically assign serial receive parameters to a communication module. This instruction configures the conditions that specify the start and the end of a received message.
	P3964_Config (Page 82)	The instruction P3964_Config(configure protocol) can be used to dynamically configure protocol parameters of the procedure 3964(R), such as character delay time, priority and block check using your program.
Operation of RS232 accompanying signals	Signal_Get (Page 91)	With the Signal_Get instruction (get RS232 signals) you can read the current states of the RS232 signals.
	Signal_Set (Page 93)	With the Signal_Set instruction (get RS232 signals), you can set the states of the RS232 signals DTR and RTS.
Enable Modbus CRC support and diagnostic interrupt	Get_Features (Page 95)	You can use the instruction Get_Features(get extended functions) to get information on the Modbus support and on generating diagnostic alarms.
	Set_Features (Page 96)	If supported by the module, you can use the instruction Set_Features(set extended functions) to activate the generation of diagnostic alarms.

Procedure for setting up Freeport or 3964(R) communication

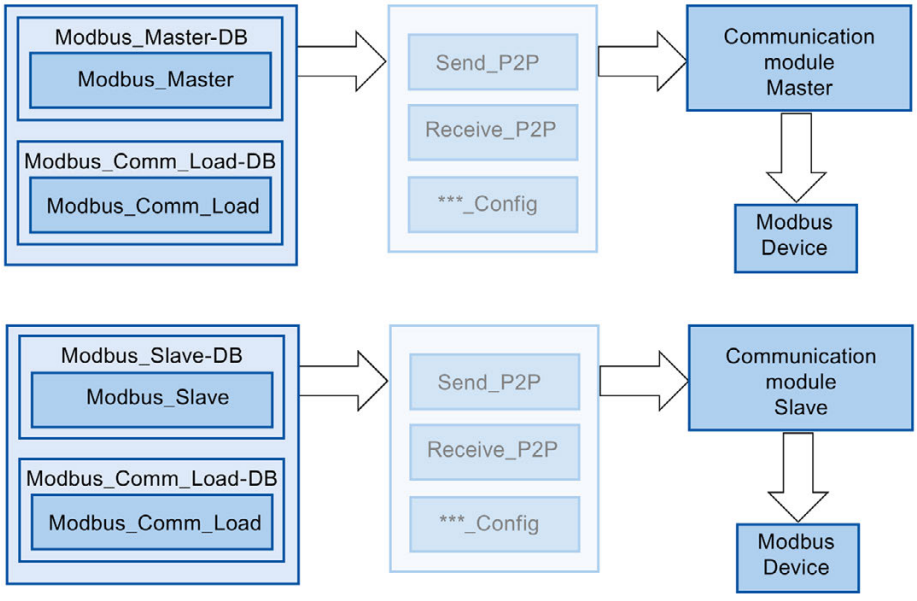
Requirement: The configuration and parameter assignment of a CPU and a communication module in the device view and in the properties dialog of the communication module are complete.

1. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instructions Send_P2P and Receive_P2P and drag-and-drop them into a network of the Main (OB1).
3. Configure the instructions in accordance with your specifications.
4. Download the hardware configuration and the user program to the CPU.

5.2 Overview of Modbus programming

Program calls for Modbus communication - sequence

The figure below shows the function of the Modbus instructions for communication between user program and Modbus device. (The instructions Send_P2P, Receive_P2P and the Config instruction are required downstream).



Modbus instructions

Application	Instruction	Description
Data exchange between user program and Modbus device (communication)	Modbus_Master (Page 120)	The Modbus_Master instruction allows you to communicate as Modbus master by means of the PtP port. The CPU can be used as Modbus RTU master device with the Modbus_Master instruction for communication with one or several Modbus slave devices.
	Modbus_Slave (Page 127)	The Modbus_Slave instruction allows you to communicate as Modbus slave by means of the PtP port. The CPU can be used as Modbus RTU slave device with the Modbus_Slave instruction for communication with one Modbus master device.
Parameter assignment of the interface and the protocol (mandatory)	Modbus_Comm_Load (Page 115)	The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU. You have to run Modbus_Comm_Load to set up PtP port parameters, such as data transmission rate, parity and flow control. Once you have configured the interface for the Modbus RTU protocol, it can only be used by the instruction Modbus_Master or the instruction Modbus_Slave .

Note

Alternative use of Modbus_Slave and Modbus_Master

A communication module can be operated either as master or as slave.

Procedure for setting up Modbus communication

Requirement: The configuration and parameter assignment of a CPU and a communication module in the device view and in the properties dialog of the communication module are complete.

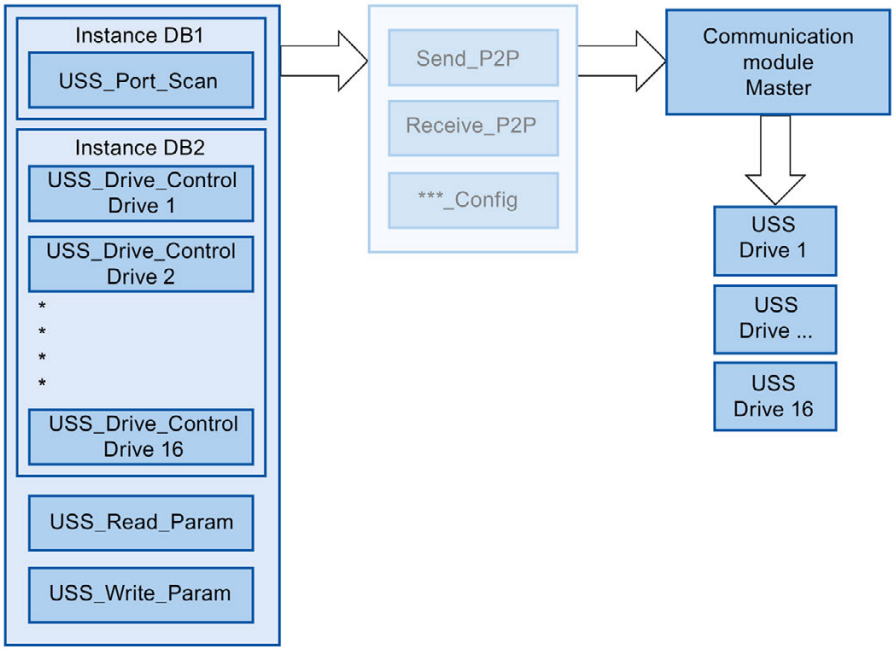
1. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instructions for Modbus communication in accordance with your task and drag-and-drop them into a network of the Main (OB1):
   - The instruction Modbus_Comm_Load configures the port of the communication module for Modbus communication.

     The Modbus_Comm_Load must be called in Main (OB1) until DONE (or ERROR) is reported.
   - The instruction Modbus_Master is used for the Modbus master functionality.
   - The instruction Modbus_Slave is used for the Modbus slave functionality.
3. Configure the instructions in accordance with your specifications.
4. Download the hardware configuration and the user program to the CPU.

5.3 Overview of USS programming

Program calls for USS communication - sequence

The figure below shows the function of the USS instructions for communication between user program and USS drive. (The instructions Send_P2P, Receive_P2P and the Config instruction are required downstream).



USS instructions

Application	Instruction	Description
Data communication between CPU, communication module and USS drive	USS_Port_Scan (Page 163)	The USS_Port_Scan instruction allows you to communicate via a communication module with up to 16 drives using a USS network (must be called cyclically). The instruction USS_Port_Scan controls the communication between CPU and the drives by means of the PtP communication port. A communication with the drive is processed every time you call this function. The instruction USS_Port_Scan is required once: Since most drives features a configurable internal function that monitors the integrity of the communication based on a timeout, the instruction USS_Port_Scan should be called from a time-controlled OB.
Exchange data with USS drive	USS_Drive_Control (Page 167)	The USS_Drive_Control instruction allows you to prepare the send data for a drive and to display the received data. The inputs and outputs of the instruction correspond to the states and operating functions of the drive. The USS_Drive_Control instruction must be called once for each drive. Only one common instance DB is required for all calls of the instruction USS_Drive_Control for a USS network. Interconnect all calls of the instructions USS_Drive_Control for a USS network with the same instance DB. The USS_Drive_Control instruction should be called from the cyclic Main (OB1) of the main program.
Read or modify parameters in USS drive	USS_Read_Param (Page 171)	The USS_Read_Param instruction allows you to read parameters from the drive. You use the USS_Read_Param instruction to read the operating parameters of the drive that controls the internal drive functions. The USS_Read_Param instruction should be called from the cyclic Main (OB1) of the main program.
	USS_Write_Param (Page 173)	The USS_Write_Param instruction allows you to change parameters in the drive. The USS_Write_Param instruction should be called from the cyclic Main (OB1) of the main program.

Procedure for setting up USS communication

Requirement: The configuration and parameter assignment of a CPU and a communication module in the device view and in the properties dialog of the communication module are complete.

1. In the project tree for the CPU, select the "Program blocks" folder and open the desired time-controlled OB by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instruction USS_Port_Scan and drag-and-drop it into a network of a time-controlled OB.

   The instruction USS_Port_Scan allows you to communicate by means of the USS network.
3. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
4. From the "Instructions" task card, "Communication" area select the instructions for USS communication in accordance with your task and drag-and-drop them into a network of the Main (OB1):
   - The instruction USS_Drive_Control is used for data exchange with the drive.
   - The instruction USS_Read_Param is used for reading parameters from the drive.
   - The instruction USS_Write_Param is used for changing parameters in the drive.
5. Configure the instructions in accordance with your specifications.
6. Download the hardware configuration and the user program to the CPU.

5.4 Instructions

5.4.1 Point-to-point

5.4.1.1 Overview of Freeport communication

STEP 7 offers extended instructions that can be used for Freeport communication with a protocol specified in the user program. These instructions can be divided into two categories:

- Configuration instructions
- Communication instructions

Note

CPU capacity

The Freeport instructions communicate with the communication modules by reading or writing data records.
When using the instructions, you should therefore check the capacity of the CPU for reading and writing data records.
If several instructions need to read or write data records simultaneously on a CPU, the user program may need to create a time offset between the calls of each instruction.

Configuration instructions

Before the user program can start the Freeport communication, the communication interface and the parameters for sending and receiving of data must be configured.

The interface configuration and the data configuration can be set for each CM in the device configuration or with the following instructions of your user program:

- Port_Config (Page 71)
- Send_Config (Page 74)
- Receive_Config (Page 76)
- P3964_Config (Page 82)

NOTICE

Device configuration <-> Configuration instructions

The device configuration parameters are transferred to the CM upon each Power On of the CPU (return of voltage).

The parameters of the configuration instructions are transferred to the CM as defined in your user program.

The parameters of the device configuration are not synchronized with the parameters of the configuration instructions, which means the parameters of the configuration instructions are not applied to the CPU device configuration.
With your user program, you determine the parameters that apply in the CM and when they apply.

Communication instructions

The user program uses the instructions for Freeport communication to send data to and receive data from the communication interfaces. The CMs send data to and receive data from the communication stations.

- Send_P2P (Page 84)
- Receive_P2P (Page 88)

Note

Data consistency

- If the data to be sent is transmitted consistently, it cannot be changed after the positive edge at the REQ parameter until DONE has been set by the Send_P2P instruction.
- If the receive data is to be read consistently, it may only be evaluated in the cycle in which NDR = TRUE.

The receive buffer can be reset with additional instructions and special RS232 signals can be queried and set.

- Receive_Reset (Page 90)
- Signal_Get (Page 91)
- Signal_Set (Page 93)

The following instructions let you read or write extended functions, as long as these are supported by the module.

- Get_Features (Page 95)
- Set_Features (Page 96)

All Freeport instructions work asynchronously. The instructions must therefore be called until the DONE output parameter indicates that execution is complete.

The user program can determine the send and receive status with the help of the query architecture. Send_P2P and Receive_P2P can be run at the same time. The communication modules buffer the send and receive data as required until a module-specific maximum buffer size has been reached.

Note

Resolution of bit times

The number of bit times is specified with the configured data transmission rate for different parameters. Specifying the parameter in bit times makes it independent of the data transmission rate. All parameters with unit of bit times can be specified with a maximum number of 65535.

5.4.1.2 Using the instructions

The Freeport instructions must be called cyclically to query received data or the end of transmission for a send process.

Depending on the data volume, data transmission may take place over several calls (program cycles).
If a command is completed with DONE = TRUE or NDR = TRUE, it has been executed without errors.

Note

Backing up STATUS

The DONE, NDR, ERROR and STATUS parameters are only available for one block cycle. To display the STATUS, you should therefore copy it to a free data area.

Master

Typical sequence for a master:

1. The Send_P2P instruction triggers transmission to the CM.
   Data transmission is initiated by a positive edge at the REQ input.
2. The Send_P2P instruction is executed in subsequent cycles to query the status of the transmission process.
3. When the Send_P2P instruction signals that transmission is complete at the DONE output, the user code can prepare the receipt of the answer.
4. The Receive_P2P instruction is run repeatedly to query an answer. If the CM has acquired response data, the Receive_P2P instruction copies the response to the CPU and signals that new data has been received at the NDR output.
5. The user program can process the response.
6. Back to step 1 and repetition of the sequence.

Slave

Typical sequence for a slave:

1. The user program runs the Receive_P2P instruction in each cycle.
2. If the CM has received a request, the Receive_P2P signals that new data is available at the NDR output and the request is copied to the CPU.
3. The user program processes the request and creates a response.
4. The response is returned to the master with the Send_P2P instruction.
5. The Send_P2P instruction must be run repeatedly to ensure that the send process is actually taking place.
6. Back to step 1 and repetition of the sequence.

The slave must ensure that Receive_P2P is called up often enough so that a transmission can be received by the master before it cancels the process due to a timeout while waiting for the response. To do so, the user program Receive_P2P can be called from within a cycle OB whose cycle time is sufficiently short so that the master can receive a transmission before the timeout setting expires. If the OB cycle time is set so that two runs can take place during the timeout setting of the master, the user program can receive all transmissions without any losses.

5.4.1.3 General parameters for Freeport operations

Table 5- 1 General input parameters of the Freeport instructions

Parameter	Description
REQ	Data transmission is initiated by a positive edge at the REQ input. Another edge at REQ may only be generated after the command has been completed (DONE or ERROR). Data transmission can take several calls (program cycles), depending on the data volume. When you add a Freeport instruction to your program, STEP 7 prompts you to specify the instance DB (or to have STEP 7 create a corresponding instance DB). Use a unique DB for each PtP instruction call.
PORT	A port address is assigned during configuration of the communication module. The PORT parameter communicates assignment to a specific communication module to the instruction. You can select a symbolic name for the standard port after the configuration. The assigned CM port value is the "Hardware ID" property of the device configuration with S7-1200/1500 and the "Input address" with S7-300/400. The symbolic port name is assigned in the symbol table.

The output parameters DONE, NDR, ERROR and STATUS of the Freeport instructions indicate the execution status of the Freeport functions.

Table 5- 2 Output parameters DONE, NDR, ERROR and STATUS

Parameter	Data type	Standard	Description
DONE	Bool	FALSE	Set to TRUE for one cycle to indicate that the last request was completed with errors; otherwise FALSE.
NDR	Bool	FALSE	Set to TRUE for one cycle to indicate that new data has been received; otherwise FALSE.
ERROR	Bool	FALSE	Set to TRUE for one cycle to indicate that the last request was completed with errors; the corresponding error code can be found in STATUS; otherwise FALSE.
STATUS	Word	16#0000 or 16#7000	Result status: • If the DONE or NDR bit is set, STATUS is set to 0/16#7000 or to a specific error code. • If the ERROR bit is set, STATUS displays an error code. • If none of the bits listed above is set, the instruction can return status results that describe the current status of the function. The value in STATUS is valid until you call this instruction again (with one and the same port address).

Table 5- 3 In/out parameter COM_RST

Parameter	Data type	Standard	Description
COM_RST	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. COM_RST is then set back to FALSE. Note: You must set COM_RST to TRUE during startup and should not subsequently change the parameter (that is, do not assign a value when you call the instruction). COM_RST is reset by the instruction following initialization of the instance DB.

Note

Please note that the parameters DONE, NDR, ERROR and STATUS are only set for one cycle.

Table 5- 4 Shared error codes

Error code	Description
16#0000	No error
16#7000	Function not active
16#7001	Initial call after request started.
16#7002	Subsequent call after request started.
16#8x3A	Invalid pointer in parameter x

Table 5- 5 Shared error classes of the STATUS parameter

Description of the class	Error classes	Description
Port configuration	16#81Ax	For the description of frequent errors in the interface configuration
Send configuration	16#81Bx	For the description of errors in the send configuration
Receive configuration	16#81Cx	For the description of errors in the receive configuration
Sending	16#81Dx	For the description of runtime errors during sending
Receiving	16#81Ex	For the description of runtime errors during receiving
RS232 accompanying signals	16#81Fx	For the description of errors in connection with signal processing

5.4.1.4 Port_Config: Configure PtP communication port

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Port_Config instruction (port configuration) allows you to change parameters such as the data transmission rate in runtime using your program. The data pending in the CM is deleted with the execution of Port_Config.

Configuration changes of Port_Config are saved on the CM and not in the CPU. When the voltage returns, the CM is configured with the data saved in the device configuration.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
PROTOCOL	IN	UInt	Word	0	Protocol • 0 = Freeport protocol • 1 = Protocol 3964(R)

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
BAUD	IN	UInt	Word	6	Data transmission rate of the port: • 1 = 300 bps • 2 = 600 bps • 3 = 1200 bps • 4 = 2400 bps • 5 = 4800 bps • 6 = 9600 bps • 7 = 19200 bps • 8 = 38400 bps • 9 = 57600 bps • 10 = 76800 bps • 11 = 115200 bps
PARITY	IN	UInt	Word	1	Parity of the port: • 1 = no parity • 2 = even parity • 3 = odd parity • 4 = mark parity • 5 = space parity • 6 = any
DATABITS	IN	UInt	Word	1	Bits per character: • 1 = 8 data bits • 2 = 7 data bits
STOPBITS	IN	UInt	Word	1	Stop bits: • 1 = 1 stop bit • 2 = 2 stop bits
FLOWCTRL	IN	UInt	Word	1	Flow control: • 1 = no flow control • 2 = XON/XOFF • 3 = Hardware RTS always ON • 4 = Hardware RTS switched • 5 = Hardware RTS always ON, ignore DTR/DSR
XONCHAR	IN	Char		16#0011	Specifies the character that serves as XON character. It is typically a DC1 character (11H). This parameter is only evaluated when software flow control is active.
XOFFCHAR	IN	Char		16#0013	Specifies the character that serves as XOFF character. It is typically a DC3 character (13H). This parameter is only evaluated when software flow control is active.

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
WAITIME	IN	UInt	Word	2000	Specifies how long to wait for an XOFF character after receipt of an XON character or how long to wait for a CTS = ON signal after CTS = OFF (0 to 65535 ms). This parameter is only evaluated when flow control is active.
MODE	IN	USInt	Byte	0	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire mode (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master; CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave; CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode [1]
LINE_PRE	IN	USInt	Byte	0	Receive line initial state Valid initial states are: • 0 = "No" initial state [1] • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
BRK_DET	IN	USInt	Byte	0	Break detection The following settings are permitted: • 0 = break detection deactivated • 1 = break detection activated
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

[1] Required setting for the use of PROFIBUS cables with CM 1241 for RS485

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.5 Send_Config: Configure PtP sender

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Send_Config instruction (send configuration) allows you to change send parameters in runtime using your program (conditions that identify the start and the end of the data to be sent). Any data pending in a CM is deleted when Send_Config is executed.

Configuration changes of Send_Config are saved on the CM and not in the CPU. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communication module.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Activates the configuration change upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
RTSONDLY	IN	UInt	Word	0	Number of milliseconds to wait after activation of RTS before a transmission of send data is started. This parameter is only valid if the hardware flow control is active. The valid range is 0 to 65535 ms. The value 0 deactivates the function.
RTSOFFDLY	IN	UInt	Word	0	Number of milliseconds to wait after transmission of send data before RTS is deactivated: This parameter is only valid if the hardware flow control is active. The valid range is 0 to 65535 ms. The value 0 deactivates the function.

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
BREAK	IN	UInt	Word	0	This parameter specifies that a BREAK is to be sent at the start of each frame for the specified number of bit times. The maximum is 65535 bit times. The value 0 deactivates the function.
IDLELINE	IN	UInt	Word	0	This parameter specifies that the line is to remain in idle for the specified number of bit times prior to the start of each frame. The maximum is 65535 bit times. The value 0 deactivates the function.
USR_END	IN	STRING[2]		0	Input of end delimiters. No more than 2 end delimiters can be configured. All data including the end delimiter(s) is sent, independent of the configured frame length.
APP_END	IN	STRING[5]		0	Input of characters to be appended. You can append up to 5 characters.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.6 Receive_Config: Configure PtP recipient

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Receive_Config instruction (receive configuration) allows you to change receive parameters in runtime using your program. This instruction configures the conditions that mark the start and the end of received data. Any data pending in a CM is deleted when Receive_Config is executed.

Configuration changes of Receive_Config are saved **non-retentive** on the CM. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communication module. The Receive_Config instruction therefore must be called again from the user program when the voltage returns to the CPU or to the communication module in order to overwrite the parameters stored in the device configuration.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Activates the configuration change upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
RECEIVE_CONDITIONS	IN	Variant	Any	-	The data structure of Receive_Conditions specifies the start and end conditions used to identify the start and end of a frame.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

Start conditions for the Receive_P2P instruction

The Receive_P2P instruction uses the configuration specified in the device configuration or by the Receive_Config instruction to determine the start and end of Freeport communication frames. The start of the frame is defined by the start conditions. The start of the frame can be determined with one or several start conditions.
If Break as well as Idle Line is activated, Break must be met first and then Idle Line as well. After that, one of the other conditions (start character or start sequence) is sufficient to start data transmission.
The start condition "Any character" cannot be combined with other start conditions.

Data type structure of the Receive_Conditions parameter, part 1 (start conditions)

Table 5- 6 Structure of Receive_Conditions for start conditions

Parameter	Declaration	Data type	Default	Description
START.STARTCOND	IN	Word	16#0002	Specifying the start condition • 01H - detection of the start character • 02H - Any character • 04H - detection of a line break • 08H - detection of an idle line • 10H - detection of start sequence 1 • 20H - detection of start sequence 2 • 40H - detection of start sequence 3 • 80H - detection of start sequence 4 The start conditions can be combined by adding the values together.
START.IDLETIME	IN	Word	16#0028	The number of bit times required in the idle state for a new frame start to be detected (default value: W#16#28). Only in connection with the condition "Detection of an idle line". 0 to FFFF
START.STARTCHAR	IN	Byte	16#0002	The start character for the condition "Start character". (default value: B#16#2)
START.SEQ[1].CTL	IN	Byte	0	Start sequence 1, deactivate/activate comparison for each character: (default value: B#16#0) These are the activation bits for each character of the start character string. • 01H - character 1 • 02H - character 2 • 04H - character 3 • 08H - character 4 • 10H - character 5 When a bit is deactivated for a specific character, this means that each character in this position in the character string represents a valid start character string (e.g. 1FH = all 5 characters interpreted).
START.SEQ[1].STR[1] .. START.SEQ[1].STR.[5]	IN	Char[5]	0	Start sequence 1, start character (5 characters).
START.SEQ[2].CTL	IN	Byte	0	Start sequence 2, deactivate/activate comparison for each character. Default value: B#16#0)
START.SEQ[2].STR[1] .. START.SEQ[2].STR.[5]	IN	Char[5]	0	Start sequence 2, start character (5 characters).
START.SEQ[3].CTL	IN	Byte	0	Start sequence 3, deactivate/activate comparison for each character. Default value: B#16#0
START.SEQ[3].STR[1] .. START.SEQ[3].STR.[5]	IN	Char[5]	0	Start sequence 3, start character (5 characters).

Parameter	Declara-tion	Data type	Default	Description
START.SEQ[4].CTL	IN	Byte	0	Start sequence 4, deactivate/activate comparison for each character. Default value: B#16#0
START.SEQ[4].STR[1] .. START.SEQ[4].STR.[5]	IN	Char[5]	0	Start sequence 4, start character (5 characters),

Example

Have a look at the following received data in hexadecimal coding: "**68** 10 aa **68** bb 10 aa 16". The configured start character strings are available in the following table. Start character strings are evaluated once the first character 68H has been successfully received. After the fourth character has been successfully received (the second 68H), start condition 1 has been met. Once the start conditions have been met, the evaluation of the end conditions starts.

Processing of the start character string can be canceled due to different errors in parity, framing or time intervals between characters. These errors prevent receipt of the data because the start condition has not been met (an error message is output).

Table 5- 7 Start conditions

Start condition	First character	First character +1	First character +2	First character +3	First character +4
1	**68**H	xx	xx	**68**H	xx
2	10H	aaH	xx	xx	xx
3	dcH	aaH	xx	xx	xx
4	e5H	xx	xx	xx	xx

End conditions for the Receive_P2P instruction

The end of a frame is defined by the first occurrence of one or more configured end conditions.

You can configure the end conditions either in the properties of the communication interface in the device configuration, or with the Receive_Config instruction. The receive parameters (start and end conditions) are reset to the settings in the device configuration each time the voltage returns to the CPU or the communication module. When the STEP 7 user program executes Receive_Config, the settings are set to the parameters of Receive_Config .

Data type structure of the Receive_Conditions parameter, part 2 (end conditions)

Table 5- 8 Structure of Receive_Conditions for end conditions

Parameter	Declaration	Data type	Default	Description
END.ENDCOND	IN	Word	0	This parameter specifies the condition for the frame end: • 01H - response timeout • 02H - message timeout • 04H - character delay time • 08H - maximum frame length • 10H - read message length from message (N+LEN+M) • 20H - end sequence • 40H - fixed frame length
END.FIXLEN	IN	Word	1	Fixed frame length: Only used if the end condition "Fixed frame length" has been selected. 1 to 4000 bytes (up to 4 KB depending on the module)
END.MAXLEN	IN	Word	1	Maximum frame length: Only used if the end condition "Maximum frame length" has been selected. 1 to 4000 bytes (up to 4 KB depending on the module)
END.N	IN	Word	0	Byte position of the length field in the frame. Only used with end condition N+LEN+M. 1 to 4000 bytes (up to 4 KB depending on the module)
END.LENGTHSIZE	IN	Word	0	Size of the length field (1, 2, or 4 bytes). Only used with end condition N+LEN+M.
END.LENGTHM	IN	Word	0	Number of characters after the length field that are not included in the value of the length field. This entry is only used with end condition N+LEN+M. 0 to 255 bytes
END.RCVTIME	IN	Word	200	Specify the wait time for the first received character after a frame has been sent. The receive instruction is terminated with an error message if a character is not received within the specified time. This information is used only with the condition "Response timeout". (0 to 65535 ms). Note: This parameter cannot be used as sole end criterion but only in connection with at least one other end condition.
END.MSGTIME	IN	Word	200	Specify how long to wait for receipt of the complete frame after receipt of the first character. This parameter is used only if the condition "Message timeout" is selected. (0 to 65535 ms)
END.CHARGAP	IN	Word	12	Enter the maximum number of bit times between characters. If the number of bit times between characters exceeds the specified value, the end condition has been met. This information is used only with the condition "Character delay time". (0 to 65535 bit times)

Parameter	Declaration	Data type	Default	Description
END.SEQ.CTL	IN	Byte	0	Character sequence 1, deactivate/activate comparison for each character: These are the activation bits for each character of the end character string. Character 1 is bit 0, character 2 is bit 1, ..., character 5 is bit 4. If a bit is deactivated for a specific character, this means that each character represents a congruence at this position of the character string.
END.SEQ.STR[1] .. END.SEQ.STR[5]	IN	Char[5]	0	Character string 1, start character (5 characters)

Table 5- 9 General parameters of the Receive_P2P instruction

Parameter	Declaration	Data type	Default	Description
GENERAL.MBUF_SIZE	IN	Byte	255	Input number of frames that are to be buffered in the receive buffer of the CM. If no other conditions are active that influence the reaction of the receive buffer (prevent timeout, data flow control), additional frames are discarded once the limit has been reached. (1 to 255 frames)
GENERAL.OW_PROT	IN	Byte	0	Activates the no overwriting function of the buffered frame if the CM receives a new frame and the receive buffer of the CM was not yet read. This step prevents already buffered received frames from being lost. • 0 - not activated • 1 - activated
GENERAL.CLR_MBUF	IN	Byte	0	Activates deletion of the receive buffer during CPU startup. The receive buffer is automatically deleted when the CPU switches from STOP to RUN. The receive buffer only contains frames received after CPU startup. • 0 - not activated • 1 - activated

5.4.1.7 P3964_Config: Configuring the 3964(R) protocol

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The P3964_Config instruction (protocol configuration) allows you to change protocol parameters for 3964(R), such as character delay time, priority and block check, in runtime using your program.

Configuration changes of P3964_Config are saved on the CM and not in the CPU. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communication module.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
BCC	IN	USInt	Byte	1	Activates/deactivates the use of the block check • 0 = without block check • 1 = with block check
Priority	IN	USInt	Byte	1	Selection of the priority • 0 = low priority • 1 = high priority

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
CharacterDelayTime	IN	UInt	Word	16#00DC	Setting the character delay time (depending on the set data transmission rate) (default value: 220 ms) 1 ms to 65535 ms
AcknDelayTime	IN	UInt	Word	16#07D0	Setting the acknowledgment delay time (depending on the set data transmission rate) (default value: 2000 ms) 1 ms to 65535 ms
BuildupAttempts	IN	SInt	Byte	16#0006	Setting the number of connection attempts (default value: 6 connection attempts) 1 to 255
RepetitionAttempts	IN	USInt	Byte	16#0006	Setting the number of transmission attempts (default value: 6 connection attempts) 1 to 255
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.8 Send_P2P: Sending data

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Send_P2P instruction (send point-to-point data) starts the transmission of data and transmits the contents of the assigned buffer to the communication module. The CPU program is still being executed while the CM sends the data with the data transmission rate. Only one send instruction per communication module may be pending at any time. The CM signals an error if a second Send_P2P instruction is executed while the CM is already sending a frame.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
BUFFER	IN	Variant	Any	0	This parameter points to the memory area of the send buffer. **Notes:** • Boolean data and Boolean fields are not supported. • If the send buffer is in the optimized memory area, the maximum permitted length of the sent data is 1024 bytes. Exception: Arrays of Byte, Word or DWord are supported up to a length of 4096 bytes. • If the send buffer is a String or WString, the content of the string is transferred without the current and maximum length. Additional information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)"
LENGTH	IN	UInt	Word	0	Length in bytes of the data to be transferred. The memory area addressed in the BUFFER parameter is completely transmitted with LENGTH = 0. Additional information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)"
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Send_P2P instruction The instruction is initialized with 1. The instruction then resets COM_RST to 0.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

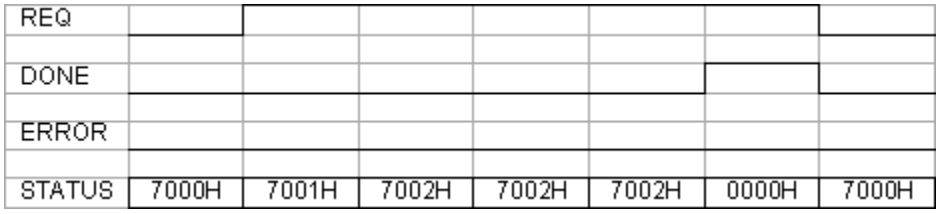
Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

Parameters

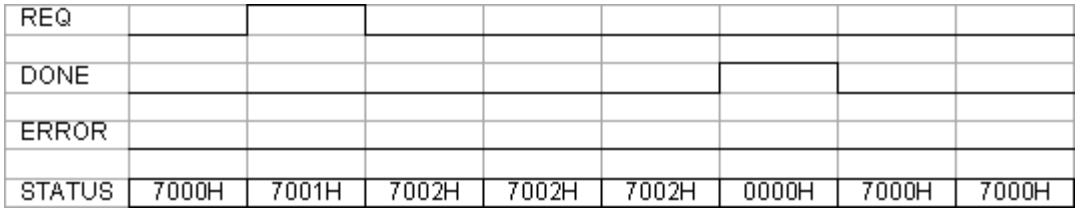
The DONE and ERROR outputs are in FALSE status when a send instruction is being processed. At the end of the send instruction, one of the DONE or ERROR outputs is set to TRUE for one cycle to signal the status of the send instruction. The error code at the STATUS output can be evaluated when the status of ERROR is TRUE.

The instruction outputs the status 16#7001 when the communication interface accepts the send data. Subsequent executions of Send_P2P output the value 16#7002 if the CM is still sending. At the end of the send instruction, the CM outputs the status 16#0000 for the send instruction (if no error has occurred). Subsequent executions of Send_P2P with REQ = 0 output the status 16#7000 (free).

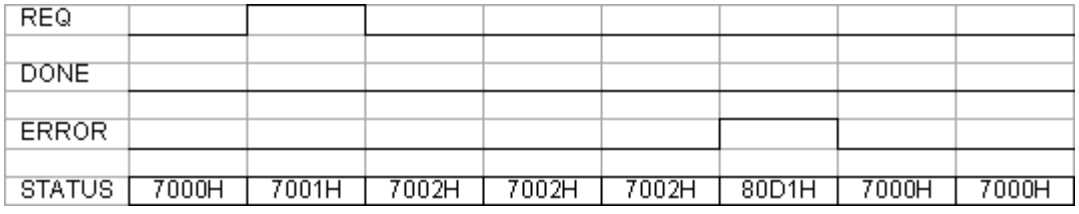
The diagram below shows the relationship between the output values and REQ. It is based on the assumption that the instruction is called cyclically to check the status of the send process (indicated by the STATUS values).



The figure below shows how the DONE and STATUS parameters are only valid for one cycle if a pulse is pending at the REQ line (for one cycle) to trigger the send instruction.



The figure below shows the relationship of the DONE, ERROR and STATUS parameters in case of an error.



The DONE, ERROR and STATUS values are only valid until Send_P2P is executed again with the same instance DB.

5.4.1.9 Using the BUFFER and LENGTH parameters for communication operations

Interaction of BUFFER and LENGTH parameters for Send_P2P

The minimum data size sent by the Send_P2P instruction is one byte.

The BUFFER parameter specifies the size of the data to be sent if a "0" is passed at the LENGTH parameter during call. The specification of a tag is sufficient for this.

You cannot use the data type Bool or arrays of the Bool type for the BUFFER parameter. If large amounts of data are being transferred we recommend the mapping to the array or structure data types.

Table 5- 10 BUFFER parameter

BUFFER	Description
Elementary data type	When sending: The LENGTH value must include the byte size of this data type. Example: For a Word value, the LENGTH must be two. For a DWord value or Real value, the LENGTH must be four.
Structure	For optimized memory: The maximum permitted length of the BUFFER is 1024 Byte; otherwise 4 KB are permitted depending on the module. For sending: The LENGTH value can include a byte size smaller than the complete byte length of the structure; in this case, only the first LENGTH bytes of the structure from BUFFER are sent.
Array	For optimized memory: If the array data type is not equal to Byte, Word or DWord, the maximum permitted buffer length is 1024 Byte. Depending on the module, up to 4 KB can be transmitted if the memory is not optimized, independent of the data structure. For sending: The LENGTH value can include a byte size smaller than the complete byte length of the array, whereby, this byte size is a multiple of the byte size of the data element. Example: The LENGTH parameter of an array of the Word type must be a multiple of two and a multiple of four for an array of the Real type. If LENGTH is specified, the number of array elements is transmitted. If BUFFER includes an array with 15 DWord elements (a total of 60 Bytes), for example, and you specify LENGTH = 20, the first five DWord elements from the array are transmitted.
String	The LENGTH parameter includes the number or characters to be sent. Only the characters of the String are transmitted. The bytes with the maximum and actual length of the String are not sent.

Table 5- 11 LENGTH parameter

LENGTH	Description
= 0	The complete content of the memory area specified by BUFFER is transferred. If BUFFER points to a string, the entire content of the string is transferred, without the bytes with the maximum and actual length.
> 0	The content up to the configured length of the memory area specified by BUFFER is transferred.

5.4.1.10 Receive_P2P: Receiving data

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Receive_P2P instruction (receive data using point-to-point communication) checks the frames received in the CM. If a frame is available, it is transmitted from the CM to the CPU. A receive error is indicated at the STATUS parameter.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
BUFFER	IN	Variant	Any	0	This parameter points to the start address of the receive buffer. This buffer must be large enough to receive the maximum frame length. **Note:** • Boolean data or Boolean fields are not supported. • If the receive buffer is in the optimized memory area, the maximum permitted length of the received data is 1024 bytes. Exception: Arrays of Byte, Word or DWord are supported up to a length of 4096 bytes. • If the receive buffer is a String or WString, the received data is written to the content of the string and the current length of the string is set accordingly. Additional information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)"
LENGTH	OUT	UInt	Word	0	Length of the frame received in bytes Additional information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)"
NDR	OUT	Bool		FALSE	TRUE for one cycle if new data is available and the instruction has been completed without errors.
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

The error code at the STATUS output can be evaluated if the status of ERROR is TRUE. The STATUS value provides the reason for terminating the receive operation in the CM. This is usually a positive value which indicates that the receive operation has been successful and the frame criterion that has been detected.
If the STATUS value is negative (the most significant bit of the hexadecimal value is set), the receive operation was terminated due to an error condition, such as a parity, framing or overflow error.

Each communication module can buffer a module-specific number for frames. If several frames are available in the CM, the Receive_P2P instruction outputs the oldest available frame (FIFO).

5.4.1.11 Receive_Reset: Clear receive buffer

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Receive_Reset instruction (reset receiver) clears the receive buffer in the CM.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
DONE	OUT	Bool		FALSE	TRUE for one cycle means that the last request was completed without errors.
ERROR	OUT	Bool		FALSE	TRUE means that the last request was completed with errors. If this output is TRUE, the STATUS output contains the corresponding error codes.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.12 Signal_Get: Read status

Note
Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Signal_Get instruction (get RS232 signals) reads the current states of the RS232 accompanying signals and displays them at the corresponding instruction outputs.

Note
Restriction

- This instruction can only be used with CMs RS232 BA and RS232 HF.
- If RS232C is set for the operating mode, this instruction can also be used with CM PtP (ET200SP).

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
NDR	OUT	Bool		FALSE	TRUE for one cycle if the RS232 accompanying signals have been read and the instruction has been completed without errors.
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
DTR	OUT	Bool		FALSE	Data device ready, module ready (output)
DSR	OUT	Bool		FALSE	Data device ready, communication station ready (input)
RTS	OUT	Bool		FALSE	Send request, module ready to send (output)
CTS	OUT	Bool		FALSE	Ready to send, communication station can receive data (input)
DCD	OUT	Bool		FALSE	Data carrier signal detected, signal level received
RING	OUT	Bool		FALSE	Call display, signaling incoming call

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.13 Signal_Set: Set accompanying signals

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Signal_Set instruction (set RS232 signals) allows you to set the RS232 communication signals.

Note

Restrictions

- This instruction can only be used with CMs RS232 BA and RS232 HF.
- If RS232C is set for the operating mode, this instruction can also be used with CM PtP (ET200SP).

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
SIGNAL	IN	Byte		0	Selection of the signal to be set (more than one possible): • 01H = RTS • 02H = DTR • 04H = DSR (for interface type DCE only)

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
RTS	IN	Bool		FALSE	Send request, module ready to send Set this value at the output (TRUE or FALSE), default value: FALSE
DTR	IN	Bool		FALSE	Data terminal ready, module ready Set this value at the output (TRUE or FALSE), default value: FALSE
DSR	IN	Bool		FALSE	Data terminal ready (for DCE interface type only), not used.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.14 Get_Features: Get extended functions

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

If supported by the module, you can use the Get_Features instruction (get extended functions) to get information on the ability of the module to support CRC and to generate diagnostic messages.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	PORT	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
NDR	OUT	Bool		FALSE	TRUE for one cycle if new data is available and the instruction has been completed without errors
MODBUS_CRC	OUT	Bool		FALSE	Modbus CRC support
DIAG_ALARM	OUT	Bool		FALSE	Generation of diagnostic messages
SUPPLY_VOLT	OUT	Bool		FALSE	Diagnostics for missing supply voltage L+ is available
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.15 Set_Features: Set extended functions

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

If supported by the module, you can use the Set_Features instruction (select extended functions) to activate CRC support and the generation of diagnostic messages.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	The instruction to set extended functions is started upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
EN_MODBUS_CRC	IN	Bool		FALSE	Activate Modbus CRC support
EN_DIAG_ALARM	IN	Bool		FALSE	Activate generation of diagnostic messages
EN_SUPPLY_VOLT	IN	Bool		FALSE	Enable diagnostics for missing supply voltage L+
DONE	OUT	Bool		FALSE	TRUE for one execution once the last request is completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

Additional information about the general parameters is available at "General parameters for Freeport operations (Page 69)".

5.4.1.16 Error messages

Overview of error messages - PtP

The error messages are provided at the STATUS output of an instruction and can be evaluated there or processed in the user program.

Error code	Description	Remedy
16#0000	No error	-
RECEIVE status and error codes		
16#0094	frame end identified based on the "Receipt of fixed/maximum frame length"	-
16#0095	frame end identified based on "Message timeout"	-
16#0096	frame end identified based on expiration of the "Character delay time"	-
16#0097	The frame was aborted because the maximum response time was reached.	-
16#0098	frame end identified based on the fulfillment of the "Read message length from message" conditions	-
16#0099	frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
16#7000	Block idle	-
16#7001	Initial call for a new frame: Data transmission initiated	-
16#7002	Interim call: Data transmission running	-
16#8085	Invalid length	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
16#8088	The specified length exceeds the range set in the receive buffer. Note: If the data type STRING has been specified at the BUFFER parameter, this error code also appears if the current string is shorter than the length specified at the LENGTH parameter.	Change the range in the receive buffer or select a frame length which corresponds to the range set in the receive buffer. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.
RECEIVE status and error codes		
16#8088	The number of characters received exceeds the number specified at the BUFFER parameter.	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.

Error code	Description	Remedy
Error message codes of the special functions		
16#818F	Incorrect parameter number setting (with USS only)	Select a suitable parameter number (PARAM). The following numbers are valid: 0-2047
16#8190	Incorrect setting of the CRC calculation	Select a suitable value for the CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
16#8191	Incorrect setting of the diagnostic error interrupt	Select a suitable value for "Diagnostic error interrupt". The following are valid: Diagnostic error interrupt deactivated or diagnostic error interrupt activated. Check whether the module addressed supports the generation of diagnostic interrupts.
Error message codes of the "Port configuration"		
16#81A0	The module does not support this protocol.	Select a valid protocol for the module (PROTOCOL).
16#81A1	The module does not support this data transmission rate.	Select a valid data transmission rate for the module (BAUD).
16#81A2	The module does not support this parity setting.	Select a suitable value for "Parity" (PARITY). The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#81A3	The module does not support this number of data bits.	Select a suitable value for "Number of data bits" (DATABITS). The following are valid: • 7 (2) • 8 (1)
16#81A4	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits" (STOPBITS). The following are valid: • 1 (1) • 2 (2)
16#81A5	The module does not support this type of data flow control.	Select a valid data flow control for the module (FLOWCTRL).
16#81A7	Invalid value for XON or XOFF	Select suitable values for XON (XONCHAR) and XOFF (XOFFCHAR). Valid range of values: 0...255

Error code	Description	Remedy
16#81AA	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) / (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint master) (2)/ (CM PtP (ET 200SP)) • Full duplex (RS 422) four-wire mode (multipoint slave) (3) • Half duplex (RS485) two-wire mode. (4)
16#81AB	Invalid receive line initial state	Valid initial states are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default setting corresponds to the idle state (no active send operation).
16#81AC	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • Break detection deactivated (0) • Break detection activated (1).
16#81AF	The module does not support this protocol.	Select a valid protocol for the module.
Error codes of the "Send configuration"		
16#81B5	More than two end delimiters or end sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
16#81B6	Send configuration rejected because the 3964(R) protocol was selected	Make sure that no send configuration is transmitted if the 3964(R) protocol is set.

Error code	Description	Remedy
Error codes of the "Receive configuration"		
16#81C0	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
16#81C1	Invalid end condition or no end condition selected	Select a suitable end condition (see Sending data with Freeport (Page 31)).
16#81C3	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length" (MAXLEN). Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
16#81C4	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
16#81C5	Invalid value for "Size of length field"	Select a suitable value for "Size of length field" (LENGTHSIZE). Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)
16#81C6	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification" (LENGTHM). Valid range of values: 0 to 255 (bytes)
16#81C7	The total of "Offset in the message + size of length field + number of characters not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of length field" and "Number of characters not counted". Valid range of values: • Offset in the message (depending on the module): 0-1024/2048/4096 (bytes) • Size of length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0 to 255 (bytes)
16#81C8	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
16#81C9	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1 to 65535 (bit times)
16#81CB	frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
16#81CC	frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.

Error code	Description	Remedy
16#81CD	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
16#81CE	Invalid value for "Clear receive buffer on startup"	Select a suitable value for "Clear receive buffer on startup". The following are valid: • Clear receive buffer at startup is deactivated (0) • Clear receive buffer at startup is activated (1)
SEND status and error codes		
16#81D0	Receiving send request during runtime of a send command	Make sure that you do not receive an additional send request during runtime of a send command.
16#81D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#81D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#81D3	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
16#81D5	Transmission canceled due to parameter changes, detected wire break, or CPU in STOP	Check the parameter assignment, wire break, and CPU status.
16#81D6	Transmission canceled because end identifier was not received	Check the parameter assignment of the end characters and the frame of the communication partner.
16#81D7	Communication error between the user program and module	Check the communication (e.g., matching the sequence number).
16#81D8	Transmission attempt rejected because module is not configured	Configure the module.
Error codes of the receive configuration		
16#81E0	Frame aborted: Send buffer overflow / send frame too long	Increase the call rate for the receive function in the user program or configure communication with data flow control.
16#81E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.
16#81E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
16#81E3	Frame aborted: Character overflow error	Firmware error: Please contact Customer Support.
16#81E4	Frame aborted: The total length of "Offset in the message + size of the length field + number of characters not counted" is greater than the receive buffer	Select a suitable value for offset in message, size of the length field, and number of characters not counted.
16#81E5	Frame aborted: Break	Receive line to partner is interrupted. Reconnect or switch on partner.

Error code	Description	Remedy
16#81E6	Maximum number of "Buffered received frames" exceeded	In the user program call the instruction more often or configure a communication with data flow control or increase the number of buffered frames.
16#81E7	Synchronization error module and Receive_P2P	Make sure that different instances of the Receive_P2P do not access the same module.
16#81E8	Frame aborted: The character delay time has expired before the message end criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.
16#81E9	Modbus CRC error (only communication modules which support Modbus)	Checksum error of the Modbus frame. Check the communication partner.
16#81EA	Modbus frame too short (only communication modules which support Modbus)	Minimum length of Modbus frame not met. Check the communication partner.
16#81EB	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (bytes) Check the parameters for end of frame detection.
Error codes V24 accompanying signals		
16#81F0	The module does not support V24 accompanying signals	You have tried to set accompanying signals for a module that does not support V24 accompanying signals. Make sure that this is an RS232 module or that RS232 mode (ET 200SP) is set.
16#81F1	No operation of the V24 accompanying signals	The V24 accompanying signals cannot be operated manually if hardware data flow control is active.
16#81F2	The DSR signal cannot be set because the module has the type DTE.	Check the configured type of the module. The module type must be DCE (data communication equipment).
16#81F3	The DTR signal cannot be set because the module has the type DCE.	Check the configured type of the module. The module type must be DTE (data terminal equipment).
16#81F4	Block header error (e.g. incorrect block type or incorrect block length)	Check the instance DB and the block header.
Error codes of the receive configuration		
16#8201 [1)]	Receive_Conditions is a pointer to an invalid data type	Enter a pointer to one of the following data types: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8225	Receive_Conditionspoints to an optimized memory area greater than 1 kB or Receive_Conditions points to an optimized memory area and the receive length is greater than the area addressed by Receive_Conditions.	Enter a pointer to an area with a maximum length of: • Optimized memory area: 1 KB • Non-optimized memory area: 4 KB Note: If the pointer points to an optimized memory area, do not send more than 1 KB.
16#8229 [1)]	Receive_Conditions is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.

Error code	Description	Remedy
Error codes, general		
16#8280	Negative acknowledgment when reading module	You can find more detailed information on error causes in theRDREC.STATUS static parameters and in the description of the SFB RDREC. • Check the input at the PORT parameter • Set the COM_RST parameter prior to the initial call.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter You can find more detailed information on error causes in the WRREC.STATUS static parameters and in the description of the SFB WRREC.
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.
Error codes of the receive configuration		
16#82C1	Invalid value for "Buffered received frames".	Select a suitable value for "Buffered received frames". Valid range of values: 1-255
16#82C2	Receive configuration rejected because the 3964(R) protocol was selected	Make sure that no receive configuration is sent if the 3964(R) protocol is set.
16#8301 [1)]	Receive_Conditions is a pointer to an invalid data type	Select a valid data type. The following are valid: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8322	Range length error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8324	Range error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8328	Setting error when reading a parameter	Check the input at the Receive_Conditions parameter
SEND status and error codes		
16#8328 [1)]	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes of the receive configuration		
16#8332	Invalid data block at the Receive_Conditions parameter	Check the input at the Receive_Conditions parameter
16#833A	The designation of the data block at the Receive_Conditions parameter refers to a data block which is not loaded.	Check the input at the Receive_Conditions parameter
16#8351	Invalid data type	Check the input at the Receive_Conditions parameter
16#8352 [1)]	Receive_Conditions does not point to a data block	Check the pointer to Receive_Conditions
16#8353 [1)]	Receive_Conditions does not point to a structure of the typeReceive_Conditions	Check the pointer to Receive_Conditions

Error code	Description	Remedy
Error codes 3964(R) protocol		
16#8380	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time" (CharacterDelayTime). Valid range of values: 1 to 65535 (ms)
16#8381	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout" (AcknDelayTime). Valid range of values: 1 to 65535 (ms)
16#8382	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority" (Priority). The following are valid: • High (1) • Low (0)
16#8383	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check" (BCC). The following are valid: • With block check (1) • Without block check (0)
16#8384	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts" (BuildupAttempts). Valid range of values: 1-255
16#8385	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts" (RepetitionAttempts). Valid range of values: 1-255
16#8386	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
16#8387	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.
16#8388	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check whether the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#8389	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is only answered with DLE when the receive buffer is empty. No additional character may be received before (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#838A	Runtime error: Logical error during receiving. After DLE was received, a further random character (other than DLE or ETX) was received.	Check if partner DLE in frame header and in data string is always in duplicate or the connection is released with DLE ETX. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.

Error code	Description	Remedy
16#838B	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Verify by using an interface test device that is switched into the transmission line, if necessary.
16#838C	Runtime error: Wait time for free receive buffer has started	In the user program call the instruction more often or configure a communication with data flow control.
16#838D	Runtime error: frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
16#838E	Runtime error: In idle mode, one or several characters (other than NAK or STX) were received.	Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
16#838F	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
16#8391	Parameter assignment error: 3964 configuration data rejected because Freeport is set	If the Freeport protocol is set, make sure that no 3964 parameter assignment data is sent.

[1] Only with instructions for S7-300/400 CPUs

Overview of error messages - Modbus

Error code	Description	Remedy
16#0000	No error	-
Configuration error of the interface - Modbus_Comm_Load		
16#8181	The module does not support this data transmission rate.	Select a valid data transmission rate for the module at the BAUD parameter.
16#8182	The module does not support this parity setting.	Select a suitable value for "Parity" at the PARITY parameter. The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#8183	The module does not support this type of data flow control.	Select a valid data flow control for the module at the FLOW_CTRL parameter.
16#8184	Invalid value for "Response timeout".	Select a suitable value for "Response timeout" at the RESP_TO parameter. Valid range of values: 1 to 65535 (ms)
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.RDREC.STATUS or Receive_Config.RDREC.STATUS static parameters or RDREC.STATUS and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.WRREC.STATUS or Receive_Config.WRREC.STATUS static parameters or WRREC.STATUS and in the description of the SFB WRREC.
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.

Error code	Description	Remedy
Configuration error - Modbus_Slave		
16#8186	Invalid slave address	Select a suitable slave address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8187	Invalid value at MB_HOLD_REG parameter	Select a suitable value for the hold register at the MB_HOLD_REG parameter.
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#818C	The pointer to a MB_HOLD_REG area must be a data block or a bit memory address area.	Select a suitable value for the pointer to the MB_HOLD_REG area.
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS, and in the description of the SFB WRREC.
16#8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
16#8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
16#8456 [1)]	Error during instruction execution. The cause of the error is shown in the STATUS parameter.	Determine the value of the SFCSTATUS parameter. Check what this means in the description for SFC51, STATUS parameter.

Error code	Description	Remedy
Configuration error - Modbus_Master		
16#8180	Invalid value for MB_DB parameter	The value configured for MB_DB (instance data DB) at the Modbus_Comm_Load instruction is not valid. Check the interconnection of the Modbus_Comm_Load instruction and its error messages.
16#8186	Invalid station address	Select a suitable station address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#8189	Invalid data address	Select a suitable value for the data address at the DATA_ADDR parameter. See description Modbus_Master (Page 120) in the Info system
16#818A	Invalid length	Select a suitable data length at the DATA_LEN parameter. See description Modbus_Master (Page 120) in the Info system
16#818B	Invalid value for DATA_PTR	Select a suitable value for the data pointer at the DATA_PTR parameter (M or DB address). See description Modbus_Master (Page 120) in the Info system
16#818C	Interconnection error of the DATA_PTR parameter	Check the interconnection of the instruction.
16#818D	The area addressed by DATA_PTR is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the DATA_PTR pointer
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS or Receive_Reset and in the description of the SFB WRREC.

Error code	Description	Remedy
Communication errors - Modbus_Master and Modbus_Slave		
16#80D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#80D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#80E0	Frame aborted: Send buffer overflow / send frame too long	In the user program call the instruction more often or configure a communication with data flow control.
16#80E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.
16#80E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
16#80E3	Frame aborted: Character overflow error	Check the number of data in the frame of the communication partner.
16#80E4	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
Communication error - Modbus_Master		
16#80C8	The slave does not respond within the set time	Check the data transmission rate, parity and wiring of the slave.
16#80C9	The slave does not respond within the time set by Blocked_Proc_Timeout.	Check the setting for Blocked_Proc_Timeout. Check if the module has been configured with the Modbus_Comm_Load instruction. The module may possibly need to be reconfigured using Modbus_Comm_Load after a pull/plug or after voltage recovery.
16#8200	The interface is busy with an ongoing request.	Repeat the command later. Make sure that there are no commands still running before you start a new one.
Protocol error - Modbus_Slave (only communication modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	The function code is not supported or is not supported for broadcast.	Check the communication partner and make sure that a valid function code is sent.
16#8382	Invalid length information in the request frame	Select a suitable data length at the DATA_LEN parameter.
16#8383	Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Invalid data value error in the request frame	Check the data value in the request frame of the Modbus master
16#8385	The diagnostic value is not supported by the Modbus slave (function code 08)	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.

Error code	Description	Remedy
Protocol error - Modbus_Master (only communication modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	Response frame from Modbus Slave with the following error message: The function code is not supported.	Check the communication partner and make sure that a valid function code is sent.
16#8382	Response frame from Modbus Slave with the following error message: Invalid length	Select a suitable data length.
16#8383	Response frame from Modbus Slave with the following error message: Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Response frame from Modbus Slave with the following error message: Data value error	Check the request frame to the Modbus slave.
16#8385	Response frame from Modbus Slave with the following error message: The diagnostic value is not supported by the Modbus slave	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.
16#8386	The returned function code does not match the requested function code.	Check the response frame and the addressing of the slave.
16#8387	A slave that was not requested answers	Check the response frame of the slave. Check the address settings of the slave.
16#8388	Error in the response of the slave to a write request.	Check the response frame of the slave.
16#8828 [1]	DATA_PTR points to a bit address that is not equal to n * 8	Check the DATA_PTR pointer
16#8852 [1]	DATA_PTR is not a pointer to a DB or a bit memory area	Check the DATA_PTR pointer
16#8853 [1]	DATA_PTR is not a pointer of type BOOL or WORD	Check the DATA_PTR pointer
16#8855 [1]	DATA_PTR points to a write-protected DB	Check the DATA_PTR pointer
16#8856 [1]	Error during call of SFC51	Call the Modbus_Master instruction again
Error - Modbus_Slave (only communication modules that support Modbus)		
16#8428 [1]	MB_HOLD_REG points to a bit address that is not equal to n * 8	Check the MB_HOLD_REG pointer
16#8452 [1]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
16#8454 [1]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
16#8456 [1]	Error during call of SFC51	Call the Modbus_Slave instruction again

[1] Only with instructions for S7-300/400 CPUs

Overview of error messages - USS

Error code	Description	Remedy
16#0000	No error	-
16#8180	Length error in response of drive	Check the response frame of the drive.
16#8181	Data type error	Select a suitable data type. The following are valid: • Real • Word • Double word
16#8182	Data type error: "Double word" or "Real" may not be returned for the "Word" request.	Check the response frame of the drive.
16#8183	Data type error: "Word" may not be returned for the "Double word" or "Real" request.	Check the response frame of the drive.
16#8184	Checksum error in response of drive	Check the drive and the communication connection.
16#8185	Addressing error	Valid drive address range: 1 to 16
16#8186	Setpoint error	Valid setpoint range: -200% to +200%
16#8187	Incorrect drive number returned	Check the response frame of the drive.
16#8188	Invalid PZD length	Permitted PZD lengths: 2, 4, 6, 8 words
16#8189	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.
16#818A	A different request for this drive is currently active.	Repeat the parameter read or write command later.
16#818B	The drive does not respond.	Check the drive.
16#818C	The drive responds with an error message to a parameter request.	Check the response frame of the drive. Check the parameter request. Check if the instructions USS_Read_Param, USS_Write_Param or USS_Port_Scan have reported an error. If they have, check the value of the static tag USS_DB. w_USSExtendedError of the USS_Drive_Control instruction.
16#818D	The drive responds with an access error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
16#818E	The drive was not initialized.	Check the user program and make sure that the USS_Drive_Control instruction is called for this drive.

Error code	Description	Remedy
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.RDREC.STATUS, Send_Config.RDREC.STATUS , Receive_Config.RDREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.WRREC.STATUS, Send_Config.WRREC.STATUS , Receive_Config.WRREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB WRREC.

1) Only with instructions for S7-300/400 CPUs

5.4.2 MODBUS (RTU)

5.4.2.1 Overview of the Modbus RTU communication

Modbus RTU communication

Modbus RTU (Remote Terminal Unit) is a standard protocol for communication in the network and uses the RS232 or RS422/485 connection for serial data transmission between Modbus devices in the network.

Modbus RTU uses a master/slave network in which all communication is triggered by a single master device while the slaves can only respond to the request of the master. The master sends a request to a slave address and only the slave with this slave address responds to the command.

Exception: Modbus slave address 0 sends a broadcast frame to all slaves (without slave response).

Modbus function codes

- A CPU that is operated as a Modbus RTU master can read and write data and I/O states in a Modbus RTU slave connected by means of a communication connection.
- A CPU operated as a Modbus RTU slave allows a Modbus RTU master connected over a communication connection to read and write data and I/O states in its own CPU.

Table 5- 12 Functions for reading data: Reading distributed I/O and program data

Modbus function code	Functions for reading data from the slave (server) - standard addressing
01	Read output bits: 1 to 2000/1992[1)] bits per request
02	Read input bits: 1 to 2000/1992[1)] bits per request
03	Read hold register: 1 to 125/124[1)] words per request
04	Read input words: 1 to 125/124[1)] words per request

1) for extended addressing

Table 5- 13 Functions for writing data: Changing distributed I/O and program data

Modbus function code	Functions for writing of data in the slave (server) - standard addressing
05	Write one output bit: 1 bit per request
06	Write one hold register: 1 word per request
15	Write one or several output bits: 1 to 1960 bits per request
16	Write one or several hold registers: 1 to 122 words per request

- The Modbus function codes 08 and 11 offer diagnostic options for communication with the slave device.
- Modbus slave address 0 sends a broadcast frame to all slaves (without slave response; for function codes 5, 6, 15, 16).

Table 5- 14 Station addresses in the Modbus network

Station		Address
RTU station	Standard station address	1 to 247 and 0 for broadcast
	Extended station address	1 to 65535 and 0 for broadcast

Modbus memory addresses

The number of Modbus memory addresses (input/output addresses) that is actually available depends on the CPU version and the available work memory.

Modbus RTU instructions in your program

- Modbus_Comm_Load: You need to run Modbus_Comm_Load to set up PtP parameters such as data transmission rate, parity and data flow control. Once you have configured the communication module for the Modbus RTU protocol, it can only be used by the Modbus_Master instruction or the Modbus_Slave instruction.
- Modbus_Master: The CPU can be used as Modbus RTU master device with the Modbus master instruction for communication with one or more Modbus slave devices.
- Modbus_Slave: The CPU can be used as Modbus RTU slave device with the Modbus slave instruction for communication with one Modbus master device.

5.4.2.2 Modbus_Comm_Load: Configure communication module for Modbus

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Modbus_Comm_Load instruction configures a communication module for communication by means of the Modbus RTU protocol. An instance data block is automatically assigned when you add the Modbus_Comm_Load instruction in your program.

Configuration changes of Modbus_Comm_Load are saved on the CM and not in the CPU. With voltage recovery and pulling/plugging, the CM is configured with the data saved in the device configuration. The Modbus_Comm_Load instruction must be called in these scenarios.

Parameters

Parameter	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	Port	Laddr	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
BAUD	IN	UDInt	DWord	9600	Selection of the data transmission rate Valid values are: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200 bit/s.
PARITY	IN	UInt	Word	1	Selection of parity: • 0 – None • 1 – Odd • 2 – Even

Parameter	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
FLOW_CTRL	IN	UInt	Word	0	Selection of flow control: • 0 – (default) no flow control • 1 – Hardware flow control with RTS always ON (not with RS422/485 CMs) • 2 – Hardware flow control with RTS switched (not with RS422/485 CMs)
RTS_ON_DLY	IN	UInt	Word	0	Selection RTS ON delay: • 0 – No delay from "RTS active" until the first character of the frame is sent. • 1 to 65535 – Delay in milliseconds from "RTS active" until the first character of the frame is sent (not with RS422/485 CMs). RTS delays must be used independent of the selection FLOW_CTRL.
RTS_OFF_DLY	IN	UInt	Word	0	Selection RTS OFF delay: • 0 – No delay after transmission of last character until "RTS inactive" • 1 to 65535 – Delay in milliseconds after transmission of last character until "RTS inactive" (not with RS422/485 ports). RTS delays must be used independent of the selection FLOW_CTRL.
RESP_TO	IN	UInt	Word	1000	Response timeout: 5 ms to 65535 ms - Time in milliseconds that Modbus_Master waits for a response from the slave. If the slave does not respond within this period, Modbus_Master repeats the request or terminates the request with an error if the specified number of repetitions (see below, RETRIES parameter) has been sent.
MB_DB	IN/OUT	MB_BASE		-	A reference to the instance data block of the Modbus_Master or Modbus_Slave instructions. The MB_DB parameter must be connected with the (static and therefore not visible in the instruction) MB_DB parameter of the Modbus_Master or Modbus_Slave instruction.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Comm_Load instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	The DONE bit is TRUE for one cycle after the last request has been completed without errors.
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. The error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 142))

Modbus_Comm_Load is executed to configure a port for the Modbus RTU protocol. Once you have configured the port for the Modbus RTU protocol, it can only be used by the Modbus_Master or Modbus_Slave instructions.

You have to run Modbus_Comm_Load for the configuration of each communication port that is to be used for Modbus communication. You must assign a unique Modbus_Comm_Load instance DB to each port that you use. Only run Modbus_Comm_Load again if you need to change communication parameters, such as data transmission rate or parity, or in case the network has returned.

For example, an instance data block is assigned to the instruction if you add Modbus_Master or Modbus_Slave to your program. You need to connect the MB_DB parameter of the Modbus_Comm_Load instruction to the MB_DB parameter of the Modbus_Master or Modbus_Slave instruction.

Modbus_Comm_Load data block tags

The table below shows the public static tags in the instance DB of Modbus_Comm_Load that you can use in your program.

Table 5- 15 Static tags in the instance DB

Tag	Data type		Stand-ard	Description
	S7-1200/1500	S7-300/400/WinAC		
ICHAR_GAP	Word		0	Maximum character delay time between characters. This parameter is specified in milliseconds and increases the anticipated period between the received characters. The corresponding number of bit times for this parameter is added to the Modbus default value of 35 bit times (3.5 character times).
RETRIES	Word		2	Number of retries that the master executes before the error code 0x80C8 for "No response" is returned.
EN_SUPPLY_VOLT	Bool		0	Enable diagnostics for missing supply voltage L+
MODE	USInt	Byte	0	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire mode (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master, CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave, CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode [1)]
LINE_PRE	USInt	Byte	0	Receive line initial state Valid initial states are: • 0 = "No" initial state [1)] • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
BRK_DET	USInt	Byte	0	Break detection The following are valid: • 0 = break detection deactivated • 1 = break detection activated

Tag	Data type		Stand-ard	Description
	S7-1200/1500	S7-300/400/WinAC		
EN_DIAG_ALARM	Bool		0	Activate diagnostics interrupt: • 0 - not activated • 1 - activated
STOP_BITS	USINT	Byte	1	Number of stop bits; • 1 = 1 stop bit, • 2 = 2 stop bits, • 0, 3 to 255 = reserved

1) Required setting for the use of PROFIBUS cables with CM 1241 for RS485

5.4.2.3 Modbus_Master: Communicate as Modbus master

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Modbus_Master instruction communicates as Modbus master via a port configured by the Modbus_Comm_Load instruction. An instance data block is automatically assigned when you add the Modbus_Master instruction in your program. The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to the (static) MB_DB parameter of the Modbus_Master instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	FALSE = no request TRUE = request to send data to the Modbus slave
MB_ADDR	IN	UInt	Word	-	Modbus RTU station address: Standard addressing range (1 to 247 as well as 0 for Broadcast) Extended addressing range (1 to 65535 as well as 0 for Broadcast) The value 0 is reserved for the broadcast of a frame to all Modbus slaves. Only the Modbus function codes 05, 06, 15 and 16 are supported for the broadcast.
MODE	IN	USInt	Byte	0	Mode selection: Specifies the type of request (read, write or diagnostics). Additional information is available in the table of Modbus functions below.
DATA_ADDR	IN	UDInt	DWord	0	Start address in the slave: Specifies the start address of the data that is accessed in the Modbus slave. The valid addresses are listed in the table of Modbus functions below.
DATA_LEN	IN	UInt	Word	0	Data length: Specifies the number of bits or words this instruction is to access. The valid lengths are listed in the table of Modbus functions below.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Master instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DATA_PTR	IN/OUT	Variant	Any	-	Data pointer: Points to the flag or DB address for the data to be written or read.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
DONE	OUT	Bool		FALSE	The DONE bit is TRUE for one cycle after the last request has been completed without errors.
BUSY	OUT	Bool		-	• FALSE – no command active for Modbus_Master • TRUE – command for Modbus_Master in progress
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. The error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		0	Error code (see Error messages (Page 142))

Tags in the data block of the Modbus master

The table below shows the public static tags in the instance DB of Modbus_Master that you can use in your program.

Table 5- 16 Static tags in the instance DB

Tag	Data type	Standard	Description
Blocked_Proc_Timeout	Real	3.0	Duration (in seconds) for which to wait for a blocked Modbus master instance before this instance is removed as ACTIVE. This may happen, for example, if a master request was output and the program then stops to call the master function before it has completely finished the request. The time value must be greater than 0 and less than 55 seconds to avoid an error to occur. See also "Rules for communication by the Modbus-Master" and "Calling theModbus_Master instruction with different parameter settings".
Extended_Addressing	Bool	FALSE	Configures the slave station address as single or double byte. • FALSE = One-byte address; 0 to 247 • TRUE = Two-byte address (corresponds to extended addressing); 0 to 65535
Compatibility_Mode [1]	Bool	FALSE	Compatibility mode with CP 341 and CP 441-2 and ET 200SP 1SI with driver for Modbus RTU and with ET 200SP 1SI for Modbus. The default value is 0. • FALSE = as per Modbus specification, not compatible • TRUE = compatible – For FC1 and FC2: The data read from the received frame is written word for word to the addressed CPU memory and exchanged byte by byte. If the number of bits to be transmitted is not a multiple of 16, the bits which are not relevant are set to null in the last word. – For FC15: The words to be transmitted are read word by word from the addressed memory and written byte by byte to the send frame. If the number of bits to be transmitted is not a multiple of 8, the bits in the last byte which are not relevant are read unchanged from the addressed memory and entered in the send frame.
MB_DB	MB_BASE	-	The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to this MB_DB parameter of the Modbus_Master instruction.

[1] The PtP communication modules respond as defined in the Modbus specification. To retain a response as with CP 341, CP 441-2 and ET 200SP 1SI for Modbus, use the "Compatibility_Mode" parameter.

You program can write values to the Blocked_Proc_Timeout and Extended_Addressing tags to control the Modbus master operations.

Rules for communication by the Modbus-Master

- Modbus_Comm_Load must be run to configure a port so that the Modbus_Master instruction can communicate with this port.
- A port which is to be used as Modbus master must not be used by Modbus_Slave . You can use one or several instances of Modbus_Master [1] with this port. But all versions of the Modbus_Master must use the same instance DB for the port.
- The Modbus instructions do not use communication alarm events to control the communication process. Your program must query the Modbus_Master instruction for completed commands (DONE, ERROR).
- We recommend to call all executions of Modbus_Master for a specific port from a program cycle OB. Modbus master instructions can only be executed in one program cycle or in one cyclical/time-controlled processing level. They may not be processed in different processing levels. The priority interruption of a Modbus master instruction by another Modbus master instruction in a processing level with higher priority results in improper operation. Modbus master instructions may mot be processed in startup, diagnostic or time error levels.

[1] "Instance of Modbus master" here means a call of the Modbus_Master instruction with the same interconnection to a Modbus_Comm_Load instruction and the same setting for the MB_ADDR, MODE, DATA_ADDR and DATA_LEN parameters.

Example

Modbus_Master is called with MODE=0 and DATA_ADDR=10

This job is now active until it is completed with DONE=1 or ERROR=1 or until the time monitoring configured at the Blocked_Proc_Timeout parameter has expired. If a new command is started after the watchdog time expires and before the previous command has been completed, the previous command is aborted without an error message.

If, while this command is running, the instruction is now called a second time with the same instance data but different MODE and DATA_ADDR parameter settings, this second call is terminated with ERROR=1 and STATUS=8200.

Calling the Modbus_Master instruction with different parameter settings

If multiple calls of the Modbus_Master instruction with different settings for MB_ADDR, MODE, DATA_ADDR or DATA_LEN are placed in your program, you must ensure that only one of these calls is active at any given time. Otherwise, the error message 16#8200 is output (interface is busy with an ongoing request).

If a call cannot be processed in full, the watchdog is activated by the Blocked_Proc_Timeout parameter and terminates the ongoing command.

REQ parameter

FALSE = no request; TRUE = request to send data to the Modbus slave

Enable the requested transmission. This transmits the contents of the buffer to the point-to-point communication interface.

You use the DATA_ADDR and MODE parameters to select the Modbus function code.

DATA_ADDR (Modbus start address in the slave): Specifies the start address of the data that is accessed in the Modbus slave.

The Modbus_Master instruction uses the MODE input instead of a function code input. The combination of MODE and DATA_ADDR specifies the function code that is used in the actual Modbus frame. The table below shows how the MODE parameter, the Modbus function code and the Modbus address range in DATA_ADDR are related.

Table 5- 17 Modbus functions

MODE	DATA_ADDR (Modbus address)			DATA_LEN (data length)			Modbus function code	Operation and data		
0				Bits per request			01	Read output bits:		
	1	to	9999	1	to	2000/1992 [1]		0	to	9998
0				Bits per request			02	Read input bits:		
	10001	to	19999	1	to	2000/1992 [1]		0	to	9998
0				Words per request			03	Read hold register:		
	40001	to	49999	1	to	125/124 [1]		0	to	9998
	400001	to	465535	1	to	125/124 [1]		0	to	65534
0				Words per request			04	Read input words:		
	30001	to	39999	1	to	125/124 [1]		0	to	9998
1				Bits per request			05	Write one output bit:		
	1	to	9999	1				0	to	9998
1				1 word per request			06	Write one hold register:		
	40001	to	49999	1				0	to	9998
	400001	to	465535	1				0	to	65524
1				Bits per request			15	Write multiple output bits:		
	1	to	9999	2	to	1968/1960 [1]		0	to	9998
1				Words per request			16	Write multiple hold registers:		
	40001	to	49999	2	to	123/122		0	to	9998
	400001	to	465534	2	to	123/122 [1]		0	to	65534
2 [2]				Bits per request			15	Write one or several output bits:		
	1	to	9999	2	to	1968/1960 [1]		0	to	9998
2 [2]				Words per request			16	Write one or several hold registers:		
	40001	to	49999	1	to	123		0	to	9998
	400001	to	465535	1	to	122 [1]		0	to	65534
11	Both DATA_ADDR and DATA_LEN operands of the Modbus_Master are ignored with this function.						11	Read status word and event counter of the slave communication. The status word indicates busy (0 – not busy, 0xFFFF - busy). The event counter is incremented for each successful processing of a frame.		

MODE	DATA_ADDR (Modbus address)			DATA_LEN (data length)			Modbus function code	Operation and data		
80				1 word per request			08	Check slave status with data diagnostic code 0x0000 (loopback test – slave returns an echo of the request)		
	-			1				-		
81				1 word per request			08	Reset slave event counter using data diagnostic code 0x000A		
	-			1				-		
104				Words per request			04	Read input words		
	0	to	65535	1	to	125/124 [1]		0	to	65535
3 to 10, 12 to 79, 82 to 103, 105 to 255	-			-				Reserved		

[1] In extended addressing, see the Extended_Adressing parameter, the maximum data length is shorter by 1 byte or 1 word depending on the data type of the function.

[2] MODE 2 allows you to write one or more output bits and one or more holding registers using the Modbus functions 15 and 16.
MODE 1 uses the Modbus functions 5 and 6 to write 1 output bit and 1 holding register, and Modbus functions 15 and 16 to write multiple output bits and multiple holding registers.

DATA_PTR parameter

The DATA_PTR parameter points to the DB or bit memory address in which reading or writing is performed. If you use a data block, you must create a global data block that provides the data memory for read and write processes on Modbus slaves.

Note

S7-1200/1500 - The data block addressed using DATA_PTR must support direct addressing

The data block must permit direct (absolute) and symbolic addressing.

Note

Using function code 5

Function code 5 is used to set or delete individual bits.

When a bit is set, the value "16#FF00" must be specified in the first word of the addressed DB or bit memory area via DATA_PTR.

- With S7-1200, the value "16#0100" can also be specified to set a bit.
- To reset a bit, the value "16#0000" must be specified in the first word of the DB or bit memory area addressed via DATA_PTR.

All other values are rejected with ERROR = TRUE and STATUS = 16#8384.

Data block structures for the DATA_PTR parameter

- These data types are valid for reading words of the Modbus address range (DATA_PTR) 30001 to 39999, 40001 to 49999 and 400001 to 465535 as well as for writing words to the Modbus address range (DATA_PTR parameter) 40001 to 49999 and 400001 to 465535.
  - Standard array of data types WORD, UINT or INT
  - Named structure of the WORD, UINT or INT type in which each element has a unique name and a 16-bit data type.
  - Named complex structure in which each element has a unique name and a 16-bit or 32-bit data type.
- For reading and writing bits for the Modbus address range (DATA_PTR parameter) 00001 to 09999 and for reading bits from 10001 to 19999.
  - Standard field from Boolean data types.
  - Named Boolean structure from clearly named Boolean tags.
- It is not essential, but nevertheless advisable, to allocate each Modbus_Master instruction its own separate memory area. The reason for this is that data destruction is far more likely if multiple Modbus_Master instructions are reading and writing in the same memory area.
- It is not necessary for the data areas for DATA_PTR to be located in the same global data block. You can create a data block with several areas for Modbus read processes, a data block for Modbus write processes or a data block for each slave station.

See also

Modbus_Slave: Communicate as Modbus slave (Page 127)

5.4.2.4 Modbus_Slave: Communicate as Modbus slave

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

Your program can use the Modbus_Slave instruction to communicate as a Modbus slave by using a CM (RS422/485 or RS232). STEP 7 automatically creates an instance DB when you add the instruction. The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to the (static) MB_DB parameter of the Modbus_Slave instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
MB_ADDR	IN	UInt	Word	-	Standard address of the Modbus slave: Standard addressing range (1 to 247) Extended addressing range (0 to 65535) Note: 0 is the broadcast address
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Slave instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
MB_HOLD_REG	IN/OUT	Variant	Any	-	Pointer to the Modbus hold register DB: The Modbus hold register may be the memory area of the flags or a data block.
NDR	OUT	Bool		FALSE	New data available: • FALSE – No new data • TRUE – Indicates that new data was written by the Modbus master The NDR bit is TRUE for one cycle after the last request has been completed without errors.
DR	OUT	Bool		FALSE	Read data: • FALSE – No data read • TRUE – Indicates that the instruction has stored the data received by the Modbus master in the target area. The DR bit is TRUE for one cycle after the last request has been completed without errors.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. If the execution was terminated with an error, the error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		0	Error code (see Error messages (Page 142))

The function codes of the Modbus communication (1, 2, 4, 5 and 15) can read and write bits and words directly in the process image input and in the process image output of the CPU. The MB_HOLD_REG parameter must be defined as data type greater than one byte for these function codes. The table below shows the sample assignment of Modbus addresses to the process image in the CPU.

Table 5- 18 Assignment of Modbus addresses to the process image

Modbus functions						S7-1200			
Code	Function	Data area	Address area			Data area	CPU address		
01	Read bits	Output	0	to	8191	Process image output	O0.0	to	O1023.7
02	Read bits	Input	0	to	8191	Process image input	I0.0	to	I1023.7
04	Read words	Input	0	to	511	Process image input	IW0	to	IW1022
05	Write bit	Output	0	to	8191	Process image output	O0.0	to	O1023.7
15	Write bits	Output	0	to	8191	Process image output	O0.0	to	O1023.7

Table 5- 19 Assignment of Modbus addresses to the process image

Modbus functions						S7-1500 / S7-300 / S7-400			
Function code	Function	Data area	Address area			Data area	CPU address		
01	Read bits	Output	0	to	9998	Process image output	O0.0	to	O1248.6
02	Read bits	Input	0	to	9998	Process image input	I0.0	to	I1248.6
04	Read words	Input	0	to	9998	Process image input	IW0	to	IW19996
05	Write bit	Output	0	to	9998	Process image output	O0.0	to	O1248.6
15	Write bits	Output	0	to	9998	Process image output	O0.0	to	O1248.6

Note

The available address area may be smaller, depending on the memory configuration of the CPU.

The function codes of the Modbus communication (3, 6, 16) use a Modbus hold register which is an address area in the memory area of the flags or a data block. The type of holding register is specified by the MB_HOLD_REG parameter of the Modbus_Slave instruction.

Note

S7-1200/1500 - type of the MB_HOLD_REG data block

The data block with Modbus hold register must permit direct (absolute) and symbolic addressing.

Table 5- 20 Diagnostics functions

Modbus diagnostic functions of the S7-1200 Modbus_Slave		
Function codes	**Subfunction**	**Description**
08	0000H	Output request data of echo test: The Modbus_Slave instruction returns the echo of a received data word to the Modbus master.
08	000AH	Clear communication event counter: The Modbus_Slave instruction clears the communication event counter used for Modbus function 11.
11		Call communication event counter: The Modbus_Slave instruction uses an internal communication event counter to detect the number of successful Modbus read and Modbus write requests that are sent to the Modbus slave. The counter is not incremented for function 8, function 11 and broadcast requests. It is also not incremented for requests that result in communication errors (for example, parity or CRC errors).

The Modbus_Slave instruction supports broadcast write requests from Modbus masters as long as the requests include access to valid addresses. Modbus_Slave generates error code 16#8188 for function codes that are not supported by the broadcast function.

Variables of the Modbus slave

This table below shows the public static tags in the instance data block of Modbus_Slave that you can use in your program.

Table 5- 21 Variables of the Modbus slave

Tag	Data type	Standard	Description
HR_Start_Offset	Word	0	Specifies the start address of the Modbus hold register (default = 0)
IB_Start	Word	0	Start address of the valid addressing range of the inputs (byte 0 to 65535)
IB_Count	Word	0xFFFF	Number of input bytes that can be addressed by the Modbus master. Example: IB_Start = 0 and IB_Count = 10; input byte 0 to 9 can be addressed IB_Count = 0; no input byte addressable
QB_Start	Word	0	Start address of the valid addressing range of the outputs (byte 0 to 65535)

Tag	Data type	Standard	Description
QB_Count	Word	0xFFFF	Number of output bytes that can be addressed by the Modbus master. Example: IB_Start = 0 and IB_Count = 10; output byte 0 to 9 can be addressed IB_Count = 0; no output byte addressable
Extended_Addressing	Bool	FALSE	Extended addressing, configures slave addressing as single or double byte (FALSE = single byte address, TRUE = double byte address)
Request_Count	Word	0	The number of all requests received by this slave
Slave_Message_Count	Word	0	The number of requests received for this specific slave
Bad_CRC_Count	Word	0	The number of received requests that have a CRC error
Broadcast_Count	Word	0	The number of received broadcast requests
Exception_Count	Word	0	Modbus-specific errors that are acknowledged with an exception to the master
Success_Count	Word	0	The number of received requests without protocol errors for this specific slave
MB_DB	MB_BASE	-	The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to this MB_DB parameter of the Modbus_Master instruction.

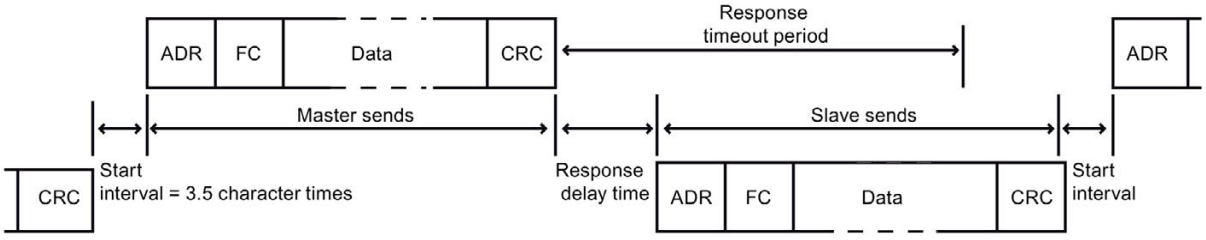
You program can write values to the HR_Start_Offset and Extended_Addressing tags and control the Modbus slave operations. The other tags can be read to monitor the Modbus status.

Rules for Modbus slave communication

- Modbus_Comm_Load must be run to configure a port so that the Modbus_Slave instruction can communicate by means of this port.
- If a port is to respond as slave to a Modbus master, this port may not be programmed with the Modbus_Master instruction.
- Only one instance of Modbus_Slave can be used with a specific port; otherwise you may encounter unexpected behavior.
- The Modbus instructions do not use communication alarm events to control the communication process. Your program must control the communication process by querying the Modbus_Slave instruction for completed send and receive processes.
- The Modbus_Slave instruction must be executed regularly with a frequency that allows a timely response to incoming requests of a Modbus master. We recommend executing Modbus_Slave in each cycle from a program cycle OB. Modbus_Slave can be executed from a cyclic interrupt OB but we do not recommend it, because excessive time delays in the interrupt program can temporarily block the execution of other interrupt programs.

Time control of the Modbus signal

Modbus_Slave must be executed regularly to receive each request of the Modbus master and respond accordingly. The frequency with which Modbus_Slave is executed depends on the timeout value specified for the response by the Modbus master. This can be seen in the figure below.



The timeout period of the (RESP_TO) response is the duration that a Modbus master waits for the beginning of an answer from a Modbus slave. This period is not defined by the Modbus protocol, but by a parameter of the Modbus_Comm_Load instruction. As both receiving and sending a frame requires multiple calls of the Modbus_Slave instruction (at least three), you should execute Modbus_Slave at least twelve times during the timeout period for the response of the Modbus master so that the Modbus slave receives and sends data twice as many times as specified by the timeout period.

HR_Start_Offset

The Modbus holding register addresses start at 40001 or 400001. These addresses correspond to the start address of the holding register in the target system memory. But you can configure the HR_Start_Offset tag to configure a start address different than 40001 or 400001 for the Modbus hold register.

The address 0 in the received frame correspond to the start address of the hold register in the target system memory. Use the tag HR_Start_Offset to configure a start address other than 0 for the Modbus hold register.

You can, for example, configure a hold register with start at MW100 and a length of 100 words. With HR_Start_Offset = 20, the address 20 in the received frame corresponds to the start address of the holding register in the target memory (MW100). Each address in the received frame below 20 and above 119 results in an addressing error.

Table 5- 22 Example for addressing the Modbus hold register when DATA_PTR is a pointer to MW100 with a length of 100 words

HR_Start_Offset	Address	Minimum	Maximum
0	Modbus address (word)	0	99
	S7-1500 address	MW100	MW298
20	Modbus address (word)	20	119
	S7-1500 address	MW100	MW298

HR_Start_Offset is a word value which specifies the start address of the Modbus hold register and is saved in the Modbus_Slave instance data block. You select this public static tag by means of the parameter drop-down list once you have added Modbus_Slave in your program.

If you have added Modbus_Slave to an LAD network, for example, you can go to a previous network and assign the value HR_Start_Offset using the move command. The value must be assigned prior to execution of Modbus_Slave.

Enter Modbus slave tag using the standard DB name:

1. Position the cursor in the OUT1 parameter field and enter the character m.
2. Select the required instance DB of the Modbus_Slave instruction from the drop-down list.
3. Position the cursor to the right of the DB name (after the quotation mark) and enter a point.
4. Select "Modbus_Slave_DB.HR_Start_Offset" in the drop-down list.

5.4.2.5 Frame structure

Extended_Addressing

You access the Extended_Addressing tag as described for the HR_Start_Offset reference, except that the Extended_Addressing tag is a Boolean value.

You can configure a single byte (Modbus standard) or two bytes (Extended_Adressing = TRUE) with Extended_Adressing = FALSE for addressing the Modbus slave. Extended addressing is used to address more than 247 devices in a single network. With Extended_Adressing = TRUE you can address up to 65535 addresses. The following example shows a Modbus frame.

Table 5- 23 Slave address with one byte (Byte 0)

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	
Request	Slave address	Function code	Start address		Data		
Valid response	Slave address	Function code	Length	Data...			
Error message	Slave address	0xxx	Exception code				

Table 5- 24 Slave address with two bytes (Byte 0 and Byte 1)

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Request	Slave address		Function code	Start address		Data	
Valid response	Slave address		Function code	Length	Data...		
Error message	Slave address		0xxx	Exception code			

Frame description

Data traffic between master and slave / slave and master starts with the slave address, following by the function code. The data is then transferred. The structure of the data field depends on the function code used. The checksum (CRC) is transmitted at the end of the frame.

Function code 1 - This function allows individual output bits to be read

Table 5- 25 FC 1 - Read output bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 1	Start address		Number of outputs	
Valid response	Slave address	Function code 1	Length [1]	Output data [3)]		
Error message	Slave address	0x81	Exception code [2]	---		

[1] Length: If there is a remainder when the number of outputs is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

[3] The output data can comprise multiple bytes

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 1	Start address		Number of outputs	
Valid response	Slave address		Function code 1	Length [1]	Output data		
Error message	Slave address		0x81	Exception code [2]	---		

[1] Length: If there is a remainder when the number of outputs is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

[3] The output data can comprise multiple bytes

Function code 2 - This function allows individual input bits to be read

Table 5- 26 FC 2 - Read input bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 2	Start address		Number of inputs	
Valid response	Slave address	Function code 2	Length [1]	Input data		
Error message	Slave address	0x82	Exception code [2]	---		

[1] Length: If there is a remainder when the number of inputs is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 2	Start address		Number of inputs	
Valid response	Slave address		Function code 2	Length [1]	Input data		
Error message	Slave address		0x82	Exception code [2]	---		

[1] Length: If there is a remainder when the number of inputs is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

Function code 3 - This function allows individual registers to be read

Table 5- 27 FC 3 - Read hold register

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 3	Start address		Number of registers	
Valid response	Slave address	Function code 3	Length [1]	Register data		
Error message	Slave address	0x83	Exception code [2]	---		

[1] Length: Number of bytes

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 3	Start address		Number of registers	
Valid response	Slave address		Function code 3	Length [1]	Register data		
Error message	Slave address		0x83	Exception code [2]	---		

[1] Length: Number of bytes

[2] E code: 01 or 02 or 03 or 04

Function code 4 - This function allows individual registers to be read

Table 5- 28 FC 4 - Read input words

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 4	Start address		Number of input words	
Valid response	Slave address	Function code 4	Length [1]	Input data		
Error message	Slave address	0x84	Exception code [2]	---		

[1] Length: 2 * number of input words

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 4	Start address		Number of input words	
Valid response	Slave address		Function code 4	Length [1]	Input data		
Error message	Slave address		0x84	Exception code [2]	---		

[1] Length: 2 * number of input words

[2] E code: 01 or 02 or 03 or 04

Function code 5 - This function can set or delete individual bits

Table 5- 29 FC 5 - Write an output bit

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 5	Start address		Value	
Valid response	Slave address	Function code 5	Length	Value		
Error message	Slave address	0x85	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 5	Start address		Value	
Valid response	Slave address		Function code 5	Length	Value		
Error message	Slave address		0x85	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

Function code 6 - This function allows individual registers to be written

Table 5- 30 FC 6 - Write hold register

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 6	Address		Register	
Valid response	Slave address	Function code 6	Address		Register	
Error message	Slave address	0x86	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 6	Address		Register	
Valid response	Slave address		Function code 6	Address		Register	
Error message	Slave address		0x86	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

Function code 8 - This function is used to check the communication connection

Table 5- 31 FC 8 - Slave status

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 8	Diagnostic code		Test value	
Valid response	Slave address	Function code 8	Diagnostic code		Test value	
Error message	Slave address	0x88	Exception code [1]	---		

[1] E code: 01 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 8	Diagnostic code		Test value	
Valid response	Slave address		Function code 8	Diagnostic code		Test value	
Error message	Slave address		0x88	Exception code [1]	---		

[1] E code: 01 or 03 or 04

Function code 11 - This function can read 2 bytes of "Status word" and 2 bytes of "Event counter"

Table 5- 32 FC 11 - Event counter for slave communication

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 11	---			
Valid response	Slave address	Function code 11	Status		Event counter	
Error message	Slave address	0x8B	Exception code [1]	---		

[1] E code: 01 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 11	---			
Valid response	Slave address		Function code 11	Status		Event counter	
Error message	Slave address		0x8B	Exception code [1]	---		

[1] E code: 01 or 04

Function code 15 - This function allows multiple bits to be written

Table 5- 33 FC 15 - Write one/multiple output bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte n
Query	Slave address	Function code 15	Start address		Number of output words		Byte counter [1]	Value	
Valid response	Slave address	Function code 15	Start address		Number of output words		---		
Error message	Slave address	0x8F	Exception code [2]	---					

[1] Byte counter: If there is a remainder when the number of bytes is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte n
Query	Slave address		Function code 15	Start address		Number of output words		Byte counter [1]	Value	
Valid response	Slave address		Function code 15	Start address		Number of output words		---		
Error message	Slave address		0x8F	Exception code [2]		---				

[1] Byte counter: If there is a remainder when the number of bytes is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

Function code 16 - This function allows individual or multiple registers to be written

Table 5- 34 FC 16 - Write one/multiple hold registers

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte n
Query	Slave address	Function code 16	Start address		Number of registers		Byte counter [1]	Value	
Valid response	Slave address	Function code 16	Start address		Number of registers		---		
Error message	Slave address	0x90	Exception code [2]	---					

[1] Byte counter: Number of registers * 2

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte n
Query	Slave address		Function code 16	Start address		Number of registers		Byte counter [1]	Value	
Valid response	Slave address		Function code 16	Start address		Number of registers		---		
Error message	Slave address		0x90	Exception code [2]		---				

[1] Byte counter: Number of registers * 2

[2] E code: 01 or 02 or 03 or 04

5.4.2.6 Error messages

Overview of error messages - PtP

The error messages are provided at the STATUS output of an instruction and can be evaluated there or processed in the user program.

Error code	Description	Remedy
16#0000	No error	-
RECEIVE status and error codes		
16#0094	frame end identified based on the "Receipt of fixed/maximum frame length"	-
16#0095	frame end identified based on "Message timeout"	-
16#0096	frame end identified based on expiration of the "Character delay time"	-
16#0097	The frame was aborted because the maximum response time was reached.	-
16#0098	frame end identified based on the fulfillment of the "Read message length from message" conditions	-
16#0099	frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
16#7000	Block idle	-
16#7001	Initial call for a new frame: Data transmission initiated	-
16#7002	Interim call: Data transmission running	-
16#8085	Invalid length	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
16#8088	The specified length exceeds the range set in the receive buffer. Note: If the data type STRING has been specified at the BUFFER parameter, this error code also appears if the current string is shorter than the length specified at the LENGTH parameter.	Change the range in the receive buffer or select a frame length which corresponds to the range set in the receive buffer. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.
RECEIVE status and error codes		
16#8088	The number of characters received exceeds the number specified at the BUFFER parameter.	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.

Error code	Description	Remedy
Error message codes of the special functions		
16#818F	Incorrect parameter number setting (with USS only)	Select a suitable parameter number (PARAM). The following numbers are valid: 0-2047
16#8190	Incorrect setting of the CRC calculation	Select a suitable value for the CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
16#8191	Incorrect setting of the diagnostic error interrupt	Select a suitable value for "Diagnostic error interrupt". The following are valid: Diagnostic error interrupt deactivated or diagnostic error interrupt activated. Check whether the module addressed supports the generation of diagnostic interrupts.
Error message codes of the "Port configuration"		
16#81A0	The module does not support this protocol.	Select a valid protocol for the module (PROTOCOL).
16#81A1	The module does not support this data transmission rate.	Select a valid data transmission rate for the module (BAUD).
16#81A2	The module does not support this parity setting.	Select a suitable value for "Parity" (PARITY). The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#81A3	The module does not support this number of data bits.	Select a suitable value for "Number of data bits" (DATABITS). The following are valid: • 7 (2) • 8 (1)
16#81A4	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits" (STOPBITS). The following are valid: • 1 (1) • 2 (2)
16#81A5	The module does not support this type of data flow control.	Select a valid data flow control for the module (FLOWCTRL).
16#81A7	Invalid value for XON or XOFF	Select suitable values for XON (XONCHAR) and XOFF (XOFFCHAR). Valid range of values: 0...255

Error code	Description	Remedy
16#81AA	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) / (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint master) (2)/ (CM PtP (ET 200SP)) • Full duplex (RS 422) four-wire mode (multipoint slave) (3) • Half duplex (RS485) two-wire mode. (4)
16#81AB	Invalid receive line initial state	Valid initial states are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default setting corresponds to the idle state (no active send operation).
16#81AC	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • Break detection deactivated (0) • Break detection activated (1).
16#81AF	The module does not support this protocol.	Select a valid protocol for the module.
Error codes of the "Send configuration"		
16#81B5	More than two end delimiters or end sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
16#81B6	Send configuration rejected because the 3964(R) protocol was selected	Make sure that no send configuration is transmitted if the 3964(R) protocol is set.

Error code	Description	Remedy
Error codes of the "Receive configuration"		
16#81C0	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
16#81C1	Invalid end condition or no end condition selected	Select a suitable end condition (see Receiving data with Freeport (Page 32)).
16#81C3	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length" (MAXLEN). Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
16#81C4	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
16#81C5	Invalid value for "Size of length field"	Select a suitable value for "Size of length field" (LENGTHSIZE). Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)
16#81C6	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification" (LENGTHM). Valid range of values: 0 to 255 (bytes)
16#81C7	The total of "Offset in the message + size of length field + number of characters not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of length field" and "Number of characters not counted". Valid range of values: • Offset in the message (depending on the module): 0-1024/2048/4096 (bytes) • Size of length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0 to 255 (bytes)
16#81C8	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
16#81C9	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1 to 65535 (bit times)
16#81CB	frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
16#81CC	frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.

Error code	Description	Remedy
16#81CD	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
16#81CE	Invalid value for "Clear receive buffer on startup"	Select a suitable value for "Clear receive buffer on startup". The following are valid: • Clear receive buffer at startup is deactivated (0) • Clear receive buffer at startup is activated (1)
SEND status and error codes		
16#81D0	Receiving send request during runtime of a send command	Make sure that you do not receive an additional send request during runtime of a send command.
16#81D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#81D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#81D3	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
16#81D5	Transmission canceled due to parameter changes, detected wire break, or CPU in STOP	Check the parameter assignment, wire break, and CPU status.
16#81D6	Transmission canceled because end identifier was not received	Check the parameter assignment of the end characters and the frame of the communication partner.
16#81D7	Communication error between the user program and module	Check the communication (e.g., matching the sequence number).
16#81D8	Transmission attempt rejected because module is not configured	Configure the module.
Error codes of the receive configuration		
16#81E0	Frame aborted: Send buffer overflow / send frame too long	Increase the call rate for the receive function in the user program or configure communication with data flow control.
16#81E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.
16#81E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
16#81E3	Frame aborted: Character overflow error	Firmware error: Please contact Customer Support.
16#81E4	Frame aborted: The total length of "Offset in the message + size of the length field + number of characters not counted" is greater than the receive buffer	Select a suitable value for offset in message, size of the length field, and number of characters not counted.
16#81E5	Frame aborted: Break	Receive line to partner is interrupted. Reconnect or switch on partner.

Error code	Description	Remedy
16#81E6	Maximum number of "Buffered received frames" exceeded	In the user program call the instruction more often or configure a communication with data flow control or increase the number of buffered frames.
16#81E7	Synchronization error module and Receive_P2P	Make sure that different instances of the Receive_P2P do not access the same module.
16#81E8	Frame aborted: The character delay time has expired before the message end criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.
16#81E9	Modbus CRC error (only communication modules which support Modbus)	Checksum error of the Modbus frame. Check the communication partner.
16#81EA	Modbus frame too short (only communication modules which support Modbus)	Minimum length of Modbus frame not met. Check the communication partner.
16#81EB	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (bytes) Check the parameters for end of frame detection.
Error codes V24 accompanying signals		
16#81F0	The module does not support V24 accompanying signals	You have tried to set accompanying signals for a module that does not support V24 accompanying signals. Make sure that this is an RS232 module or that RS232 mode (ET 200SP) is set.
16#81F1	No operation of the V24 accompanying signals	The V24 accompanying signals cannot be operated manually if hardware data flow control is active.
16#81F2	The DSR signal cannot be set because the module has the type DTE.	Check the configured type of the module. The module type must be DCE (data communication equipment).
16#81F3	The DTR signal cannot be set because the module has the type DCE.	Check the configured type of the module. The module type must be DTE (data terminal equipment).
16#81F4	Block header error (e.g. incorrect block type or incorrect block length)	Check the instance DB and the block header.
Error codes of the receive configuration		
16#8201 [1)]	Receive_Conditions is a pointer to an invalid data type	Enter a pointer to one of the following data types: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8225	Receive_Conditionspoints to an optimized memory area greater than 1 kB or Receive_Conditions points to an optimized memory area and the receive length is greater than the area addressed by Receive_Conditions.	Enter a pointer to an area with a maximum length of: • Optimized memory area: 1 KB • Non-optimized memory area: 4 KB Note: If the pointer points to an optimized memory area, do not send more than 1 KB.
16#8229 [1)]	Receive_Conditions is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.

Error code	Description	Remedy
Error codes, general		
16#8280	Negative acknowledgment when reading module	You can find more detailed information on error causes in theRDREC.STATUS static parameters and in the description of the SFB RDREC. • Check the input at the PORT parameter • Set the COM_RST parameter prior to the initial call.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter You can find more detailed information on error causes in the WRREC.STATUS static parameters and in the description of the SFB WRREC.
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.
Error codes of the receive configuration		
16#82C1	Invalid value for "Buffered received frames".	Select a suitable value for "Buffered received frames". Valid range of values: 1-255
16#82C2	Receive configuration rejected because the 3964(R) protocol was selected	Make sure that no receive configuration is sent if the 3964(R) protocol is set.
16#8301 1)	Receive_Conditions is a pointer to an invalid data type	Select a valid data type. The following are valid: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8322	Range length error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8324	Range error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8328	Setting error when reading a parameter	Check the input at the Receive_Conditions parameter
SEND status and error codes		
16#8328 1)	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes of the receive configuration		
16#8332	Invalid data block at the Receive_Conditions parameter	Check the input at the Receive_Conditions parameter
16#833A	The designation of the data block at the Receive_Conditions parameter refers to a data block which is not loaded.	Check the input at the Receive_Conditions parameter
16#8351	Invalid data type	Check the input at the Receive_Conditions parameter
16#8352 1)	Receive_Conditions does not point to a data block	Check the pointer to Receive_Conditions
16#8353 1)	Receive_Conditions does not point to a structure of the typeReceive_Conditions	Check the pointer to Receive_Conditions

Error code	Description	Remedy
Error codes 3964(R) protocol		
16#8380	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time" (CharacterDelayTime). Valid range of values: 1 to 65535 (ms)
16#8381	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout" (AcknDelayTime). Valid range of values: 1 to 65535 (ms)
16#8382	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority" (Priority). The following are valid: • High (1) • Low (0)
16#8383	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check" (BCC). The following are valid: • With block check (1) • Without block check (0)
16#8384	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts" (BuildupAttempts). Valid range of values: 1-255
16#8385	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts" (RepetitionAttempts). Valid range of values: 1-255
16#8386	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
16#8387	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.
16#8388	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check whether the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#8389	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is only answered with DLE when the receive buffer is empty. No additional character may be received before (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#838A	Runtime error: Logical error during receiving. After DLE was received, a further random character (other than DLE or ETX) was received.	Check if partner DLE in frame header and in data string is always in duplicate or the connection is released with DLE ETX. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.

Error code	Description	Remedy
16#838B	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Verify by using an interface test device that is switched into the transmission line, if necessary.
16#838C	Runtime error: Wait time for free receive buffer has started	In the user program call the instruction more often or configure a communication with data flow control.
16#838D	Runtime error: frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
16#838E	Runtime error: In idle mode, one or several characters (other than NAK or STX) were received.	Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
16#838F	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
16#8391	Parameter assignment error: 3964 configuration data rejected because Freeport is set	If the Freeport protocol is set, make sure that no 3964 parameter assignment data is sent.

[1] Only with instructions for S7-300/400 CPUs

Overview of error messages - Modbus

Error code	Description	Remedy
16#0000	No error	-
Configuration error of the interface - Modbus_Comm_Load		
16#8181	The module does not support this data transmission rate.	Select a valid data transmission rate for the module at the BAUD parameter.
16#8182	The module does not support this parity setting.	Select a suitable value for "Parity" at the PARITY parameter. The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#8183	The module does not support this type of data flow control.	Select a valid data flow control for the module at the FLOW_CTRL parameter.
16#8184	Invalid value for "Response timeout".	Select a suitable value for "Response timeout" at the RESP_TO parameter. Valid range of values: 1 to 65535 (ms)
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.RDREC.STATUS or Receive_Config.RDREC.STATUS static parameters or RDREC.STATUS and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.WRREC.STATUS or Receive_Config.WRREC.STATUS static parameters or WRREC.STATUS and in the description of the SFB WRREC.
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.

Error code	Description	Remedy
Configuration error - Modbus_Slave		
16#8186	Invalid slave address	Select a suitable slave address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8187	Invalid value at MB_HOLD_REG parameter	Select a suitable value for the hold register at the MB_HOLD_REG parameter.
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#818C	The pointer to a MB_HOLD_REG area must be a data block or a bit memory address area.	Select a suitable value for the pointer to the MB_HOLD_REG area.
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS, and in the description of the SFB WRREC.
16#8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
16#8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
16#8456 [1)]	Error during instruction execution. The cause of the error is shown in the STATUS parameter.	Determine the value of the SFCSTATUS parameter. Check what this means in the description for SFC51, STATUS parameter.

Error code	Description	Remedy
Configuration error - Modbus_Master		
16#8180	Invalid value for MB_DB parameter	The value configured for MB_DB (instance data DB) at the Modbus_Comm_Load instruction is not valid. Check the interconnection of the Modbus_Comm_Load instruction and its error messages.
16#8186	Invalid station address	Select a suitable station address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#8189	Invalid data address	Select a suitable value for the data address at the DATA_ADDR parameter. See description Modbus_Master (Page 120) in the Info system
16#818A	Invalid length	Select a suitable data length at the DATA_LEN parameter. See description Modbus_Master (Page 120) in the Info system
16#818B	Invalid value for DATA_PTR	Select a suitable value for the data pointer at the DATA_PTR parameter (M or DB address). See description Modbus_Master (Page 120) in the Info system
16#818C	Interconnection error of the DATA_PTR parameter	Check the interconnection of the instruction.
16#818D	The area addressed by DATA_PTR is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the DATA_PTR pointer
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS or Receive_Reset and in the description of the SFB WRREC.

Error code	Description	Remedy
Communication errors - Modbus_Master and Modbus_Slave		
16#80D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#80D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#80E0	Frame aborted: Send buffer overflow / send frame too long	In the user program call the instruction more often or configure a communication with data flow control.
16#80E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.
16#80E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
16#80E3	Frame aborted: Character overflow error	Check the number of data in the frame of the communication partner.
16#80E4	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
Communication error - Modbus_Master		
16#80C8	The slave does not respond within the set time	Check the data transmission rate, parity and wiring of the slave.
16#80C9	The slave does not respond within the time set by Blocked_Proc_Timeout.	Check the setting for Blocked_Proc_Timeout. Check if the module has been configured with the Modbus_Comm_Load instruction. The module may possibly need to be reconfigured using Modbus_Comm_Load after a pull/plug or after voltage recovery.
16#8200	The interface is busy with an ongoing request.	Repeat the command later. Make sure that there are no commands still running before you start a new one.
Protocol error - Modbus_Slave (only communication modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	The function code is not supported or is not supported for broadcast.	Check the communication partner and make sure that a valid function code is sent.
16#8382	Invalid length information in the request frame	Select a suitable data length at the DATA_LEN parameter.
16#8383	Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Invalid data value error in the request frame	Check the data value in the request frame of the Modbus master
16#8385	The diagnostic value is not supported by the Modbus slave (function code 08)	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.

Error code	Description	Remedy
Protocol error - Modbus_Master (only communication modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	Response frame from Modbus Slave with the following error message: The function code is not supported.	Check the communication partner and make sure that a valid function code is sent.
16#8382	Response frame from Modbus Slave with the following error message: Invalid length	Select a suitable data length.
16#8383	Response frame from Modbus Slave with the following error message: Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Response frame from Modbus Slave with the following error message: Data value error	Check the request frame to the Modbus slave.
16#8385	Response frame from Modbus Slave with the following error message: The diagnostic value is not supported by the Modbus slave	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.
16#8386	The returned function code does not match the requested function code.	Check the response frame and the addressing of the slave.
16#8387	A slave that was not requested answers	Check the response frame of the slave. Check the address settings of the slave.
16#8388	Error in the response of the slave to a write request.	Check the response frame of the slave.
16#8828 [1)]	DATA_PTR points to a bit address that is not equal to n * 8	Check the DATA_PTR pointer
16#8852 [1)]	DATA_PTR is not a pointer to a DB or a bit memory area	Check the DATA_PTR pointer
16#8853 [1)]	DATA_PTR is not a pointer of type BOOL or WORD	Check the DATA_PTR pointer
16#8855 [1)]	DATA_PTR points to a write-protected DB	Check the DATA_PTR pointer
16#8856 [1)]	Error during call of SFC51	Call the Modbus_Master instruction again
Error - Modbus_Slave (only communication modules that support Modbus)		
16#8428 [1)]	MB_HOLD_REG points to a bit address that is not equal to n * 8	Check the MB_HOLD_REG pointer
16#8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
16#8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
16#8456 [1)]	Error during call of SFC51	Call the Modbus_Slave instruction again

[1)] Only with instructions for S7-300/400 CPUs

Overview of error messages - USS

Error code	Description	Remedy
16#0000	No error	-
16#8180	Length error in response of drive	Check the response frame of the drive.
16#8181	Data type error	Select a suitable data type. The following are valid: • Real • Word • Double word
16#8182	Data type error: "Double word" or "Real" may not be returned for the "Word" request.	Check the response frame of the drive.
16#8183	Data type error: "Word" may not be returned for the "Double word" or "Real" request.	Check the response frame of the drive.
16#8184	Checksum error in response of drive	Check the drive and the communication connection.
16#8185	Addressing error	Valid drive address range: 1 to 16
16#8186	Setpoint error	Valid setpoint range: -200% to +200%
16#8187	Incorrect drive number returned	Check the response frame of the drive.
16#8188	Invalid PZD length	Permitted PZD lengths: 2, 4, 6, 8 words
16#8189	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.
16#818A	A different request for this drive is currently active.	Repeat the parameter read or write command later.
16#818B	The drive does not respond.	Check the drive.
16#818C	The drive responds with an error message to a parameter request.	Check the response frame of the drive. Check the parameter request. Check if the instructions USS_Read_Param, USS_Write_Param or USS_Port_Scan have reported an error. If they have, check the value of the static tag USS_DB. w_USSExtendedError of the USS_Drive_Control instruction.
16#818D	The drive responds with an access error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
16#818E	The drive was not initialized.	Check the user program and make sure that the USS_Drive_Control instruction is called for this drive.

Error code	Description	Remedy
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.RDREC.STATUS, Send_Config.RDREC.STATUS , Receive_Config.RDREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.WRREC.STATUS, Send_Config.WRREC.STATUS , Receive_Config.WRREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB WRREC.

[1] Only with instructions for S7-300/400 CPUs

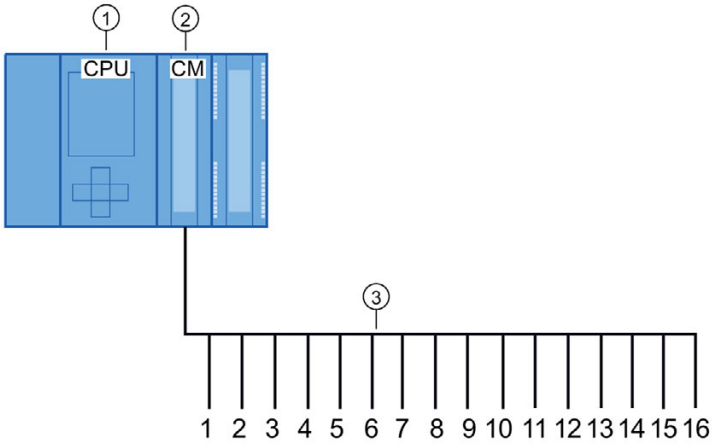
5.4.3 USS

5.4.3.1 Overview of USS communication

USS communication

The USS instructions control the operation of drives which support the protocol of the universal serial interface (USS). You can communicate with several drives by means of RS485 connections and the USS instructions with the PtP communication modules. Each RS485 port can operate up to 16 drives.

The USS protocol uses a master-slave network for communication via a serial bus. The master uses an address parameter to send data to a selected slave. A slave cannot send without having first received a send request. Communication between individual slaves is not possible. USS communication takes place in half-duplex mode. The figure below shows a network diagram for a sample application with 16 drives.



① CPU
② CM
③ USS drives in a USS network

Figure 5-1 Wiring example with S7-1500 communication module

Note

Communicating with a drive via RS232

You can basically also use CM PtP RS232 BA and CM PtP RS232 HF for communication with a drive. However, only **one** drive can be connected to an RS232 port.

Communicating with a drive via RS422

You can basically also use the RS422 interface of the CM PtP RS422/485 BA and CM PtP RS422/485 HF for communication with a drive. However, only **one** drive can be connected to an RS422 port.

USS instructions in your program

- USS_Port_Scan: The instruction USS_Port_Scan allows you to communicate via a communication module with up to 16 drives using a USS network (must be called cyclically).

  There is only one USS_Port_Scan instruction per PtP communication port in the program, and it controls transmission to all drives.

- USS_Drive_Control: The instruction USS_Drive_Control allows you to prepare the send data from USS_Port_Scan for a drive and display its receive data.

  USS_Drive_Control configures the data to be sent and evaluates the data received in a previous request from USS_Port_Scan.

- USS_Read_Param: The instruction USS_Read_Param allows you to read parameters from a drive.

- USS_Write_Param: The instruction USS_Write_Param allows you to change parameters in a drive.

5.4.3.2 Requirements for using the USS protocol

The four USS instructions use 2 FBs and 2 FCs to support the USS protocol. For each USS network, one instance data block (DB) is used for USS_Port_Scan and one instance data block for all calls of USS_Drive_Conrol.

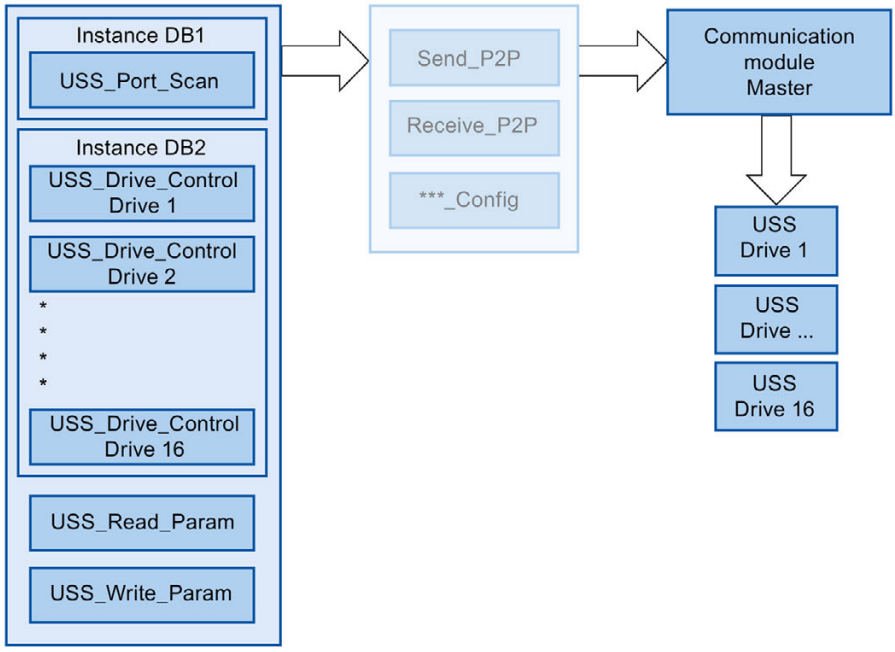


Figure 5-2 USS program sequence

All drives (max. 16) that are connected to one RS485 port are part of the same USS network. All drives that are connected to another RS485 port are part of a different USS network. Each USS network is managed using a unique instance data block for all USS_Drive_Control instructions and one further instance data block for the USS_Port_Scan instruction. All instructions that are part of a USS network must share this instance data block for USS_Drive_Conrol. The USS_Port_Scan, USS_Read_Param and USS_Write_Param instructions have the USS_DB parameter for this function. This parameter must be connected to the (static) USS_DB parameter of the instance DB of the USS_Drive_Control instruction.

- The instructions USS_Drive_Control and USS_Port_Scan are function blocks (FB). If you add the USS_Drive_Control or USS_Port_Scan instruction to the programming editor, you are prompted to assign a DB for this FB in the "Call options" dialog. If it is the first USS_Drive_Control instruction in this program for this USS network, you can apply the DB standard assignment (or change the name, if necessary) and the new DB is created for you. If, however, it is not the first USS_Drive_Control instruction for this drive, you need to select the DB which has already been assigned to this USS network from the drop-down list in the "Call options" dialog.
- The USS_Port_Scan and USS_Read_Param instructions are functions (FCs). No DB is assigned when you add these FCs in the editor. If you add these FCs or the USS_Port_Scan instruction in the editor, you need to assign the USS_DB parameter of the corresponding USS_Drive_Control instance DB to the USS_DB input of these instructions. Double-click the parameter field and click the symbol to display the available DBs. Enter a period "." and select the USS_DB parameter from the drop-down list.

- The USS_Port_Scan function controls communication between the CPU and the drives via the point-to-point RS485 communication port. A communication with the drive is processed every time you call this function. Your program must call this function fast enough so that the drives do not signal a timeout. To ensure a constant time response for frame communication, you should call this instruction in a cyclic interrupt OB.
- The USS_Drive_Control instruction gives your program access to a specified drive in the USS network. Its inputs and outputs correspond to the states and operating functions of the drive. If there are 16 drives in your network, you must call USS_Drive_Control at least 16 times in your program, i.e. once for each drive.

  You should only call the USS_Drive_Control instruction from a cyclic OB.
- The operating parameters of the drive are read and written with the USS_Read_Param and USS_Write_Param functions. These parameters control the internal operation of the drive. See the drive manual for a definition of these parameters. Your program may include any number of these functions, but only one read or write request may be active for a drive at any particular time. You may only call the USS_Read_Param and USS_Write_Param functions from the cycle OB of a main program.

NOTICE
USS instruction calls Only ever call USS_Drive_Control, USS_Read_Param or USS_Write_Param from a cycle OB of the main program. The USS_Port_Scan instruction function can be called from any OB, but it is usually called from a cyclic interrupt OB. Do not use the USS_Drive_Control, USS_Read_Param or USS_Write_Param instruction in an OB with a higher priority than the corresponding USS_Port_Scan instruction. For example, do not add USS_Port_Scan to the main program or USS_Read_Param to a cyclic interrupt OB. You may encounter unexpected errors if the execution of USS_Port_Scan is interrupted by another instruction.

Calculating time for communication with the drive

Communication with the drive takes place asynchronously to the cycle of the CPU. The CPU usually runs through several cycles before communication with a drive is complete.

To ensure that the watchdog set for the drive is not triggered, the send frames must be sent to the drive within the watchdog time. You must allow for the number of any retries which may be needed to complete the transaction if communication errors occur. By default, up to 2 retries are made for each transaction with the USS protocol.
The maximum time interval between two send frames is calculated as follows:

N * (5 * cycle time + frame runtime + timeout of the receive frame max.) * (number of transmission attempts)

N	Number of drives in this network
Factor 5	5 cycles are typically needed for sending and receiving frames.
Cycle time	Max. cycle time of the cyclic interrupt OB in which the USS_Port_Scan instruction is called.
Frame runtime	Frame time = (number of characters per frame) * (11 Bit per character) / (data transmission rate in Bit/s)
Number of transmission attempts	Number of retries + 1
Timeout of the receive frame	RCVTIME (if no response is received from the drive)
Timeout of the receive frame max.	RCVTIME + MSGTIME (if an incomplete answer is received shortly before the expiration of RCVTIME and monitoring of MSGTIME has expired **or** if a response is still being processed at the expiration of RCVTIME, the timeout is extended by the MSGTIME)

The following times apply for "Received frame timeout" (ms):

Bit/s	115200	57600	38400	19200	9600	4800	2400	1200
Receive_Conditions.END.RCVTIME	25	29	33	56	72	100	100	100
Receive_Conditions.END.MSGTIME	25	29	33	56	72	124	240	460

Timeout of the receive frame max. = (Receive_Conditions.END.RCVTIME (0.072 s) + Receive_Conditions.END.MSGTIME (0.072 s))

Example:

5 drives
Data transmission rate = 9600 bps
28 characters per frame
Cycle time = 0.020 s
Number of retries = 2

Time interval = 5 * (5 * 0.02 s + 1 * 28 * 11 / 9600 s + 0.072 s + 0.072 s) * 3 = 3 s

The time monitoring of the drive must be set to about 3 seconds in this case.

5.4.3.3 USS_Port_Scan / USS_Port_Scan_31: Communication by means of a USS network

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Note

Using the USS_Port_Scan_31 instruction

It is only possible to use the USS_Port_Scan_31 instruction on an S7-1500 CPU.

Description

The USS_Port_Scan instruction processes the communication by means of a USS network for max. 16 drives.

The USS_Port_Scan_31 instruction processes the communication by means of a USS network for max. 31 drives.

STEP 7 automatically creates the instance DB when you add the instruction.

Parameters

Parameter	Declaration	Data type		Standard	Description
		S7-1200/ 1500	S7-300/400/ WinAC		
PORT	IN	Port	Word	0	Specifies the communication module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • For S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems the PORT parameter is assigned the input address assigned in HWCN.
BAUD	IN	DInt		9600	Data transmission rate for USS communication The following are valid: • 1200 bps • 2400 bps • 4800 bps • 9600 bps • 19200 bps • 38400 bps • 57600 bps • 115200 bps
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control / USS_Drive_Control_31 instruction to your program.
COM_RST	INOUT	---	Bool	FALSE	Initialization of the USS_Port_Scan / USS_Port_Scan_31 instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
ERROR	OUT	Bool		FALSE	If TRUE, this output indicates that an error has occurred and that the STATUS output is valid. You may need to check the value of the static tag USS_DB. w_USSExtendedError in the instance DB of the USS_Drive_Control / USS_Drive_Control_31 instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 180)).

There is only one USS_Port_Scan / USS_Port_Scan_31 instruction per PtP communication port in the program and each call of this instruction controls a transmission to or from all drives in this network. All USS functions assigned to one USS network and one PtP communication port must use the same instance DB.

Your program must execute the USS_Port_Scan / USS_Port_Scan_31 instruction often enough to prevent a timeout in the drive (see Requirements for using the USS protocol (Page 160) "Calculating time for communication with the drive").

The USS_Port_Scan / USS_Port_Scan_31 instruction is usually called from a cyclic interrupt OB to prevent drive timeouts and to make the last USS data updates available for calls of USS_Drive_Control / USS_Drive_Control_31 .

USS_Port_Scan / USS_Port_Scan_31 data block tags

The table below shows the public static tags in the instance DB of USS_Port_Scan / USS_Port_Scan_31 that you can use in your program.

Table 5- 35 Static tags in the instance DB

Tag	Data type	Standard	Description
MODE	USInt	4	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire mode (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master; CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave; CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode [1)]
LINE_PRE	USInt	2	Receive line initial state Valid initial states are: • 0 = "No" initial state [1)] • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
BRK_DET	USInt	0	Activate diagnostics interrupt: • 0 - not activated • 1 - activated
RETRIES_MAX	SInt/Byte	2	Number of retries when communication errors occur. You can use this parameter to set the number of send retries for a request frame if the response frame is not received within the set time.

Tag	Data type	Standard	Description
EN_DIAG_ALARM	Bool	0	Activate diagnostics interrupt: • 0 - not activated • 1 - activated
EN_SUPPLY_VOLT	Bool	0	Enable diagnostics for missing supply voltage L+ • 0 - not activated • 1 - activated

[1] Required setting for the use of PROFIBUS cables with CM 1241 for RS485

5.4.3.4 USS_Drive_Control / USS_Drive_Control_31: Preparing and displaying data for the drive

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Note

Using the USS_Drive_Control_31 instruction

It is only possible to use the USS_Drive_Control_31 instruction on an S7-1500 CPU.

Description

The USS_Drive_Control instruction prepares send data for max. 16 drives and evaluates the response data of the drives.

The USS_Drive_Control_31 instruction prepares send data for max. 31 drives and evaluates the response data of the drives.

You need to use a separate instance of the instruction for each drive, and all USS functions assigned to one USS network and one PtP communication port must use the same instance DB. You must enter the DB name when you add the first USS_Drive_Control / USS_Drive_Control_31 instruction. You then refer to this DB that was created when the first instruction was added.

STEP 7 automatically creates the DB when you add the instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
RUN	IN	Bool		FALSE	Start bit of the drive: If this parameter is TRUE, this input allows you to operate the drive with the preset speed. If RUN changes to FALSE during operation of the drive, the motor coasts to a standstill. This behavior differs from disconnection of the power supply (OFF2) and braking of the motor (OFF3).
OFF2	IN	Bool		FALSE	"Coast to standstill" bit: If this parameter is FALSE, this bit causes the drive to coast to a standstill without braking.
OFF3	IN	Bool		FALSE	Fast stop bit: If this parameter is FALSE, this bit causes a fast stop by braking the drive.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
F_ACK	IN	Bool		FALSE	Error acknowledgment bit: This bit resets the error bit of a drive. The bit is set after clearing the error and the drive detects this way that the previous error no longer has to be reported.
DIR	IN	Bool		FALSE	Direction control of the drive: This bit is set if the drive is to run forward (if SPEED_SP is positive; see table "Interaction of SPEED_SP and DIR parameters").
DRIVE	IN	USInt	Byte	1	Address of the drive: This input is the address of the USS drive. The valid range is between drive 1 and drive 16.
PZD_LEN	IN	USInt	Byte	2	Word length: This is the number of PZD data words. Valid values are 2, 4, 6 or 8 words.
SPEED_SP	IN	Real		0.0	Speed setpoint: This is the speed of the drive as a percentage of the configured frequency. A positive value means that the drive runs forward (if DIR is true). The valid range is 200.00 to -200.00.
CTRL3	IN	Word		0	Control word 3: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL4	IN	Word		0	Control word 4: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL5	IN	Word		0	Control word 5: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL6	IN	Word		0	Control word 6: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL7	IN	Word		0	Control word 7: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL8	IN	Word		0	Control word 8: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the USS_Drive_Control / USS_Drive_Control_31 instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
NDR	OUT	Bool		FALSE	New data available: If this parameter is TRUE, the bit signals that data of a new communication request is available at the output.
ERROR	OUT	Bool		FALSE	Error occurred: If TRUE, this indicates that an error has occurred and that the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan / USS_Port_Scan_31 instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 180)).

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
RUN_EN	OUT	Bool		FALSE	Operation enabled: This bit signals if the drive is running.
D_DIR	OUT	Bool		FALSE	Drive direction: This bit signals if the drive is running forward. • FALSE – forward • TRUE – backward
INHIBIT	OUT	Bool		FALSE	Drive blocked: This bit signals the status of the block bit for the drive. • FALSE – not blocked • TRUE – blocked
FAULT	OUT	Bool		FALSE	Drive error: This bit signals that an error occurred in the drive. You must remedy the fault and set the F_ACK bit to clear this bit.
SPEED	OUT	Real		0.0	Actual value drive speed (scaled value of STATUS 2 of the drive): This is the speed of the drive as a percentage of the configured speed.
STATUS1	OUT	Word		0	STATUS 1 of the drive This value includes fixed status bits of a drive.
STATUS3	OUT	Word		0	STATUS 3 of the drive This value includes a user-definable status word of the drive.
STATUS4	OUT	Word		0	STATUS 4 of the drive This value includes a user-definable status word of the drive.
STATUS5	OUT	Word		0	STATUS 5 of the drive This value includes a user-definable status word of the drive.
STATUS6	OUT	Word		0	STATUS 6 of the drive This value includes a user-definable status word of the drive.
STATUS7	OUT	Word		0	STATUS 7 of the drive This value includes a user-definable status word of the drive.
STATUS8	OUT	Word		0	STATUS 8 of the drive This value includes a user-definable status word of the drive.

When the initial execution of USS_Drive_Control / USS_Drive_Control_31 takes place, the drive specified by the USS address (DRIVE parameter) is initialized in the instance DB. After initialization, subsequent USS_Port_Scan / USS_Port_Scan_31 instructions can start communication with the drive from this drive number.

If you change the drive number, you must first place the CPU in STOP and then back in RUN to initialize the instance DB. The input parameters are configured in the USS send buffer and any outputs are read from a "previous" valid response buffer. USS_Drive_Control / USS_Drive_Control_31 only configures the data to be sent and evaluates data received in a previous request.

You can control the drive's direction of rotation by using the D_IR input (Bool) or the sign (positive or negative) at the SPEED_SP input (Real). The table below explains how these inputs work together to determine the direction of rotation of the drive, provided the motor rotates forward.

Table 5- 36 Interaction of SPEED_SP and DIR parameters

SPEED_SP	DIR	Direction of rotation of the drive
Value > 0	0	Backward
Value > 0	1	Forward
Value < 0	0	Forward
Value < 0	1	Backward

USS_Drive_Control / USS_Drive_Control_31 data block tags

The table below shows the public static tags in the instance DB of USS_Drive_Control / USS_Drive_Control_31 that you can use in your program.

Table 5- 37 Static tags in the instance DB

Tag	Data type	Standard	Description
USS_DB. w_USSExtended Error	Word	16#0	USS Drive Extended Error Code - drive-specific value The meaning of the error message depends on which instruction reported an error **first** (ERROR = TRUE). The following cases are distinguished: • USS_Write_Param / USS_Write_Param_31: You can find the meaning of the error code in the description of the drive. • USS_Read_Param / USS_Read_Param_31: You can find the meaning of the error code in the description of the drive. • USS_Port_Scan / USS_Port_Scan_31: Number of the drive affected by the error message.

5.4.3.5 USS_Read_Param / USS_Read_Param_31: Read data from drive

Note
Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Note
Using the USS_Read_Param_31 instruction

It is only possible to use the USS_Read_Param_31 instruction on an S7-1500 CPU.

Description

The USS_Read_Param instruction reads a parameter from one of max. 16 drives.

The USS_Read_Param_31 instruction reads a parameter from one of max. 31 drives.

All USS functions assigned to one USS network and one PtP communication port must use the instance data block of the USS_Drive_Control / USS_Drive_Control_31 instruction. USS_Read_Param / USS_Read_Param_31 must be called from a cycle OB of the main program.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		–	A positive edge at REQ creates a new read request.
DRIVE	IN	USInt	Byte	–	Address of the drive: DRIVE is the address of the USS drive. The valid range is between drive 1 and drive 16.
PARAM	IN	UInt		–	Parameter number: PARAM specifies the drive parameter to write. The range for this parameter is between 0 and 2047. With some drives, the most significant byte of the INDEX parameter can be used to access parameter values greater than 2047. Additional information on access to an extended range is available in your drive manual.
INDEX	IN	UInt		–	Parameter index: INDEX specifies the drive parameter index to which to write. It is a 16-bit value in which the least significant bit is the actual index value with a range of (0 to 255). The drive can also use the most significant byte, which is drive-specific. Additional information is available in your drive manual.
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control / USS_Drive_Control_31 instruction to your program.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
DONE[1]	OUT	Bool		FALSE	If this parameter is TRUE, the previously requested value of the read parameter is available at the VALUE output. This bit is set when the USS_Drive_Control / USS_Drive_Control_31 instruction recognizes the read response of the drive. This bit is reset the next time USS_Read_Param / USS_Read_Param_31 is called.
ERROR	OUT	Bool		FALSE	ERROR = TRUE: An error has occurred and the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan / USS_Port_Scan_31 instruction. You may need to check the value of the static tag USS_DB. w_USSExtendedError in the instance DB of the USS_Drive_Control / USS_Drive_Control_31 instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 180)).
VALUE	OUT	Variant (Word, Int, UInt, DWord, DInt, UDInt, Real)	Any (Word, Int, UInt, DWord, DInt, UDInt, Real)	–	This is the value of the parameter that was read and is only valid if the DONE bit is true.

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the instruction is cabable of immediately read an additional parameter. An empty read request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param / USS_Read_Param_31 or USS_Write_Param / USS_Write_Param_31 for the specific motor drive results in error 16#818A.

5.4.3.6 USS_Write_Param / USS_Write_Param_31: Change data in drive

Note

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Note

Using the USS_Write_Param_31 instruction

It is only possible to use the USS_Write_Param_31 instruction on an S7-1500 CPU.

Note

For EEPROM write instructions (EEPROM in a USS drive):

Keep the number of EEPROM write operations to a minimum in order to maximize the EEPROM service life.

Description

The USS_Write_Param instruction changes a parameter in one of max. 16 drives.

The USS_Write_Param_31 instruction changes a parameter in one of max. 31 drives.

All USS functions assigned to one USS network and one PtP communication port must use the instance data block of the USS_Drive_Control / USS_Drive_Control_31.

USS_Write_Param / USS_Write_Param_31 must be called from the cycle OB of a main program.

Parameters

Table 5- 38 Data types for the parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		–	A positive edge at REQ creates a new write request.
DRIVE	IN	USInt	Byte	–	Address of the drive: DRIVE is the address of the USS drive. The valid range is between drive 1 and drive 16.
PARAM	IN	UInt		–	Parameter number: PARAM specifies the drive parameter to write. The range for this parameter is between 0 and 2047. With some drives, the most significant byte of the INDEX parameter can be used to access parameter values greater than 2047. Additional information on access to an extended range is available in your drive manual.
INDEX	IN	UInt		–	Parameter index: INDEX specifies the drive parameter index to which to write. It is a 16-bit value in which the least significant bit is the actual index value with a range of (0 to 255). The drive can also use the most significant byte, which is drive-specific. Additional information is available in your drive manual.
EEPROM	IN	Bool		–	Save in EEPROM of the drive: If TRUE, the transaction of a parameter for writing to the drive is saved in the EEPROM of the drive. If FALSE, the written value is saved only temporarily and is lost the next time you switch on the drive.
VALUE	IN	Variant (Word, Int, UInt, DWord, DInt, UDInt, Real)	Any (Word, Int, UInt, DWord, DInt, UDInt, Real)	–	Value of the parameter in which you want to write. It must be valid with a positive edge of REQ.
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control / USS_Drive_Control_31 instruction to your program.
DONE[1]	OUT	Bool		FALSE	If TRUE, the VALUE input is written to the drive. This bit is set when the USS_Drive_Control / USS_Drive_Control_31 instruction recognizes the write response of the drive. This bit is reset the next time USS_Write_Param / USS_Write_Param_31 is called.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
ERROR	OUT	Bool		FALSE	If TRUE, an error has occurred and the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan / USS_Port_Scan_31 instruction. You may need to check the value of the static tag USS_DB. w_USSExtendedError in the instance DB of the USS_Drive_Control / USS_Drive_Control_31 instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 180)).

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the USS library is able to read out an additional parameter immediately. An empty write request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param / USS_Read_Param_31 or USS_Write_Param / USS_Write_Param_31 FC for the specific motor drive results in error 0x818A.

5.4.3.7 General information on drive setup

Requirements for the drive setup

- You need to configure the use of 4 PIV words (**P**arameter**I**D**V**alue) for the drives.
- The drives can be configured for 2, 4, 6 or 8 PZD words (**P**ro**c**ess **d**ata area).
- The number of PZD words in the drive must correspond to the PZD_LEN input of the USS_Drive_Control instruction of the drive.
- Make sure that the data transmission rate of all drives corresponds to the BAUD input of the USS_Port_Scan instruction.
- Make sure that the drive is set up for USS communication.
- Make sure that it is specified in the drive that the frequency setpoint is provided by the USS interface.
- Make sure that the drive address is specified (areas: 1-16).
  This address must correspond to the DRIVE input at the USS_Drive_Control block of the drive.
- Make sure that the RS485 network is terminated correctly.

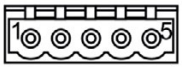
Connection and setup of SINAMICS V20 drive

An application example for operation of a SINAMICS V20 at an S7-1200 is available on the Internet. (http://support.automation.siemens.com/WW/view/en/63696870)

Connecting the SINAMICS V20 drive

Connection example of a SIEMENS G120(C) drive to a USS network. Connection examples for other drives are available in the manual of the respective drive.

The connection of a SINAMICS G120(C) drive to the USS network takes place via plug-in connection. The connection is short-circuit proof and isolated.



1 0 V reference potential
2 RS485N, receiving and sending (-)
3 RS485N, receiving and sending (+)
4 Cable shield
5 Not used

Figure 5-3 USS connection

NOTICE

Different reference voltages

If you connect devices that do not have the same reference voltage, you may create unwanted currents in the connection cable. These unwanted currents may cause communication errors or damages in the devices.

Make sure that all devices you connect with a communication cable either have the same reference conductor in the circuit or are electrically disconnected to prevent the occurrence of unwanted currents.

Make sure that the shield is connected to the ground or pin 1 of the bus connector on the drive.

Make sure that wiring terminal 2 (GND) of the G120(C) is connected to the ground.

If the RS485 master (e.g., S7-1200 CPU with CM1241 communication module) is connected by means of a PROFIBUS connector, wire the bus cables as follows:

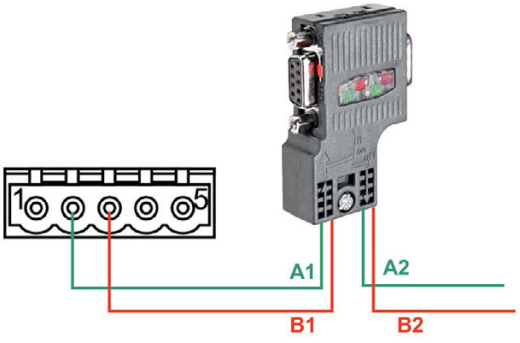


Figure 5-4 Connection of communication module

If the RS485 master is a terminating station in the network or a point-to-point connection, you must use terminals A1 and B1 (not A2 and B2) of the PROFIBUS connector, as these terminals provide termination settings (for example, with the DP plug connector 6ES7972-0BB52-0XA0).

If the G120(C) is configured as terminating station in the network, you must set the switch for the bus terminating resistor to "ON".

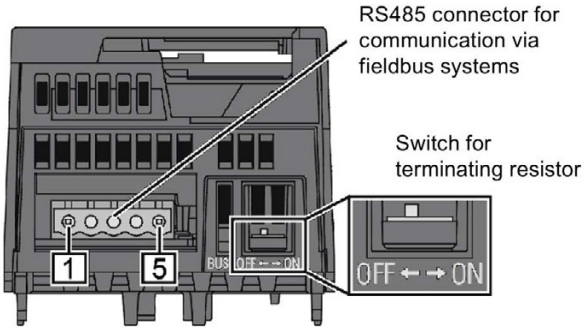


Figure 5-5 Connection of terminating stations

Setup of a G120(C) drive

Before you connect a drive to the S7-1500 or ET 200SP, make sure that the drive has the following system parameters.

Step	Instruction	Operating Instructions	
		G120 [1]	G120C [2]
1	Perform a basic commissioning of the drive with the Operator Panel BOP-2. The converter offers different defaults (macros) for its inputs and outputs and the fieldbus interface. In the ninth step of the basic commissioning (MAC PAR p15), select macro 21 for USS communication. This determines the default for the following parameters: • Data transmission rate (p2020): 38400 bps • Number of PZD (p2022): 2 • Number of PIV (p2023): variable Note: You can also conduct basic commissioning with the STARTER commissioning software or with SINAMICS Startdrive.	Chapter 4.4.3	Chapter 6.4.1
2	Specify the USS address of the converter with the address switch on the control unit of the G120 or on the G120(C). • Valid address range: 1 … 30 Note: Yon can also set the USS address with the parameter p2021 or with STARTER or SINAMICS Startdrive.	Chapter 6.2.2.1	Chapter 8.4.2.1
	With the following steps you are accessing the parameters directly with the BOP-2 by entering their numbers and modifying their values.	Chapter 4.4.2	Chapter 6.4.2

Step	Instruction	Operating Instructions	
		G120 [1]	G120C [2]
3	Adapt the following communication-related converter parameters of your application: • Data transmission rate (p2020), of ≠ 38400 bps (Make sure that setting is identical with the BAUD parameter of the USS_Port_Scan communication instruction.) • Number of PZD (p2022), if ≠ 2 (Make sure that the setting is identical with the PZD_LEN parameter of the USS_Drive_Control communication instruction.) • Number of PIV (p2023) = 4 (Change the value set to "variable" (127) with macro 21 by default to "4" (required by instructions USS_Read_Param and USS_Write_Param.) • Fieldbus SS monitoring time [ms] (p2040)	Chapter 6.2.2.2	Chapter 8.4.2.1
4	Specify the source for the speed setpoint. • n_set Eval (p1000[0]) = 6 (The speed setpoint is provided by the USS bus.)		
5	Set the reference value for speed and frequency. • n_reference f_reference (p2000) = (6,00 min^{-1} to 210000,00 min^{-1}) (all relative speeds or frequencies refer to this reference value. The reference value corresponds to 100% or 4000_{hex} (word) or 4000 0000_{hex} (double word). The following applies: $f_{reference_value}$ (in Hz) = $n_{reference_value}$ (in ((min^{-1}) / 60) x number of pole pairs))		
6	Transfer the parameters to the non-volatile memory. • Save par (p0971) = 1		

1) G120 (http://support.automation.siemens.com/WW/view/en/62089662)

2) G120(C) (http://support.automation.siemens.com/WW/view/en/61462568)

5.4.3.8 Error messages

Overview of error messages - PtP

The error messages are provided at the STATUS output of an instruction and can be evaluated there or processed in the user program.

Error code	Description	Remedy
16#0000	No error	-
RECEIVE status and error codes		
16#0094	frame end identified based on the "Receipt of fixed/maximum frame length"	-
16#0095	frame end identified based on "Message timeout"	-
16#0096	frame end identified based on expiration of the "Character delay time"	-
16#0097	The frame was aborted because the maximum response time was reached.	-
16#0098	frame end identified based on the fulfillment of the "Read message length from message" conditions	-
16#0099	frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
16#7000	Block idle	-
16#7001	Initial call for a new frame: Data transmission initiated	-
16#7002	Interim call: Data transmission running	-
16#8085	Invalid length	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
16#8088	The specified length exceeds the range set in the receive buffer. Note: If the data type STRING has been specified at the BUFFER parameter, this error code also appears if the current string is shorter than the length specified at the LENGTH parameter.	Change the range in the receive buffer or select a frame length which corresponds to the range set in the receive buffer. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.
RECEIVE status and error codes		
16#8088	The number of characters received exceeds the number specified at the BUFFER parameter.	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.

Error code	Description	Remedy
Error message codes of the special functions		
16#818F	Incorrect parameter number setting (with USS only)	Select a suitable parameter number (PARAM). The following numbers are valid: 0-2047
16#8190	Incorrect setting of the CRC calculation	Select a suitable value for the CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
16#8191	Incorrect setting of the diagnostic error interrupt	Select a suitable value for "Diagnostic error interrupt". The following are valid: Diagnostic error interrupt deactivated or diagnostic error interrupt activated. Check whether the module addressed supports the generation of diagnostic interrupts.
Error message codes of the "Port configuration"		
16#81A0	The module does not support this protocol.	Select a valid protocol for the module (PROTOCOL).
16#81A1	The module does not support this data transmission rate.	Select a valid data transmission rate for the module (BAUD).
16#81A2	The module does not support this parity setting.	Select a suitable value for "Parity" (PARITY). The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#81A3	The module does not support this number of data bits.	Select a suitable value for "Number of data bits" (DATABITS). The following are valid: • 7 (2) • 8 (1)
16#81A4	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits" (STOPBITS). The following are valid: • 1 (1) • 2 (2)
16#81A5	The module does not support this type of data flow control.	Select a valid data flow control for the module (FLOWCTRL).
16#81A7	Invalid value for XON or XOFF	Select suitable values for XON (XONCHAR) and XOFF (XOFFCHAR). Valid range of values: 0...255

Error code	Description	Remedy
16#81AA	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) / (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint master) (2)/ (CM PtP (ET 200SP)) • Full duplex (RS 422) four-wire mode (multipoint slave) (3) • Half duplex (RS485) two-wire mode. (4)
16#81AB	Invalid receive line initial state	Valid initial states are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default setting corresponds to the idle state (no active send operation).
16#81AC	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • Break detection deactivated (0) • Break detection activated (1).
16#81AF	The module does not support this protocol.	Select a valid protocol for the module.
Error codes of the "Send configuration"		
16#81B5	More than two end delimiters or end sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
16#81B6	Send configuration rejected because the 3964(R) protocol was selected	Make sure that no send configuration is transmitted if the 3964(R) protocol is set.

Error code	Description	Remedy
Error codes of the "Receive configuration"		
16#81C0	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
16#81C1	Invalid end condition or no end condition selected	Select a suitable end condition (see Receiving data with Freeport (Page 32)).
16#81C3	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length" (MAXLEN). Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
16#81C4	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
16#81C5	Invalid value for "Size of length field"	Select a suitable value for "Size of length field" (LENGTHSIZE). Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)
16#81C6	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification" (LENGTHM). Valid range of values: 0 to 255 (bytes)
16#81C7	The total of "Offset in the message + size of length field + number of characters not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of length field" and "Number of characters not counted". Valid range of values: • Offset in the message (depending on the module): 0-1024/2048/4096 (bytes) • Size of length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0 to 255 (bytes)
16#81C8	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
16#81C9	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1 to 65535 (bit times)
16#81CB	frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
16#81CC	frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.

Error code	Description	Remedy
16#81CD	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
16#81CE	Invalid value for "Clear receive buffer on startup"	Select a suitable value for "Clear receive buffer on startup". The following are valid: • Clear receive buffer at startup is deactivated (0) • Clear receive buffer at startup is activated (1)
SEND status and error codes		
16#81D0	Receiving send request during runtime of a send command	Make sure that you do not receive an additional send request during runtime of a send command.
16#81D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#81D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#81D3	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
16#81D5	Transmission canceled due to parameter changes, detected wire break, or CPU in STOP	Check the parameter assignment, wire break, and CPU status.
16#81D6	Transmission canceled because end identifier was not received	Check the parameter assignment of the end characters and the frame of the communication partner.
16#81D7	Communication error between the user program and module	Check the communication (e.g., matching the sequence number).
16#81D8	Transmission attempt rejected because module is not configured	Configure the module.
Error codes of the receive configuration		
16#81E0	Frame aborted: Send buffer overflow / send frame too long	Increase the call rate for the receive function in the user program or configure communication with data flow control.
16#81E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.
16#81E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
16#81E3	Frame aborted: Character overflow error	Firmware error: Please contact Customer Support.
16#81E4	Frame aborted: The total length of "Offset in the message + size of the length field + number of characters not counted" is greater than the receive buffer	Select a suitable value for offset in message, size of the length field, and number of characters not counted.
16#81E5	Frame aborted: Break	Receive line to partner is interrupted. Reconnect or switch on partner.

Error code	Description	Remedy
16#81E6	Maximum number of "Buffered received frames" exceeded	In the user program call the instruction more often or configure a communication with data flow control or increase the number of buffered frames.
16#81E7	Synchronization error module and Receive_P2P	Make sure that different instances of the Receive_P2P do not access the same module.
16#81E8	Frame aborted: The character delay time has expired before the message end criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.
16#81E9	Modbus CRC error (only communication modules which support Modbus)	Checksum error of the Modbus frame. Check the communication partner.
16#81EA	Modbus frame too short (only communication modules which support Modbus)	Minimum length of Modbus frame not met. Check the communication partner.
16#81EB	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (bytes) Check the parameters for end of frame detection.
Error codes V24 accompanying signals		
16#81F0	The module does not support V24 accompanying signals	You have tried to set accompanying signals for a module that does not support V24 accompanying signals. Make sure that this is an RS232 module or that RS232 mode (ET 200SP) is set.
16#81F1	No operation of the V24 accompanying signals	The V24 accompanying signals cannot be operated manually if hardware data flow control is active.
16#81F2	The DSR signal cannot be set because the module has the type DTE.	Check the configured type of the module. The module type must be DCE (data communication equipment).
16#81F3	The DTR signal cannot be set because the module has the type DCE.	Check the configured type of the module. The module type must be DTE (data terminal equipment).
16#81F4	Block header error (e.g. incorrect block type or incorrect block length)	Check the instance DB and the block header.
Error codes of the receive configuration		
16#8201 [1)]	Receive_Conditions is a pointer to an invalid data type	Enter a pointer to one of the following data types: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8225	Receive_Conditionspoints to an optimized memory area greater than 1 kB or Receive_Conditions points to an optimized memory area and the receive length is greater than the area addressed by Receive_Conditions.	Enter a pointer to an area with a maximum length of: • Optimized memory area: 1 KB • Non-optimized memory area: 4 KB Note: If the pointer points to an optimized memory area, do not send more than 1 KB.
16#8229 [1)]	Receive_Conditions is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.

Error code	Description	Remedy
Error codes, general		
16#8280	Negative acknowledgment when reading module	You can find more detailed information on error causes in theRDREC.STATUS static parameters and in the description of the SFB RDREC. • Check the input at the PORT parameter • Set the COM_RST parameter prior to the initial call.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter You can find more detailed information on error causes in the WRREC.STATUS static parameters and in the description of the SFB WRREC.
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.
Error codes of the receive configuration		
16#82C1	Invalid value for "Buffered received frames".	Select a suitable value for "Buffered received frames". Valid range of values: 1-255
16#82C2	Receive configuration rejected because the 3964(R) protocol was selected	Make sure that no receive configuration is sent if the 3964(R) protocol is set.
16#8301 [1)]	Receive_Conditions is a pointer to an invalid data type	Select a valid data type. The following are valid: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8322	Range length error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8324	Range error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8328	Setting error when reading a parameter	Check the input at the Receive_Conditions parameter
SEND status and error codes		
16#8328 [1)]	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes of the receive configuration		
16#8332	Invalid data block at the Receive_Conditions parameter	Check the input at the Receive_Conditions parameter
16#833A	The designation of the data block at the Receive_Conditions parameter refers to a data block which is not loaded.	Check the input at the Receive_Conditions parameter
16#8351	Invalid data type	Check the input at the Receive_Conditions parameter
16#8352 [1)]	Receive_Conditions does not point to a data block	Check the pointer to Receive_Conditions
16#8353 [1)]	Receive_Conditions does not point to a structure of the typeReceive_Conditions	Check the pointer to Receive_Conditions

Error code	Description	Remedy
Error codes 3964(R) protocol		
16#8380	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time" (CharacterDelayTime). Valid range of values: 1 to 65535 (ms)
16#8381	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout" (AcknDelayTime). Valid range of values: 1 to 65535 (ms)
16#8382	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority" (Priority). The following are valid: • High (1) • Low (0)
16#8383	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check" (BCC). The following are valid: • With block check (1) • Without block check (0)
16#8384	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts" (BuildupAttempts). Valid range of values: 1-255
16#8385	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts" (RepetitionAttempts). Valid range of values: 1-255
16#8386	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
16#8387	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.
16#8388	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check whether the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#8389	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is only answered with DLE when the receive buffer is empty. No additional character may be received before (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#838A	Runtime error: Logical error during receiving. After DLE was received, a further random character (other than DLE or ETX) was received.	Check if partner DLE in frame header and in data string is always in duplicate or the connection is released with DLE ETX. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.

Error code	Description	Remedy
16#838B	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Verify by using an interface test device that is switched into the transmission line, if necessary.
16#838C	Runtime error: Wait time for free receive buffer has started	In the user program call the instruction more often or configure a communication with data flow control.
16#838D	Runtime error: frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
16#838E	Runtime error: In idle mode, one or several characters (other than NAK or STX) were received.	Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
16#838F	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
16#8391	Parameter assignment error: 3964 configuration data rejected because Freeport is set	If the Freeport protocol is set, make sure that no 3964 parameter assignment data is sent.

[1] Only with instructions for S7-300/400 CPUs

Overview of error messages - Modbus

Error code	Description	Remedy
16#0000	No error	-
Configuration error of the interface - Modbus_Comm_Load		
16#8181	The module does not support this data transmission rate.	Select a valid data transmission rate for the module at the BAUD parameter.
16#8182	The module does not support this parity setting.	Select a suitable value for "Parity" at the PARITY parameter. The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#8183	The module does not support this type of data flow control.	Select a valid data flow control for the module at the FLOW_CTRL parameter.
16#8184	Invalid value for "Response timeout".	Select a suitable value for "Response timeout" at the RESP_TO parameter. Valid range of values: 1 to 65535 (ms)
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.RDREC.STATUS or Receive_Config.RDREC.STATUS static parameters or RDREC.STATUS and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.WRREC.STATUS or Receive_Config.WRREC.STATUS static parameters or WRREC.STATUS and in the description of the SFB WRREC.
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.

Error code	Description	Remedy
Configuration error - Modbus_Slave		
16#8186	Invalid slave address	Select a suitable slave address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8187	Invalid value at MB_HOLD_REG parameter	Select a suitable value for the hold register at the MB_HOLD_REG parameter.
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#818C	The pointer to a MB_HOLD_REG area must be a data block or a bit memory address area.	Select a suitable value for the pointer to the MB_HOLD_REG area.
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS, and in the description of the SFB WRREC.
16#8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
16#8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
16#8456 [1)]	Error during instruction execution. The cause of the error is shown in the STATUS parameter.	Determine the value of the SFCSTATUS parameter. Check what this means in the description for SFC51, STATUS parameter.

Error code	Description	Remedy
Configuration error - Modbus_Master		
16#8180	Invalid value for MB_DB parameter	The value configured for MB_DB (instance data DB) at the Modbus_Comm_Load instruction is not valid. Check the interconnection of the Modbus_Comm_Load instruction and its error messages.
16#8186	Invalid station address	Select a suitable station address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#8189	Invalid data address	Select a suitable value for the data address at the DATA_ADDR parameter. See description Modbus_Master (Page 120) in the Info system
16#818A	Invalid length	Select a suitable data length at the DATA_LEN parameter. See description Modbus_Master (Page 120) in the Info system
16#818B	Invalid value for DATA_PTR	Select a suitable value for the data pointer at the DATA_PTR parameter (M or DB address). See description Modbus_Master (Page 120) in the Info system
16#818C	Interconnection error of the DATA_PTR parameter	Check the interconnection of the instruction.
16#818D	The area addressed by DATA_PTR is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the DATA_PTR pointer
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS or Receive_Reset and in the description of the SFB WRREC.

Error code	Description	Remedy
Communication errors - Modbus_Master and Modbus_Slave		
16#80D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#80D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#80E0	Frame aborted: Send buffer overflow / send frame too long	In the user program call the instruction more often or configure a communication with data flow control.
16#80E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.
16#80E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
16#80E3	Frame aborted: Character overflow error	Check the number of data in the frame of the communication partner.
16#80E4	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
Communication error - Modbus_Master		
16#80C8	The slave does not respond within the set time	Check the data transmission rate, parity and wiring of the slave.
16#80C9	The slave does not respond within the time set by Blocked_Proc_Timeout.	Check the setting for Blocked_Proc_Timeout. Check if the module has been configured with the Modbus_Comm_Load instruction. The module may possibly need to be reconfigured using Modbus_Comm_Load after a pull/plug or after voltage recovery.
16#8200	The interface is busy with an ongoing request.	Repeat the command later. Make sure that there are no commands still running before you start a new one.
Protocol error - Modbus_Slave (only communication modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	The function code is not supported or is not supported for broadcast.	Check the communication partner and make sure that a valid function code is sent.
16#8382	Invalid length information in the request frame	Select a suitable data length at the DATA_LEN parameter.
16#8383	Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Invalid data value error in the request frame	Check the data value in the request frame of the Modbus master
16#8385	The diagnostic value is not supported by the Modbus slave (function code 08)	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.

Error code	Description	Remedy
Protocol error - Modbus_Master (only communication modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	Response frame from Modbus Slave with the following error message: The function code is not supported.	Check the communication partner and make sure that a valid function code is sent.
16#8382	Response frame from Modbus Slave with the following error message: Invalid length	Select a suitable data length.
16#8383	Response frame from Modbus Slave with the following error message: Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Response frame from Modbus Slave with the following error message: Data value error	Check the request frame to the Modbus slave.
16#8385	Response frame from Modbus Slave with the following error message: The diagnostic value is not supported by the Modbus slave	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.
16#8386	The returned function code does not match the requested function code.	Check the response frame and the addressing of the slave.
16#8387	A slave that was not requested answers	Check the response frame of the slave. Check the address settings of the slave.
16#8388	Error in the response of the slave to a write request.	Check the response frame of the slave.
16#8828 [1)]	DATA_PTR points to a bit address that is not equal to n * 8	Check the DATA_PTR pointer
16#8852 [1)]	DATA_PTR is not a pointer to a DB or a bit memory area	Check the DATA_PTR pointer
16#8853 [1)]	DATA_PTR is not a pointer of type BOOL or WORD	Check the DATA_PTR pointer
16#8855 [1)]	DATA_PTR points to a write-protected DB	Check the DATA_PTR pointer
16#8856 [1)]	Error during call of SFC51	Call the Modbus_Master instruction again
Error - Modbus_Slave (only communication modules that support Modbus)		
16#8428 [1)]	MB_HOLD_REG points to a bit address that is not equal to n * 8	Check the MB_HOLD_REG pointer
16#8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
16#8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
16#8456 [1)]	Error during call of SFC51	Call the Modbus_Slave instruction again

[1)] Only with instructions for S7-300/400 CPUs

Overview of error messages - USS

Error code	Description	Remedy
16#0000	No error	-
16#8180	Length error in response of drive	Check the response frame of the drive.
16#8181	Data type error	Select a suitable data type. The following are valid: • Real • Word • Double word
16#8182	Data type error: "Double word" or "Real" may not be returned for the "Word" request.	Check the response frame of the drive.
16#8183	Data type error: "Word" may not be returned for the "Double word" or "Real" request.	Check the response frame of the drive.
16#8184	Checksum error in response of drive	Check the drive and the communication connection.
16#8185	Addressing error	Valid drive address range: 1 to 16
16#8186	Setpoint error	Valid setpoint range: -200% to +200%
16#8187	Incorrect drive number returned	Check the response frame of the drive.
16#8188	Invalid PZD length	Permitted PZD lengths: 2, 4, 6, 8 words
16#8189	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.
16#818A	A different request for this drive is currently active.	Repeat the parameter read or write command later.
16#818B	The drive does not respond.	Check the drive.
16#818C	The drive responds with an error message to a parameter request.	Check the response frame of the drive. Check the parameter request. Check if the instructions USS_Read_Param, USS_Write_Param or USS_Port_Scan have reported an error. If they have, check the value of the static tag USS_DB. w_USSExtendedError of the USS_Drive_Control instruction.
16#818D	The drive responds with an access error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
16#818E	The drive was not initialized.	Check the user program and make sure that the USS_Drive_Control instruction is called for this drive.

Error code	Description	Remedy
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.RDREC.STATUS, Send_Config.RDREC.STATUS , Receive_Config.RDREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.WRREC.STATUS, Send_Config.WRREC.STATUS , Receive_Config.WRREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB WRREC.

[1] Only with instructions for S7-300/400 CPUs

Startup and Diagnostics 6

6.1 Startup characteristics

Operating mode transitions

After the communication module starts up, all data between the CPU and the communication module is exchanged by means of instructions.

CPU STOP	During a running data transmission communication module - CPU, both a send and a receive job is aborted.
CPU RUN	Send and receive operation is ensured in the RUN state of the CPU. With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

From the view of the communication module, there are no further operating states/operating state transitions.

6.2 Diagnostic functions

Introduction

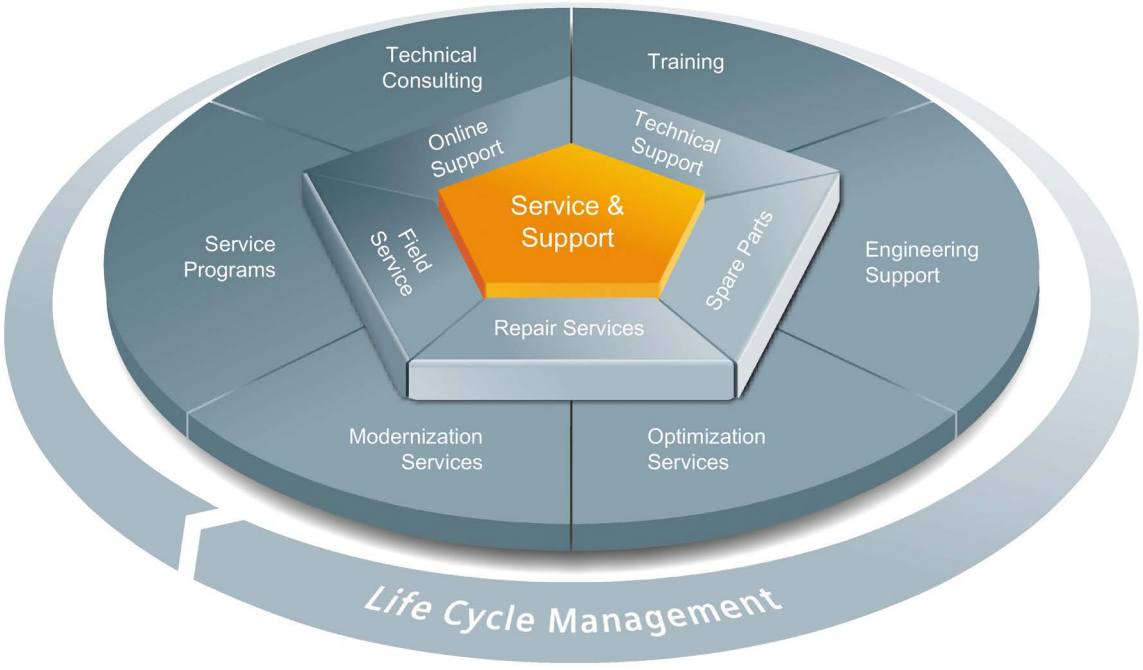
The diagnostic functions of the communication module allow errors that have occurred to be located quickly. The following diagnostic options are available to you:

Diagnostics by means of the display elements of the communication module	The indicators provide information on the operating mode or the possible error states of the communication module. The indicators provide an initial overview of any internal or external errors and interface-specific errors. For more information refer to the device manual of the corresponding communication module.
Diagnostics via the STATUS output of the instructions	Instructions have a STATUS output for error diagnostics; it provides information about communication errors between the communication module and the CPU. You can evaluate the STATUS parameter in the user program (it is active for exactly one cycle).
Diagnostic error interrupt	The communication module can trigger a diagnostic error interrupt on the CPU assigned to it. The communication module makes diagnostic information available. The analysis of this information is made via the user program or by reading the CPU diagnostics buffer.

Service & Support

A

A.1 Service & Support



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Glossary

Automation system

An automation system is a programmable logic controller consisting of at least one CPU, various input and output modules, and operating and monitoring devices.

Bit times

"Bit times" are always specified as a number of bits.

The "time" set with bits depends on the selected data transmission rate that is taken into consideration automatically.

Example:

The telegram end is to be detected after a gap of two characters.

The set data transmission rate is 9600 bit/s.

The set character frame is 10 bits.

10 x 2 = 20 bit times

This corresponds to a time of:

20 x 1/9600 ≈ 0.0021 s

Communication module

Communication modules are used for point-to-point connections and bus links.

Configuring

Configuring refers to the configuration of separate modules of an automation system in the configuration table.

CPU

Central Processing Unit = Central module of the automation system that consists of the control and computing units, memory, system program, and interfaces to the I/O modules.

CTS

Clear to send. The communication partner is ready to receive data.

Cycle time

The cycle time is the time that the CPU requires to process the user program once.

Cyclic program processing

In cyclic program processing the user program runs in program loop, or cycle, that is constantly repeated.

DCD

Data carrier detect. The communication partner signals that it recognizes incoming data.

Default setting

The default setting is a reasonable basic setting that can be used whenever no other value is specified.

Diagnostic events

Diagnostics events are, for example, module errors or system errors in the CPU that may be caused by a program error.

Diagnostic functions

The diagnostic functions cover the entire system diagnostics and include the recognition, interpretation and reporting of errors within the automation system.

Diagnostics buffer

Memory area in which detailed information on all diagnostics events is entered based on the order of their occurrence.

DSR

Data set ready. The communication partner is ready.

DTR

Data terminal ready. The communication module is ready.

Hardware

Hardware is the entire physical and technical equipment of a automation system.

Module parameters

Module parameters are values with which the behavior of the module can be set.

Online/Offline

When you are online there is a data connection between the automation system and programming device, when you are offline there is no data connection between them.

Parameter assignment

Parameter assignment refers to the setting of a module's behavior.

Parameters

Parameters are values that can be allocated. There are two different types of parameters: block parameters and module parameters.

Point-to-point communication

In point-to-point communication the communication processor forms the interface between a programmable logic controller and a communication partner.

Procedure

Procedure refers to the process of a data transmission according to a specific protocol.

Protocol

All communication partners involved in data transmission must follow fixed rules for handling and implementing the data traffic. Such rules are called protocols.

Receive line initial state

The initial state of the receive line for RS422 and RS485 mode:

- enables break detection (wire break)
- ensures a defined level on the receive line while it is not sending.

RI

Ring indicator. Incoming call for connecting a modem.

RTS

Request to send. The communication module is ready to send.

Software

Software refers to the entirety of all programs that are used on a computing system. The operating system and user programs belong to this.

User program

The user program contains all instructions and declarations for processing the signals used for controlling a system or a process. In SIMATIC S7 the user program is structured and divided into small units, the blocks.

USS

The USS® protocol (universal serial interface protocol) defines an access method based on the master-slave principle for communication by means of a serial bus. The point-to-point connection is included as a subset in this protocol.

XON/XOFF

Software data flow control with XON/XOFF. You can configure the characters for XON and XOFF (any ASCII character). The user data may not contain these characters.

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SIEMENS

SIMATIC

S7-1500 / ET 200MP / ET 200SP CM PtP operation with PROFINET controller

Programming and Operating Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation addresses users who want to use the point-to-point communication modules independently of the SIMATIC S7. It offers you important information with regard to the configuration and commissioning of the point-to-point communication modules for S7-1500 (ET 200MP) and ET 200SP.

Requirements

To use PtP communication modules in a system independently of the SIMATIC S7, the CPU must support communication by means of data records and come equipped with a PROFINET IO controller. For more information on this topic, refer to the *Distributed I/O System ET 200SP* and *Distributed I/O System ET 200MP* system manuals.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

GSDML file

Engineering must be provided with information regarding functionality and parameters of the communication modules for the higher-level application.

The properties of the PtP communication modules are defined in a GSDML (Generic Station Description Markup Language) file, an XML-based language that is defined based on the GSDML scheme (ISO 15745: GSD for PROFIBUS and GSDML for PROFINET IEC 61804: EDDL IEC 62453: FDT/DTM).

The Engineering System must provide a suitable interpreter that makes the GSDML data available to the system.

The name of a GSDML file for the communication modules can have the following syntax, for example: GSDML-V2.3-Siemens-ET200SP-20110824.xml

The GSDML file contains:

- Device and identification data
- Parameter assignment data
- Diagnostics data

In order to enable parameter assignment of the communication modules, the GSDML file must be installed/imported in the Engineering System.

Validity of the documentation

This documentation is valid for the following point-to-point communication modules

- CM PtP RS232 BA (6ES7540-1AD00-0AA0) communication module
- CM PtP RS422/485 BA (6ES7540-1AB00-0AA0) communication module
- CM PtP RS232 HF (6ES7541-1AD00-0AB0) communication module
- CM PtP RS422/485 HF (6ES7541-1AB00-0AB0) communication module
- CM PtP (6ES7137-6AA00-0BA0) communication module

Conventions

Please also observe notes labeled as follows:

Note

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Recycling and disposal

The products can be recycled due to their low pollutant content. For environmentally compliant recycling and disposal of your old device, please contact a company certified for the disposal of electronic waste.

Additional assistance

- Information about the Technical support (http://www.siemens.com/automation/support-request) available can be found in the appendix to this documentation.
- The portfolio of technical documentation for SIMATIC products and systems is available on the SIMATIC Portal (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available in the Catalog (http://mall.automation.siemens.com).

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-300/400, ET 200MP/SP systems consists of the relevant operating instructions, manuals and product information.

Overview of documentation on the topic of point-to-point communication

The table below includes additional documentation which amends this description.

Subject	Documentation	Important contents
System	System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214) System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installing • Connecting • Addressing • Commissioning • Maintenance
Communication	Function manual Communication (http://support.automation.siemens.com/WW/view/en/59192925)	• Basics of serial communication • Data transmission functions • Diagnostic functions
	Device manual CM PtP RS232 BA communication module (http://support.automation.siemens.com/WW/view/en/59057152) Device manual CM PtP RS232 HF communication module (http://support.automation.siemens.com/WW/view/en/59057160) Device manual CM PtP RS422/485 BA communication module (http://support.automation.siemens.com/WW/view/en59057390) Device manual CM PtP RS422/485 HF communication module (http://support.automation.siemens.com/WW/view/59061372) Device manual CM PtP communication module (http://support.automation.siemens.com/WW/view/en/59061378)	• Product overview • Connecting • Assigning parameters • Programming • Diagnostics

Subject	Documentation	Important contents
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	For S7-1500, ET 200MP, ET 200SP: • Diagnostic evaluation Hardware/software
Setup	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection

SIMATIC Manuals

The latest manuals of SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) and can be downloaded free of charge.

Overview

2

Overview of components and order numbers

Tabular overview of communication modules

Communication module	Order number
CM PtP RS232 BA	6ES7 540-1AD00-0AA0
CM PtP RS422/485 BA	6ES7 540-1AB00-0AA0
CM PtP RS232 HF	6ES7 541-1AD00-0AB0
CM PtP RS422/485 HF	6ES7 541-1AB00-0AB0
CM PtP (ET 200SP)	6ES7 137-6AA00-0BA0

Overview of components and interfaces

Tabular overview of communication modules and their functions.

Communication module	Interface	Protocols		D-sub	
		Freeport	3964(R)	9-pin	15-pin
CM PtP RS232 BA	RS232	●	●	●	-
CM PtP RS422/485 BA	RS422	●	●	-	●
	RS485	●	-	-	●
CM PtP RS232 HF	RS232	●	●	●	-
CM PtP RS422/485 HF	RS422	●	●	-	●
	RS485	●	-	-	●
CM PtP (ET 200SP)	RS232	●	●	ET 200SP Base Unit with 18 terminals *)	
	RS422	●	●		
	RS485	●	-		

*) ET 200SP Base Unit instead of sub D; same for all; pin assignment depending on physical transmission properties

Overview of components and data transmission rates

Communication module	Data transmission rate in bps										
	300	600	1200	2400	4800	9600	19200	38400	57600	76800	115200
CM PtP RS232 BA	●	●	●	●	●	●	●	-	-	-	-
CM PtP RS422/485 BA	●	●	●	●	●	●	●	-	-	-	-
CM PtP RS232 HF	●	●	●	●	●	●	●	●	●	●	●
CM PtP RS422/485 HF	●	●	●	●	●	●	●	●	●	●	●
CM PtP (ET 200SP)	●	●	●	●	●	●	●	●	●	●	●

Overview of components and receive buffer size

Module	Receive buffer size KB	Max. frame length KB	Bufferable frames
CM PtP RS232 BA	2	1	255
CM PtP RS422/485 BA	2	1	255
CM PtP RS232 HF	8	4	255
CM PtP RS422/485 HF	8	4	255
CM PtP (ET 200SP)	4	2	255

Secondary signals and data flow control

- Software data flow control with XON/XOFF

  The Freeport protocol supports data flow control with XON/XOFF via the RS232 and RS422 interfaces.

- Hardware data flow control with RTS/CTS

  The Freeport protocol supports data flow control with RTS/CTS via the RS232 interface.

- Automatic operation of secondary signals

  The Freeport protocol supports operation of the RS232 secondary signals by means of the RS232 interface. (Only available if hardware data flow control is not activated.)

Application options for the communication modules

You may set up a communication connection with different partners, depending on the communication modules used:

- Freeport: Transmission of ASCII character strings without specified protocol format
- 3964(R): Communication between programmable logic controllers (master/master communication)

Basic information

3

3.1 Serial transmission of a character

Introduction

Different networking options are available for the exchange of data between two or more communication partners. The PtP connection between two communication partners is the simplest means of information exchange.

Point-to-point connection

In point-to-point connection, the communication processor forms the interface between a programmable logic controller and a communication partner. Data is sent in serial mode via PtP connection with the communication module.

Serial data transmission

During serial data transmission, the individual bits of a character of information to be transferred are sent successively in a defined sequence.

Bidirectional data traffic - operating mode

In the context of bidirectional data traffic, we distinguish between two operating modes for the communication module:

- Half duplex mode

  The data is transferred between one or several communication partners in both directions alternately. Half duplex mode means that data is either sent or received at a given point in time.

- Full duplex mode

  The data is exchanged simultaneously between one or several communication partners, i.e. it is possible to send and receive data simultaneously at a given point in time.

Asynchronous data transmission

Serial data transmission occurs asynchronously at the communication module. The so-called time base synchronism (fixed time base for transmission of a fixed character string) is only upheld during transmission of a character. Each character to be sent is preceded by a synchronization pulse, which is also known as start bit. The length of the start bit transmission determines the clock cycle. The end of character transmission is formed by one or two stop bits.

Handshakes

In addition to the start and stop bits, both communication partners need further handshake procedures for serial data transmission. These include:

- Data transmission rate
- Character and acknowledgment delay time
- Parity
- Number of data bits (7 or 8 bits/characters)
- Number of stop bits (1 or 2)

3.2 Transmission security

Transmission security plays an important role in the transmission of data and in the selection of the transmission procedure. Generally speaking, the more layers of the reference model are applied, the higher the transmission security.

Classification of existing protocols

The figure below illustrates how the protocols of the communication module fit into the reference model.

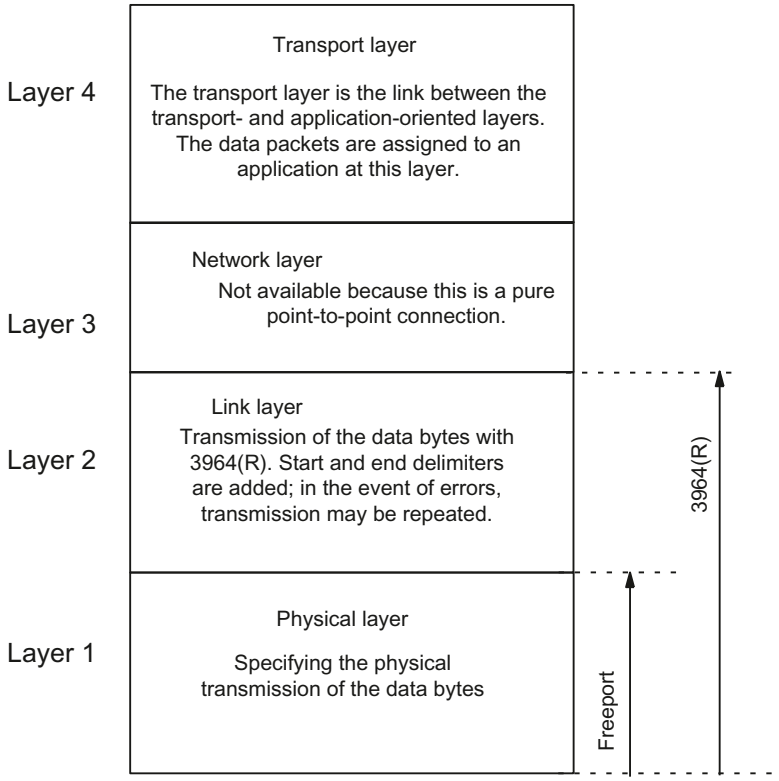


Figure 3-1 Classification of the existing protocols of the communication module in the reference model

Transmission security with Freeport

Data security when using Freeport:

- Despite the efficiency of data transmission with the Freeport protocol, it is not possible to ensure secure data transmission with Freeport because no data security measures other than the use of a parity bit (can also be disabled, depending on the character frame setting) are applied. A certain degree of data security can be achieved through parameter assignment of the frame start and frame end conditions.
- The parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, this error can no longer be detected.
- To increase transmission security, you can, for example, implement a checksum, a frame length specification, or configurable end conditions. These measures must be implemented by the user.
- A further increase in data security can be achieved by means of acknowledgment message frames in response to send or receive message frames. This is the case with high-grade protocols for data communication (ISO 7-layer reference model).

Transmission security with 3964(R)

Two different procedures for data transmission can be used, either with or without a block check character:

- Data transmission without block check character: 3964

  Transmission security is achieved by means of a specified frame structure, frame breakdown, and frame repetitions.

- Data transmission with block check character: 3964R

  The high degree of transmission security is achieved by means of a specified frame structure and breakdown, frame repetitions, as well as inclusion of a block check character (BCC). The hamming distance in 3964R mode is 3.

The hamming distance represents a measure for data transmission security.

In this manual, the term 3964(R) is used when descriptions and notes refer to both data transmission modes.

Basic communication mechanisms

4

Reading/writing data records

Note

Reading/writing data records

For information about the functions for reading/writing data records, refer to the documentation of your controller.

The "Write data record" function can be used to configure the devices by means of configuration data records. The "Write data record" function also transmits the send data to the devices. Accordingly, "Read data record" can be used to read diagnostics data and receive data from the devices.

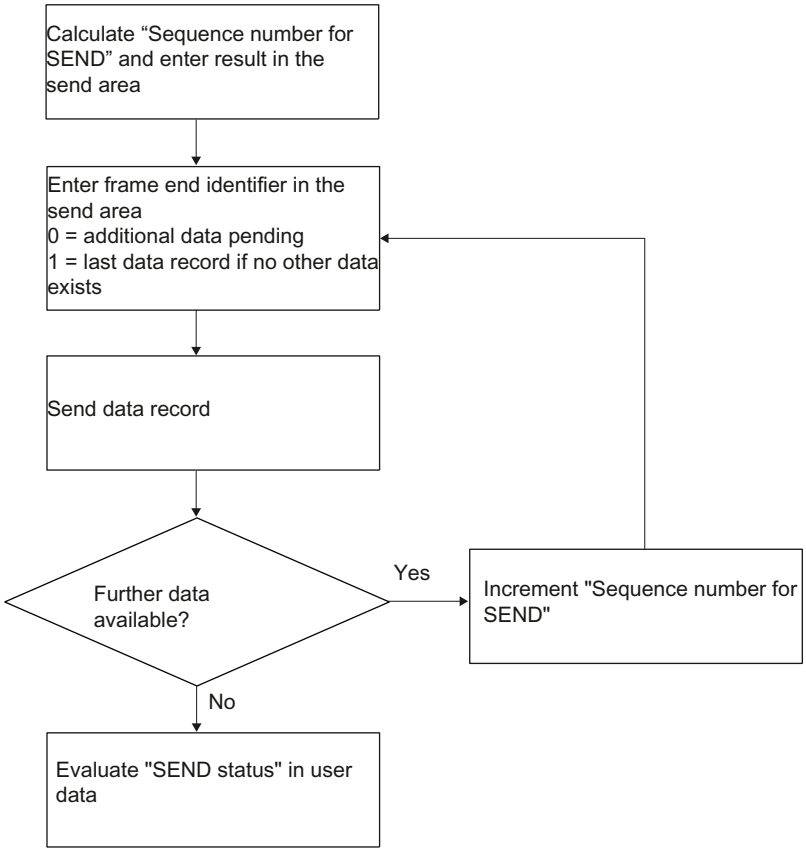
- For operation, you need to configure the communication modules for the relevant application.
  The following configuration data records can be used for this purpose:
  - Freeport communication (Page 41)
  - 3964 communication (Page 49)
- Use the following data records to send and receive data:
  - Sending data (Page 55)
  - Receiving data (Page 59)
- The cyclic user data shows you whether the module has sent or received new data.
  - Querying send acknowledgment - input user data (Page 57)
  - Query: New receive frame - input user data (Page 61)
- In RS232 mode, you can derive the current state of the secondary signals from the cyclic user data of the module, or control the RS232 secondary signals by means of the user program (provided hardware data flow control is not activated).
  - RS232 signals (Page 65)
- Data records can also be used to send additional control and verification commands.
  - Activate special function (Page 51)

Additional information

Chapter Data records and user data interface (Page 20) provides an overview of all configuration data records.

Send - flow chart

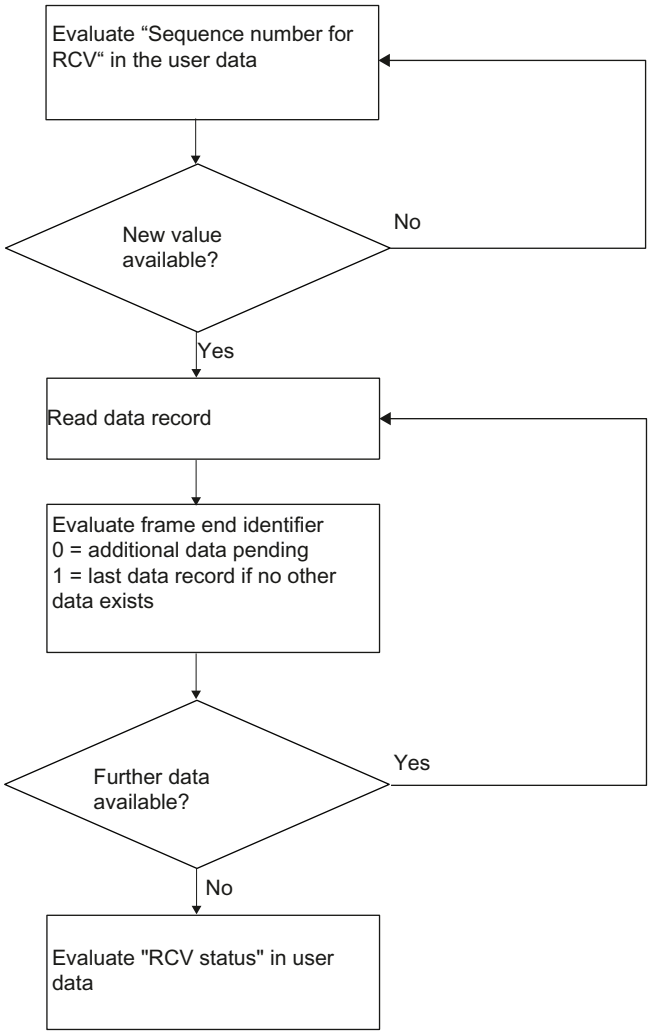
Users can transmit data based on the sequence outlined below (refer to Sending data (Page 55) for details). Management data and send data is transmitted to the communication module by means of a special data record. The communication module provides the acknowledgment in the input user data.



Receive - flow chart

The communication module signals the availability of new received data in the input user data (refer to Receiving data (Page 59) for details). The communication module provides management and receive data in a special data record.

Users can receive data based on the sequence outlined below.



4.1 Data records and user data interface

Overview of data records

Configuration data records are available for the following tasks:

- Freeport communication
  Configuration of the communication module for data transmission using the open Freeport frame
  - Activate special function (Page 51)
  - Send configuration record - data record 59 (Page 44)
  - Receive configuration record - data record 60 (Page 46)
- 3964 communication
  Configuration of the communication module for data transmission with 3964(R) protocol
  - Port configuration record - data record 57 (Page 41)
  - 3964 protocol configuration - data record 61 (Page 49)
- Special functions - Activation
  Activating or verifying the active state of diagnostic interrupts.
  - Activate special function (Page 51)

The following data records are available for operating the communication modules:

- Query error status
  Acknowledgment of the communication module in response to the writing of a configuration data record
  - Read error status - data record 55 (Page 53)
- Send data
  Transmitting send data to the communication module and querying transmission acknowledgment in the user data
  - Send data - data record 48 (Page 55)
  - Querying send acknowledgment - input user data (Page 57)
- Receive data
  Display of a receive frame in the user data
  - Data received - data record 49/50 (Page 59)
  - Query: New receive frame - input user data (Page 61)
- Clear receive buffer
  Clearing the receive buffer of the communication module
  - Clear receive buffer - data record 54 (Page 63)
- RS232 secondary signals
  Manipulation of the RS232 secondary signals of the communication module and reading the RS232 secondary signals in the user data
  - Set RS232 secondary signals - data record 53 (Page 65)
  - Read RS232 secondary signals - input user data (Page 66)

Data transmission with Freeport

5

Introduction

Freeport is a freely programmable, frame-based protocol.

The Freeport driver controls data transmission via point-to-point connection between the communication module and a communication partner. The Freeport driver contains the physical layer (layer 1).

The Freeport driver supports sending and receiving of messages with any structure - all characters from 00 to FFH (for character frames with 8 data bits), or from 00 to 7FH (for character frames with 7 data bits).

The frame start and end criteria must be configured both for the send and the receive direction. The structure of the send frames may differ from that of the receive frames.

5.1 Sending data with Freeport

Sending data

Note

During parameter assignment of the XON/XOFF data flow control, user data may not contain any of the configured XON or XOFF characters. Default settings are DC1 = 11H for XON and DC3 = 13H for XOFF.

Specifying settings for sending

To send a message, the partner must be informed of the start and end of the message (see Send configuration record - data record 59 (Page 44)). You can select one of the following options:

- Send the Break signal at the start of the message

  You can specify that an additional Break is sent at the beginning of each message transmission on expiration of the RTS ON delay time.
  The duration of the "Break" is specified in bit times (refer to Send configuration record - data record 59 (Page 44) bytes 12 and 13).

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- Send Idle Line

  You can specify that an additional "Idle Line" signal is output at the start of each message transmission.
  The duration of the "Idle Line" is specified in bit times (see Send configuration record - data record 59 (Page 44) bytes 14 and 15).

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- RTS ON delay

  You can configure the time that has to expire after the RTS (Request to send) before the actual data transmission starts (see Send configuration record - data record 59 (Page 44) bytes 8 and 9).

- RTS OFF delay

  You can configure the time that has to expire after transmission has been completed before the RTS signal is deactivated (see Send configuration record - data record 59 (Page 44) bytes 10 and 11).

- Sending including the end delimiter

  You can configure the number of end delimiters (1 or 2) and their value.

  All data up to the end delimiter(s) is sent, independent of the selected frame length. The end delimiter must be included in the data to be sent. Data is sent only up to and including the end delimiter, even if the data length specified is longer (refer to Send configuration record - data record 59 (Page 44) bytes 18 and 21).

- Number of appended characters

  Input of the number of appended characters. All data transferred to the communication module will be sent. The end delimiter(s) is/are appended automatically. 1 to 5 characters more than the specified number are sent to the partner, depending on the number of end delimiters (see Send configuration record - data record 59 (Page 44) bytes 22 and 28).

Note

If you do not configure either the "End delimiter" (0) or the "Number of appended characters" (0), all data transferred to the communication module is sent to the partner in a transparent operation.

5.2 Receiving data with Freeport

Introduction

You need to specify message start and end criteria in the Freeport driver to enable detection of a message in the incoming data flow.

Note

The start and end criteria described below can be combined as required. Such combinations may lead to unwanted results if the start and end criteria influence or even exclude each other.

Specifying the message start

For data transmission with Freeport, you can choose between several different start criteria. The start criterion defines when a frame starts. Once a criterion that indicates the start of the message is met, the data stream is scanned for message end criteria. (See Receive configuration record - data record 60 (Page 46) byte 9)

Two different methods are available for detecting the message start:

- Start on any character
- Start on special condition

Start on any character

- Start on any character

  Any character can be used to define the start of the message (default).

  This means that the first character sent at the start of communication, or after the frame end has been detected, will be identified as the first character of a message. (See Receive configuration record - data record 60 (Page 46) byte 12)

Start on special condition

The start of the message is detected based on the following specified conditions:

- **After detection of a line break**

  The frame start is not accepted unless a break has been received beforehand, in other words, it is compulsory for the partner to send a break before sending a frame.

- **After detection of an idle line**

  The frame start is not accepted until the configured idle line duration has expired. This procedure requires a minimum interval between two frames. (See Receive configuration record - data record 60 (Page 46) bytes 10 and 11)

- **After receipt of a start character**

  The frame start is detected when the configured start character is identified. (See Receive configuration record - data record 60 (Page 46) byte 12)

- **After detection of one or several start sequences**

  The frame start is detected when the configured string with a length of up to five characters is identified. You can configure up to 4 start sequences. (See Receive configuration record - data record 60 (Page 46) bytes 13 to 37)

Specifying the message end

You can choose from several different end criteria for data transmission using the Freeport driver. The end criterion defines the point at which a message frame has been received completely. (See Receive configuration record - data record 60 (Page 46) byte 39)

Configurable end criteria are:

- **Recognize message end by message timeout**
- **Recognize message end by response timeout**
- **After character delay time elapses (default)**
- **After receipt of a fixed frame length**
- **After receipt of a maximum number of characters**
- **Read message length from message**
- **After receipt of an end sequence**

Message timeout

When data is received, the end of frame is detected on expiration of the configured time for transferring a frame. Time measurement starts after the start criterion has been met. (See Receive configuration record - data record 60 (Page 46) bytes 52 and 53)

An error message is output and the frame is discarded if a message end condition is met before the fixed frame length has been reached.

Response timeout

When data is received, the end of frame is detected on expiration of the configured time between the end of the send operation and the receipt of a frame start. (See Receive configuration record - data record 60 (Page 46) bytes 50 and 51)

An error message is output and the frame is discarded if a message end condition is met before the fixed frame length has been reached.

Expiration of character delay time

When data is received, the frame end is detected when the configured maximum time (bit times) between successive characters is exceeded (character delay time). (See Receive configuration record - data record 60 (Page 46) bytes 54 and 55)

In this case, the character delay time must be set in such a way as to ensure that it expires between two consecutive frames. However, it should be of sufficient length to exclude incorrect identification of the end of the frame whenever the communication partner performs a transmission pause within a frame.

Fixed frame length

When data is received, the end of the frame is identified after the configured frame length has been reached. (See Receive configuration record - data record 60 (Page 46) bytes 40 and 41)

An error message is output and the frame is discarded if the character delay time expires (if activated) before the fixed frame length has been reached.

Please note the following if the frame length of the received characters does not match the fixed configured frame length:

- All characters received after the fixed configured frame length has been reached will be discarded until a new start criterion (e.g. "any character") is detected.
- Receiving is terminated if the character delay time (if activated) expires before the fixed configured frame length has been reached. An error message is generated and the message frame fragment is discarded.
- If a different (activated) end criterion is met before the fixed configured frame length has been reached, this "frame part" is assessed as a valid frame and the partner waits for a new start criterion. All characters received prior to fulfillment of a new start criterion are discarded.

Maximum number of characters

When receiving data, the end of the message frame is recognized after the declared number of characters have arrived. (See Receive configuration record - data record 60 (Page 46) bytes 42 and 43)

This setting can be combined with the "Character delay time" settings. The frame received is also assessed as free of error if another end condition occurs, regardless of whether the maximum number of characters has been reached.

Please note the following if the frame length of the received characters does not match the configured maximum frame length:

- All characters received after the configured maximum number of characters has been reached will be discarded until a new start criterion (e.g. "Idle Line") is detected.
- If a different (activated) end criterion is met before the configured maximum number of characters has been reached, this "frame part" is assessed as a valid frame and the partner waits for a new start criterion. All characters received prior to fulfillment of a new start criterion are discarded.

Note

If no further end criterion is activated, the fixed frame length and maximum number of characters will respond in the same way.

Message length in the message

The length of the receive frame is also sent. When data is received, the frame end is identified after the frame length also sent has been reached. If "After character delay time elapses" is activated as an additional end criterion, receiving will be terminated prematurely. An error message is generated and the message frame fragment is discarded.

The following parameters define the characters to be used for evaluation of the message length:

- **Offset of the length field in the message**

  In the message, the value defines the position of the character that is to be used to determine the message length.

  You can set values from 1 to 4096 characters, depending on the buffer size.

  (See Receive configuration record - data record 60 (Page 46) bytes 44 to 45)

- **Size of the length field**

  This value specifies the number of characters as of the first evaluation position to be used to determine the message length.

  You can set values of 0, 1, 2 and 4 characters.

  (See Receive configuration record - data record 60 (Page 46) bytes 46 to 47)

- **Number of characters not counted in length specification**

  Number of characters appended to the frame without counting towards the frame length. This value defines the number of bytes at the end of the frame which should not be included in the evaluation of the message length.

  You can set values from 0 to 255 characters.

  (See Receive configuration record - data record 60 (Page 46) bytes 48 to 49)

End sequence

When data is received, the end of the frame is identified when the configured end sequence (max. 5 characters) is received. The received data is applied by the CPU, including the end sequence. (See Receive configuration record - data record 60 (Page 46) bytes 56 to 61)

If you are working with the end sequence, transmission is not code-transparent and you must exclude the presence of end code in the user data.

5.3 Code transparency

Code transparency

Code-transparent means that any character combinations can occur in the user data without the end criterion being recognized.

The code transparency of the protocol depends on the selection of the parameterized end criterion and flow control:

- With up to five end delimiters or using XON/XOFF flow control
  - Not code-transparent
- End criterion character delay time, fixed frame length, maximum frame length, message timeout, or response timeout and message length in the message
  - Code-transparent

5.4 Receive buffer

Receive buffer of the module

The receive buffer of the module may have a size of up to 8 KB, depending on the communication module used (see chapter Overview (Page 11)). The maximum frame length always equals half the length of the receive buffer. This means that each communication module is capable of buffering at least two frames.

During parameter assignment, you can specify whether to clear the receive buffer at startup and whether to prevent overwriting of data in the receive buffer. You can also specify the range of values (1 to 255) for the number of buffered receive frames. (See Receive configuration record - data record 60 (Page 46) bytes 62 to 64)

The receive buffer on the communication module is organized as FIFO:

- If several frames are entered in the receive buffer of the communication module, the communication module always sends the oldest frame to the CPU.
- If you always want to transfer the last frame received to the CPU, you must set the value "1" for the number of buffered frames and deactivate overwrite protection.

Note

If continuous reading of the receive data in the user program is interrupted for a certain time and the receive data is then requested again, the communication module will possibly transmit an older frame before the CPU receives the most recent one. At the time of interruption, the old frame had already been transferred from the receive buffer of the communication module and prepared for transmission to the CPU.

5.5 RS232 mode

The following communication modules support RS232 mode:

- CM PtP RS232 BA
- CM PtP RS232 HF
- CM PtP (ET 200SP)

In RS232 mode, data is sent via two lines. A separate line is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

RS232 secondary signals

In addition to the TXD, RXD and GND signals, the communication module provides the following RS232 secondary signals when RS232 hardware is used:

DCD	(input)	Data Carrier detect; Data carrier signal detected
DTR	(output)	Data terminal ready; Module ready for operation
DSR	(input)	Data set ready; Communication partner ready for operation
RTS	(output)	Request to send; Module is ready to send
CTS	(input)	Clear to send; Communication partner can receive data from the module (response to RTS = ON of the communication module)
RI	(input)	Ring Indicator; Ring indicator

After power on of the communication module, the output signals are in the OFF state (inactive).

You can parameterize the operation of the DTR/DSR and RTS/CTS control signals in the configuration data record of the module (Port configuration record - data record 57 (Page 41)).

The RS232 secondary signals cannot be manipulated by data record communication (Set RS232 secondary signals - data record 53 (Page 65)) in case of:

- parameterized data flow control "Hardware RTS always ON"

  (corresponds to automatic operation of the secondary signals)
- parameterized data flow control "Hardware RTS always ON"

  (corresponds to hardware flow control with RTS/CTS)
- parameterized data flow control "Hardware RTS always ON, ignore DTR/DSR "

An error message is generated if an attempt is made to manipulate RS232 secondary signals by means of data record communication.

For more information, refer to chapter Handshaking (Page 33).

5.6 RS422 mode

The following communication modules support RS422 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS422 mode, data is transmitted via two line pairs (four-wire mode). A separate line pair is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

All communication partners must be capable of simultaneous operation of a sender and receiver unit.

The data can be exchanged simultaneously between one or several communication partners. In RS422 multipoint mode, only one multipoint slave may send data at any given time.

Interface operating modes

The following table is a summary of the interface operating modes for the various communication modules and protocols.

The communication module can be used in the following topologies in RS422 mode:

- Link between two nodes: Point-to-point connection
- Link between several nodes: Multipoint coupling
  (only available with CM PtP (ET 200SP))

Operating mode	Description
Full duplex (RS 422) four-wire mode (point-to-point connection)	Both devices have the same priority in this operating mode.
Full duplex (RS422) four-wire mode (multipoint master)	The communication module can be used as multipoint master.
Full duplex (RS 422) four-wire mode (multipoint slave)	The communication module can be used as multipoint slave.

The following applies for a multipoint master/slave topology in RS422 mode:

- The master's sender is interconnected with the receivers of all slaves.
- The slaves' senders are interconnected with the master's receiver.
- The receiver of the master and the receiver of one slave are assigned default settings (refer to chapter Port configuration record - data record 57 (Page 41) byte 25). All other slaves operate without default settings.

5.7 RS485 mode

The following communication modules support RS485 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS485 mode, data is transferred via one line pair (two-wire mode). The line pair is available alternately for the send and receive directions. It is possible to either send or receive (half duplex). On completion of a send operation, operation is immediately switched to receive mode (ready to receive). Send mode is reset again as soon as a new send job is received.

RS485 mode

The following table is a summary of the interface operating modes for the various communication modules and protocols.

Operating mode	Description
Half duplex (RS485) two-wire mode	Operating mode for point-to-point connection or multipoint connection (multipoint) in two-wire mode. The communication module can be the master as well as the slave.

When you operate the Freeport driver in RS485 mode (half duplex, two-wire mode), you must make provisions in the user program to ensure that only one device sends data at any given time. If more than one device sends data at the same time, the frame is corrupted.

Changeover times for RS485 communication module in half duplex mode

A maximum time of 0.1 ms is set for the changeover between sending and receiving.

5.8 Handshaking

Introduction

Handshaking controls the data flow between two communication partners. The use of the handshaking method prevents data loss during transmission if the devices are operating at different speeds.

We can basically distinguish between the following methods:

Table 5- 1 Overview of methods and interfaces

Method	RS232	RS422	RS485
Software data flow control XON/XOFF	X	X	
Hardware data flow control (RTS/CTS)	X		
Automatic operation of secondary signals	X		

Software data flow control

Software data flow control is implemented as follows on the communication module:

- XON/XOFF
  - As soon as the communication module has been set to the "XON/XOFF" operating mode by means of parameter assignment, it sends the XON character, thereby allowing the communication partner to send data.
  - On reaching the configured maximum number of frames, or 16 characters ahead of receive buffer overflow, the communication module sends the XOFF character, thereby requesting that the communication partner stop sending. If the communication partner nonetheless continues to send data, an error message is generated if the receive buffer overflows. Data received in the last frame is discarded.
  - As soon as a frame has been fetched by the CPU and the receive buffer is ready to receive data again, the communication module sends the XON character.
  - If the communication module receives the XOFF character during sending, it cancels the current send operation until it receives a XON again from its communication partner. If no XON is received within a specific configurable time, send operation is canceled and a corresponding error message is output.

Note

You can configure the characters for XON and XOFF (any ASCII character).

During parameter assignment of the XON/XOFF software data flow control, user data may not contain any of the configured XON or XOFF characters.

Hardware data flow control

Note

The DTR/DSR signals do not have to be wired for "Hardware RTS always ON, ignore DTR/DSR" parameter assignment.

If "Hardware RTS always ON" is configured, it is imperative that you fully wire the interface signals used. Make sure that the local RTS (out) is connected with the CTS (in) of the communication partner and the local CTS is connected with the RTS of the communication partner. Accordingly, the local DTR must be connected with the DSR of the communication partner and the local DSR with the DTR of the communication partner.

- **Hardware RTS always ON, ignore DTR/DSR**
  - As soon as the communication module has been set to an operating mode with "Hardware RTS always ON" through parameter assignment, it outputs the RTS = ON signal to the communication partner to indicate its ready state.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
- **Hardware RTS always ON**

  The "Hardware RTS always ON" mode corresponds to the "Hardware RTS always ON, ignore DTR/DSR" mode. However, you also need to wire DTR and DSR.
  - As soon as the communication module has been set set to an operating mode with "Hardware RTS always ON" through parameter assignment, it sets DTR = ON and RTS = ON to signal its general ready state to the communication partner.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
  - A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

Automatic operation of secondary signals

- **Hardware RTS always switched**

  "Hardware RTS always switched" is implemented as follows on the communication module:

  – As soon as the communication module is set to the operating mode with "Hardware RTS always switched" through parameter assignment, it sets the line RTS to OFF and DTR to ON (communication module ready for operation).

    It is not possible to send frames until the DSR line is set to ON. No data is sent via the RS232C interface as long as DSR is set to OFF. A send job is canceled and a corresponding error message is generated.

  – If a send job is pending, RTS is set to ON and the configured data output wait time starts. On expiration of the data output time, the system checks whether the communication partner has set CTS to ON. If so, the data is sent via the RS232 interface.

  – If the CTS line is not set to ON within the data output time, or changes to OFF during the send operation, the send job is aborted and an error message generated.

  – Once the data has been sent and the configured clear RTS time has elapsed, the RTS line is set to OFF. The system does not wait for CTS to change to OFF.

  – It is always possible to receive data via the RS232 interface. There will be no reaction if there is a danger of the receive buffer of the communication module overflowing.

  – A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

  Note

  Set the "data output wait time" in such a way that the communication partner is able to enter the ready to receive state before the time elapses.

  Set the "Clear RTS time" in such a way that the communication partner is able to receive the last characters of the frame completely before RTS is set to OFF and the send request is canceled.

Additional information

For information on the settings, refer to chapter Port configuration record - data record 57 (Page 49).

Note

Operation of DTR/DSR or RTS/CTS is accepted by the communication module with the following settings. Operation by means of Set RS232 secondary signals - data record 53 (Page 65) is impossible (any attempt made will trigger an error message):

- Hardware RTS always ON, ignore DTR/DSR
- Hardware RTS always ON
- Hardware RTS always switched

Data transmission with 3964(R) 6

6.1 Data transmission with 3964(R) protocol

Introduction

The 3964(R) protocol controls PtP data exchange between the communication module and a communication partner. The 3964(R) protocol contains both the physical layer (layer 1) and the link layer (layer 2).

6.2 Control characters

Introduction

During data transmission, the 3964(R) protocol adds control characters to the information data (link layer). The communication partner can use these control characters to check whether it has received all data completely and without errors.

Control characters of the 3964(R) protocol

The 3964(R) protocol evaluates the following control characters:

- **STX** Start of Text; start of the string to be sent
- **DLE** Data Link Escape
- **ETX** End of Text; end of the string to be sent
- **BCC** Block Check Character (only with 3964R)
- **NAK** Negative Acknowledge; negative response

Note

If the DLE character is transferred as an information character, it is sent twice during connection setup and shutdown (DLE duplication) in order to distinguish it from the DLE control character. The receiver reverses the DLE duplication.

Priority

For operation with 3964(R) protocol, one communication partner must be assigned a higher priority and one communication partner a lower priority. If both partners simultaneously start the connection setup, the partner having lower priority will postpone its send job.

6.3 Block checksum

Block checksum

With the 3964R transfer protocol, data security is enhanced by sending an additional block check character (BCC = Block Check Character).

The block checksum represents the even longitudinal parity (EXOR logic operation of all data bytes) of a sent or received block. Its calculation begins with the first byte of user data (first byte of the frame) after the connection establishment, and ends after the DLE ETX character at connection termination.

Note

With DLE duplication, the DLE character is included twice in the BCC calculation.

6.4 Sending data with 3964(R)

Connection setup for sending

The 3964(R) protocol sends the STX control character to set up the connection. The transition to send mode is initiated when the communication partner responds with the DLE character before the ACK delay time has expired.

The protocol retries to connect if the communication partner responds with NAK or any other character (except DLE or STX), or if inactivity triggers an acknowledgment timeout. After the parameterized number of unsuccessful retries to connect, the connection setup is canceled and the NAK character is transmitted to the communication partner. The communication module outputs a corresponding error message.

Sending data

On successful connection setup, the user data from the output buffer of the communication module and the selected transmission parameters are sent to the communication partner. The partner monitors the time intervals between incoming characters. The interval between two characters must not exceed the character delay time. Monitoring of the character delay time starts immediately after the connection was set up.

If the communication partner transmits an NAK while a transmission is busy, the block transmission is aborted and repeated as shown above starting with the connection setup. If any other character is received, a wait time for expiration of the character delay time is triggered and an NAK is then transmitted to set the communication partner to idle state. Transmission is then restarted with STX connection setup.

Connection shutdown during transmission

After the buffer content has been transmitted, the routine inserts the DLE, ETX characters, appends the BCC block checksum (only for 3964R) and waits for an ACK character. If the communication partner sends the DLE characters within the acknowledgment delay time, the data block has been received without errors. If the communication partner responds with NAK, or any other character (except DLE), or with a corrupt character, or if the acknowledgment delay time expires without response, the routine restarts transmission with STX connection setup.

After the parameterized number of retries to connect, the routine is aborted and NAK is transmitted to the communication partner. The communication module outputs a corresponding error message.

6.5 Receiving data with 3964(R)

Connection setup for receiving

While in idle state and not processing a send job, the module waits for the communication partner to set up the connection.

A wait time is started (wait time = acknowledgment delay time - 10 ms, however, maximum of 400 ms) if no free receive buffer is available during the connection setup with STX. An error message is generated if no free receive buffer is available on expiration of this time. An NAK is transmitted and initiates the transition to idle state. Otherwise, the DLE character is transmitted and the data is received as described above.

The acknowledgment delay time should be set to the same value at both communication partners.

If any character (except for STX or NAK) is received in idle state, the routine waits for expiration of the character delay time (CDT) and then transmits the NAK character. The communication module outputs a corresponding error message.

Receiving data

After successful connection setup, the incoming receive characters are saved to the receive buffer. If two consecutive DLE characters are received, only one of these is saved to the receive buffer.

After connection setup and after each receive character, the routine waits for the next character within the character delay time. If this period expires before another character is received, an NAK is sent to the communication partner. The communication module outputs a corresponding error message. A retry is then expected.

If transfer errors occur during receiving (lost character, frame error, parity error, etc.), the procedure continues to receive data until the connection is terminated and then sends an NAK to the communication partner. A retry is then expected. Receiving is aborted if the block cannot be received without errors after the specified number of transmission retries, or if the communication partner fails to retry transmission within a block delay time of 4 seconds. The communication module reports the first corrupted transfer and the final cancelation.

Connection setup for receiving

Once the DLE ETX string is detected, receiving is terminated and DLE is transmitted to the communication partner for a block that was received without error. In the case of a receive error, an NAK is sent to the communication partner. A retry is then expected.

Receiving is stopped once the DLE ETX BCC string is detected. The BCC is compared with the internally generated longitudinal parity. DLE is transmitted (return to idle state) if the BCC is correct and no other receive error is pending. If the BCC is faulty or a different receive error occurs, an NAK is sent to the communication partner. A retry is then expected.

Configuration data records

7

7.1 Freeport communication

The following three configuration data records must be sent to the communication module for Freeport communication.

7.1.1 Port configuration record - data record 57

Note

Parameter assignment error

If the communication module detects a parameter assignment error when writing the "Port Configuration Record - data record 57", the data record is rejected with error status 0x80E1.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the port configuration).

Port configuration *Italic* = not supported								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0039H – PORT_CFG							
1								
2	Block length: 0018H							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
°	Protocol:							
8	0000H – Freeport protocol							
9	0001H – 3964 protocol							
	0002H to FFFFH – Reserved							

Port configuration *Italic* = not supported			
°	Data transmission rate:		
10	*0000H - Reserved*	0007H - 19.2 kbps	
11	0001H - 300 bps	0008H - 38.4 kbps	
	0002H - 600 bps	0009H - 57.6 kbps	
	0003H - 1.2 kbps	000AH - 76.8 kbps	
	0004H - 2.4 kbps	000BH - 115.2 kbps	
	0005H - 4.8 kbps	*000CH to FFFFH - Reserved*	
	0006H - 9.6 kbps		
°	Parity:		
12	*0000H - Reserved*		
13	0001H - None		
	0002H - Even		
	0003H - Odd		
	0004H - Mark (set parity bit to 1)		
	0005H - Space (set parity bit to 0)		
	0006H - Any (the parity is not checked during receiving. The parity is always set to "0" during sending.)		
	0007H to FFFFH - Reserved		
°	Data bits:		
14	*0000H - Reserved*		
15	0001H - 8 data bits per character		
	0002H - 7 data bits per character		
	0003H to FFFFH - Reserved		
°	Stop bits:		
16	*0000H - Reserved*		
17	0001H - 1 stop bit		
	0002H - 2 stop bits		
	0003H to FFFFH - Reserved		
°	Data flow control:		
18	RS232 settings:	RS485 settings:	RS422 settings:
19	*0000H - Reserved*	*0000H - Reserved*	*0000H - Reserved*
	0001H - None	0001H - None	0001H - None
	0002H - XON/XOFF	*0002H to FFFFH - Reserved*	0002H - XON/XOFF
	0003H - Hardware RTS always ON, DSR required		*0003H to FFFFH - Reserved*
	0004H - Hardware RTS always switched, DSR required		
	0005H - Hardware RTS always ON, ignore DTR/DSR		
	0006H to FFFFH - Reserved		

Port configuration *Italic* = not supported	
20	XON: 00H to FFH - XON character
21	XOFF: 00H to FFH - XOFF character
22	Wait for XON after XOFF in ms: (0000H to FFFFH)
23	
24	Operating mode:
	00H - RS232 01H - RS422 full duplex four-wire mode (point-to-point) 02H - RS422 full duplex (RS422) four-wire mode (multipoint master) (CM PtP (ET 200SP)) 03H - Full duplex (RS422) four-wire mode (multipoint slave) (CM PtP (ET 200SP)) 04H - Half duplex (RS485) two-wire mode *05H to FFH - Reserved*
25	Receive line default:
	00H - "No" default 01H - Signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this default setting. Can only be selected with: "Full duplex (RS 422) four-wire mode (point-to-point connection)" and "Full duplex (RS 422) four-wire mode (multipoint slave)". 02H - Signal R(A)=0 V, signal R(B)=5 V: This default corresponds to the idle state (no active send operation). No break detection is possible with this default setting. *03H to FFH - Reserved*
26	Break detection:
	00H - Break detection deactivated 01H - Break detection activated *02H to FFH - Reserved*
27	*Reserved: 00H*

7.1.2 Send configuration record - data record 59

Note

Parameter assignment error

If the communication module detects a parameter assignment error when writing the "Send Configuration Record - data record 59", the data record is rejected with error status 0x80E1.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the send configuration).

Send configuration *Italic* = not supported								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type 003BH - SEND_CFG							
1								
2	Block length: 001CH							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
8	RTS ON delay in 1 ms: (0000H - FFFFH)							
9	(not available for RS422/485 modules)							
10	RTS OFF delay in 1 ms: (0000H - FFFFH)							
11	(not available for RS422/485 modules)							
12	Break duration in bit times: (0000H to FFFFH)							
13								
14	Idle Line duration in bit times: (0000H to FFFFH)							
15								
°	Settings:							
16	Reserved: 0000H							
17								
°	USR_END							
18	STRING[2,0,xx,yy] - No end delimiter							
19	STRING[2,1,xx,yy] - One end delimiter							
20	STRING[2,2,xx,yy] - Two end delimiters							
21	Note: The first character (2; byte 18) contains the maximum string length, the second character (0, 1, 2, byte 19) the actual string length, and xx (byte 20) and yy (byte 21) contain the characters.							

Send configuration *Italic* = not supported	
°	APP_END
22	STRING[5,0,aa,bb,cc,dd,ee] - No appended characters (default)
23	STRING[5,1,aa,bb,cc,dd,ee] - One appended character
24	STRING[5,2,aa,bb,cc,dd,ee] - Two appended characters
25	STRING[5,3,aa,bb,cc,dd,ee] - Three appended characters
26	STRING[5,4,aa,bb,cc,dd,ee] - Four appended characters
27	STRING[5,5,aa,bb,cc,dd,ee] - Five appended characters
28	Note: The first character (5; byte 22) contains the maximum string length, the second character (0, 1, 2, 3, 4, 5; byte 23) the actual string length, and aa to ee (bytes 24-28) contain the characters.
29	*Reserved: 00H*
30	*Reserved: 00H*
31	*Reserved: 00H*

7.1.3 Receive configuration record - data record 60

Note

Parameter assignment error

If the communication module detects a parameter assignment error when writing the "Receive Configuration Record - data record 60", the data record is rejected with error status 0x80E1.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the receive configuration).

Receive configuration ***Italic*** **= not supported**								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 003CH - RCV_CFG							
1								
2	Block length: 0040H							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
°	Start conditions:							
8	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved
9	Seq. #4 Rcv. Active. 0 - inactive. 1 - activated	Seq. #3 Rcv. Active. 0 - inactive. 1 - activated	Seq. #2 Rcv. Active. 0 - inactive. 1 - activated	Seq. #1 Rcv. Active. 0 - inactive. 1 - activated	Idle Line Rcv. Active. 0 - inactive. 1 - activated	Break Rcv. Active. 0 - inactive. 1 - activated	Used char. Rcv. Active. 0 - inactive. 1 - activated	Start char. Rcv. Active. 0 - inactive. 1 - activated
10	Idle Line duration in bit times: 0000H to FFFFH							
11								
12	Start characters: 00H to FFH							
°	Frame start sequence #1 character check							
13	0 Reserved	0 Reserved	0 Reserved	Char #5 Ac 0 - inactive. 1 - activated	Char #4 Ac 0 - inactive. 1 - activated	Char #3 Ac 0 - inactive. 1 - activated	Char #2 Ac 0 - inactive. 1 - activated	Char #1 Ac 0 - inactive. 1 - activated
14	Character #1: 00H to FFH							
15	Character #2: 00H to FFH							
16	Character #3: 00H to FFH							
17	Character #4: 00H to FFH							
18	Character #5: 00H to FFH							

Receive configuration *Italic* = not supported								
°	Frame start sequence #2 character check							
19	0 Reserved	0 Reserved	0 Reserved	Char #5 Ac 0 – inactive. 1 – activated	Char #4 Ac 0 – inactive. 1 – activated	Char #3 Ac 0 – inactive. 1 – activated	Char #2 Ac 0 – inactive. 1 – activated	Char #1 Ac 0 – inactive. 1 – activated
20	Character #1: 00H to FFH							
21	Character #2: 00H to FFH							
22	Character #3: 00H to FFH							
23	Character #4: 00H to FFH							
24	Character #5: 00H to FFH							
°	Frame start sequence #3 character check							
25	0 Reserved	0 Reserved	0 Reserved	Char #5 Ac 0 – inactive. 1 – activated	Char #4 Ac 0 – inactive. 1 – activated	Char #3 Ac 0 – inactive. 1 – activated	Char #2 Ac 0 – inactive. 1 – activated	Char #1 Ac 0 – inactive. 1 – activated
26	Character #1: 00H to FFH							
27	Character #2: 00H to FFH							
28	Character #3: 00H to FFH							
29	Character #4: 00H to FFH							
30	Character #5: 00H to FFH							
°	Frame start sequence #4 character check							
31	0 Reserved	0 Reserved	0 Reserved	Char #5 Ac 0 – inactive. 1 – activated	Char #4 Ac 0 – inactive. 1 – activated	Char #3 Ac 0 – inactive. 1 – activated	Char #2 Ac 0 – inactive. 1 – activated	Char #1 Ac 0 – inactive. 1 – activated
32	Character #1: 00H to FFH							
33	Character #2: 00H to FFH							
34	Character #3: 00H to FFH							
35	Character #4: 00H to FFH							
36	Character #5: 00H to FFH							
37	must always be 00H							
°	End conditions:							
38	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved	0 Reserved
39	0 Reserved	Fixed length Rcv. Active. 0 – inactive. 1 – activated	Seq. #1 Rcv. Active. 0 – inactive. 1 – activated	Read length Rcv. Active. 0 – inactive. 1 – activated	Max length Rcv. Active. 0 – inactive. 1 – activated	CDT Rcv. Active. 0 – inactive. 1 – activated	Mess. TO Rcv. Active. 0 – inactive. 1 – activated	Resp. TO Rcv. Active. 0 – inactive. 1 – activated

Receive configuration *Italic* = not supported								
40 41	Fixed frame length: 0001H to 0xxxH*							
42 43	Maximum frame length: 0001H to 0xxxH*							
44 45	Offset of the length field in the message: 0000H to 0xxx*							
46 47	Size of the length field: 01H, 02H, 04H - all other values are invalid							
48 49	Number of characters not counted in length specification: 00H to FFH							
50 51	Response timeout in 1ms: 0000H to FFFFH							
52 53	Message timeout in 1 ms: 0000H to FFFFH							
54 55	Character delay time in bit times: 0000H to FFFFH							
°	End sequence #1 character check							
56	0 Reserved	0 Reserved	0 Reserved	Char #5 Ac 0 - inactive. 1 - activated	Char #4 Ac 0 - inactive. 1 - activated	Char #3 Ac 0 - inactive. 1 - activated	Char #2 Ac 0 - inactive. 1 - activated	Char #1 Ac 0 - inactive. 1 - activated
57	Character #1: 00H to FFH							
58	Character #2: 00H to FFH							
59	Character #3: 00H to FFH							
60	Character #4: 00H to FFH							
61	Character #5: 00H to FFH							
°	Buffered receive frames:							
62	00H - Reserved 01H to FEH - 1 to 254 FFH - 255							
°	Prevent overwriting:							
63	00H - Deactivated (on receive buffer overflow, a new message overwrites the oldest message) 01H - Activated (if the receive buffer is full, the new message is discarded) *02H to FFH - Reserved*							
°	Clear receive buffer at startup:							
64	00H - Deactivated 01H - Activated *02H to FFH - Reserved*							
65	*Reserved: 00H*							
66	*Reserved: 00H*							
67	*Reserved: 00H*							

* the buffer size depends on the communication module used

7.2 3964 communication

The following two configuration data records must be transferred to the communication module for 3964 communication:

7.2.1 Port configuration record - data record 57

Note

The "Port configuration record" is described in chapter Port configuration record - data record 57 (Page 41).

7.2.2 3964 protocol configuration - data record 61

Note

Parameter assignment error

If the communication module detects a parameter assignment error when writing the "3964 Protocol Configuration - data record 61", the data record is rejected with error status 0x80E1.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the 3964 protocol).

3964 protocol configuration ***Italic* = not supported**								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 003DH - P3964							
1								
2	Block length: 000CH							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
8	3964(R) - With block check:							
	00H - Deactivated 01H - Activated *02H to FFH - Reserved*							

3964 protocol configuration *Italic* = not supported	
9	3964(R) priority:
	00H - low priority 01H - high priority *02H to FFH - Reserved*
°	3964(R) character delay time:
10	*0000H to 0013H - Reserved*
11	0014H to FFFFH - 20 to 65535 ms Default: 00DCH - 220 ms
°	3964(R) acknowledgment delay time:
12	*0000H to 0013H - Reserved*
13	0014H to FFFFH - 20 to 65535 ms Default: 07D0H - 2000 ms
14	3964(R) connection attempts:
	00H - Reserved 01H to FFH - 1 to 255 connection attempts Default: 06H - 6 connection attempts
15	3964(R) transmission attempts:
	00H - Reserved 01H to FFH - 1 to 255 connection attempts Default: 06H - 6 transmission attempts

7.3 Activate special function

The following data record can be used to activate diagnostic interrupts (write) and check whether diagnostic interrupts are activated (read).

Note

Parameter assignment error

If the communication module detects a parameter assignment error when writing the "Activate special function - data record 58", the data record is rejected with error status 0x80E1.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the special functions).

PtP SET_FTRS (write record 003AH) *Italic* = not supported								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 003AH - SET_FTRS							
1								
2	Block length: 0008H							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
8	Reserved: 0000H							
9	Diagnostic interrupt							
	00H - Deactivated 01H - Activated *02H to FFH* - Reserved							
10	*Reserved: 00H*							
11	*Reserved: 00H*							

Error status

8

The following data record contains the acknowledgment of the communication module to the writing a configuration data record.

8.1 Read error status - data record 55

PtP RD_ESTAT (read record 0037H)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0037H - RD_ESTAT							
1								
2	Block length: 0010H							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
8	Error codes of the special functions *							
9								
10	Error codes of the port configuration *							
11								
12	Error codes of the send configuration *							
13								
14	Error codes of the receive configuration *							
15								
16	Error codes of the RS32 secondary signals *							
17								
18	Error codes of the 3964 protocol *							
19								

* A list of all error codes is available in chapter Error messages (Page 67).

Sending data

9

9.1 Send data - data record 48

The following data record is used to write send data to the communication module:

SEND_PTP record (write record 0030H)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Sequence number for SEND (0 to 255)							
1	Frame end identifier (0 or 1)							
2	Data to transmit byte 0							
:	:							
:	:							

Sequence number for SEND

The "Sequence number for SEND" parameter identifies a new send frame, or a new data record of a frame. The "SEND acknowledgment from module" (refer to chapter "Querying send acknowledgment - input user data (Page 57)") must be read as first "Sequence number for SEND" and incremented by the count of one. For the first data record, the "Sequence number for SEND" therefore starts with 1 after a STOP/RUN transition of the CPU and is then incremented by one for each data record with new content.

The value "0" may not be used as "Sequence number for SEND". as it serves to detect the start of the module. The value is reset to 1 again after 255 has been reached.

Frame end identifier

The "Frame end identifier" parameter serves to identify the last data record belonging to a frame.

- The value 0 means that at least one more data record follows for the current frame.
- The value 1 means that this data record is the last one for the current frame.

Data to transmit byte 0

The data must be stored in the data record as of "Data to transmit byte 0". The size and therefore the number of data records for transmitting a frame is defined by the transmission medium, for example, 240 bytes with PROFIBUS.

If the length of the data to transmit is not a multiple of the data record length, the length of the last data record corresponds to the length of the remaining data to transmit.

Send acknowledgment from module

The module writes the "Sequence number" received in the data record as send acknowledgment to the user data. See "SEND acknowledgment from module", chapter "Querying send acknowledgment - input user data (Page 57)".

For the last data record belonging to a frame,the acknowledgment is not written until the module has sent the frame.

This means that the "SEND acknowledgment from module" must be evaluated along with the "SEND status" after the last data record was written.

Startup characteristics

At startup, the module writes a zero value to "SEND acknowledgment from module" (see chapter "Querying send acknowledgment - input user data (Page 57)"

A busy job must be aborted if "SEND acknowledgment from module" equals zero.

9.2 Querying send acknowledgment - input user data

The communication module enters the send acknowledgment in the user data that has the following structure:

Input process image structure ***Italic* = not supported**								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	SGN_STAT 0 - no status 1 - Status valid	Reserved = 0	Ring_Status	DCD_Status	CTS_Status	RTS_Status	DSR_Status	DTR_Status
1	SEND acknowledgment from module							
2	SEND status *							
3								
4	Sequence number for RCV							
5	*Reserved: 00H*							
6	*Reserved: 00H*							
7	*Reserved: 00H*							

* A list of all status and error codes is available in chapter Error messages (Page 67)

You can read status information as well as error numbers (value unequal to 0) from "SEND Status".

If "SEND acknowledgment from module" equals the number transferred in the last data record ("Sequence number for SEND") and the "SEND Status" equals 0, the frame or data record was transmitted without errors.

It is necessary to wait for this communication module feedback, which means "SEND Status" is equal to an error code, or "SEND acknowledgment from module" equals "Sequence number for SEND" and "SEND Status" equals zero, before a new frame is transmitted.

Reaction of the module to an unexpected sequence number for SEND

The module rejects a data record with an unexpected sequence number for SEND when writing the data record and returns error message 0x80B8. The code 0x81D7 is then stored in "SEND status or error code" in the user data. In this case, active communication must be canceled and transmission must be repeated with the first data record. Set the sequence number for SEND as described in chapter Send data - data record 48 (Page 55).

9.3 Example

A frame with a length of 500 bytes is to be transmitted. The data record has a length of 240 bytes.

- First data record, length of 240 bytes:

  "Sequence number for SEND" = 1

  "Frame end identifier" = 0

  238 bytes user data

- Second data record, length of 240 bytes:

  "Sequence number for SEND" = 2

  "Frame end identifier" = 0

  238 bytes user data

- Third data record, length of 26 bytes

  "Sequence number for SEND" = 3

  "Frame end identifier" = 1

  24 bytes user data

- Wait for feedback from the communication module; see Querying send acknowledgment - input user data (Page 57).

Afterwards, a frame with a length of 100 bytes is to be transmitted.

- First = last data record, length of 102 bytes:

  "Sequence number for SEND" = 4

  "Frame end identifier" = 1

  100 bytes user data

- Wait for feedback from the communication module; see Querying send acknowledgment - input user data (Page 57).

Receiving data

10

10.1 Data received - data record 49/50

A new value at "Sequence number for RCV" (Query: New receive frame - input user data (Page 61)) indicates a new frame is ready for reading in the communication module.

The following data records are used to read receive data from the communication module:

RCV_PTP record (read record 0031H/0032H)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Sequence number for this data record (1 to 255)							
1	Frame end identifier (0 or 1)							
2	RCV status *							
3								
4	Receive data byte 0							
:	:							
:	:							

* A list of all status and error codes is available in chapter Error messages (Page 67)

Change of the data record number when receiving data

After startup of the communication module, reading of the frame content must start at data record number 16#0031, while the data record numbers change between 16#0032 and 16#0031 in all subsequent read operations.

Sequence number of this data record

For the first data record of a frame, the "Sequence number of this data record" is equal to the "Sequence number for RCV" in the user data that indicated the new frame. This value is incremented by the count of one for each data record read subsequently. An overflow to 2 is triggered at 255. The values 0 and 1 have a special significance (see below).

Frame end identifier

The "Frame end identifier" is equal to 1 for the last data record that has to be read for this frame, while it is 0 for all other data records.

The size of the last data record that belongs to a frame is determined by the frame length and limited accordingly by the communication module.

RCV status

"RCV Status" displays the result of the last data reception.

0x009x: Frame received without error

0x8xxx: Frame received with error

See chapter Error messages (Page 67).

Resetting communication after power on of the communication module

- "Sequence number for RCV" is equal to 0

  A "Sequence number for RCV" with value 0 in the input user data indicates that the communication module has performed a restart after power on and that no frame has been received yet.

- "Sequence number for RCV" is equal to 1

  A "Sequence number for RCV" with value 1 in the input user data indicates that this is the first frame after power on of the communication module.

A busy job must be aborted in both cases.

In the second case, reading of the frame content must start at data record number 16#0031.

10.2 Query: New receive frame - input user data

Sequence number for RCV

A new received frame is indicated by a "Sequence number for RCV" in byte 4 of the user data that has the following structure.

Input process image structure ***Italic* = not supported**								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	SGN_STAT 0 - no status 1 - Status valid	Reserved = 0	Ring_Status	DCD_Status	CTS_Status	RTS_Status	DSR_Status	DTR_Status
1	Sequence number from module							
2	SEND status *							
3								
4	Sequence number for RCV							
5	*Reserved: 00H*							
6	*Reserved: 00H*							
7	*Reserved: 00H*							

* A list of all status and error codes is available in chapter Error messages (Page 67)

10.3 Example

A frame with a length of 500 bytes was received. The data record has a length of 240 bytes

- In the user data, the frame is indicated by "Sequence number for RCV" = 1.
- Read data record 16#0031 that contains:

  "Sequence number of this record" = 1

  "Frame end identifier" = 0

  "RCV status or error code return value" = 0x009x [1)]

  It contains 236 bytes of user data.
- Read the second data record 16#0032 that contains:

  "Sequence number of this data record" = 2

  "Frame end identifier" = 0

  "RCV status or error code" = 0x009x [1)]

  It contains 236 bytes of user data.
- Read the third data record 16#0031 that contains:

  "Sequence number of this data record" = 3

  "Frame end identifier" = 1

  "RCV status or error code" = 0x009x [1)]

  It contains 28 bytes of user data. The communication module has limited the data record length to 32 bytes.

  This completes reading of the first frame from the CM.

A frame with a length of 100 bytes was received subsequently.

The sequence number for RCV changes from 1 to 4 in the user data.

- Read the data record 16#0032 that contains:

  "Sequence number of this data record" = 4

  "Frame end identifier" = 1

  "RCV status or error code" = 0x009x [1)]

  The data record contains 100 bytes of user data and the communication module has limited the data record length to 104 bytes.

1) 0x009x Frame received without error
   0x8xxx Frame received with error
   (see error codes in chapter Query: New receive frame - input user data (Page 61))

Clear receive buffer

11

11.1 Clear receive buffer - data record 54

The receive buffer of the communication module is cleared by writing the following data record with "RST_RCV_BUF" = TRUE.

PtP RCV_RST(write record 0036H) *Italic* = not supported								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0036H - RCV_RST							
1								
2	Block length: 0008H							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
8	0	0	0	0	0	0	0	RST_RCV_BUF
9	*Reserved: 00H*							
10	*Reserved: 00H*							
11	*Reserved: 00H*							

Note: RST_RCV_BUF = 0; no changes are made to the receive buffer.
RST_RCV_BUF = 1; the receive buffer is cleared.

The communication module does not acknowledge the reset of its receive buffer.

RS232 signals

12

12.1 Set RS232 secondary signals - data record 53

The RS232 secondary signals of the communication module are manipulated by writing to the following data record, provided the communication module supports this action in the current mode.

Note

Parameter assignment error

If the communication module detects a parameter assignment error when writing the "Set RS232 secondary signals - data record 53", the data record is rejected with error status 0x80E1.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the RS232 secondary signals).

PtP SGN_SET(write record 0035H) *Italic* = not supported								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0035H - SGN_SET							
1								
2	Block length: 0008H							
3								
4	Block version high byte: 01H							
5	Block version low byte: 00H							
6	Reserved: 0000H							
7								
8	0	0	0	0	0	0	Set_DTR_State	Set_RTS_State
9	0	0	0	0	0	0	DTR_State	RTS_State
10	*Reserved: 00H*							
11	*Reserved: 00H*							

Note: Set_xxx_State = 0, the status of the specified control bit is not changed. Set_xxx_State = 1, the status of the specified control bit must be set to the value that was specified by xxx_State.

For information on reading the acknowledgment to the writing of this data record, refer to chapter "Error status (Page 53) ".

12.2 Read RS232 secondary signals - input user data

The RS232 secondary signals of the communication module can be read from the user data.

Input process image structure *Italic* = not supported								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	SGN_STAT 0 - no status 1 - Status valid	Reserved = 0	Ring_Status	DCD_Status	CTS_Status	RTS_Status	DSR_Status	DTR_Status
1	Sequence number for SEND (acknowledgment from module)							
2	SEND status or error code *							
3								
4	Sequence number for RCV							
5	*Reserved: 00H*							
6	*Reserved: 00H*							
7	*Reserved: 00H*							

* A list of all error codes is available in chapter Error messages (Page 67)

SGN_STAT = 0 indicates that no RS232 secondary signals are available in the current operating mode of the communication module.

Error messages

13

Overview of error messages

Error code	Description	Remedy
0x0000	No error	-
RECEIVE status and error codes		
0x0094	Frame end identified based on the "Receipt of fixed/maximum frame length"	-
0x0095	Frame end identified based on "Message timeout"	-
0x0096	Frame end identified based on expiration of the "Character delay time"	-
0x0097	No response frame was received within the parameterized maximum response time.	-
0x0098	Frame end identified based on the fulfillment of the "Read message length from message" conditions	-
0x0099	Frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
0x7000	Block idle	-
0x7001	Initial call for a new frame: Data record transmission initiated	-
0x7002	Interim call: Data record transmission in process	-
0x8085	Invalid length specification	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
0x8088	The specified length exceeds the range set in the receive buffer	Change the range in the receive buffer or select a frame length which corresponds to the range set in the receive buffer. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
Error codes of the special functions		
0x8190	Incorrect setting of the CRC calculation	Select a suitable value for CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
0x8191	Incorrect setting of the diagnostic interrupt	Select a suitable value for "Diagnostic interrupt". The following are valid: Diagnostic interrupt deactivated (0) or diagnostic interrupt activated (1). Check whether the module addressed supports the generation of diagnostic interrupts.

Error code	Description	Remedy
Error codes of the "Port configuration"		
0x81A0	The module does not support this protocol.	Select a valid protocol for the module.
0x81A1	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.
0x81A2	The module does not support this parity setting.	Select a suitable value for "Parity". The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
0x81A3	The module does not support this number of data bits.	Select a suitable value for "Number of data bits". The following are valid: • 7 (2) • 8 (1)
0x81A4	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits". The following are valid: • 1 (1) • 2 (2)
0x81A5	The module does not support this type of data flow control.	Select a valid data flow control for the module.
0x81A7	Invalid value for XON or XOFF	Select suitable values for XON and XOFF. Valid range of values: 0 - FF.
0x81A8	Error in frame header	Check the data/values in the frame header.
0x81AA	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) • Full duplex (RS422) four-wire mode (multipoint master) (2) / (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint slave) (3) / (CM PtP (ET 200SP)) • Half duplex (RS485) two-wire mode (4)

Error code	Description	Remedy
0x81AB	Invalid default setting of the receive line	Valid default settings are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default corresponds to the idle state (no active send operation). No break detection is possible with this default setting.
0x81AC	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • "0" (break detection deactivated) • "1" (break detection activated)
0x81AF	The module does not support this protocol.	Select a valid protocol for the module.
Error codes of the "Send configuration"		
0x81B5	More than two end delimiters or end sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
0x81B6	Send configuration rejected because the 3964(R) protocol was selected	Verify that no send configuration is transmitted if the 3964R) protocol is set.
Error codes of the "Receive configuration"		
0x81C0	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
0x81C1	Invalid end condition or no end condition selected	Select a suitable end condition.
0x81C3	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length". Valid range of values (module-dependent): 1-1024/2048/4096 (Byte)
0x81C4	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (module-dependent): 1-1024/2048/4096 (Byte)

Error code	Description	Remedy
0x81C5	Invalid value for "Size of length field"	Select a suitable value for "Size of length field". Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)
0x81C6	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification". Valid range of values: 0 to 255 (bytes)
0x81C7	The total of "Offset in the message + size of the length field + number of character not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of the length field" and "Number of characters not counted". Valid range of values: • Offset in the message (module-dependent): 0-1022/2046/4094 (Byte) • Size of the length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0-255 (bytes)
0x81C8	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
0x81C9	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1-65535 (bit times)
0x81CB	Frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
0x81CC	Frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
0x81CD	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
0x81CE	Invalid value for "Clear receive buffer at startup"	Select a suitable value for "Clear receive buffer at startup". The following are valid: • Clear receive buffer at startup is deactivated (0) • Clear receive buffer at startup is activated (1)

Error code	Description	Remedy
SEND status and error codes		
0x81D0	Receiving send requests during runtime of a send job	Make sure that you do not receive send requests during runtime of a send job.
0x81D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or, if necessary, change the parameter assignment.
0x81D2	"Hardware RTS always ON": Send command aborted due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ONfor the entire duration of transmission.
0x81D3	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
0x81D5	Transmission aborted due to parameter changes, detected wire break, or because CPU in STOP	Check the parameter assignment, for wire break, and the CPU status.
0x81D6	Transmission canceled because end identifier was not received	Check the parameter assignment of the end delimiters and the frame of the communication partner.
0x81D7	Communication error between the user program and module	Check communication (e.g. consistency of the sequence number).
0x81D8	Transmission attempt rejected because module is not configured	Configure the module.
Error codes of the receive configuration		
0x81E0	Frame canceled: Send buffer overflow / send frame too long	Increase the call rate for the receive function in the user program, or parameterize communication with data flow control.
0x81E1	Frame canceled: Parity error	Check the connection line of the communication partners, or verify that both devices are configured for the same data transmission rate, parity and stop bit number.
0x81E2	Frame canceled: Character frame error	Check the settings for the start bit, data bits, parity bit, data transmission rate, and stop bit(s).
0x81E3	Frame canceled: Character overflow error	Firmware error: Contact Customer Support.
0x81E4	Frame canceled: The total length of "Offset in the message + size of the length field + number of character not counted" is greater than the receive buffer	Select a suitable value for Offset in message, Size of the length field, and Number of characters not counted.
0x81E5	Frame canceled: Break	Receive line to partner is interrupted. Reconnect or switch on partner.
0x81E6	Maximum number of "Buffered receive frames" exceeded	In the user program, increase the call rate of the instruction, or parameterize communication with data flow control, or increase the number of buffered frames.
0x81E8	Frame canceled: The character delay time has expired before the message and criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.

Error code	Description	Remedy
0x81EB	Frame canceled: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (Byte) Check the parameters of the frame end detection.
Error codes of RS232 secondary signals		
0x81F0	The module does not support RS232 secondary signals	You have made an attempt to set up secondary signals on a module that does not support RS232 secondary signals. Verify that this is an RS232 module or that RS232 mode (ET 200SP) is set.
0x81F1	No operation of RS232 secondary signals	RS232 secondary signals cannot be manipulated manually as long as hardware data flow is active.
Error codes of the receive configuration		
0x82C1	Invalid value for "Buffered receive frames".	Select a suitable value for "Buffered receive frames". Valid range of values: 1-255
0x82C2	Receive configuration rejected because the 3964(R) protocol was selected	Verify that no receive configuration is transmitted if the 3964(R) protocol is set.
3964(R) protocol error codes		
0x8380	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time". Valid range of values: 1-65535 (ms)
0x8381	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
0x8382	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority". The following are valid: • High (1) • Low (0)
0x8383	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check". The following are valid: • with block check (1) • without block check (0)
0x8384	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts". Valid range of values: 1-255
0x8385	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts". Valid range of values: 1-255
0x8386	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
0x8387	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.

Error code	Description	Remedy
0x8388	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check whether the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x8389	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is not answered with DLE until the receive buffer has been cleared. No additional character may be received before it has been cleared (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x838A	Runtime error: Logical error during receiving. Another character (other than DLE, ETX) was received after receipt of DLE.	Check whether the partner DLE in the frame header and in the data string is always in duplicate or the connection is released with DLE ETX. Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
0x838B	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
0x838C	Runtime error: Wait time for free receive buffer has started	Increase the call rate of the instruction in the user program, or parameterize communication with data flow control.
0x838D	Runtime error: Frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
0x838E	Runtime error: One or several characters (except NAK and STX) were received in idle mode.	Verify the proper function of the partner device, for example, by means an interface tester that is interconnected in the transmission line.
0x838F	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
0x8390	Parameter assignment error: Error in frame header	Check the data/values in the frame header.
0x8391	Parameter assignment error: 3964 Parameter data record rejected because Freeport is set	Verify that no 3964 parameter data is transmitted if the Freeport protocol is set.

Glossary

Address

The address indicates the physical storage space and enables direct access to the operand that is stored under this address.

Automation system

An automation system is a programmable logic controller consisting of at least one CPU, various I/O modules, and operator control and monitoring devices.

Communication module

Communication modules are used for point-to-point connections and bus links.

Configuration

The term configuration refers to the summary of individual modules of an automation system in the configuration table.

CPU

Central Processing Unit = Central module of the automation system that consists of the control and computing units, memory, system program, and interfaces to the I/O modules.

CPU operating system

The CPU operating system organizes all the functions and sequences of the CPU that are not linked to a special control task.

Cycle time

The cycle time denotes the time a CPU requires to execute one user program cycle.

Cyclic program processing

In cyclic program processing, the term cycle denotes execution of the user program in a continuous repetitive program loop.

Default setting

The default is a useful basic setting that is used whenever no other value is specified.

Diagnostic functions

The diagnostic functions cover the entire system diagnostics and the detection, evaluation and reporting of errors in the automation system.

Diagnostics buffer

Memory area in which detailed information on all diagnostics events is entered based on the order of their occurrence.

Diagnostics events

Diagnostics events are, for example, module errors or system errors in the CPU that may be caused by a program error.

Hardware

The term hardware denotes the entire physical and technical equipment of an automation system.

Interrupt

The term interrupt designates the interruption of program execution in the processor of an automation system which is triggered by an external alarm.

Module parameters

Module parameters are values that are used to determine the behavior of the module. We distinguish between static and dynamic module parameters.

Online/Offline

In online mode, there is a data connection between the automation system and programming device, while there is no data connection in offline mode.

Parameter assignment

The term parameter assignment denotes actions that define the response of a module or block.

Parameters

Parameters represent values that can be used to define the behavior of a module or software. We distinguish between module parameters and block parameters.

Point-to-point connection

In a point-to-point connection the communication module interfaces a programmable logic controller and a communication partner.

Protocol

The communication partners participating in data transmission must conform to fixed rules for the handling and execution of data traffic. These rules are called protocols.

Rack

The rack is a mounting rail with slots that can be used to mount modules.

Software

The term software refers to all programs that are used on a computing system. These include the operating system and user programs.

User program

The user program contains all instructions and declarations for processing the signals used for controlling a system or a process. In SIMATIC S7, the user program is structured and divided into small units, namely the blocks.

Work memory

Work memory is CPU RAM (Random Access Memory) that is accessed by the processor when processing the user program.

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SIMATIC

IO-Link system

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Preface

Purpose of the documentation

This function manual provides a general overview of the IO-Link communication system.

It shows the interaction of the various components of an IO-Link system and will help you improve your general understanding of IO-Link.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Proficiency with STEP 7

Scope of the documentation

This documentation is the basic documentation for IO-Link systems at Siemens. The product documentation is based on this documentation.

Additional support

- Information about the technical support available can be found in the appendix to this documentation (Page 29).
- The range of technical documentation for the individual SIMATIC products and automation systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Guide

1

Documentation

Various IO-Link products are available from Siemens. Each of these products has a separate documentation. The IO-Link products are embedded in systems, such as ET 200SP. The documentation for the system consists of the respective system manual, function manuals and manuals. In addition, the STEP 7 online help and the Port Configuration Tool - S7-PCT online help assist you in configuring and programming your automation system with IO-Link.

IO-Link components from Siemens

Siemens offers a wide range of products and support for IO-Link:

- Master
- Device, I/O modules
- Device, industrial switchgear
- Device, RFID systems (RFID = radio-frequency identification)
- Port Configuration Tool - S7-PCT (http://support.automation.siemens.com/WW/view/en/37936752)
- "IOL_CALL" function blocks for SIMATIC S7-300 and S7-400 (http://support.automation.siemens.com/WW/view/en/38487085)
- IO-Link application example (http://support.automation.siemens.com/WW/view/en/38006560)

Additional information on the products can be found on the Internet (http://www.siemens.com/io-link).

Additional documentation for IO-Link

All current documentation for IO-Link products is available for download free of charge on the Internet (http://support.automation.siemens.com/WW/view/en/29036712/133300).

System overview

2

Introduction

A continuous communication down to the lowest field level ensures enhanced use of the functions and performance capability of sensors and actuators. Enhanced use of sensors and actuators allows you to operate your machines and plants more productively.

No data other than the actual process value can be exchanged via the standard interfaces (digital, analog) used at the sensor/actuator level. Sensors and actuators with integrated intelligence are now used for increasingly complex functions and require a communication interface tailored to these requirements.

Definition

IO-Link is an innovative, point-to-point communication interface for the sensor/actuator area that is specified in IEC 61131-9.

IO-Link consists of the following system components:

- IO-Link master
- IO-Link device
- Unshielded 3-wire standard cable
- Engineering tool for configuring and assigning parameters of IO-Link

2.1 Advantages of IO-Link

The IO-Link system offers decisive advantages for connecting complex (intelligent) sensors and actuators.

- Open standard in accordance with IEC 61131-9
  - Devices can be integrated in the same way in all standard fieldbus systems and automation systems.
- Tool supported parameter setting and central data management
  - Fast configuration and commissioning
  - Simple creation of current plant documentation even for sensors/actuators
- Single, uniform wiring and far fewer different interfaces at the sensors/actors
  - Reduction in the variety of types and inventory
  - Fast commissioning
  - Reduction in space requirement
  - Any combination of IO-Link devices and sensors/actuators without IO-Link at IO-Link master
- Continuous communication between sensors/actuators and the CPU
  - Access to all process data, diagnostic data and device information
  - Access to device-specific data, such as energy data
  - Remote diagnostics can be performed
- Continuous diagnostic information down to sensor/actuator level
  - Reduction in troubleshooting effort
  - Minimizing risk of failure
  - Preventive maintenance and optimization of service and maintenance planning
- Dynamic change of sensor/actuators parameters by the controller or the operator at the HMI
  - Reduction in downtimes during product change
  - Increase in product diversity of machine
- Automatic reassignment of parameters when devices are replaced during operation
  - Minimization of downtimes
  - Device replacement by untrained personnel without additional aids
  - Avoidance of incorrect settings

2.2 Overview of IO-Link system

Components

An IO-Link system consists of the following components:

- IO-Link master
- IO-Link device, for example:
  - Sensors/actuators
  - RFID readers
  - I/O modules
  - Valves
- Unshielded 3-wire standard cables
- Engineering tool for configuring and assigning parameters of IO-Link

Example plant with IO-Link

The figure below shows an example of plant architecture with IO-Link.

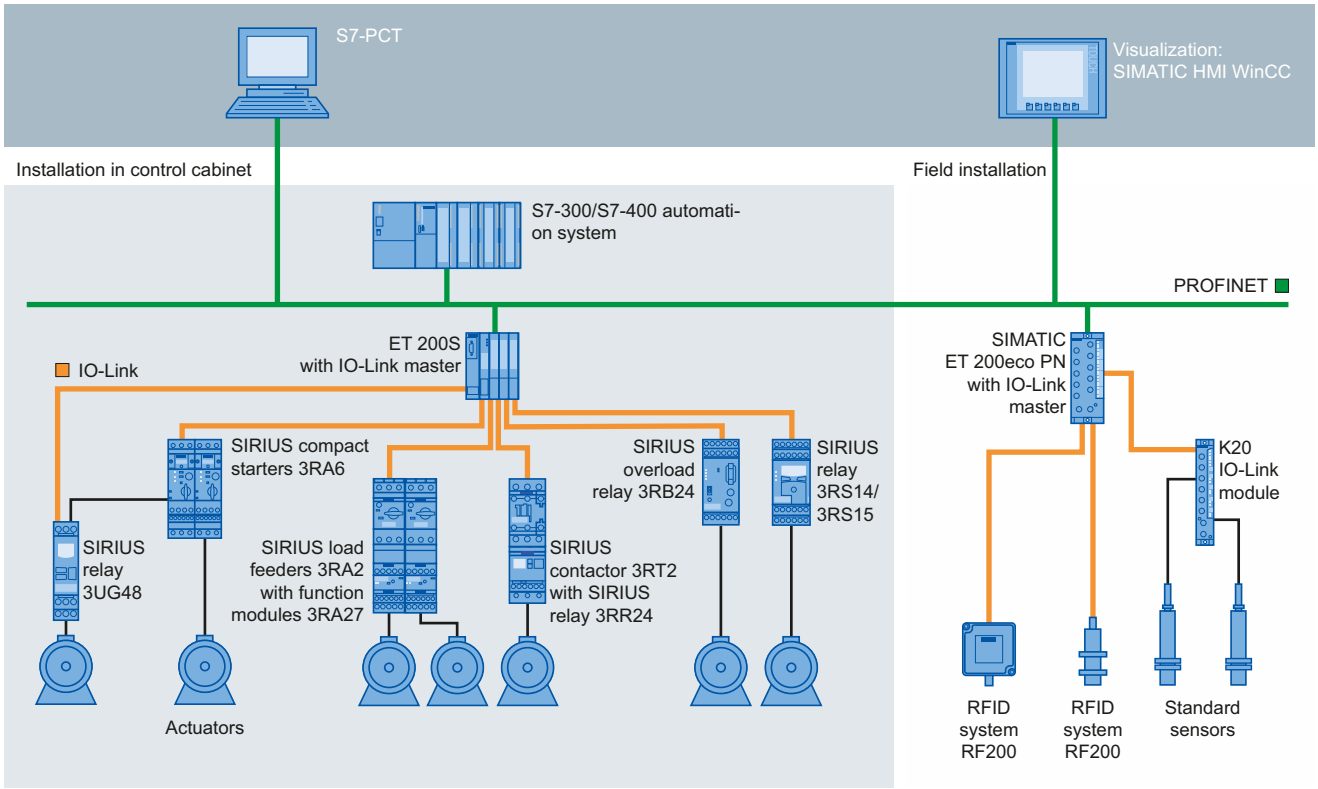


Figure 2-1 Plant architecture with IO-Link

The IO-Link master establishes the connection between the IO-Link devices and the automation system. If the IO-Link master is a component of the I/O system, it is installed either in the control cabinet or directly in the field as remote I/O in degree of protection IP65/67. The IO-Link master communicates by means of various fieldbuses or product-specific backplane buses. An IO-Link master can have multiple IO-Link ports (channels). An IO-Link device can be connected (point-to-point communication) to each port.

Engineering

The IO-Link system is engineered parallel to the overall automation system and can be embedded in it and intermeshed with it.

2.3 IO-Link interface

Introduction

The IO-Link is a serial, bidirectional point-to-point connection for signal transmission and power distribution under any network, fieldbus or backplane bus.

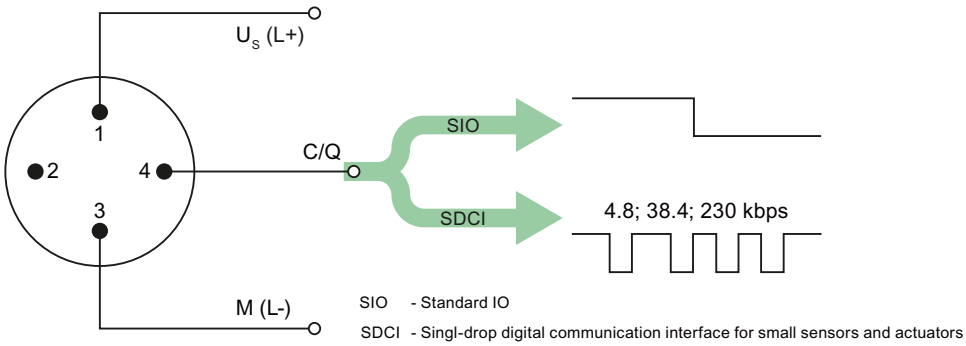
Connection system in IP65/67

M12 connectors and other connectors are defined for the connection system in IP65/67; sensors have a 4-pin connector, actuators a 5-pin connector. IO-Link masters are always equipped with a 5-pin M12 socket.

The pin assignment according to IEC 60974-5-2 is specified as follows:

- Pin 1: 24 V
- Pin 3: 0 V
- Pin 4: Switching and communication cable (C/Q)

In addition to providing IO-Link communication, these three pins supply a maximum of 200 mA to the device.



Pin	Signal	Definition	Standard
1	U_S (L+)	24 V	IEC 61131-2
2	-	not defined	-
3	M (L-)	0 V	IEC 61131-2
4	Q	Switching signal DI, DQ (SIO)	IEC 61131-2
4	C	"coded switching signal" (IO-Link)	IEC 61131-9

Figure 2-2 Pin assignment IO-Link device

Port types in IP65/67

Two types of ports are distinguished in the specifications for IO-Link masters:

- Port Class A (Type A)
  With this type, the functions of pins 2 and 5 are not assigned. The manufacturer defines this function. Generally, an additional digital channel is assigned to pin 2.

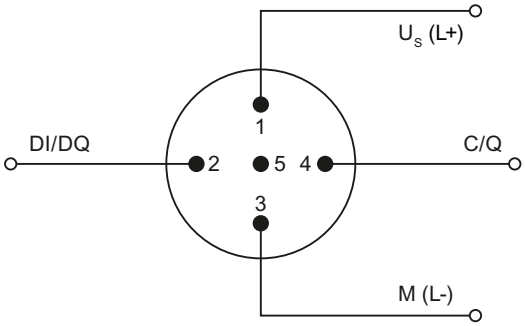


Figure 2-3 Pin assignment Port Class A

- Port Class B (Type B)
  This type offers an additional supply voltage and is suitable for the connection of devices that have an increased power requirement. In this case an additional (galvanically isolated) supply voltage is made available by pins 2 and 5. A 5-wire standard cable is required to use this additional supply voltage.

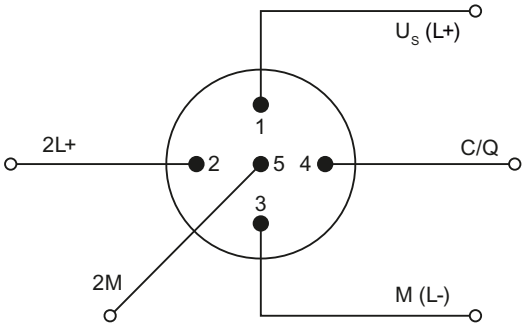


Figure 2-4 Pin assignment Port Class B

Connecting cables

The devices are connected to the master by means of an unshielded 3-wire standard cable that is up to 20 m long. Standard cables can be used to wire the sensors. No shielding or compliance with specific regulations is necessary for the installation of the cables.

2.4 IO-Link protocol

Operating modes

The IO-Link port of the master can be operated in the following modes:

- IO-Link:
  In "IO-Link" operating mode, the port is in IO-Link communication.
- DI:
  In "DI" operating mode the port behaves like a digital input.
- DQ:
  In "DQ" operating mode the port behaves like a digital output.
- Deactivated:
  The "Deactivated" operating mode is used for unused ports.

Transmission rate

In the IO-Link specification V1.1, three data transmission rates (baud rates) are specified for the IO-Link operating mode:

- COM 1 = 4.8 kBaud
- COM 2 = 38.4 kBaud
- COM 3 = 230.4 kBaud (optional according to Specification V1.0)

The IO-Link device only supports one of the defined data transmission rates. The IO-Link master to Specification V1.1 supports all data transmission rates and adjusts automatically to the data transmission rated supported by the device.

Response time of the IO-Link system

The response time of the IO-Link system provides information about the frequency and speed of the data transmission between device and master. The response time depends on various factors.

A value for the minimum cycle time of the device is stored in the device description file IODD of the device (Page 18). This value indicates in which time intervals the master may address the device. The value has a big influence on the response time. The master also has an internal processing time that is factored into the calculation of the response time.

Devices with different minimum cycle time can be configured on a master. The response time for these devices differs accordingly. In other words, the response time for various devices connected to a master can vary greatly.

When you configure the master you can specify a fixed cycle time in addition to the device-specific minimum cycle time stored in the IODD. The master then addresses the device according to this specification.

The typical response time for a device thus results from the effective cycle time of the device and the typical internal processing time of the master.

Transmission performance

IO-Link is a very robust communication system. This communication system operates with a 24V level. If transmissions fail, the frame is repeated two more times. The IO-Link master only detects a break in communication after the failure of the second repeat attempt and reports this to the higher-level CPU.

Data types

Four data types are available:

- Process data → Cyclic data
- Value status → Cyclic data
- Device data → Acyclic data
- Events → Acyclic data

Process data

The process data of the devices is transferred cyclically in a data frame with the process data size being determined by the device. Process data from 0 to 32 bytes is possible per device (input and output, respectively). No fixed consistency width is set for the transmission; as a result the consistency width depends on the master.

Value status

Each port has a value status (PortQualifier). The value status indicates whether the process data is valid or invalid. The value status is transferred cyclically together with the process data. By default, the value status is deactivated.

Device data

Device data can be parameters, identification data or diagnostic information. The data is exchanged cyclically and at the request of the IO-Link master. Device data can be written to the device and also read from the device.

Events

When an event occurs, the device signals to the master that an event is present. The master then reads the event. Events can be error messages (for example, short-circuit) and warning/maintenance data (for example, dirt, overheating).

Error messages are transferred from the device to the CPU or the HMI by the IO-Link master.

The IO-Link master can also transfer events and states. Such events are, for example, wire break, break in communication or overload.

Device parameters or events are transmitted independently of the cyclic transmission of process data. The transmissions do not influence or impair each other.

Startup of the IO system

If the port of the master is set to IO-Link mode, the IO-Link master attempts to communicate with the connected IO-Link device. For this purpose the IO-Link master sends a defined signal and waits for the reply of the IO-Link device.

The IO-Link master first attempts a communication with the highest defined data transmission rate. If this transmission attempt fails the IO-Link master attempts a communication with the lowest data transmission rate. The device always supports only one defined data transmission rate.

If the master receives a reply, communication starts. First they exchange communication parameters. If necessary the parameters stored in the system are transferred to the device.

Then the cyclic data exchange of process data and value status starts.

2.5 Device profiles

Introduction

Device profiles are defined for IO-Link to standardize access of the CPU user program to the devices.

Data structure, data contents and basic functionality are defined in the device profiles. A standard user view and an identical program access is thus achieved for a number of different devices that have the same device profile.

IO-Link profiles

The device profile "Smart Sensor Profile" is currently defined for IO-Link. This profile is especially suited for measurement sensors. In other words, measured values are transmitted in addition to switching points.

In addition, the switchgear (for example, contactors) support the LVSG (Low Voltage Switchgear) profile defined in IEC 61915-2.

2.6 IODD and Port Configuration Tool - S7-PCT

Device description IODD

An electronic device description, the IODD file (IO Device Description) is available for each device. The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the identical manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

Two different IODD versions are available for devices that support both V1.0 and V1.1 functionality.

IO-Link configuration tool

Configuration tools are required to configure the entire IO-Link system. The IO-Link configuration tools of the master manufacturers are able to read IODDs.

The main tasks of the IO-Link configuration tool include:

- Assigning the devices to the ports of the master
- Address assignment of ports within the address area of the master
- Assigning parameters for the IO-Link device

Diagnostics can also be carried out on the connected devices.

This means the IO-Link configuration tool supports the transparent representation of the IO-Link system down to field level.

Siemens provides S7-PCT for engineering of the IO-Link system.

S7-PCT with IODD of a device

The following figure shows a section from S7-PCT with IODD of a device and the device information contained therein.

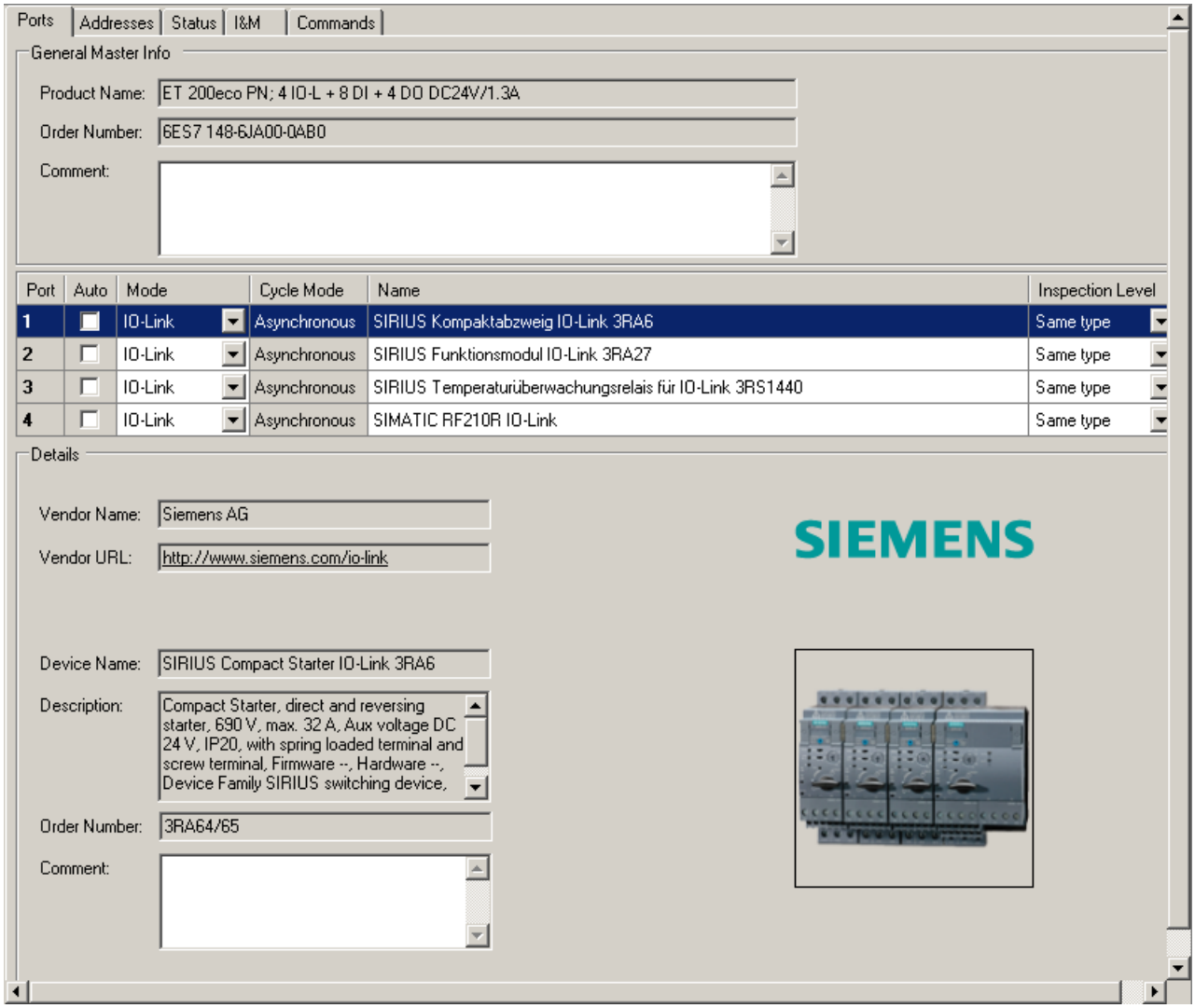


Figure 2-5 S7-PCT with IODD of a device and the device information contained therein

2.7 Differences between IO-Link specifications V1.0 and V1.1

Specification

The technical definition of the IO-Link system is described in a specification of the IO-Link consortium. The first step was the creation of specification version 1.0. The further development and added functions of the IO-Link system led to version 1.1.

The main enhancements of version 1.1 are:

- Parameter assignment server function (data storage)
- Data transmission rate 230.4 kBaud is mandatory for IO-Link master

Combination of IO-Link devices

Note the following when combining IO-Link devices:

- Only IO-Link devices that comply with V1.0 can be operated on the IO-Link master to V1.0.
- IO-Link devices that comply with V1.0 and V1.1 can be operated on the IO-Link master to V1.1.
- The parameter assignment function and the 230.4 kBaud data transmission rate of the IO-Link master to V1.1 can only be used if these functions are also supported by the IO-Link device.

Integration into the automation system 3

3.1 Configuration of the IO-Link system

Introduction

An IO-Link system is configured in several steps. In the first step the IO-Link master is integrated into the automation system and configured. In the second step the parameters are assigned for the IO-Link devices.

Integration in STEP 7

If you are using a SIMATIC S7 CPU, use V5.x or STEP 7 TIA Portal to configure the STEP 7 engineering tool. In the configuration, the IO-Link system is represented by the IO-Link master and integrated using the corresponding device description (for example, GSD). The IO-Link master can also be a fieldbus device (for example, ET 200eco PN IO-Link master) or part of a modular IO system that is connected with the fieldbus (for example, ET 200SP IO-Link master). In both cases, the number of ports, the address range and the module properties are described. However, no additional information is available for the IO-Link system, for example, for the IO-Link devices to be connected.

Example configuration in STEP 7 TIA-Portal

The following figure shows a PROFINET configuration in which the PROFINET devices ET 200SP and ET 200ecoPN are integrated with IO-Link masters.

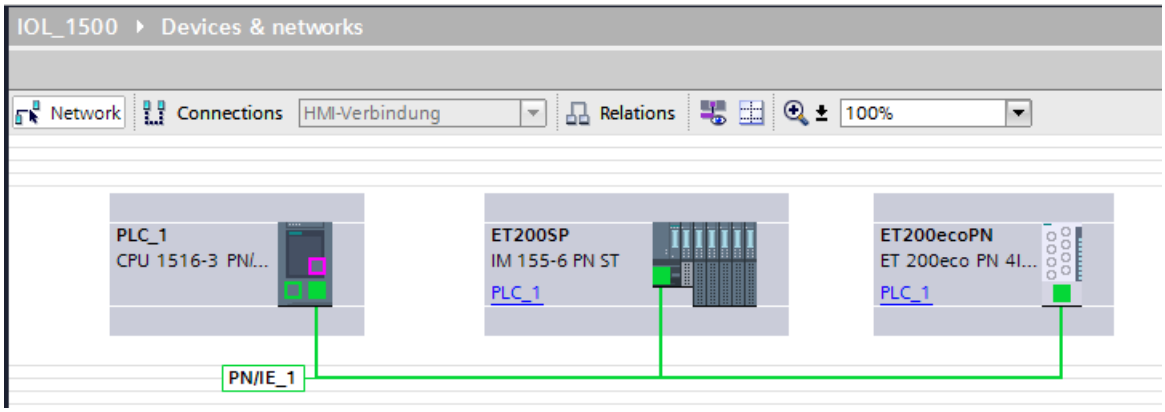


Figure 3-1 Configuring a PROFINET network with lower-level IO-Link masters

The address areas for the exchange of the cyclic data (process values) are specified by the IO-Link in the device view of the PROFINET device.

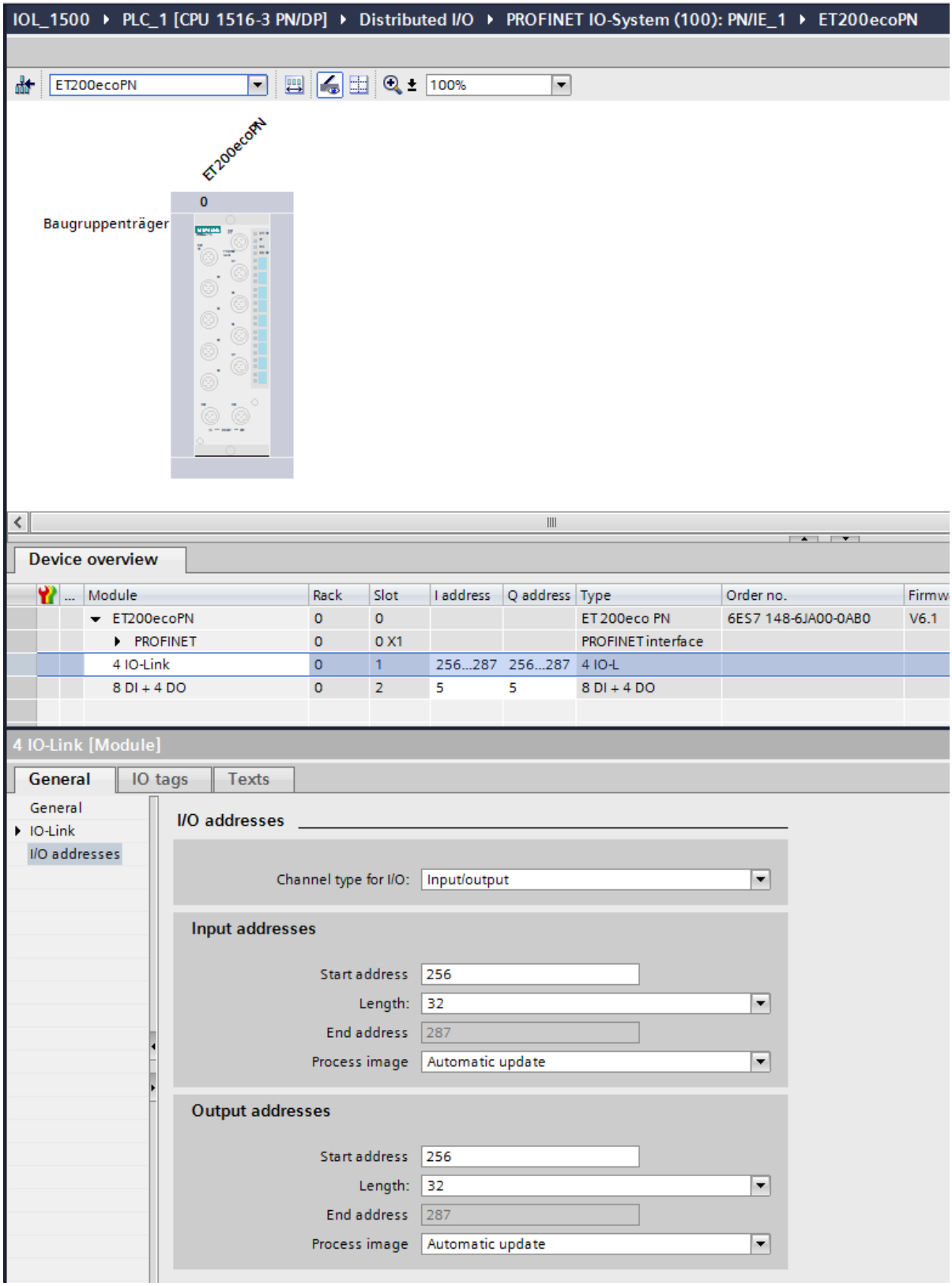


Figure 3-2 Device view with setting of the IO-Link address range

Port Configuration Tool - S7-PCT

S7-PCT is required to represent the system architecture fully and transparently down the IO-Link device and to configure and parameterize the IO-Link system in detail.

Start S7-PCT from the hardware configuration of STEP 7. S7-PCT displays all Siemens IO-Link masters configured in the automation system. After you select an IO-Link master you can assign its IO-Link ports to the respective IO-Link devices. To do this, select the corresponding devices (or their IODDs) from the device catalog and drag these to the IO-Link master port.

Example configuration in S7-PCT

The following figure shows the configuration of an IO-Link master in S7-PCT.

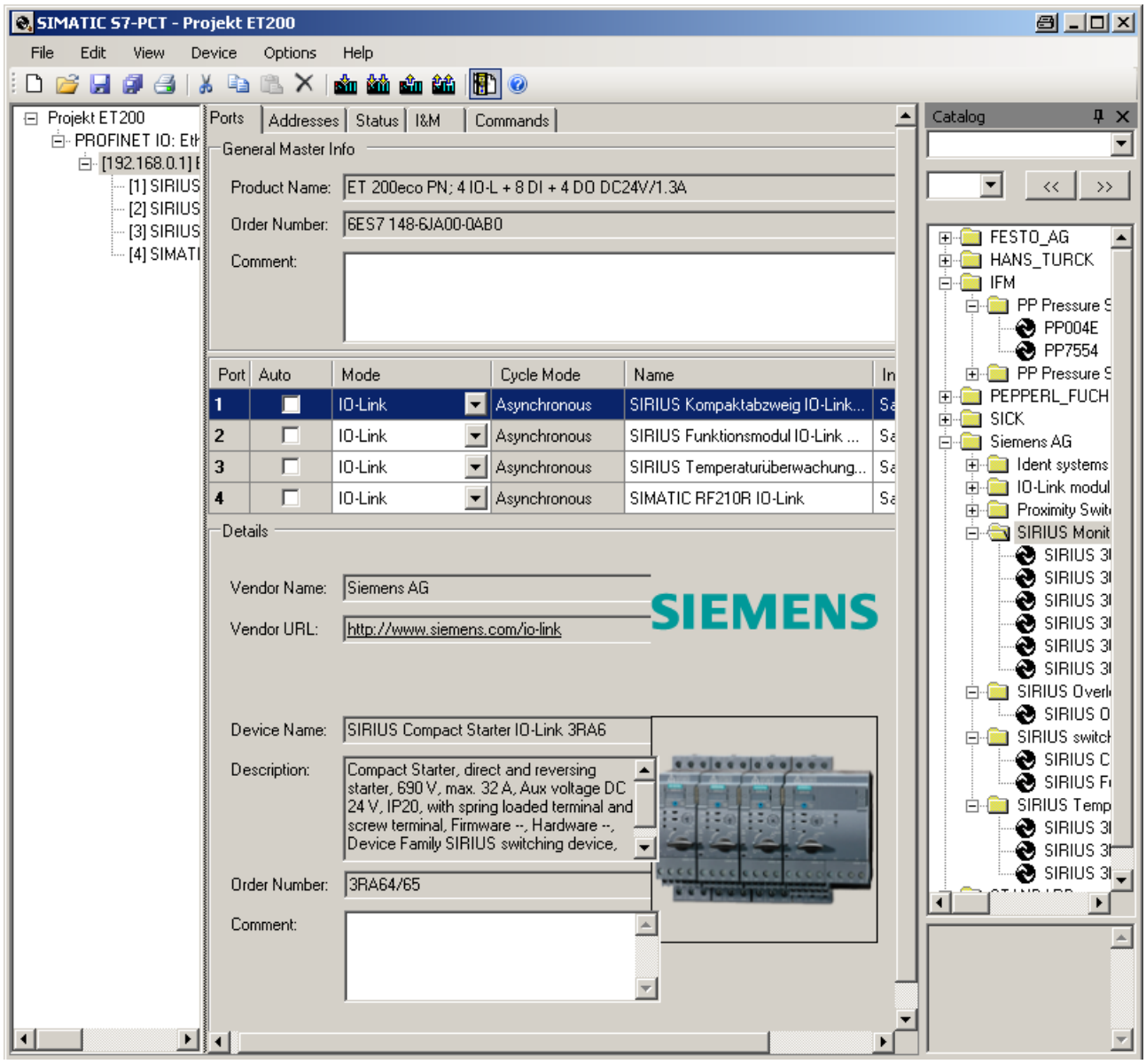


Figure 3-3 Configuring an IO-Link master in S7-PCT

This S7-PCT view shows you a wide variety of information:

- Higher-level fieldbus and overview or structure of the lower-level IO-Link masters (left tree)
- Detailed information on the selected IO-Link master
- Current configuration of the IO-Link ports of the selected IO-Link master
- Detailed information on the selected IO-Link device
- Device catalog with the IODDs of the IO-Link device from various manufacturers (right tree)

Address range of the ports

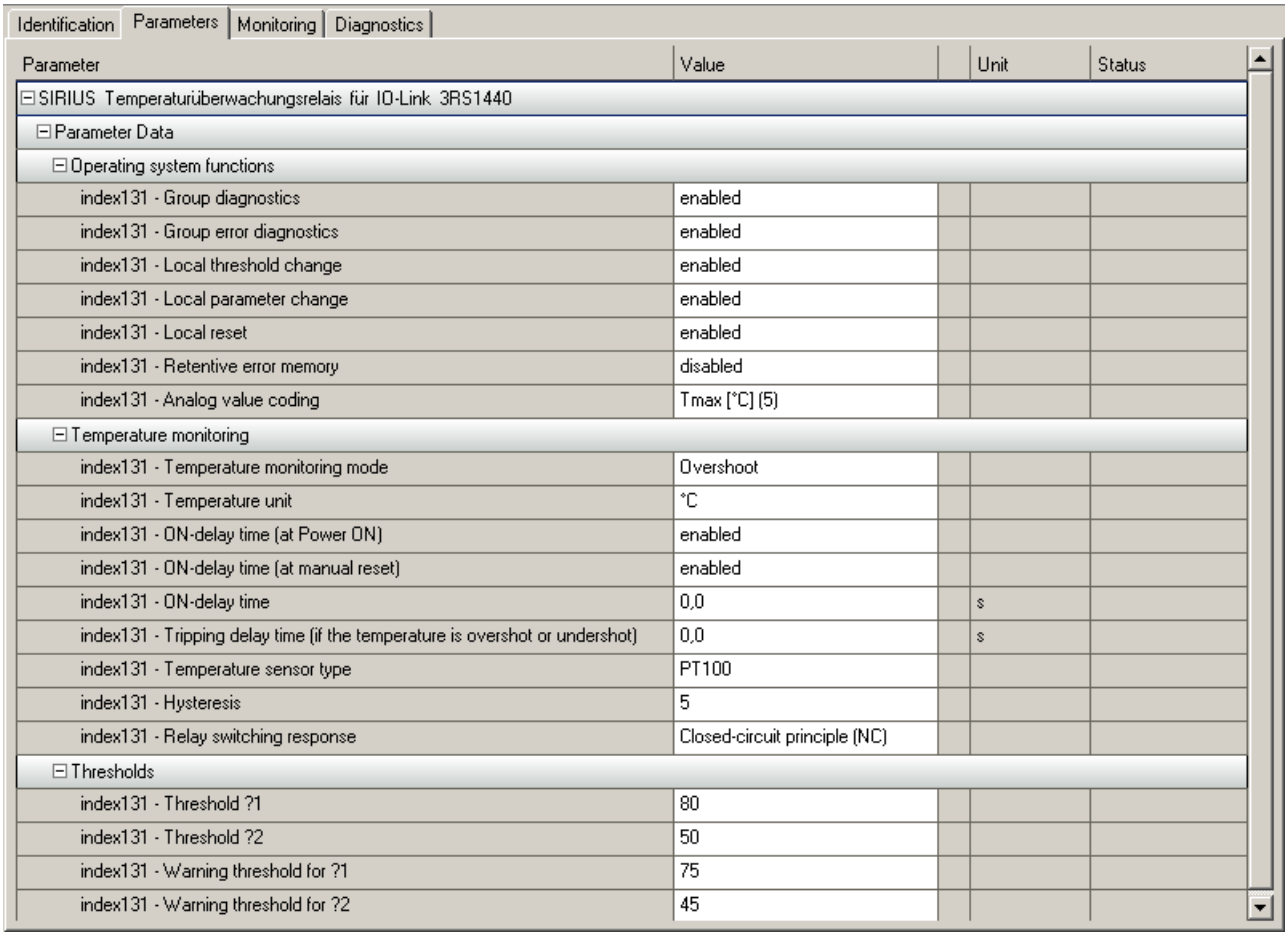
In addition to the assignment of the IO-Link devices to the IO-Link master ports, the default address ranges of the ports can be changed. The IO-Link master transfers the process values that it receives from the IO-Link device in these address ranges and makes the process values available to the higher-level automation system.

To set this address range, select the "Addresses" tab (see previous figure).

Setting device parameters

Specific parameter settings are required to adjust the device to the respective application task. The possible parameters and set values are contained in the IODD of each device. You set the device parameters directly in S7-PCT.

To do this, select the "Parameters" tab in the project tree (left tree) after you have selected the appropriate device.



Parameter	Value	Unit	Status
SIRIUS Temperaturüberwachungsrelais für IO-Link 3RS1440			
Parameter Data			
Operating system functions			
index131 - Group diagnostics	enabled		
index131 - Group error diagnostics	enabled		
index131 - Local threshold change	enabled		
index131 - Local parameter change	enabled		
index131 - Local reset	enabled		
index131 - Retentive error memory	disabled		
index131 - Analog value coding	Tmax [°C] (5)		
Temperature monitoring			
index131 - Temperature monitoring mode	Overshoot		
index131 - Temperature unit	°C		
index131 - ON-delay time (at Power ON)	enabled		
index131 - ON-delay time (at manual reset)	enabled		
index131 - ON-delay time	0,0	s	
index131 - Tripping delay time (if the temperature is overshot or undershot)	0,0	s	
index131 - Temperature sensor type	PT100		
index131 - Hysteresis	5		
index131 - Relay switching response	Closed-circuit principle (NC)		
Thresholds			
index131 - Threshold ?1	80		
index131 - Threshold ?2	50		
index131 - Warning threshold for ?1	75		
index131 - Warning threshold for ?2	45		

Figure 3-4 Setting the parameter values of the IO-Link device

Starting from the displayed defaults, you can edit and save the values in the defined value range.

The configuration of the IO-Link system and the parameters of the devices are available to the IO-Link system and the entire automation project. You have the option of saving and printing the configuration and the parameters.

3.2 Data access of the automation system and the HMI device

Cyclic data exchange

To exchange cyclic process data between an IO-Link device and a CPU, the IO-Link data is assigned by the IO-Link master to the previously set address ranges. The user program of the CPU accesses and processes the process values by using these addresses. The cyclic data from the CPU to the IO-Link device (for example, IO-Link actuator) takes place in reverse order.

Acyclic data exchange

Acyclic data, such as device parameters or events, is exchanged by means of a fixed index and subindex area. The CPU accesses the data using system mechanisms (for example, for online functions such as reading the status). You can use the index and subindex area to access specific device information (for example, to re-assign parameters of the device or master during operation).

Programming the user program

The programming of the CPU user program is another task in addition to the configuration and parameterization of the IO-Link system and its integration into the overall automation system.

To support the programming of acyclic access, Siemens offers the "IOL_CALL" function block/instruction for the automation systems SIMATIC S7-300 and S7-400 for IO-Link.

This instruction is used to write (parameter) data to an IO-Link device or to read it from an IO-Link device. The data is uniquely addressed with index and subindex on the IO-Link device. For information on the structure of data objects, refer to the respective documentation of the IO-Link device.

Application example

An IO-Link application example is available on the Internet (http://support.automation.siemens.com/WW/view/en/38006560).

This application example implements the reading and writing of process data and parameterization data from IO-Link masters and switchgear and the visualization on the HMI. In the process, the CPU and HMI configuration is performed so that it can be easily integrated into your own projects.

3.3 Replacing devices during operation

Introduction

Replacing a device during operation is a scenario that occurs again and again and has to be completed without longer plant downtimes. Replace a device quickly and avoid incorrect settings. Devices can also be replaced by operators without special knowledge and aids.

Parameter assignment server function

The device parameters set during engineering with S7-PCT and IODD are transferred to the device. The device stores these parameters in a non-volatile manner. These parameters can be used at any time with S7-PCT or modified from the CPU/HMI and stored in the device.

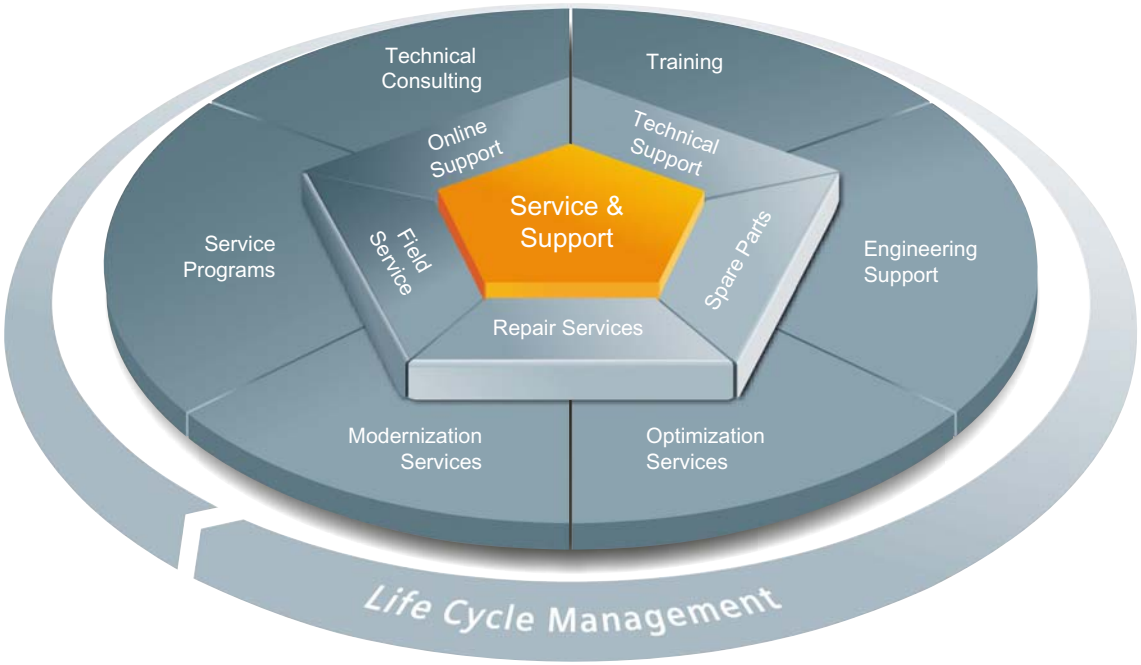
The following different scenarios apply to the backup of device parameter data in the master:

1. You have set the device parameters with S7-PCT and downloaded them to the device; in this case the backup is triggered by S7-PCT (default in the "Data Storage" tab).
2. You have modified the device parameters online in the S7-PCT; in this case you have to explicitly trigger the backup afterward. To do this, trigger the backup in S7-PCT in the "Data Storage" tab.
3. You have modified the device parameters by means of a parameter transfer from the CPU/HMI; in this case you have to trigger the backup using a system command after the parameters have been transferred. To do this, transfer a system command to index 2 and subindex 0 of the device with the coding 0x05. If the device parameters were stored in the master, the master automatically makes these parameters available to the new device when the device is replaced.

Device replacement is thus supported, because the new device is automatically parameterized by the IO-Link master. Requirement for the use of the parameter assignment server function is the implementation of the IO-Link specification V1.1 in the master and in the devices.

Master and devices to IO-Link specification V1.0 do not feature this function. In these cases we recommend to store the device parameters in the higher-level automation system. Use the "IOL_CALL" function block/instruction to store the parameters and to reassign the parameters of a replaced device.

Service & Support



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SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro, ET 200eco PN Analog value processing

Function Manual

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06/2014

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Preface

Purpose of the documentation

This documentation covers general topics applicable to all products.

In addition to introductory information about analog value processing, this manual covers the following topics:

- Wiring transducers to analog inputs
- Wiring actuators/loads to analog outputs
- Compensating for reference junction temperatures
- Calibrating analog modules
- Diagnostics options of an analog module
- High-speed analog modules

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of analog value processing (analog technology)
- Knowledge of the industrial automation system SIMATIC
- Knowledge about how to use STEP 7 (TIA Portal)

Scope of the documentation

This manual is considered the basic documentation for all analog input and analog output modules of the S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro and ET 200eco PN product series.

Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version (version 12/2013):

- Extension of the scope of validity to the distributed I/O system ET 200AL

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for "STEP 7 as of V12 (TIA Portal)" and subsequent versions of the configuration and programming software.
This documentation includes images of the products it describes. The products supplied may differ slightly from these images.

Please observe notes labeled as follows:

Note

Notes contain important information on a point in the documentation of particular importance.

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- The portfolio of technical documentation for SIMATIC products and systems can be accessed on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro and ET 200eco PN systems consists of the respective system manuals, function manuals and product manuals.

Overview of additional documents related to analog value processing

The following table lists further references that supplement this description of analog value processing.

Table 1- 1 References for analog value processing

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Connecting • Commissioning
	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	
	System Manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
	System manual Distributed I/O System ET 200AL (http://support.automation.siemens.com/WW/view/en/89254965)	
	Operating instructions ET 200pro Distributed I/O System (http://support.automation.siemens.com/WW/view/en/21210852)	
	Operating instructions ET 200eco PN Distributed I/O System (http://support.automation.siemens.com/WW/view/en/29999018)	

Topic	Documentation	Most important contents
Configuring interference-free controllers	Function manual Configuring Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
Analog module	Product manual of the respective analog module	• Connecting • Parameters • Technical specifications • Parameter data record • Tables of analog values

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

What you should know about analog technology 2

2.1 Overview

Introduction

This chapter is intended to familiarize you with the essential parameters of analog input modules and analog output modules based on the fundamentals of analog technology. The descriptions and examples provided on the following pages serve as a reference to the manuals for the respective analog module and are intended to facilitate the handling of these manuals.

Analog and binary signals

Binary signals can assume only 2 signal states: signal state 1 (voltage present) and signal state 0 (no voltage present). In control engineering, it is frequently necessary to read, process and output analog signals in addition to binary signals. In contrast to binary signals, analog signals take on any number of values within a specific range. Possible analog variables include:

- Temperature
- Pressure
- Speed
- Fill level
- pH value

Transducers

Controllers are only capable of processing analog values in the form of bit patterns. For this purpose, transducers which can be connected to the analog module measure physical variables such as pressure or temperature. The analog input module reads this analog value in the form of current, voltage or resistance. To enable the CPU to process the current or voltage measured, an integrated analog-to-digital converter in the analog input module converts the value into a 16-bit integer value. Depending on the type of measurement, you can use the following transducers:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

Additional information on wiring various types of transducers to analog inputs can be found in Wiring transducers (Page 65).

Example

Speed is acquired using a transducer which converts the speed range of 0 to 1500 rpm to a voltage range of 1 to 5 V. At a measured speed of 865 rpm, the transducer outputs a value of 3.3 V.

The resulting voltage value is calculated as follows:

$$U = \frac{5\ V - 1\ V}{1500\ \frac{U}{min}} * 865\ \frac{U}{min} + 1\ V = 3.3\ V$$

The graph below illustrates voltage acquisition:

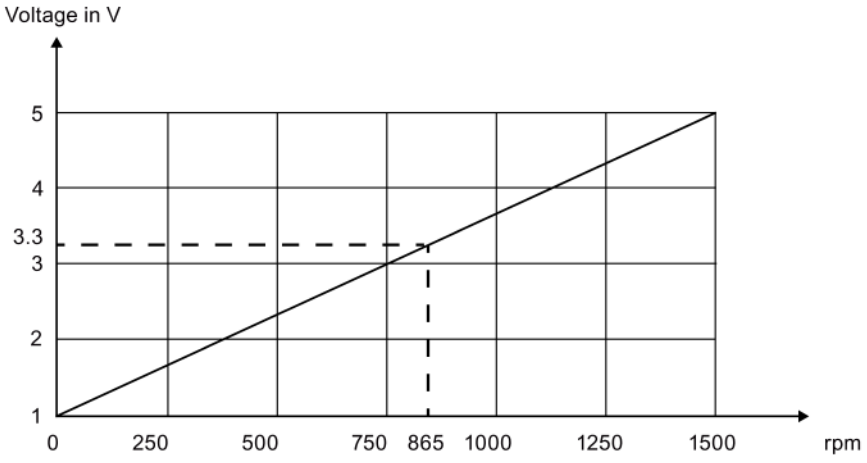
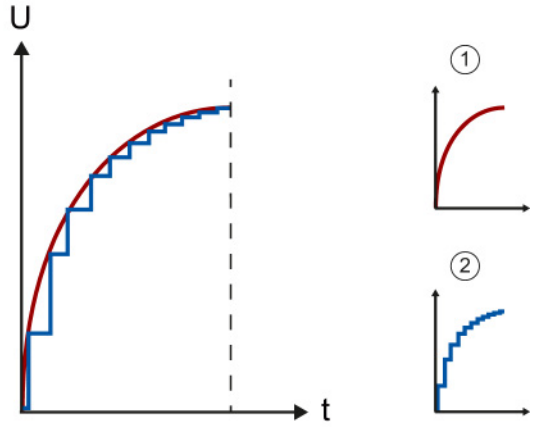


Figure 2-1 Speed measurement

Analog-to-digital conversion

A CPU processes information exclusively in digital format. The analog value is therefore converted into a bit pattern. Conversion is done using an integrated ADC (analog-to-digital converter) in the analog input module. For the CPU, this conversion always returns a 16-bit word for SIMATIC products. The ADC used digitalizes the analog signal and approximates its value with a stepped curve. Resolution and conversion speed are the most important ADC parameters.



① Analog value
② Digital value

Figure 2-2 Approximation of an analog graph with low- and high-resolution stepped curves

Digital-to-analog conversion

Once the CPU has processed the digital signal, an integrated DAC (digital-to-analog converter) in the analog output module converts the output signal to an analog current or voltage value. The resulting value of the output signal corresponds to the output value used to control the analog actuators. Such actuators include, for example, small servo drives or proportional valves. You will find more information on wiring actuators in Wiring loads/actuators (Page 103).

Important parameters of analog modules

Alongside the type and range of measurement, the precision, resolution and conversion time are the main points to consider when selecting an analog module. For some applications such as systems which cover a large area, common mode or channel isolation are also important. The parameters listed here are examined in more detail in the following pages.

Processing analog signals

The following figure demonstrates analog signal processing in a PLC.

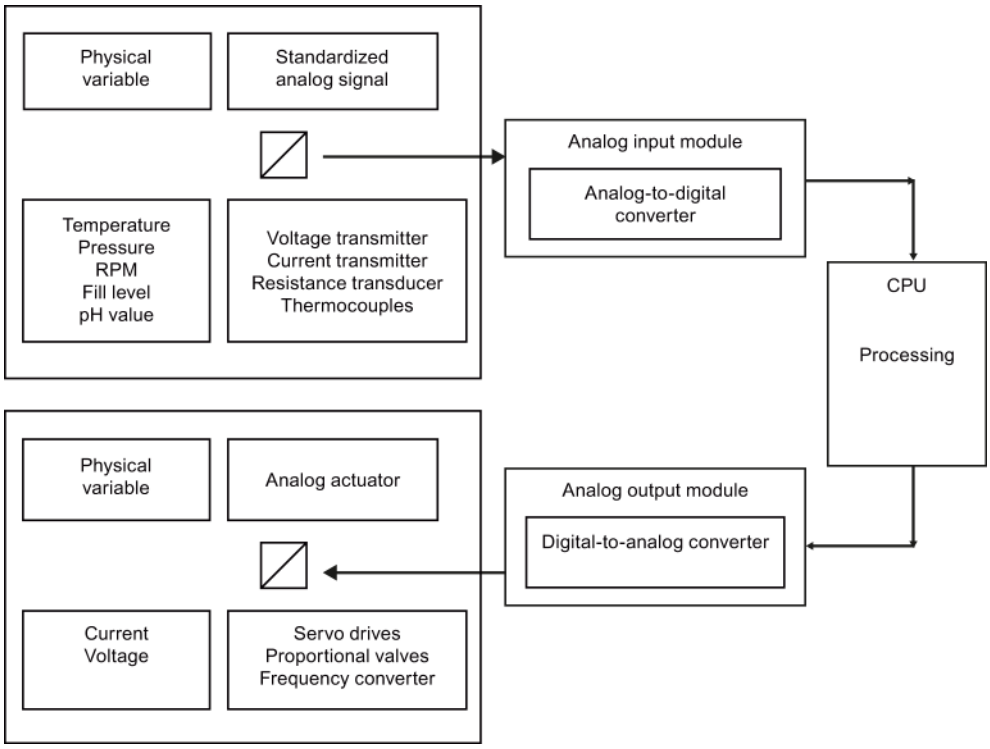


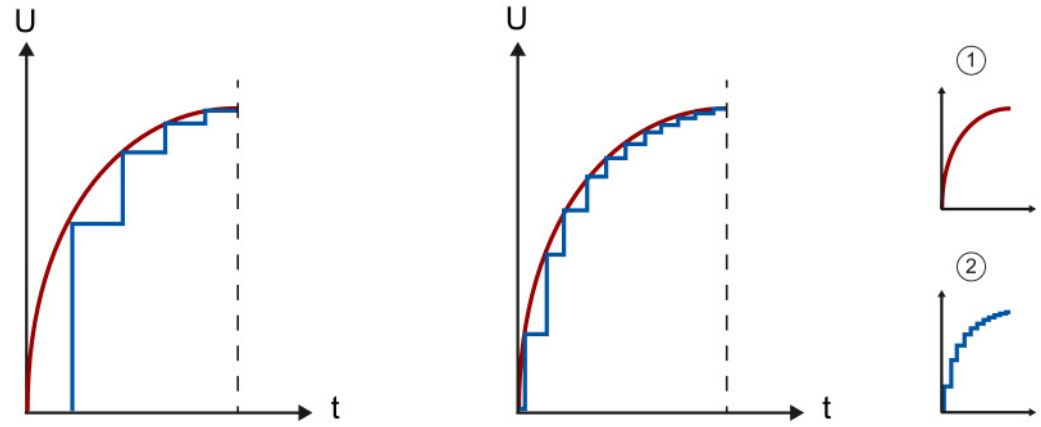
Figure 2-3 Analog value processing

2.2 Precision/resolution

The resolution of an analog module depends on the converter and its external circuitry. An approximation of the analog signal to be acquired/output is returned by a stepped curve. The resolution determines the number of increments of the analog value along this stepped curve. A higher module resolution reduces the length of increments and adds precision to the digitization of the analog signal.

Approximation of an analog value

The figures below show the approximation of an analog value by means of a stepped curve. A low resolution only returns a rough approximation of the actual curve (left figure), while the approximation is more precise at higher resolutions (right figure).



① Analog value
② Digital value

Figure 2-4 Approximation of an analog curve with a stepped curve

Visualization of the measuring range at a resolution of 13 bits and 16 bits

The unipolar measured value from a module having a resolution of 13 bits (= 12 bits + S) is segmented into a total of 2^{12} = 4096 increments. The smallest increment in a measuring range of 0 to10 V is 10 V/4096, equal to 2.4 mV.

A module with16-bit (= 15 bits + S) resolution thus provides an increment of 0.3 mV. If the resolution increases by one bit, the number of increments doubles and the width of an increment halves.

If the resolution increases from 13 bits to 16 bits, the number of increments increases eightfold from 4096 to 32768. With a resolution of 13 bits, the smallest value that can be displayed is therefore 2.4 mV. By contrast, this value is approximately 0.3 mV at a resolution of 16 bits.

Measuring ranges

For the display of the measuring range, SIMATIC S7 distinguishes between the rated range, the overrange and underrange, and the overflow or underflow. This distinction allows you to recognize whether the measured value is actually in the measuring range determined in the technical specifications. The overflow and underflow ranges are reserved for error detection.

At a resolution of 16 bits the theoretically possible 32768 increments are distributed across a voltage range of 11.852 V, which means that only 27648 increments are actually available for the resolution of a measuring range of 10 V. The minimum value which can be represented is therefore 0.3617 mV (see table).

Table 2- 1 Example of resolution for the 0 to 10 V measuring range of a SIMATIC S7 module

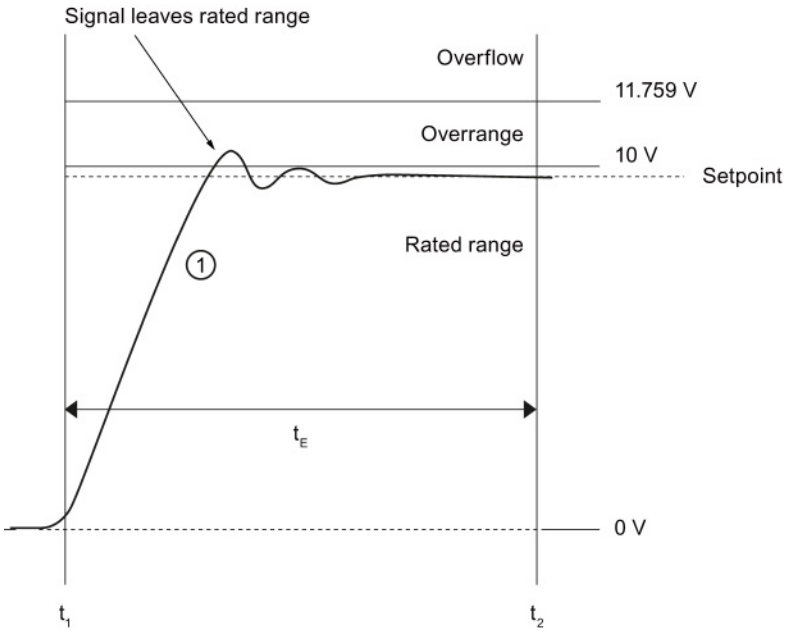
Value (increments)	Voltage measuring range	
Decimal	0 to 10 V	Range
32767	11.852 V	Overflow
32512		
32511	11.759 V	Overrange
27649		
27648	10.0 V	Rated range
20736	7.5 V	
1	361.7 µV	
0	0 V	
not relevant for this example		Underrange
as negative values are not possible		Underflow

The digitized visualization of the input ranges, separated into bipolar and unipolar input ranges, is shown in the section Visualization of the input ranges (Page 62). The digitized visualization of the output ranges, separated into bipolar and unipolar output ranges, is shown in the section Visualization of the output ranges (Page 63). You will find a summary of all measuring ranges which you can use with your analog module in the corresponding device manual.

Over and underrange

It may happen for control processes with high signal jumps that the settling curve of the signal briefly leaves the rated range until it reaches the setpoint. The over and underrange ensures that no error is reported while the signal is not in the rated range. If the signal exceeds the over or underrange, however, and reaches the overflow or underflow range, the error state "Overflow" or "Underflow" is diagnosed. This means the over or underrange correspond to a tolerance range between the rated range and the overflow or underflow. Additional information on the settling time is available in the section Settling and response times of analog output modules (Page 52).

The figure below shows the rated range, the overrange and overflow of a unipolar measuring range. The signal leaves the rated range briefly during the settling phase.



① Analog output signal

t_E Settling time of the signal to the setpoint

t_1 Module ends conversion at the terminal of the analog output channel and outputs the signal

t_2 Signal has settled and the specified analog output value has been reached

Analog module precision

The precision of an analog module is specified as a percentage value or absolute value, for example, in K or °C. This characterizes the total error of measured value acquisition. The basic error limit at 25 °C, as well as the operational limit, are specified in accordance with international standard IEC 61131, which also forms the basis for European Standard EN 61131. For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 23) section.

Relation between resolution and precision

A certain resolution must be given to reach a specific precision (operational error).

Example

Measuring error as a result of digitization at a resolution of 8 bits and 14 bits

An analog module has a measuring range of 0 V to 10 V. A resolution of 8 bits represents a total of 256 values. This is equivalent to a minimum possible voltage step of 39 mV or 0.4% of the measuring range end value. A resolution of 14 bits represents a total of 16384 values. This is equivalent to a minimum possible voltage step of 0.61 mV or 0.006% of the measuring range end value.

The percentages derived in this way also represent the theoretical best-case values for the operational limit. With a resolution of 8 bits and a measuring range of 0 to 10 V, it is therefore impossible to achieve a precision of more than 0.4 %. In practical life, this value would be clearly worse, depending on the implemented circuitry.

Calculating the maximum measuring error

The maximum measuring error of a 0 to 10 V analog module with an operational limit of ±0.5 % across the entire temperature range is calculated as follows:

10 V x 0.5/100 = 50 mV

This means the maximum measuring error is approximately ±50 mV. This also means that each analog voltage input is subject to a distortion of ±50 mV across the entire input range. A voltage of 3.5 V that is to be measured can therefore be visualized by any value between 3.45 V and 3.55 V.

For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 23) section.

2.3 Scaling analog values

Scaling

It is often necessary to calculate the actual process value rather than increments (e.g., 10 V = 27648 increments) for further processing of digitalized analog values. The conversion of a value range (e.g., -27648 to +27648 increments) to the original physical quantity (e.g., 0 to 500 liters) is referred to as scaling.

Scaling blocks

STEP 7 offers the suitable program block for scaling of analog values. The SCALE block is included in the STEP 7 scope of delivery and permits input of a high and low limit (e.g., 0 to 500 liters).

Example

In the example below the fill level of a tank with a capacity of 500 liters is to be measured. The transducer used measures a voltage of -10 V with an empty tank and a voltage of +10 V with a full tank. The analog module converts the voltage range from -10 V to +10 V into the value range -27648 to +27648 and converts this range into the original quantity of 0 to 500 liters with the SCALE program block.

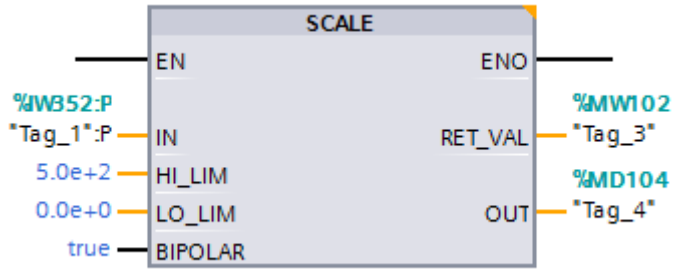


Figure 2-5 Scaling in the SCALE program block

The analog value at input **IN** is read directly by the module or is transferred by a data interface in INT format. The input **LO_LIM** is used to determine the low limit (0 liters) and **HI_LIM** to determine the high limit (500 liters) of the physical quantity. The output **OUT** outputs the scaled value (physical quantity) as floating-point number (LO_LIM <= OUT <= HI_LIM). You can assign parameters via the input **BIPOLAR** to specify if only positive or only negative values are to be converted. If the parameter receives an operand with the state '0', there is a unipolar scaling. An operand with the state '1' results in a bipolar scaling. The output **RET_VAL** outputs an error code in case of an error (e.g., overflow) and the value '0' in case of an error-free execution.

Additional information on the SCALE block can be found in the STEP 7 online help.

Unipolar and bipolar measuring ranges

The measurement of the fill level in our example took place within a bipolar measuring range. In addition to the positive voltage the transducer also provides negative voltage. Because the tank volume is mapped to the range from -27648 to +27648 increments, the measurement of the fill level takes place with twice the resolution (Δ) as in the unipolar measuring range.

Note

Transducers

The prerequisite for a measurement within a bipolar measuring range is that the used transducer supports bipolar measuring ranges.

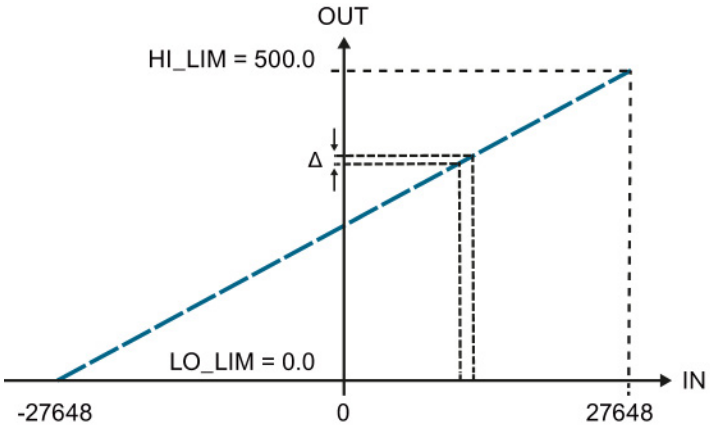


Figure 2-6 Bipolar measuring range

The measurement of the fill level in the bipolar measuring range takes place with twice the resolution (Δ) as in the unipolar measuring range.

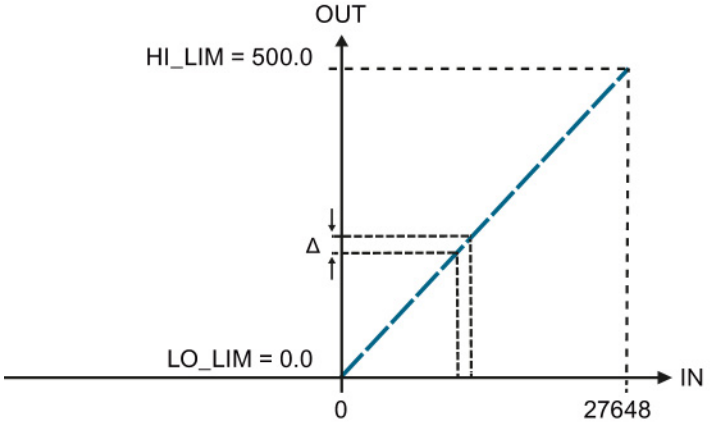


Figure 2-7 Unipolar measuring range

2.4 Unscaling analog values

Unscaling

The output of scaled analog values often requires conversion of the analog value calculated by the user program into the value range of the analog output module. This conversion is referred to as unscaling.

Unscaling blocks

STEP 7 offers the suitable program block for unscaling of analog values. The UNSCALE block is included in the STEP 7 scope of delivery and permits the input of a high and low limit that defines the range of the program value.

Example

An analog value from 0.0 to 100.0% calculated by the user program is to be converted with the UNSCALE block to the value range -27648 to +27648. When the unscaled value is output to an analog output module, this module addresses an analog actuator (e.g., modulating valve). The actuator is to be addressed at a program value of 0% with the minimum value (-10 V or -20 mA) and at 100% with the maximum value (+10 V or +20 mA).

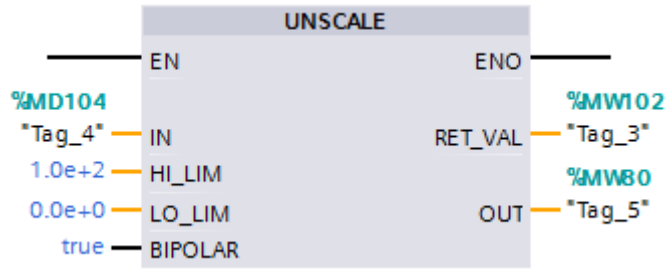


Figure 2-8 Unscaling in the UNSCALE program block

The value calculated by the program must be transferred in the REAL format (**IN**). You use the input **LO_LIM** to determine the low limit (0.0%), and **HI_LIM** to determine the high limit (100.0%) within which the program value moves. The unscaled value is output in INT format at the **OUT** output. You can assign parameters via the input **BIPOLAR** to specify if only positive or only negative values are to be converted. If the parameter receives an operand with the state '0', there is a unipolar scaling. An operand with the state '1' results in a bipolar scaling. The output **RET_VAL** outputs an error code in case of an error and the value '0' in case of an error-free execution.

Additional information on the UNSCALE block can be found in the STEP 7 online help.

Unipolar and bipolar measuring ranges

The figure below shows the scaling for an actuator that is to be addressed at a program value of 0% with the minimum value 0 (0 V or 0 mA) and at 100% (+27648) with the maximum value (10 V or 20 mA).

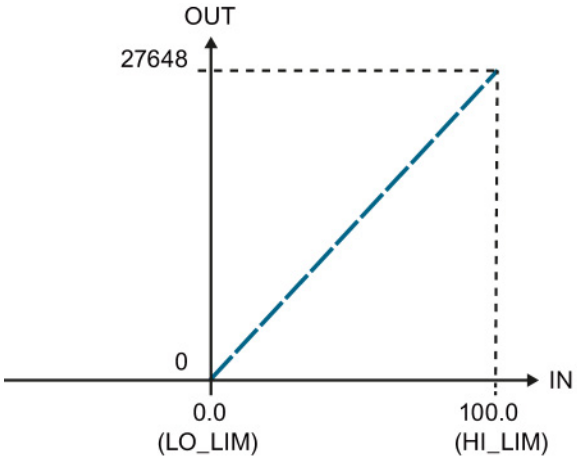


Figure 2-9 Unipolar measuring range

The figure below shows the scaling for an actuator that is to be addressed at a program value of 0% (-27648) with the minimum value 0 (-10 V or -20 mA) and at 100% (+27648) with the maximum value (+10 V or +20 mA).

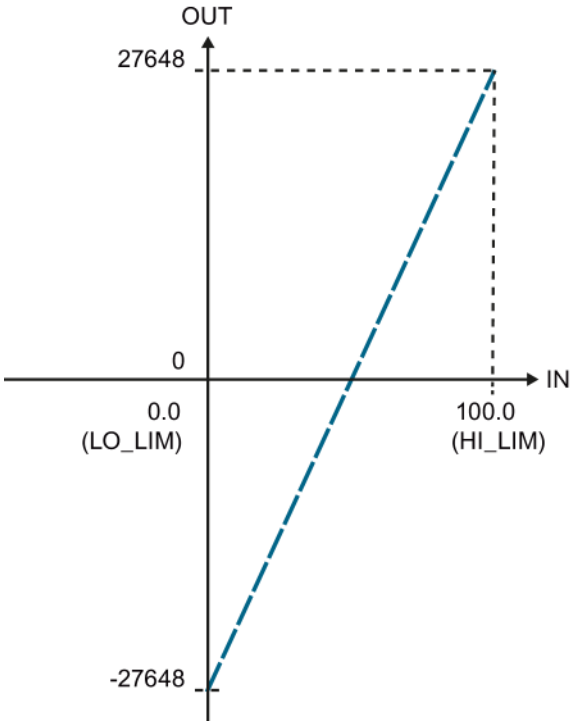


Figure 2-10 Bipolar measuring range

2.5 Linearity errors

Definition

Linearity denotes the deviation of the actual A/D or D/A conversion from the ideal lines within a specified measuring range. The linearity error therefore represents the deviation of the real transmission function from the ideal straight line. The error is given in the technical data as a percentage of the rated range of the analog module.

The figure below shows the linearity error of an ADC, magnified for better visibility.

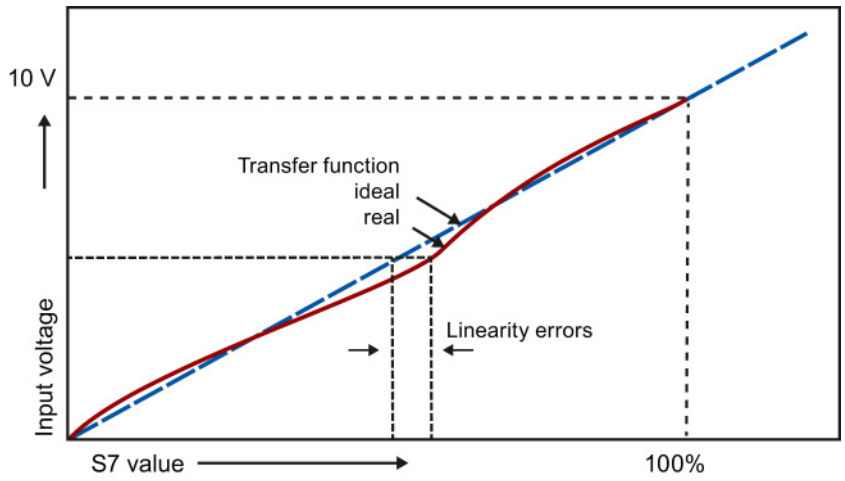


Figure 2-11 Linearity errors

Example

An error of ±1 mV is returned at an input range of ±10 V and a linearity error of ±0.01%. The error is calculated as follows: 10 V · 0.01 % = 1 mV

The linearity error information given in the technical specifications is taken into account in the operational limit. You will find a detailed description of the operational limit in Operational and basic error limits (Page 23).

2.6 Repeat accuracy

Definition

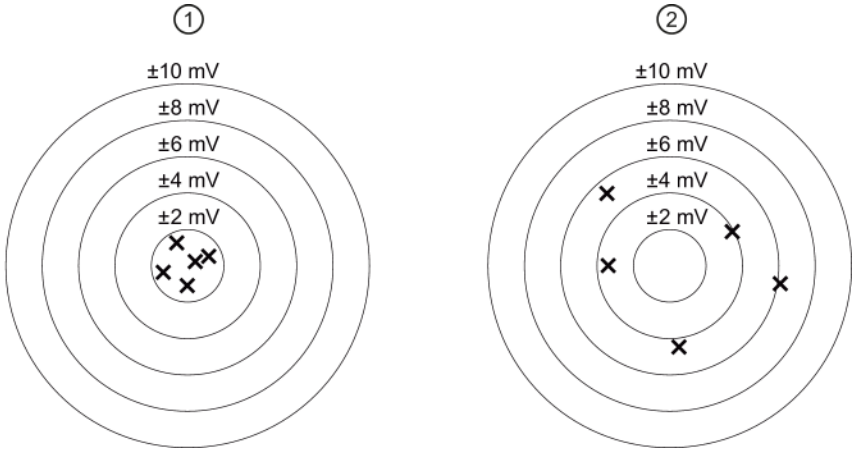
The repeat accuracy is the maximum deviation in measured/output value for the same input signal or output value after another value has been created or output. Other parameters, e.g. the Temperature parameter, remain unchanged. The repeat accuracy refers to the rated range of the module and applies in a steady temperature state.

Measured value variance

The repeat accuracy provides information on the variance of individual measurements. The smaller the variance, the greater the repeat accuracy. The repeat accuracy is therefore one of the most important properties of measuring devices. In the technical data, the repeat accuracy is given as a percentage of the input or output range at 25°C in the steady state.

Example

The specified repeat accuracy for an analog input module as a percentage of the measuring range end value is ±0.02 %. This corresponds to a repeat accuracy of 2 mV for any value within the measuring range of ±10 V. If you change the measured value from 10 V to -10 V, for example, and then measure with 10 V again, the measured value deviation may not exceed ±2 mV.



① Good repeat accuracy
② Poor repeat accuracy

Figure 2-12 Repeat accuracy of measured values output

2.7 Operational and basic error limits

Introduction

The following section shows you how to determine the operational or basic error limits and thus the measurement error or output error with the help of the technical specification. The worst-case configuration ensures that the module will not exceed the specified value within the valid operational range.

The precision of analog input or output modules is only part of the precision of the entire measurement section. A measurement section usually consists of transducer, transmitter, transmission line as well as input / output module.

Operational limit

The operational limit is the entire measurement or output error rate of the analog module in the rated range in temperature-settled state within the approved temperature range.

Basic error limit

The basic error limit is the entire measurement or output error rate in the rated range at an ambient temperature of 25 °C and temperature-settled state.

The basic error limit of the module is more or less a theoretical value, because a constant ambient temperature of 25 °C is rarely maintained in plants. For this reason, the operational limit always takes priority in terms of the practical selection and assessment of a module.

Note

The operational limit and basic error limit percentages listed in the technical specifications always relate to the **maximum possible** I/O value (the measuring range end value) in the rated range of the module.

The following image shows an example of operational and basic error limits in comparison with the ideal curve.

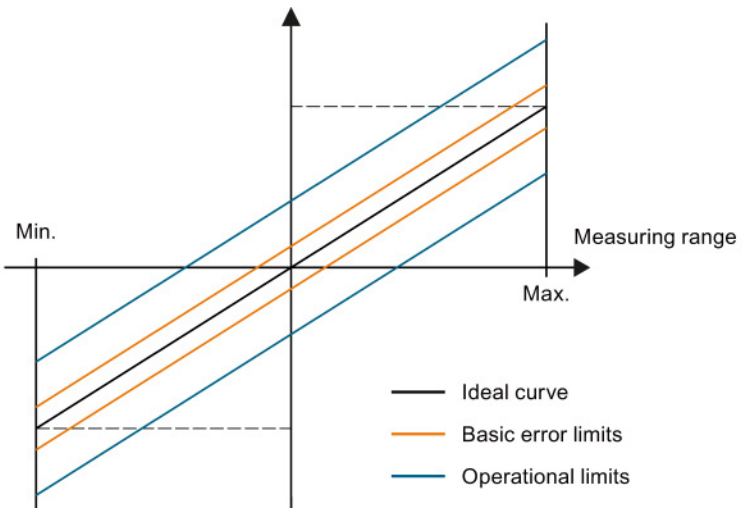


Figure 2-13 Operational and basic error limits

Example of output error calculation

An analog output module is used for voltage output in a range of 0 to 10 V. The module is operating at an ambient temperature of 30 °C, which means that the operational limit applies. Technical specifications of the module:

- Operational limit for the voltage output: ±0.1 %

The result is an output error of approximately ±10 mV (±0.1 % of 10 V) across the rated range of the module.

For example, the output value may range from 2.49 V to 2.51 V at an actual voltage of 2.50 V.

Note

Bipolar measuring ranges

The calculation also applies to bipolar measuring ranges.

An error of ±10 mV is also returned at an input range of ±10 V and a linearity error of ±0.1%.

2.8 Temperature error

Introduction

Analog modules are exposed to operational conditions that have an impact on their precision and on the measurement results they return. Temperature errors develop, for example, if the operating temperature of the module deviates from the ambient temperature of 25 °C. These temperature errors within the approved temperature range are taken into account in the operational limit.

Definition

The temperature error identifies the maximum drift of measuring/output values caused by fluctuation of the ambient temperature at the analog module. The maximum drift can occur at any ambient temperature. The temperature error is specified depending on the module used in percent per degree Celsius and/or percent per Kelvin, e.g. ±0.005%/K, and relates to the measuring range end value of the analog module.

Operational limits of compensation

The temperature error of the reference junction temperature compensation function only occurs with thermocouple measurements. The temperature error of compensation is added to the actual temperature error if "Internal reference junction" operating mode is selected. The temperature error of compensation is defined in the technical specifications as a percentage of the physical rated range of the analog module or as an absolute value in °C.

Note

Calculating the error in thermocouple measurements

Add the error of a thermocouple measurement to the error of the compensation measurement to determine the total error of a thermocouple measurement. These errors are defined in the respective manual.

Example

In this example, the total error of the temperature measurement is determined with the help of a type K thermocouple. The type K thermocouple takes measurements at a temperature range from -270 °C to +1372 °C.

The technical specifications state an operational limit of >-200 °C ±2.4 K for the type K thermocouple. The temperature error of compensation amounts to ±6 °C. The total temperature error is measured as follows at a temperature of >-200 °C:

Operational error (±2.4 K) + temperature error of compensation (±6 °C) = ±8.4 °C.

2.9 Interference frequency suppression

Definition

The interference frequency suppression function is applied to analog input modules to suppress the noise caused by the frequency of the AC voltage supply used.

The frequency of the AC voltage supply is likely to have a negative effect particularly on the values returned by measurements in the low voltage range and on thermocouples.

Parameter assignment

The line frequency at which the system is operated can be set by means of module parameters, for example, in STEP 7.

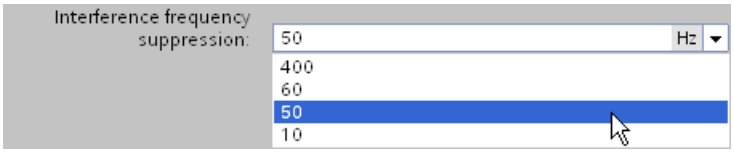


Figure 2-14 Interference frequency suppression

The conversion time changes depending on the set interference frequency suppression. The data sheets of the respective module define this dependency.

Please note the following when selecting interference frequency suppression:

The higher the frequency setting, the shorter the conversion time.

Note

Line frequency

Always select the interference frequency based on the line frequency used. Mismatch errors must be expected if a frequency that deviates from this line frequency is set, for example, to reduce the conversion time. In this case, the specified technical data and, in particular, precision are possibly outside the specified range.

Smoothing

By smoothing analog values, you achieve an additional improvement for the suppression of interference frequencies. For more information on the smoothing of analog values, refer to the section Smoothing (Page 54).

Line frequencies used

The line frequency is the frequency used in an electricity network for AC supply. It is measured in hertz and indicates the number of oscillations per second in a periodic signal. A line frequency of 50 Hz, for example, means 50 oscillations per second.

Europe, Australia and most countries in Asia and Africa use a line frequency of 50 Hz. North and Central America and most countries in South America have electricity networks with a line frequency of 60 Hz.

Frequencies of 400 Hz are most commonly used in on-board networks for airplanes, in the aerospace sector and for military applications. One reason for this is that engines with a line frequency of 400 Hz can usually be made smaller and lighter. As, however, it is not economic to transport such high frequencies over large distances, 400 Hz applications are usually subject to significant spatial limits.

A frequency of 16 2/3 Hz is used for the traction power supply in Germany, Austria and Switzerland. Some modules of the SIMATIC S7 product range also support the interference frequency suppression of this line frequency. The configurable interference frequency suppression in these cases is 16.6 Hz.

2.10 Common mode interference (UCM)

Definition

Common mode interference denotes interference voltages and currents in the lines connecting electrical devices and system components. They affect both the positive and negative line with the same phase angle and amplitude. The interference signal needs an additional current path to affect the utility signal. This current path is usually provided by common reference potential, e.g. earth or ground connection, of the utility signal and interference source.

Common mode interference in analog modules

Common mode interference occurs in analog input and output modules if their reference potential is different from the reference potential of the connected sensor or actuator.

Common mode interference is most likely to occur when analog modules are operated with grounded sensors. The size of the overall system means that voltage differences may develop between machine components with grounded sensors and the analog module reference. These voltage differences affect both the positive and negative signal path equally, which is why they are termed common mode interference.

In operation with non-grounded sensors, the occurrence of common mode interference is not as obvious as in grounded operation. Nevertheless, capacitive or inductive coupling can also create voltage differences in such cases which have the effect of common mode interference. Depending on the conditions in grounded and non-grounded operation, common mode voltage can occur as direct or as alternating voltage.

Example

The following figure of an analog module with two inputs (Ch_1/Ch_2) shows the coupled interference voltages at the inputs (U_{CM1}/U_{CM2}) as well as an interference voltage coupled between these inputs (U_{CM3}). Common mode rejection indicates the extent to which these interference signals can be suppressed. It is calculated using the following equation:
$CMR\ [dB] = 20 \cdot \log (U_{CM} / U_a)$

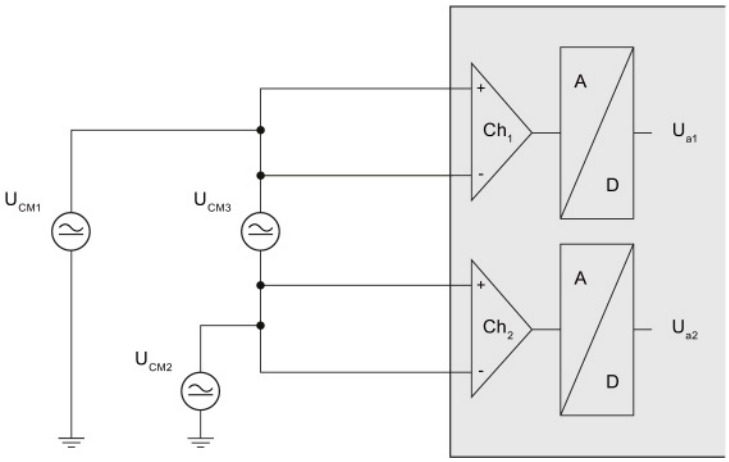


Figure 2-15 Common mode voltage coupled between two inputs

If there is common-mode voltage (U_{CM}), the equation is solved for U_a to calculate the measuring error (U_a):

$$U_a = U_{CM} * 10^{-\frac{CMR}{20}}$$

Note

The common mode rejection (CMR) is detailed in "Common mode interference" in the technical data of the device manual for your analog module.

2.11 Series mode interference (USM)

Definition

Series mode interference is interference voltages and currents affecting the connection lines in opposite directions. They have opposite polarity in the positive and negative directions. Series mode interference currents cause a voltage drop at the input impedance that has the effect of an interference voltage.

Causes

Series mode interference is caused by capacitive or inductive coupling. Inductive coupling generates a magnetic flow that is radiated between adjacent current-carrying conductors. This induces an interference voltage in the conductor. Galvanic coupling is given where different circuits influence each other due to common conductor sections, e.g. common ground connection.

The diagram below shows series mode interference as a voltage source (U_{SM}) connected in series to the actual measuring signal (U_M). The index "SM" stands for "Series Mode". Series Mode rejection indicates the extent to which these interference signals are suppressed. It is calculated using the following equation: SMR [dB] = 20 · log (U_{SM} / U_a)

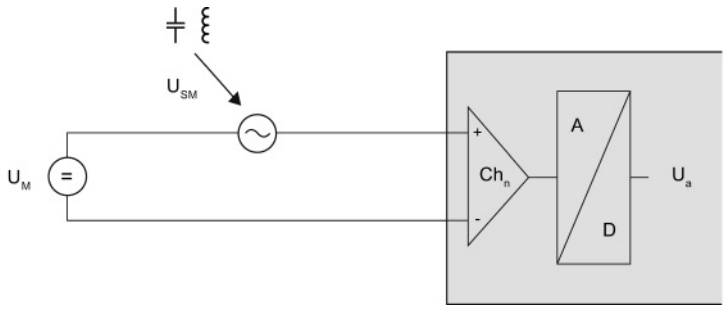


Figure 2-16 Capacitive or inductive interference coupling to the signal cable

The voltage (U_a) measurement error is calculated by solving the equation for U_a.

$$U_a = U_{SM} * 10^{-\frac{SMR}{20}}$$

The following equation shows the calculation of current (I_a) measuring errors using a current input.

$$I_a = \frac{U_{SM}}{R_{ein}} * 10^{-\frac{SMR}{20}}$$

Note

The series mode rejection (SMR) is detailed in "Series mode interference" in the technical data of the device manual for your analog module. The level of input resistance (R_{ein}) is also specified in the technical data.

2.12 Interference voltage suppression

Definition

Interference voltage suppression gives the factor by which the interference signal is suppressed in measurement value acquisition. Higher values reduce the effect of interference on the measurement signal. The technical data differentiates between "Common mode interference" and "Series mode interference". Interference voltage suppression is specified in decibels.

Example

The diagram below shows the measuring error for interference voltages in volts and interference voltage suppression of 0 to 120 dB.

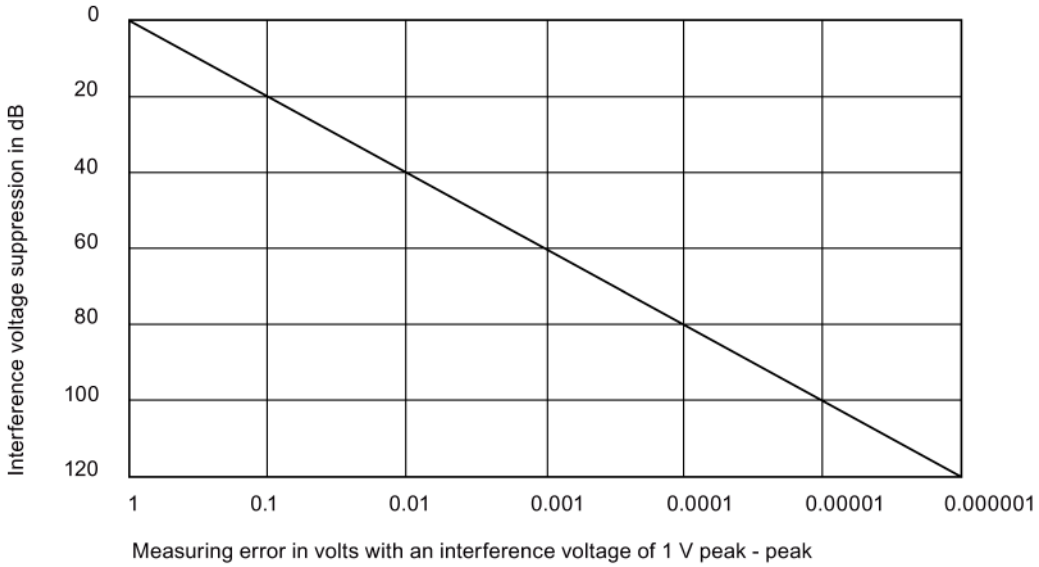


Figure 2-17 Interference voltage suppression

With an interference voltage suppression of 40 dB and an interference voltage of 1 V, the measured value is only distorted by 0.01 V.

Note

Interference-free design

Disturbance variables can be substantially reduced by means of appropriate grounding and shielding to increase interference immunity of the configuration. You will find a detailed description of how to avoid interference in the Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

Common mode rejection

The table below sets out the possible common mode rejection specifications in the technical data of an analog input module:

Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency), n = 1, 2, ...	
Common mode interference	> 100 dB
Common mode voltage, max.	10 V

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression for common mode interference will only apply for the frequencies 50 Hz ±1 %, 100 Hz ±1 %, 150 Hz ±1 %, etc. Immunity is lower for all other frequencies. Interferences caused by the line voltage distort the measured utility signal in the ratio of 100,000 : 1. An interference voltage amplitude of 1 V, for example, will affect the utility signal by 10 µV.

The Common Mode voltage (U_{CM}) defines the maximum permitted deviation of the potential between two channels and between one channel and analog ground. The interference voltage suppression defined in the technical specifications must not be exceeded. If the maximum common mode voltage specified, for example, 10 V, is exceeded, the analog signal is processed incorrectly. Depending on the module used, this error may be diagnosed and an error message output. The maximum common mode voltage may be exceeded as a result of varying input or overly long lines.

Series mode rejection

The table below sets out the possible series mode rejection specifications in the technical data of an analog module:

Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency), n = 1, 2, ...	
Series mode interference	> 60 dB

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression for series mode interference will only apply for the frequencies 50 Hz ±1 %, 100 Hz ±1 %, 150 Hz ±1 %, etc. Immunity is lower for all other frequencies. Overall, interference caused by the line voltage distorts the utility signal measured by 1000 : 1. For example, an interference voltage amplitude of 1 V will affect the utility signal by 1 mV.

2.13 Crosstalk between channels

Origin of the term

The term crosstalk/XT was originally used in the field of telecommunication to denote unwanted coupling of voice signals between two cable conductors of different subscribers.

Definition

Crosstalk between signal channels denotes the interactive influence between two independent channels as a result of leakage currents and capacitive or inductive coupling. Crosstalk between the channels changes the signal by the value of the amplitude of the crosstalk signal.

Causes

Technically, it is not feasible to totally isolate the module channels from environmental conditions. This means that it is always possible for leakage currents or disturbance coupling having an interactive effect.

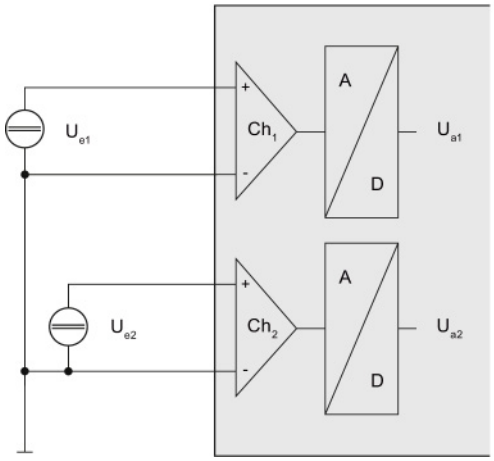


Figure 2-18 Crosstalk between two channels

The diagram shows the effects of crosstalk for the user with two channels (Ch_1/Ch_2) of an analog module. The crosstalk value is the factor by which the utility signal at a second channel U_{a2} is affected by the signal at the first channel U_{e1}. The measuring error (U_{a1}) can be calculated using the following equation:

$$U_{a1} = U_{e2} * 10^{\frac{XT\ [dB]}{20}}$$

Example of crosstalk attenuation

The "crosstalk between inputs" value in the technical specifications is defined as a value of >-100 dB at a measuring range of -10 V to +10 V on channel 1 of an eight-channel analog input module. The voltage at the input has an amplitude of 10 V. What is the error caused by crosstalk at channel 0 (measuring range ±10 V) and channel 2 (measuring range ±80 mV)?

100 dB are equal to a factor of 100,000. The measured values at channels 0 and 2 to 7 are therefore affected by 10 V / 100,000 = 100 µV. This distortion is added to or subtracted from the pending measuring signal and its effect depends on the selected measuring range.

- Channel 0: 100 µV / 10 V = 0.001 %
- Channel 2: 100 µV / 80 mV = 0.125 %

A voltage of 10 V set at channel 1 distorts the measured value at channel 0 by 0.001% and the measured value at channel 2 by 0.125%. The measuring error resulting from crosstalk in this example is therefore 0.001 % or 0.125 %. The basic error limit already includes the error generated as a result of crosstalk between the channels.

Calculating measuring error

You calculate the measurement error at channel 1 in this example based on a change in the measurement voltage of 10 V at channel 2. The crosstalk (XT [dB]) value is defined in the technical specifications in the manual of the analog module that you are using.

$$\text{Measured value error channel 1 [in V]} = \text{measured value change at channel 2 [in V]} * 10^{\frac{\text{XT [dB]}}{20}}$$

$$\text{Measured value error channel 1 [in V]} = 10\ \text{V} * 10^{\frac{-80\ \text{dB}}{20}} = 0.001\ \text{V}$$

A change in the measurement voltage of 10 V at channel 2 causes a measurement deviation of 0.001 V at channel 1.

2.14 Diagnostics

Diagnostics for analog modules

SIMATIC analog modules can diagnose errors. A number of different types of diagnostics are available for analog modules in STEP 7. Please note that the parameter assignment options vary depending on the analog module and product family used. More detailed information on the types of diagnostics can be found in the device manual for your analog input or analog output module.

Proceed as follows to select the diagnostics types of the analog module used:

1. Open STEP 7.
2. Select the analog module in the Device view.
3. Select the "Properties" tab.
4. Select the inputs or the required channel of the analog module in the Inspector window.

Table 2- 2 Overview of diagnosable errors

Type of diagnostics	Analog input module	Analog output module
Wire break	✓	✓
No supply voltage L+	✓	✓
Overflow	✓	✓
Underflow	✓	✓
Common mode error	✓	-
Short-circuit	✓	✓
Overload	-	✓
Reference junction	✓	-

Diagnostics of the analog module are carried out while the system is in operation, on the basis of the current output variables such as current or voltage. If the output current or output voltage is no longer sufficient, the module will not be able to run reliable diagnostics. The limits within which diagnostics are possible are specified in the technical data for each module.

The module reports the diagnosed state to the CPU using a diagnostics error interrupt. If several diagnostics are pending at the same time, the diagnostics with the highest priority is reported to the CPU first. Diagnostics are output on LED displays on the affected module, on the CPU display, on the Web server or on an HMI device.

The configurable diagnostics types depend on the respective selected measuring type or output type. The following tables shows the relationship between the diagnostics types, measuring types or output types of an analog input module or analog output module.

Diagnostics Analog input modules

Table 2- 3 **Diagnostics types of an analog input module to be configured depending on the measurement type "Voltage"**

	No supply voltage L+	Wire break (1 to 5 V)	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	✓	-	-
ET 200SP	✓	-	✓	✓	-	-	✓
ET 200AL	-	✓	✓	✓	-	-	✓
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	✓

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 4 **Diagnostics types of an analog input module to be configured depending on the measurement type "Current (4-wire transducer)"**

	No supply voltage L+	Wire break (4 to 20 mA)	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	✓	-	-
ET 200SP	✓	✓	✓	✓	-	-	✓**
ET 200AL	-	✓	✓	✓	-	-	✓**
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	✓

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

** Diagnostics for encoder supply only

Table 2- 5 **Diagnostics types of an analog input module to be configured depending on the measurement type "Current (2-wire transducer)"**

	No supply voltage L+	Wire break (4 to 20 mA)	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	✓	-	-
ET 200SP	✓	✓	✓	-	-	-	✓**
ET 200AL	-	✓	✓	✓	-	-	✓**
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	✓

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

** Diagnostics for encoder supply only

Table 2- 6 **Configurable diagnostics types of an analog input module depending on the measurement type "Resistor (4-wire connection)"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	-	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 7 **Configurable diagnostics types of an analog input module depending on the measurement type "Resistor (3-wire connection)"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	-	-	-	-
ET 200eco PN	✓	✓	✓	-	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 8 **Configurable diagnostics types of an analog input module depending on the measurement type "Resistor (2-wire connection)"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	-	-	✓	-	-	-
ET 200MP	✓	-	-	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	-	-	-	-
ET 200eco PN	✓	✓	✓	-	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 9 **Configurable diagnostics types of an analog input module depending on the measurement type "Thermal resistor (4-wire connection)"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 10 **Configurable diagnostics types of an analog input module depending on the measurement type "Thermal resistor (3-wire connection)"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 11 **Configurable diagnostics types of an analog input module depending on the measurement type "Thermal resistor (2-wire connection)"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	-	-	-	✓	-	-	-
ET 200MP	-	-	-	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 2- 12 **Diagnostics types of an analog input module to be configured depending on the measurement type "Thermocouple"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	✓	-
ET 200MP	✓	✓	✓	✓	✓	✓	-
ET 200SP	✓	✓	✓	✓	-	✓	-
ET 200eco PN	✓	-	✓	✓	-	✓	-
ET 200pro	-	-	✓*	✓*	-	✓	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Diagnostics for analog output modules

Table 2- 13 **Diagnostics types of an analog output module to be configured depending on the measurement type "Voltage"**

	No supply voltage L+	Wire break	Overflow	Underflow	Short-circuit	Overload
S7-1500	✓	-	✓	✓	✓	-
ET 200MP	✓	-	✓	✓	✓	-
ET 200SP	✓	-	✓	✓	✓	-
ET 200eco PN	✓	-	-	-	✓	✓
ET 200pro	-	-	-	-	✓	-

Table 2- 14 **Diagnostics types of an analog output module to be configured depending on the measurement type "Current"**

	No supply voltage L+	Wire break	Overflow	Underflow	Short-circuit	Overload
S7-1500	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	-	-
ET 200SP	✓	✓	✓	✓	-	-
ET 200eco PN	✓	✓	-	-	-	✓
ET 200pro	-	✓	-	-	-	-

Note

Measuring ranges

Note that the diagnostics types that can be parameterized depend on the selected measurement/output type as well as on the respective measuring range.

Note

Minimum output values

Certain errors such as wire break and short circuit cannot be diagnosed below a given current or voltage value. Diagnostics are only possible again once the output returns to above this minimum value.

No supply voltage L+

You can diagnose a missing or low supply voltage L+ at the analog module by activating the "No supply voltage L+" checkbox. If the supply voltage is missing or too low, the status and error display on the analog module will provide the relevant information. The entry in the diagnostics buffer also makes this information available to the CPU.

If there is no supply voltage, no other types of diagnostics available are possible either.

Wire break

The term wire break denotes a failure state that is triggered by the interruption of a usually closed electrical circuit.

Wire break in analog input modules

The "Wire break" diagnostics function facilitates the detection of errors during system operation. In STEP 7 you define the module properties by setting various parameters. Depending on the module used, you may, for example, be able to set a current limit parameter at which a wire break is to be reported.

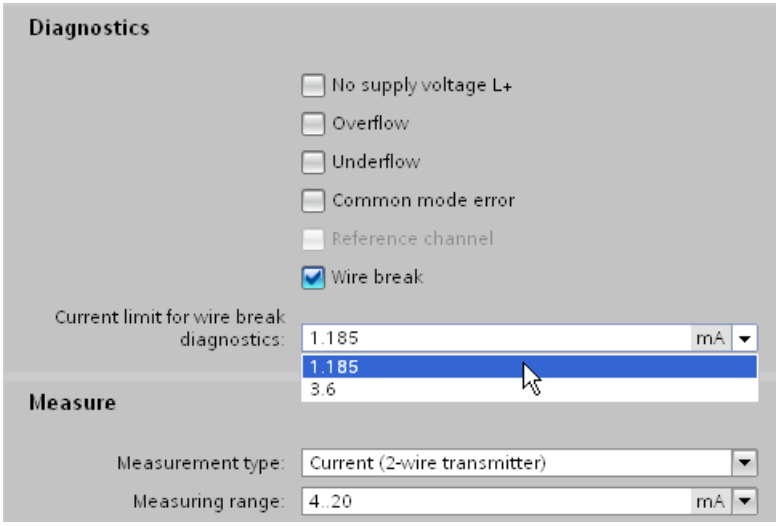


Figure 2-19 Configuring the wire break current limit for an analog input module in STEP 7

Usually, the live zero technique is deployed to detect wire breaks. The start of the measuring range for the standard live zero signal of 4 to 20 mA is assigned the 4 mA signal value. A wire break between the input and sensor can therefore be detected based on the missing current flow. Instead of a current signal, you may also use a voltage signal from 1 to 5 V to detect a wire break. The "Wire break" diagnostics function can therefore only be configured for a range of 4 to 20 mA or 1 to 5 V.

For "Resistor", "Thermal resistor" and "Thermocouple" measurements, a current is impressed into the line. If a wire break occurs, the flow of current is interrupted and the analog module therefore detects the wire break.

Wire break in analog output modules

The analog signal output is used for wire break detection. Reliable wire break diagnostics is not possible if the voltage is too low. In this case, the diagnostics function is deactivated without triggering a change of the diagnostics status.

The current limit up to which the module will diagnose wire break can be found in the technical data for the module.

Overflow/underflow

The resolution of the measuring range of an analog input module distinguishes between the rated range, the overrange or underrange, and the overflow or underflow. The following table assign the number of increments into which the measured signal is divided to the various voltage measuring ranges.

Table 2- 15 Voltage measuring range ±10 V of an analog input module

Value (increments)	Voltage measuring range	Range
Decimal	±10 V	
32767	> 11.759 V	Overflow
32511	11.759 V	Overrange
27649		
27648	10.0 V	Rated range
0	0 V	
-27648	-10 V	
-27649		Underrange
-32512	-11.759 V	
-32768	< -11.759 V	Underflow

As of a decimal value of 32512, the value acquired is beyond the overrange and is no longer valid. If this is the case, the error status "Overflow" is diagnosed. The overrange is a tolerance range before overflow is reached.

As of a decimal value of -32513, the value acquired is below the configured measuring range and is no longer valid. If this is the case, the error status "Underflow" is diagnosed. The underrange is the equivalent of the overrange, but for negative values.

An "Overflow" or "Underflow" diagnostics may be caused, for example, by a wire break, an incorrect measuring range or incorrect wiring.

Note

Accuracy

The accuracy specified in the technical data of the relevant module is only guaranteed within the rated range.

Common mode error

Activating the "Common mode" checkbox diagnoses a violation of the maximum potential difference U_{CM}. A violation of the permitted potential difference U_{CM} has occurred, for example, between the reference point of the measuring inputs and the analog ground M_{ANA} .

Possible causes:

- Wiring error
- Environments with EMC disturbance
- Incorrectly grounded transducers
- Long line lengths
- Sensor not connected
- 2-wire transducer connected to M_{ANA}

Note

With 4-wire transducers, a current meter connected in series will result in too great a drop in voltage.

Potential differences U_{CM} beyond the valid limits may lead to measurement errors and malfunctions. If you want to ensure that the maximum value is not exceeded, interconnect the measuring inputs and analog ground M_{ANA} with an equipotential bonding cable. More detailed information can be found in Wiring transducers.

Short-circuit

Activating the "Short circuit" checkbox activates short-circuit diagnostics for an analog channel. The diagnostics function is triggered by channel overload.

Possible causes:

- Wiring error (e.g. short circuit between conductors at the connections or in the cable)
- Use of faulty or incorrect actuators (e.g. internal short circuit or low input resistance as a result of actuator failure)

The analog signal output is used for short circuit detection. If the voltage is too low, reliable short-circuit diagnostics are not possible. In this case, the diagnostics function is deactivated without triggering a change of the diagnostics status. The voltage limit up to which the module will diagnose a short circuit can be found in the technical data for the module.

SIMATIC modules have a special protective circuit to prevent short circuit. The short circuit current is limited internally in the module. The level of short circuit current is specified in the technical data of your analog module.

Note

Overload

Please note that overload exposes the modules are exposed to a greater thermal load. This can affect the output channels. You should therefore avoid continuously running analog output modules in overload.

Reference junction

This type of diagnostics can only be selected for analog input modules for "Thermocouple" measuring. Selecting the "Reference junction" check box diagnoses an error on the reference channel for compensating the reference junction temperature.

The temperature at the reference junction of a thermocouple is measured at the reference channel of the module using an external thermal resistor (RTD). If an error occurs, for example as a result of a wire break, the temperature measured at the reference junction of the thermocouple will no longer be compensated. The reference temperature may then be outside the valid range.

Additional information on connecting thermocouples and thermal resistors and on how they operate can be found in Thermocouples and Wiring transducers.

Overload

Activating the "Overload" checkbox activates the diagnostics of the thermal monitoring of the output level. The "Overload" diagnostics is triggered when the maximum temperature is exceeded at the output and is detected channel by channel.

The maximum temperature may be exceeded for the following reasons:

- Ambient temperature is too high
- Output is being operated outside the specification

Note

Overload

Please note that overload exposes the modules to a high thermal load. This can affect the output channels. You should therefore avoid continuously running analog output modules in overload.

2.15 Value status

Value status

In case of a faulty analog value, the analog module outputs the error values 0x7FFF (error value for overflow and all other error states) or 0x8000 (error value for underflow) for the affected channel. The user program is now able to detect and evaluate a channel error. The user also has the option to evaluate the system diagnostics event-driven by means of diagnostics alarms.

In addition to the error values 0x7FFF or 0x8000 and the configured diagnostic types, analog input and output modules provide diagnostics information by means of the Process image input (PII). It is referred to as Value status and transferred synchronously with the user data. The value status (Quality Information = QI) provides a statement regarding the validity of the input signal. A distinction is made between the quality level "Good" (signal valid = 1) and "Bad" (signal invalid = 0).

Note

For analog input modules, the use of the value status is an alternative to the evaluation of the channels by the error values 0x7FFF or 0x8000. Compared to the error values, the binary evaluation of the value status (0 or 1) in the user program is simpler and more clearly arranged.

For analog output modules, the value status informs you as to whether the written value can be output by the respective channel. Using the value status you can respond to this information without having to evaluate the diagnostics of the module in the first place.

Example

Enabling the value status of an analog input module

To enable the value status of an analog input module, follow these steps:

- Select the required analog module in STEP 7.
- Select "AI configuration" in the "Properties" tab of the analog module.
- Click the "Value status" button.

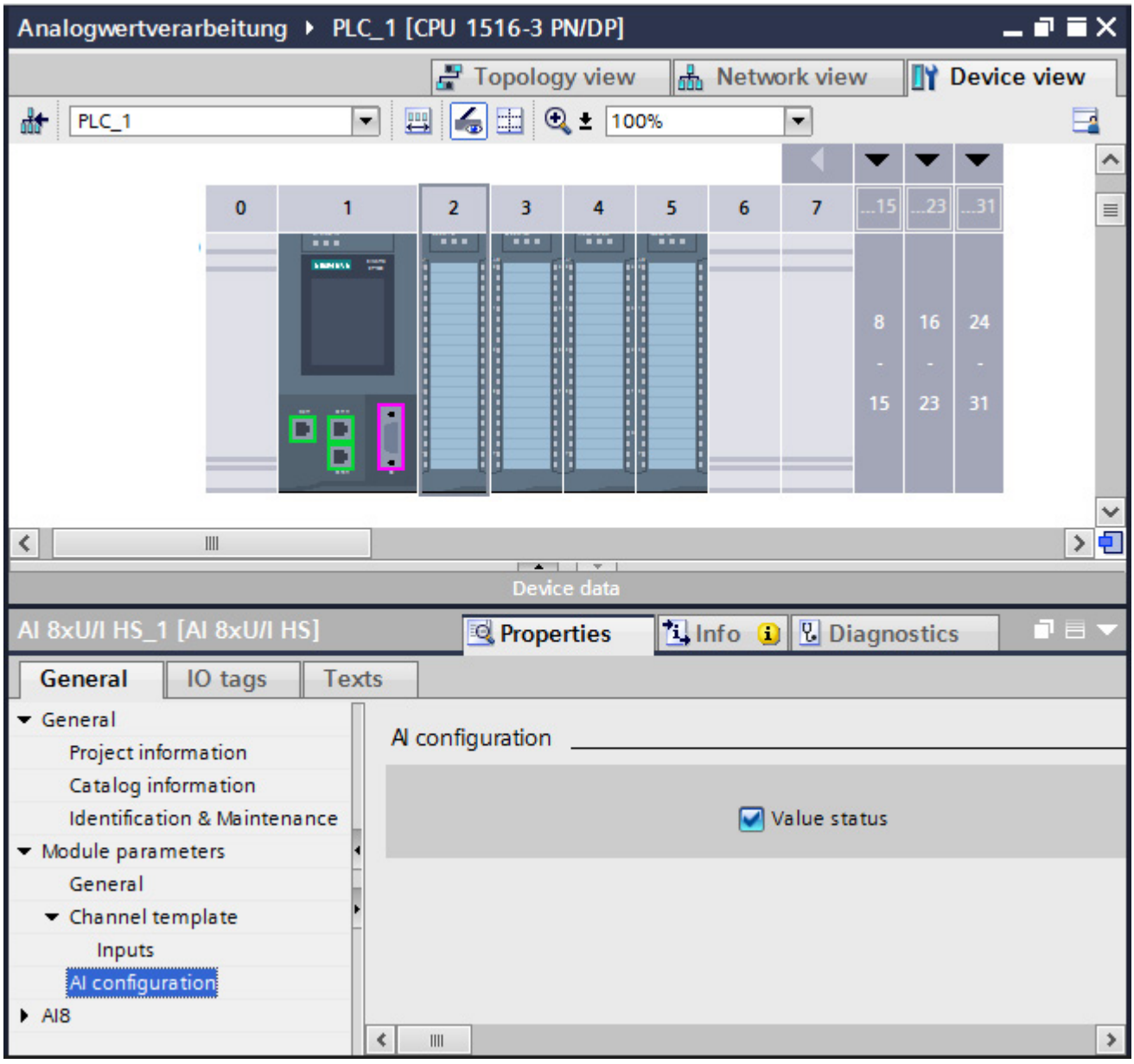


Figure 2-20 Enabling the value status in STEP 7

An additional byte is occupied in the input address space of the respective module when you enable the value status. Each bit in this byte is assigned to a channel and provides information on, for example, whether the output value specified by the user program is actually queued at the module terminal (0= value is invalid; 1= value is valid).

Error occurrence

If a wire break occurs at an analog input module, for example, the current signal state is entered in the process image and the value status of the signal is set to "invalid". To trigger an indicator light in case of an error, for example, evaluate the value status in the user program.

Diagnostics alarms and value status

If you configure analog modules in a third-party product with the help of a GSD file and the diagnostics alarms are not evaluated event-driven, it is best to use the value status.

Note

The Value status represents a group diagnostics which only gives the user a Good or Bad information. The Value status is not suitable for a more specific identification of the cause of the error (e.g., wire break, short circuit in the encoder cable or load voltage failure).

2.16 Conversion time of an analog module

Basic conversion time and conversion time of an analog input channel

The basic conversion time is the minimum time required by one single channel to convert analog values. The actual conversion time comprises both the basic conversion time and, depending on the analog input module used:

- Processing time for measuring resistance
- Processing time for wire break monitoring
- Processing time for overflow/underflow monitoring
- Processing time for checking common mode errors

Example

This example shows channel 6 of an analog input module for resistance measurement in the range of 6000 Ω, a configured integration time of 20 ms, and activated wire break monitoring.

The conversion time of the channel is derived from the total of the following measurement variables:

Measurement variable	Time in ms
Basic conversion time	27
Processing time for RTD/resistance (6000 Ω)	4
Processing time for wire break monitoring in the RTD/resistance and thermocouple areas	9
Conversion time of the channel	**40**

Conversion time of the analog output channels

The conversion time of an output channel starts with the transfer of the digital value from the internal memory of the module and ends with the digital-to-analog conversion.

The conversion time does not include the settling time for the analog signal at the module terminal. Detailed information on the settling time can be found in Settling and response times of analog output modules (Page 52).

Note

Relationship between diagnostics and conversion time

While some diagnostics run parallel to the conversion and do not extend the conversion time, other diagnostics types can lead to an extension of the conversion time, as demonstrated in the example above.

Conversion time for high-speed analog modules

High-Speed analog modules (HS modules) are designed for faster processing of signals. HS modules offer fewer diagnostics and measurement types than standard modules (ST modules). You can find more information on HS modules in the section High-Speed analog modules (Page 113).

2.17 Cycle time of an analog module

Definition

The cycle time of an analog module represents the time that the module needs to process all channels used. The cycle time depends on the form of measured value acquisition used, e.g. multiplex or parallel measured value acquisition.

Sequential measured value processing

This procedure processes the analog channels in the module one after another (sequentially). For analog inputs, the values are connected to a converter, for example using a multiplexer, and sequentially converted.

The cycle time of the analog module is derived from the total conversion time of all activated analog channels of the module. STEP 7 provides the option of deactivating unused analog channels. to reduce the cycle time.

The figure below gives an overview of the factors that determine the cycle time of an n-channel analog module.

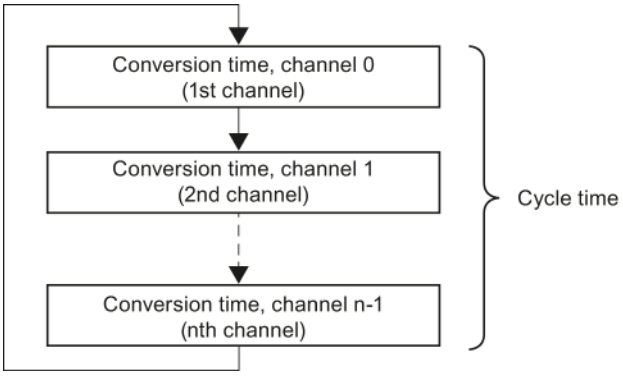


Figure 2-21 Cycle time of an analog module with multiplex conversion

Parallel measured value acquisition

This procedure processes the analog channels of a module at the same time (in parallel) rather than one after another. In parallel measured value processing, the cycle time of the module is usually constant and does not depend on the number of channels used. The goal of parallel measured value acquisition as it is applied by high-speed analog modules, for example, is a shorter cycle time. You can find more information on HS modules in the section High-Speed analog modules (Page 113).

2.18 Settling and response times of analog output modules

Settling and response times provide information on the delay of the output of a specified analog output variable and its availability to the process.

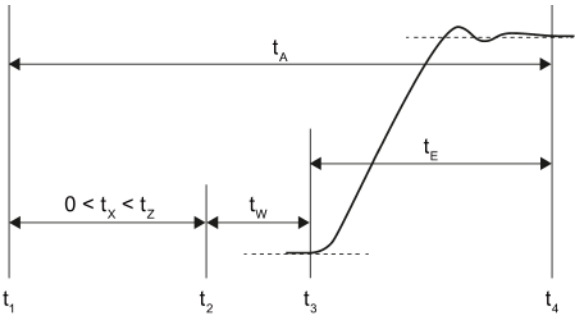
Response time

The response time for a new output value is defined as the time between the input of a digital output value to the internal memory of the module and the value to be output at the analog output being reached (with a residual error of 1 %).

The response time (t_A) is the sum of application time (t_X), conversion time (t_W) and settling time (t_E):

$t_A = t_X + t_W + t_E$

Settling and response times of analog output modules



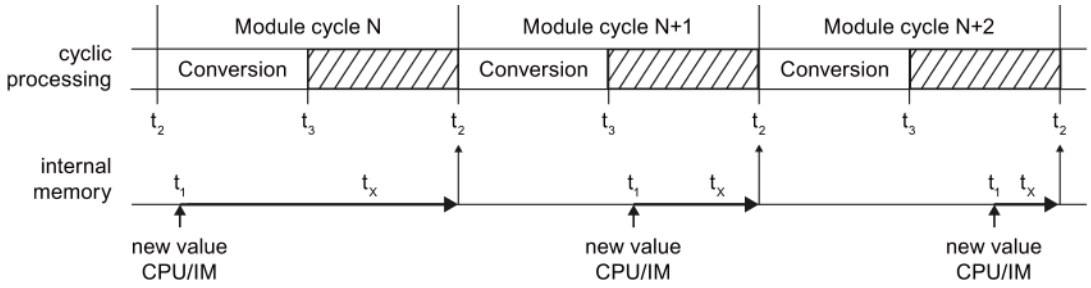
t_A Response time
t_X Application time
t_Z Module cycle time
t_W Conversion time
t_E Settling time
t_1 New digital output value is available in the internal memory of the module
t_2 Module activates the digital output value and starts conversion
t_3 Module ends conversion at the terminal of the analog output channel and outputs the analog signal
t_4 Signal has settled and the specified analog output value has been reached (residual error 1 %)

Figure 2-22 Settling and response time of an output channel

Application time

The CPU/IM (interface module) writes new output values to the internal memory of the analog output module. The time required for this is not determined by the CPU/IM. These output values are converted asynchronously to their entry in buffer memory. The worst-case application time (t_X) may be equal to the cycle time (t_Z). This situation develops if the CPU writes a new value to the internal memory of the module immediately after the transfer of the value for conversion. This new value will not be processed until the next conversion.

The figure below shows acyclic access of the analog output module to output values from the internal memory in non-isochronous mode. You can find more information on isochronous mode in the paragraph on isochronous mode of the section High-Speed analog modules (Page 113).



t_X Application time

t_1 New digital output value is available in the internal memory of the module

t_2 Module activates the digital output value and starts conversion

t_3 Module ends conversion at the terminal of the analog output channel and outputs the analog signal

Figure 2-23 Application of the output values

Conversion time

The conversion time of an output channel starts with the transfer of the digital value from the internal memory of the module (t_2) and ends with the digital-to-analog conversion (t_3).

Settling time

The settling time starts when the analog signal is output to the module (t_3) terminals and ends when the output value (t_4) is reached. The output value is reached as soon as the output signal has settled at its final value, taking into account a residual error of 1%.

The settling time depends on the type of output for the module, and on the connected load. The load for the analog output consists of connecting line and connected actuator. When the output is "Current", the settling time increases with high ohmic resistance. Inductive loads cause subsequent fluctuation in the output value. When the output is "Voltage", the capacitive load causes subsequent fluctuation.

2.19 Smoothing

Using the smoothing functions

Most analog input modules allow you to configure smoothing for the measuring signal in STEP 7. Smoothing analog values reduces the effect of interference signals. Smoothing is useful with slow changes in measured values, for example in temperature measurements.

Smoothing principle

The measured values are smoothed by means of filtering. The module forms mean values from a specified number of converted (digitalized) analog values. Smoothing should not be confused with the integration of measured values over a defined period of time. It is therefore not possible to smooth measured signals to filter out a specific interference frequency. However, this smoothing returns more "stable" data values because it suppresses peaks which overlay the measured signal.

4 (none, weak, medium, strong) or more levels of smoothing can be configured by the user depending on the module used. The level determines the number of analog values from which the mean value is generated. The greater the smoothing factor, the better the filtering.

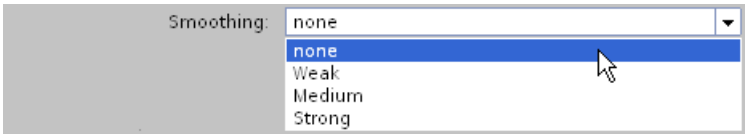


Figure 2-24 Selecting the smoothing level in STEP 7

Smoothing method

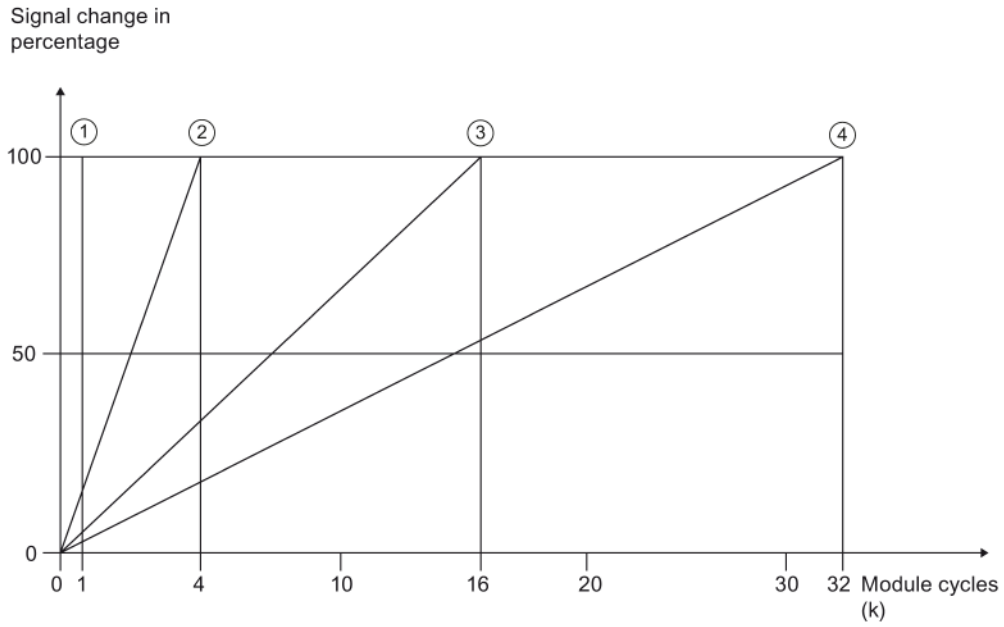
A smoothing algorithm is applied to a configurable number of measured values (e.g. 4, 8, 32) in line with the moving average. Each new measured value is factored in, and the oldest measured value then ignored. This mechanism suppresses interference peaks which overlay the measured signal. Utility signal jumps only become evident in the data after some time (see examples below).

The modules of the various product ranges use different smoothing algorithms. Smoothing is either linear or exponential. The differences are apparent particularly with strong smoothing and lead to a faster or slower rate of rise depending on the product used.

For information on whether or not a specific module supports customization of the smoothing function, please refer to the manual of the analog input module.

Example 1: Linear smoothing

The diagram below shows the number of module cycles (k) it takes for each smoothing level setting for the smoothed analog value to reach approximately 100 % after a step response. This specification is valid for all signal changes at the analog input.

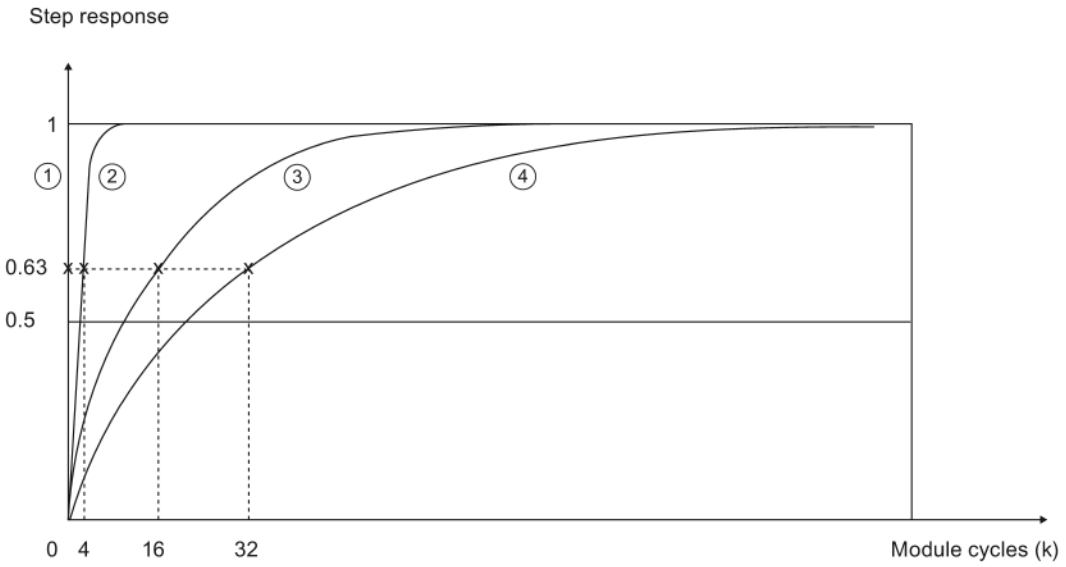


① No smoothing (k = 1)
② Weak smoothing (k = 4)
③ Medium smoothing (k = 16)
④ Strong smoothing (k = 32)

Figure 2-25 Linear smoothing with four smoothing levels

Example 2: Exponential smoothing

The diagram below shows the step response of the smoothing factor for different numbers of module cycles.



① No smoothing (k = 1)
② Weak smoothing (k = 4)
③ Medium smoothing (k = 16)
④ Strong smoothing (k = 32)

Figure 2-26 Exponential smoothing with four smoothing levels

2.20 Burden with 2-wire transducers

2-wire transducers

2-wire transducers are current transducers which convert the process variable into a current signal of between 4 and 20 mA. Two connection lines supply the transducer with an output current of at least 4 mA. Additional information on connecting 2-wire transducers to analog input modules can be found in the section Wiring current transducers (Page 72).

Burden

The burden indicates how great the external resistance in a current loop may be. If the external resistance is greater than the specified burden, the 2-wire transducer supply voltage is too low. The burden consists of the resistance of the transducer and all other resistances connected to the current loop.

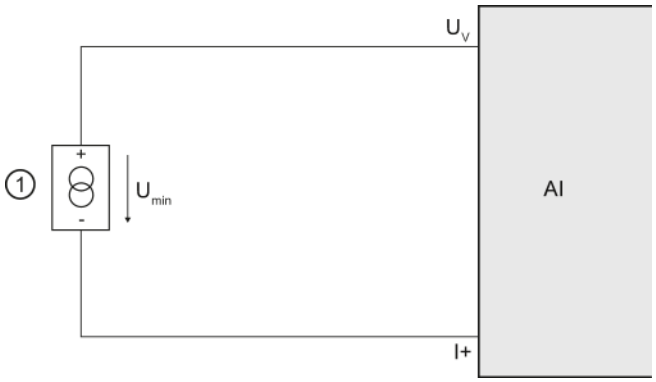
The maximum admissible burden of the transducer, e.g. 820 Ω, is specified in the technical data of the analog module.

Example 1: Connecting a transducer to the electrical circuit

In accordance with the technical data of the 2-wire transducer used, it requires a supply voltage (U_{min}) of at least 8.5 V. Using Ohm's Law, you can calculate the resistance of the transducer used (R_{2DMU}) for a current of 20 mA.

$$R_{2DMU} = \frac{U_{min}}{I} = \frac{8.5\ V}{0.020\ A} = 425\ \Omega$$

With a supply voltage of at least 8.5 V, the transducer has a resistance of 425 Ω. The resistance is less than 820 Ω. You can therefore connect the transducer to the analog input module (AI) without exceeding the maximum burden.



① 2-wire transducers
U_V Terminal for feed voltage at the channel
I+ Terminal for current input
U_{min} Voltage drop at 2-wire transducer

Figure 2-27 Connecting a transducer to the electrical circuit

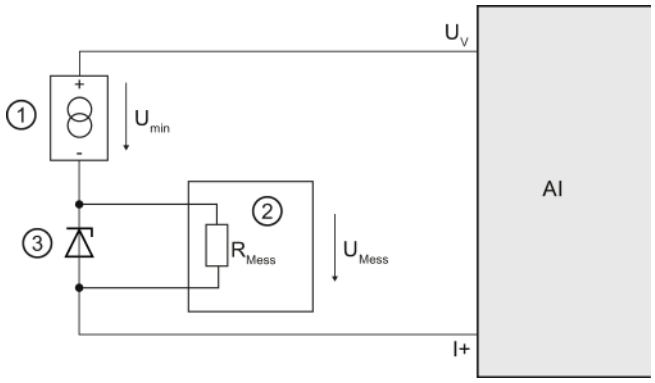
Example 2: Connecting a transducer and other devices

If multiple measuring devices are connected in series, the sum of all connected resistances may not exceed the value of the maximum burden.

If you have connected a 2-wire transducer to a supply voltage of 8.5 V, you will need to allow for the resistance of the measuring device connected ②.

Maximum transducer burden:	820 Ω
Transducer resistance upon a voltage drop of 8.5 V:	425 Ω
Maximum resistance of additional devices connected:	395 Ω

The resistance of the measuring instrument may therefore not exceed 395 Ω.



① 2-wire transducers
② Digital multimeter
③ Zener diode
U_V Terminal for feed voltage at the channel
I+ Terminal for current input
U_{min} Voltage drop at 2-wire transducer
R_{Mess} Resistance at measuring instrument
U_{Mess} Voltage drop at the measuring instrument

Figure 2-28 Connecting a transducer and other devices to the circuit

Calculating admissible voltage drop

The maximum additional resistance in the current loop may not exceed 395 Ω at a maximum current of 20 mA. You can calculate the voltage drop at the connected measuring instrument (U_{Mess}) as follows using Ohm's Law:

$U_{Mess} = R_{Mess} * I = 395\ \Omega * 0.020\ A = 7.9\ V$

The voltage drop at the measuring instrument should therefore not exceed 7.9 V.

Representation of analog values

3

3.1 Overview

Conversion of analog values

The CPU only processes analog values in digitalized format.

Analog input modules convert the analog signal into a digital value for further processing by the CPU.

Analog output modules convert the digital output value from the CPU into an analog signal.

Analog value representation at 16-bit resolution

The digitized analog value is the same for all I/O values at the same rated range. The analog values are represented as fixed point numbers in twos complement. This leads to the following conditions:

Table 3- 1 Representation of analog values

Resolution	Analog value															
Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Significance of the bits	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Sign

The sign (S) of the analog value is always set in bit 15:

- "0" → +
- "1" → -

Resolution less than 16 bits

The analog value is left-aligned in the memory of analog modules with a resolution of less than 16 bits. The unused least significant digits are padded with "0" values.

This reduces the number of measured values that can be represented. Modules occupy a range of values of between+32767 and -32768 regardless of the resolution. The scaling between two successive values depends on the resolution of the module.

Example

The following example shows how the least significant digits are padded with "0" values:

- The module with 16-bit resolution is capable of incrementing the values in steps of one unit ($2^0 = 1$).
- The module with 13-bit resolution is capable of incrementing the values in steps of 8 units ($2^3 = 8$).

Table 3- 2 Example: Bit pattern of a 16-bit and 13-bit analog value

Resolution	Analog value															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16-bit	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
13-bit	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	0	0	0

S = sign

Note

For information on the resolution supported by each analog module, please refer to the technical data for the relevant module.

3.2 Representation of input ranges

The tables below set out the digitalized representation of the input ranges by bipolar and unipolar input ranges. The resolution is 16 bits.

Please see the device manuals for each analog input module for assignment of the values to the specific measured values in each measuring range.

Table 3- 3 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Under range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 3- 4 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Under range
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

3.3 Representation of output ranges

The tables below set out the digitalized representation of the output ranges by bipolar and unipolar range. The resolution is 16 bits.

Please see the device manuals for each analog output module for assignment of the values to the specific output values in each measuring range.

Table 3- 5 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Under range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

** When values < -32512 are specified, the output value is limited to -117.593 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

Table 3- 6 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

** When values < 0 are specified, the output value is limited to 0% (0.0 V / 0.0 mA).

Connecting transducers

4

4.1 Overview

Introduction

This chapter describes the basic procedure for wiring transducers to analog inputs. Information on specific wiring options is available in the manual of each module.

For more information, e.g. on cable routing and shielding or potential equalization, etc., refer to the function manual for Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

Transducers that can be wired to analog inputs

You can wire the following transducers to the analog input modules, depending on the type of measurement:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

Isolated transducers and non-isolated transducers

Transducers are available in various models:

- Isolated transducers are **not connected** locally to the ground potential. Floating operation is possible.
- Non-isolated transducers are **connected** locally to the ground potential.

  Non-isolated transducer connections are connected to the conductive enclosure.

  Note: All non-isolated transducers must have a galvanic connection to each other and be locally connected to the ground potential.

Abbreviations used in the figures

Key to the abbreviations in the figures below:

AI	Analog input module
M	Ground connection
L+	Supply voltage connection
M_n+/M_n-	Measuring input, channel n
I_{Cn}+/I_{Cn}-	Current output to thermal resistor (RTD) channel n
U_n+/U_n-	Voltage input channel n
I_n+/I_n-	Current input channel n
COMP+/COMP-	Compensation input
I_{Comp}+/I_{Comp}-	Current output for compensation
U_V	Feed voltage at channel (the connection can be used for 2-wire transducer (2DMU) or with ET 200eco PN and ET 200pro for 2/4-wire transducer).
U_{CM}	Potential difference between the reference points of the measuring inputs / the analog ground M_{ANA}
U_{ISO}	Potential difference between the reference points of the measuring inputs and the central ground
M_{ANA}	Reference point of the analog ground

Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

4.2 Wiring analog inputs with MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated in analog input modules with M_{ANA} connection.

Limited potential difference U_{ISO} (insulation voltage)

Always verify that the admissible potential difference U_{ISO} between the reference point of the analog ground M_{ANA} and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure that the permitted value U_{ISO} is not exceeded, install an equipotential bonding cable between the terminal M_{ANA} and the central grounding point.

Limited potential difference U_{CM} (common mode)

Always verify that the admissible potential difference U_{CM} between the reference point of the measuring inputs and the analog groundM_{ANA} is not exceeded.

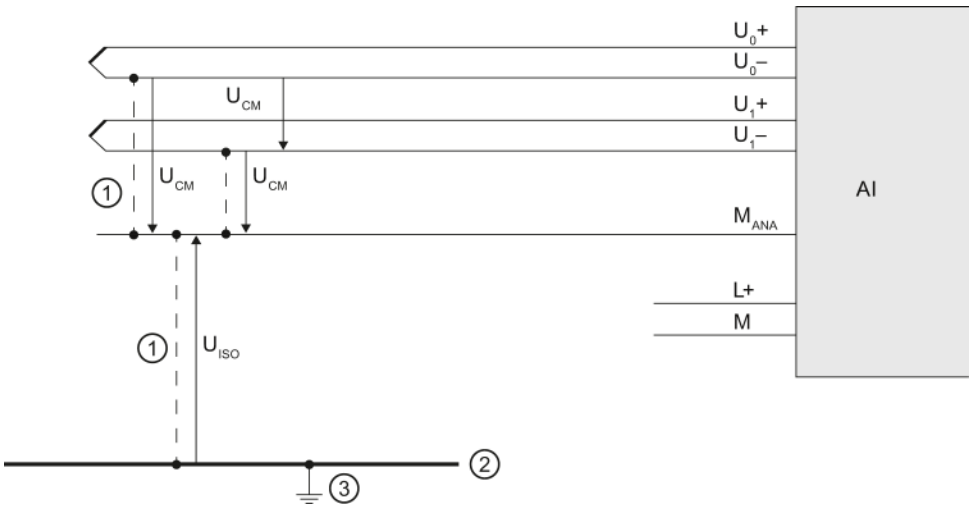
Potential differences U_{CM} may be caused by:

- Environments with EMC disturbance
- Use of grounded transducers
- Use of long cable lengths

Measuring errors / malfunctions can occur if the admissible potential difference U_{CM} is exceeded.

Some modules can detect an invalid potential difference U_{CM} and report this error with an entry in the diagnostics buffer of the CPU.

If you want to ensure that the maximum value U_{CM} is not exceeded, interconnect the reference points of the measuring inputs and the analog ground M_{ANA} with an equipotential bonding cable.



① Equipotential bonding cable
② Grounding bus cable
③ Central ground

Figure 4-1 Example: Reference potential for analog input modules with M_{ANA} connection

4.3 Wiring analog inputs without MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated from each other in analog input modules without an M_{ANA} connection.

Limited potential difference U_{ISO} (insulation voltage)

Always verify that the maximum potential difference U_{ISO} between the reference points of the measuring inputs and central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure that the permitted value U_{ISO} is not exceeded, install an equipotential bonding cable between the reference points of the measuring inputs and the central grounding point.

Limited potential difference U_{CM} (common mode)

Always ensure that the permitted potential difference U_{CM} between the reference points of the measuring inputs is not exceeded.

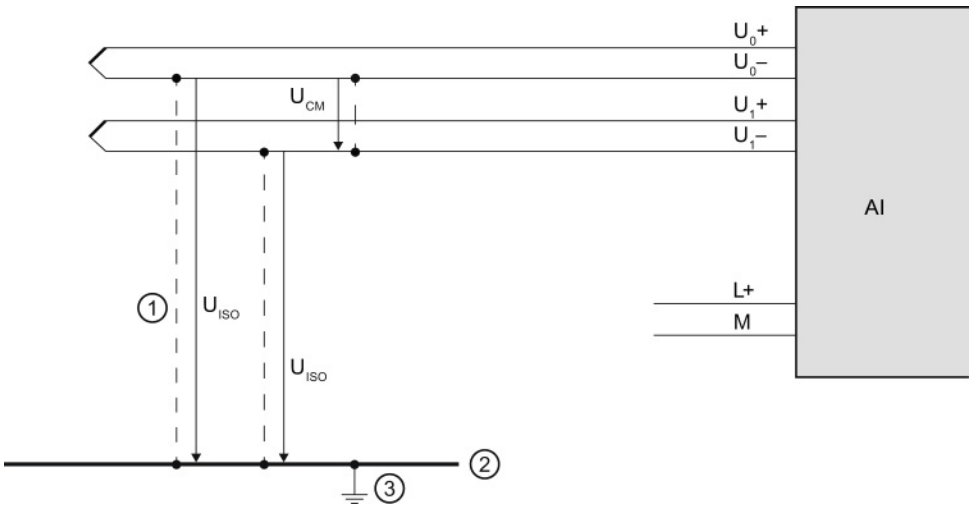
Potential differences U_{CM} may be caused by:

- Environments with EMC disturbance
- Use of grounded transducers
- Use of long cable lengths

Measuring errors / malfunctions can occur if the admissible potential difference U_{CM} is exceeded.

Some modules can detect an invalid potential difference U_{CM} and report this error with an entry in the diagnostics buffer of the CPU.

If you want to ensure that the permitted value U_{CM} is not exceeded, install equipotential bonding cables between the reference points of the measuring inputs or, with the ET 200eco PN and ET 200pro, between the reference points of the measuring inputs and ground.

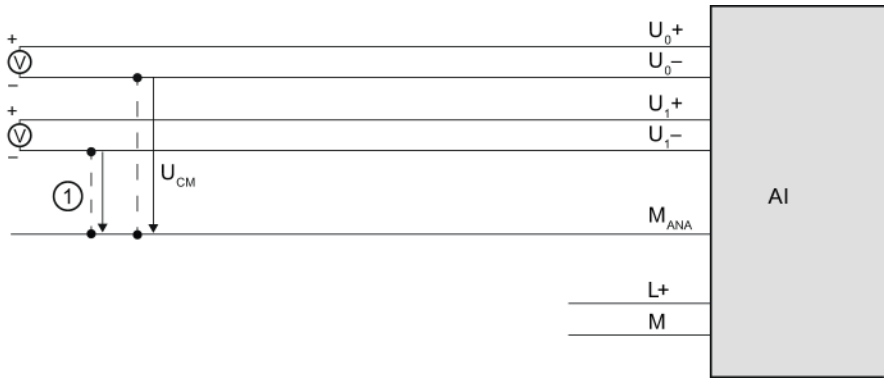


① Equipotential bonding cable (not for 2-wire and resistance transducers)
② Grounding bus cable
③ Central ground

Figure 4-2 Example: Reference potential for analog input modules without M_{ANA} connection

4.4 Wiring voltage transducers

The figure below shows how to connect voltage transducers. If you want to ensure that the permitted value U_{CM} is not exceeded, install equipotential bonding cables to connect the reference points of the measuring inputs to the analog ground M_{ANA}, or with ET 200eco PN and ET 200pro the reference points of the measuring inputs to the ground.



① Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-3 Example: Wiring voltage transducers to an analog input module

4.5 Wiring current transducers

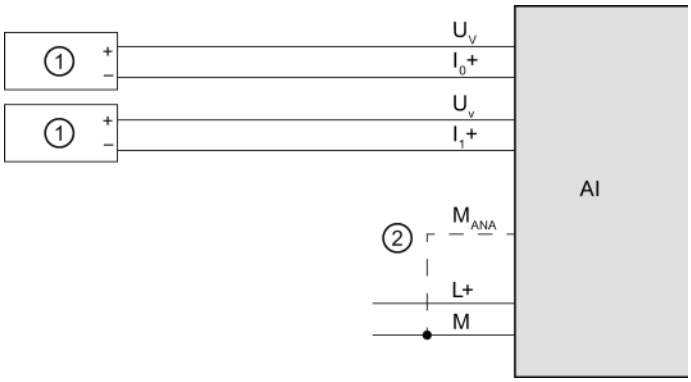
Current transducers are available as 2-wire transducers and 4-wire transducers. Below are a number of ways to supply current transducers with voltage.

Wiring 2-wire transducers with power supply from the module

The 2-wire transducer converts the process variable into a current. The 2-wire transducer is wired to the short circuit-proof supply voltage at the terminals of the analog input module. The transducer is therefore frequently also called a "passive transducer". Its simple wiring means that the 2-wire transducer is frequently used in industrial environments. If you use this type of connection, you will need to set the "Current (**2-wire transducer**)" measurement type in STEP 7.

Note

2-wire transducers must be electrically isolated.



① 2-wire transducers (2WT)

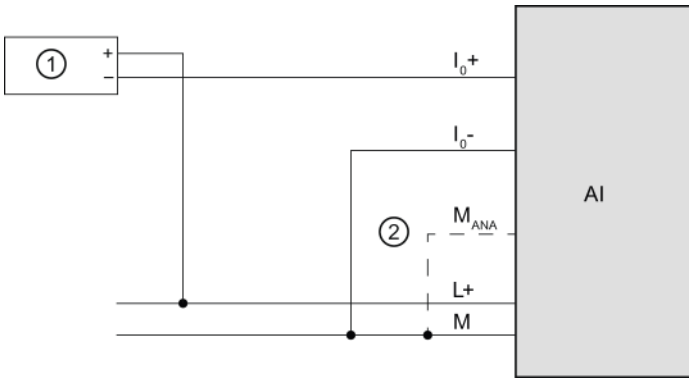
② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-4 Example: Wiring 2-wire transducers to an analog input module

Wiring 2-wire transducers to an analog input for 4-wire transducers

The figure below shows an alternative to the above connection: supplying the 2-wire transducer from supply line L+ of the module. If you use this type of connection, you will need to set the "Current (**4-wire transducer**)" measurement type in STEP 7.

In this type of connection, galvanic isolation between the supply voltage L+ and the analog circuit will be removed.



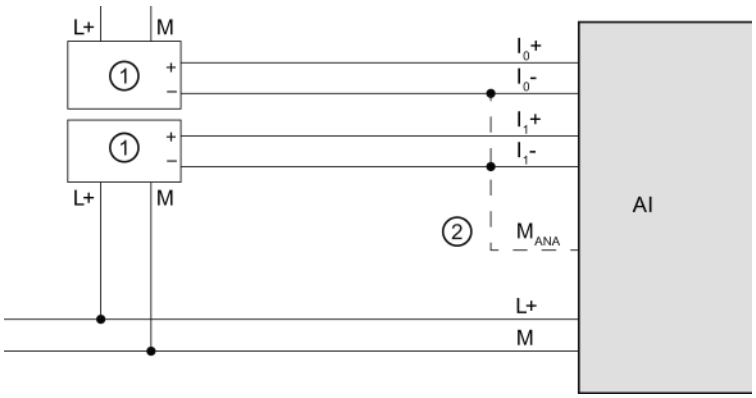
① 2-wire transducers (2WT)

② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-5 Example: Wiring 2-wire transducers to an analog input for 4-wire transducers

Wiring and connecting 4-wire transducers

4-wire transducers provide terminals for connecting a separate supply voltage. They are powered with an external supply and are frequently called "active transducers". If you use this type of connection, you will need to set the "Current (**4-wire transducer**)" measurement type in STEP 7.



① 4-wire transducers (4WT)

② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 4-6 Example: Wiring 4-wire transducers to an analog input module

4.6 Wiring thermal resistors and resistors

The module provides a constant current at terminals I_C+ and I_C- for resistance measurements. The constant current is fed to the resistance to be measured where it is measured as voltage drop. It is important to wire the connected constant current cables directly to the thermal resistor/resistor.

Measurements with 4-wire or 3-wire connection compensate for line resistance and therefore achieve greater accuracy compared to measurements with 2-wire connection.

Measurements with two-wire connection always acquire line resistance in addition to the actual resistance; you must therefore allow for a significant loss of precision in the measuring results.

The figures below give some connection examples.

4-wire connection of a thermal resistor

The voltage at the thermal resistor is acquired using high-impedance measurement via the M_0+ and M_0- terminals. Make sure the wiring is correctly poled (I_{C0}+ and M_0+, and I_{C0}- and M_0- at the thermal resistor).

Always wire the **I_{C0}+ and M_0+** lines, and the **I_{C0}- and M_0-** lines directly to the thermal resistor.

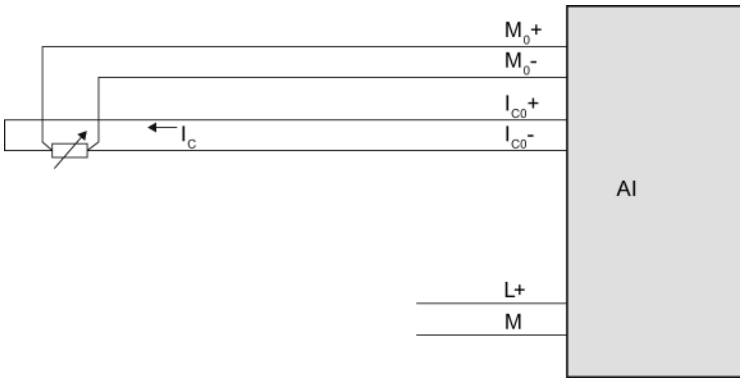


Figure 4-7 Example: 4-wire connection of thermal resistor to an analog input module

3-wire connection of a thermal resistor

Depending on the module, for a 3-wire connection to modules with 4 terminals (per channel), you may need to insert a bridge between **M_0- and I_{C0}-** (see figure below) or between **M_0+ and I_{C0}+**. Always wire the I_{C0}+ and M_0+ lines directly to the thermal resistor. Use cable with wires with identical cross-section.

For ET 200AL, ET 200eco PN and ET 200pro, no bridge is required as all necessary connections are implemented internally.

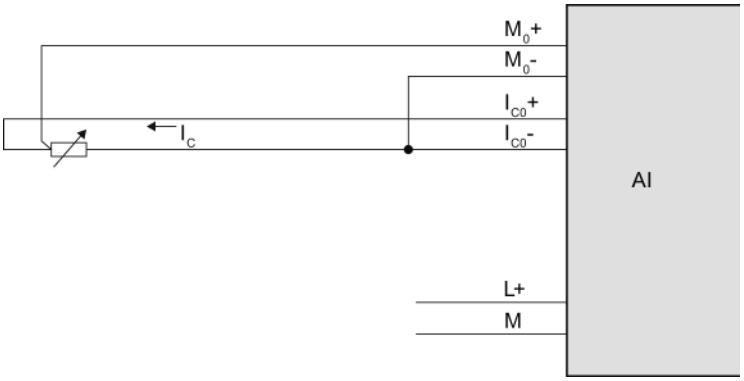


Figure 4-8 Example: 3-wire connection of thermal resistor to an analog input module

2-wire connection of a thermal resistor

When installing a 2-wire device on modules with 4 terminals (per channel), you will need to insert bridges at the module between **M_0+ and I_{C0}+** and between **M_0- and I_{C0}-** as shown in the figure below. The line resistance is measured, but not compensated. As a result of physical limitations, this measurement type is less accurate than measurement with 3-wire or 4-wire connections. The wiring for this type of measurement is, however, simple as the bridges required can be wired in the plug, saving line.

For ET 200AL, ET 200eco PN and ET 200pro, no bridge is required as all necessary connections are implemented internally.

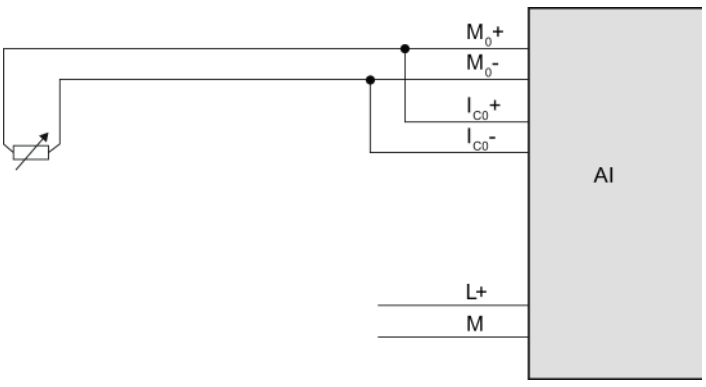


Figure 4-9 Example: 2-wire connection of thermal resistor to an analog input module

4.7 Wiring thermocouples

Introduction

Thermocouples are generally supplied ready-to-use. Protective casing prevents the thermocouples from being destroyed by mechanical force, for example.

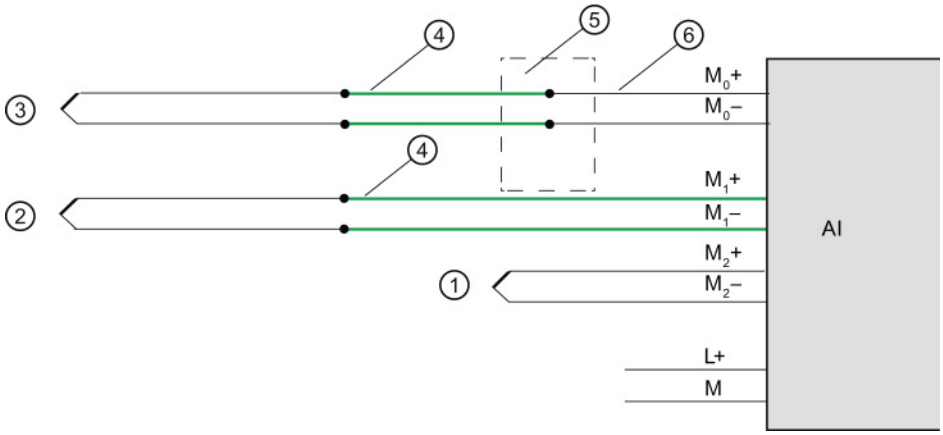
Compensating lines

The compensating lines belonging to the respective thermocouples are identified by a special color code, because only the compensating line that is made of the material matching the thermocouple may be used. The standardized compensating lines are specified in DIN EN 60584. Observe the maximum temperatures in the manufacturer's specifications.

Thermocouple connection options

There are various different ways to wire thermocouples to an analog input module:

- Directly ①.
- Using compensating lines ②.
- With a compensating line to the reference junction, connected with a supply line, e.g. copper ③.



① Thermocouple without compensating line
② Thermocouple with compensating line
③ Thermocouple with compensating line and supply line
④ Compensating line (same material as thermocouple)
⑤ External reference junction
⑥ Copper supply cable, for example

Figure 4-10 Example: Wiring thermocouples to an analog input module

Further information

Further information, such as the selection of thermocouples and how they operate, can be found in the section Thermocouples (Page 77).

Thermocouples

5

5.1 Selecting thermocouples

Introduction

Thermocouples are electrical devices for precise temperature measurement. They consist of two different metals connected at one point. Temperature affecting this point generates a voltage difference from which the temperature can be calculated.

Thermocouples can measure a wide range of temperatures and come in extremely robust models. They are therefore frequently used in industrial applications. Below are some of the criteria to consider when selecting the right thermocouple:

- Temperature range
- Atmospheric conditions
- Price

Grounded thermocouples

In grounded thermocouples, a conductive thermocouple wire is attached to the inside of the sensor housing. This results in good heat transfer from the sensor housing to the thermocouple measuring tip.

Non-grounded thermocouples

In non-grounded thermocouples, the thermocouple is not connected to the sensor housing. The response time following temperature changes is longer than with grounded thermocouples. The measuring point is galvanically isolated.

Type and temperature range

The different thermocouple types are derived from different material compositions.

Note

Due to physical conditions, thermocouples are extremely inaccurate outside the specified temperature range. Only use thermocouple in the temperature range specified by the manufacturer.

The following table lists the types and material compositions, as well as the temperature measuring range of different thermocouples:

Type	Material composition	Temperature range
B	PtRh-PtRh	250 to 1820 °C
C	W-Re	0 to 2315 °C
E	NiCr-CuNi	-270 to 1000 °C
J	Fe-CuNi	-210 to 1200 °C
K	NiCr-Ni	-270 to 1372 °C
L	Fe-CuNi	-200 to 900 °C
N	NiCrSi-NiSi	-270 to 1300 °C
R	PtRh-Pt (Pt 13%)	- 50 to 1769 °C
S	PtRh-Pt (Pt 10%)	-50 to 1769 °C
T	Cu-CuNi	-270 to 400 °C
U	Cu-CuNi	-200 to 600 °C
TXK/XKL	NiCr-CuCr	-200 to 800 °C

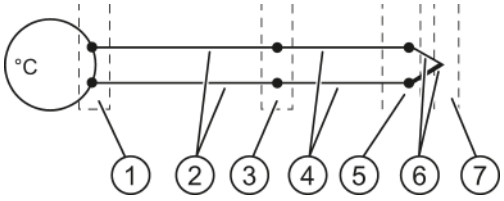
5.2 Structure and operating principle of thermocouples

Thermocouple structure

A thermocouple consists of a pair of thermal sensors and the respective installation and wiring elements. Two wires made of different metals/alloys are welded together at their ends (hot end). The welding point forms the so-called measuring point, while the free ends of the thermocouple form the reference junction.

The free ends are interconnected with the evaluation device (e.g. analog input module) via insulated wires or cables.

The different thermocouple types, e.g. K/J/N, are derived from different material composition; the same measuring principle is applied to all thermocouples, independent on their type.



① Thermal voltage acquisition point
② Copper supply cable, for example
③ Reference junction
④ Compensating line (same material as thermocouple)
⑤ Connection point
⑥ Thermocouple with positive and negative thermal elements
⑦ Measurement point

Figure 5-1 Thermocouple

Operating principle of thermocouples

Temperature differences between the measuring point and the free ends of the pair of thermal sensors (connection point) generate a thermal voltage at the reference junction. The value of the thermal voltage is determined by the temperature difference between the measuring point and the free ends, as well as by the material composition of the pair of thermal sensors.

Thermocouples always acquire a differential temperature, which means that the temperature at their free ends (reference junction) must be known to determine the temperature at the measuring point.

The thermocouple can be extended with compensating lines from the connection point. This allows the reference junction to be located at a specific point, for example, where the temperature can be kept constant or the temperature sensor is easy to install. The compensating lines and thermocouple wires are made of the same material. Copper cables are used to connect the reference junction to the module.

Note

Always observe the polarity, as incorrect wiring will result in unacceptable measuring errors.

5.3 Compensation for the reference junction temperature

5.3.1 Overview

Introduction

You have several options for measuring the reference junction temperature in order to obtain a correct temperature value as a function of the temperature difference between the reference junction and the measuring point.

You have various compensation options to suit requirements at the location of the reference junction.

The compensation options supported by the analog module used are specified in the manual of the respective module.

Options of compensating for the reference junction temperature

Table 5- 1 Compensation options: Explanation and use case

Compensation options	Explanation	Use case / special feature
Internal reference junction	**Function principle** With this type of compensation, the temperature of the reference junction is measured using an integrated sensor in the analog module. **Procedure** Connect the thermocouple to the I/O module directly, or with compensating lines; see chapter Compensation with internal reference junction (Page 84).	• For the connection, use compensating lines that match the thermocouple material. • If the reference junction temperature and the module temperature are identical in your system, you may also use lines made from a different material. • Advantages: – Inexpensive – No external reference junction required – No additional wiring required

Compensation options	Explanation	Use case / special feature
Reference channel of the module	**Properties** With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD). **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Wire the thermal resistor (RTD) to the reference channel of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation with reference channel of the module (Page 86).	• They acquire the temperature directly at the reference junction. • The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction. • Advantages: – More precise compared to compensation with internal reference junction; however, you need to install and wire an additional thermal resistor.
Reference channel of group 0	**Properties** With the "TC" (thermocouple...) setting, the channel acts as receiver for the reference junction temperature of group 0. The associated transmitter of group 0 is set up to for the RTD channel. **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Wire the thermal resistor (RTD) to the configured reference channel for group 0 of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation, reference channel of Group 0 (Page 88).	• They acquire the temperature directly at the reference junction. • The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction (transmitter).
Fixed reference temperature	**Properties** With this type of compensation, the reference junction temperature is stored in the module as fixed value. **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Depending on the module, you can enter a fixed reference junction temperature in the configuration data (e.g. 20 °C), or use the fixed reference junction temperature of the module (0 °C); see chapter Compensation with fixed reference temperature (Page 91).	• You keep the reference junction temperature constant and know the temperature value. • To ensure high precision, you must ensure that the temperature remains constant (this can be complicated, depending on the application).

Compensation options	Explanation	Use case / special feature
Dynamic reference temperature	**Properties** With this type of compensation, the reference junction temperature is determined using a module. Transfer this temperature value to other modules in the user program by means of a data record. **Procedure** Wire the thermal resistor (RTD) for the reference junction to any channel. The reference junction temperature is transferred with a function block by means of data records from the CPU or IM to the module, see section Compensation by means of dynamic reference temperature (Page 94).	• You are using multiple modules at the reference junction and can therefore compensate for all channels using a common temperature value. • You only need a thermal resistor (RTD) or a thermocouple to measure the temperature value.
No/external compensation	**Properties** With this type of compensation, the reference junction temperature is measured outside the analog input module. You can, for example, connect a compensating box to the thermocouple for this purpose. **Procedure** Connect the compensating box with the connection module of the analog input module with copper cables, see section "None" or external compensation (Page 98).	• The temperature of the reference junction for this type of compensation is specified as 0 °C. This can be achieved by using a compensating box. A separate compensating box is required for each thermocouple. • Thermocouples of type B do not require a compensating box.
RTD (0)	**Properties** This compensation is based on a measurement of the resistance value of a Pt1000 at the clamping unit of a compensation connector or of an external resistance value Pt1000. **Procedure** Additional information about the connection options with and without compensation connector is available in the section Type of compensation RTD (0) (Page 100).	• The reference junction temperature is determined with resistance value of the Pt1000. • All channels of the analog input module that you select for this type of compensation receive the same reference junction temperature.

5.3.2 Compensation with internal reference junction

Function principle

The reference junction for compensation via internal reference junction is at the terminals of the analog input module. Wire the thermocouples or compensating lines directly to the module inputs. The internal temperature sensor acquires the module temperature and returns a compensating voltage.

Note that compensation via internal reference junction will not always reach the precision of external compensation!

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Internal reference junction".

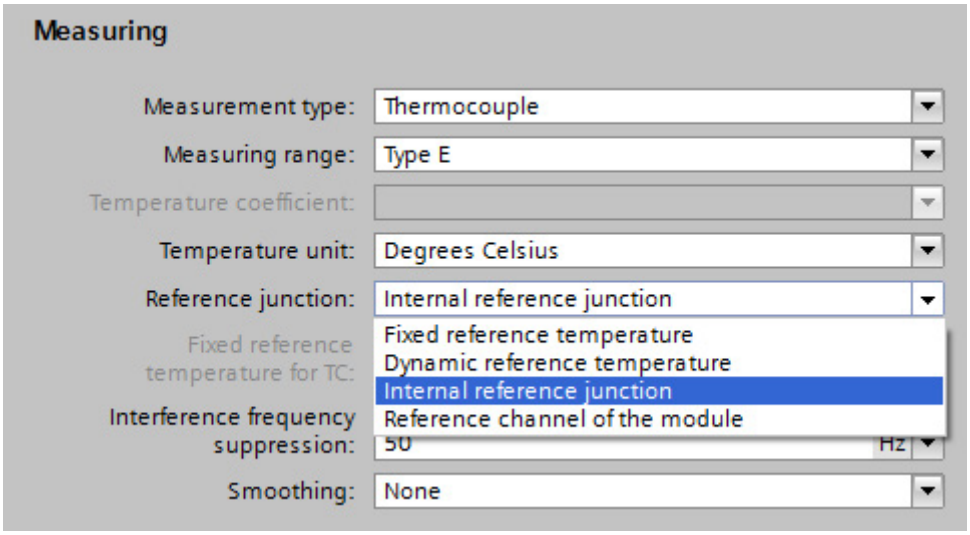
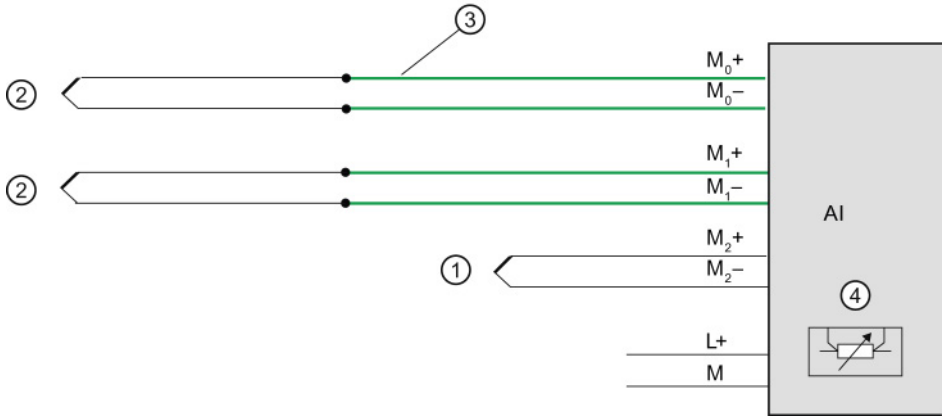


Figure 5-2 Internal reference junction

Wiring thermocouples

Wire the thermocouples directly or indirectly via compensating lines to the module inputs.



① Thermocouple without compensating line
② Thermocouple with compensating line
③ Compensating line (same material as thermocouple)
④ Internal reference junction

Figure 5-3 Example: Wiring thermocouples for compensation via internal reference junction

5.3.3 Compensation with reference channel of the module

Function principle

With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD). Certain modules provide an internal reference channel.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Reference channel of the module"".

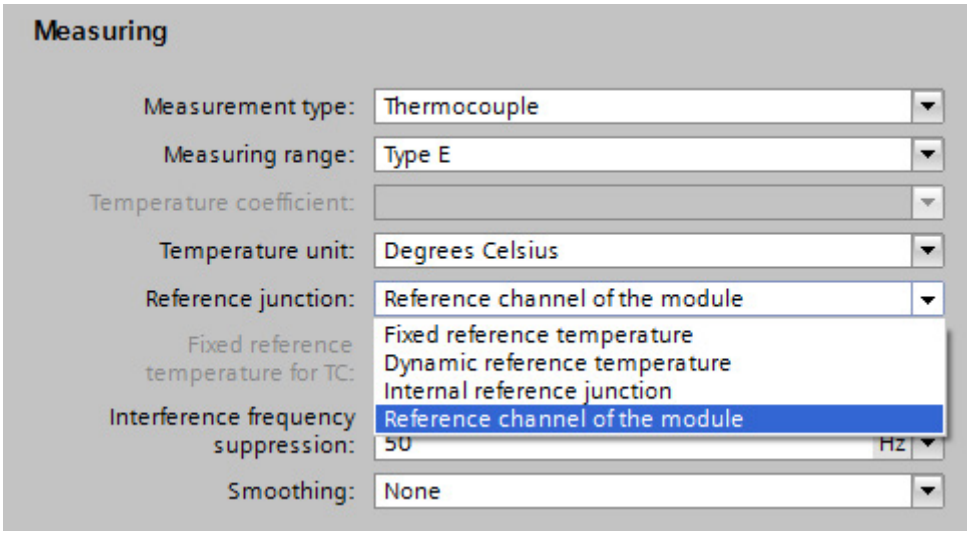
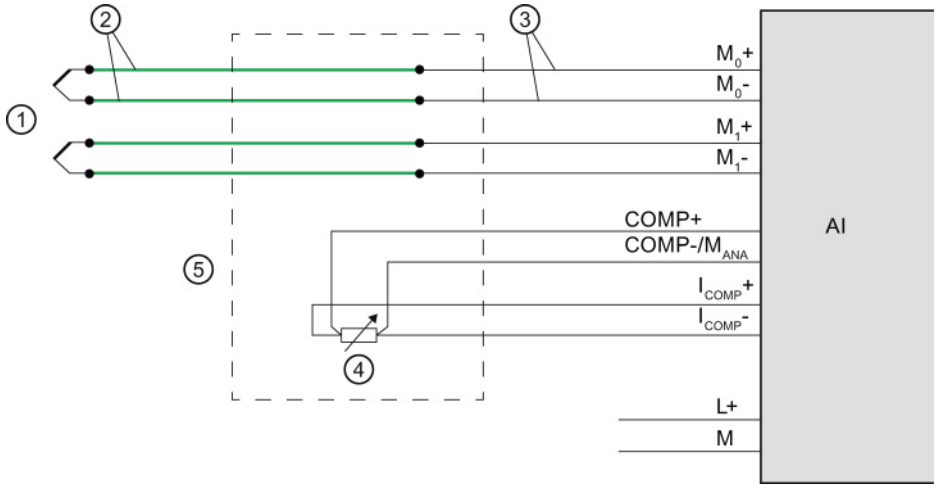


Figure 5-4 Reference channel of the module

Wiring thermocouples and thermal resistors

Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.



① Thermocouple
② Compensating line (same material as thermocouple)
③ Copper supply cable, for example
④ Thermal resistor (RTD)
⑤ Reference junction

Figure 5-5 Example: Wiring thermocouples/thermal resistors for compensation by means of reference channel of the module

5.3.4 Compensation, reference channel of Group 0

Function principle

For this compensation, a module channel with a connected thermal resistor (RTD) acts as "Reference temperature transmitter". Other channels (reference temperature receivers) with connected thermocouples can be compensated using this reference temperature. The measured temperatures of all channels (receivers) that you have configured for this compensation type will be compensated automatically by the temperature value of the reference junction (transmitter).

The reference junction temperature is determined by means of an external thermal resistor (RTD).

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the area "Inputs/measurement".
5. For the channel of the relevant module, specify as transmitter:

   As "Measurement type" select, for example, "Thermal resistor (4-wire connection)".

   As "Reference junction", select the value "Reference channel of group 0".

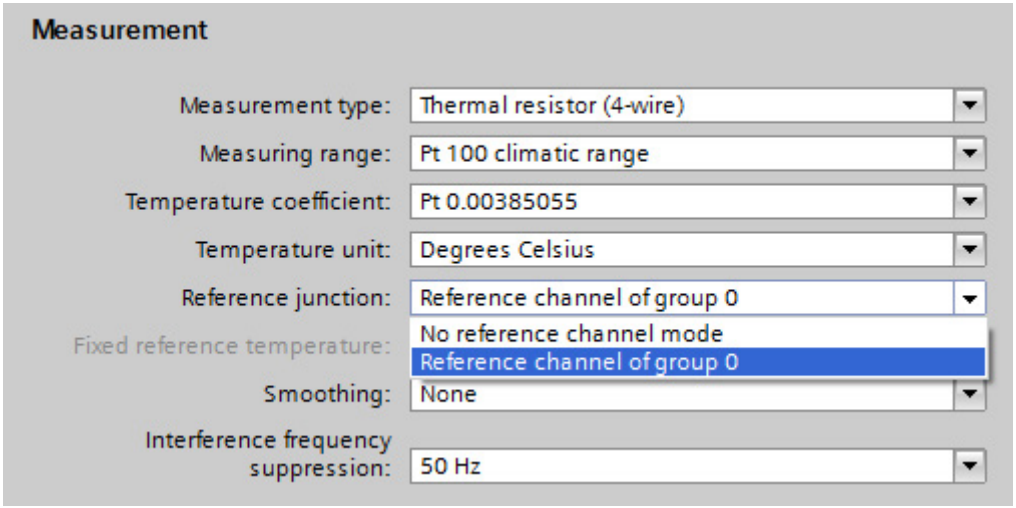


Figure 5-6 Transmitter: Reference channel of group 0

6. For the channels you specify as receivers:

   Select the "Thermocouple" value as "Measurement type".

   As "Reference junction", select the value "Reference channel of group 0".

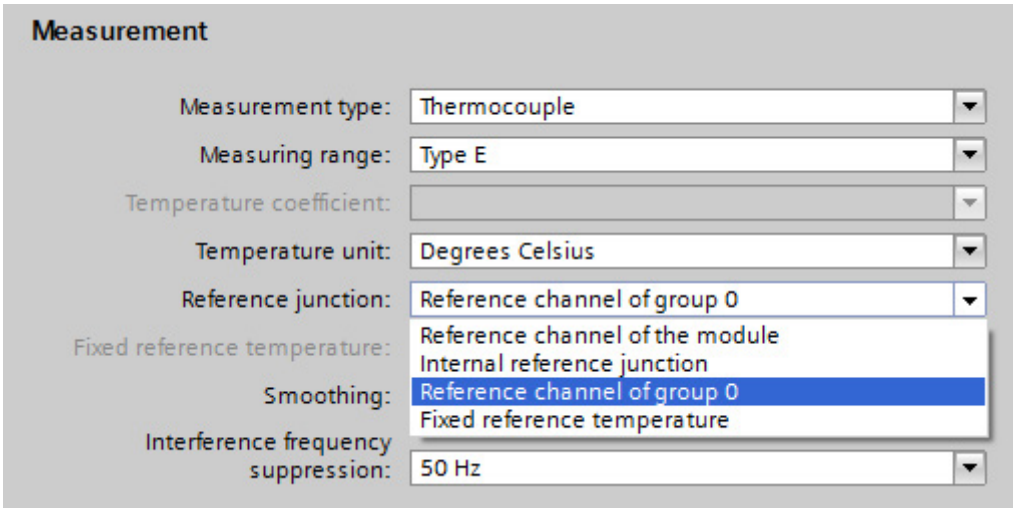


Figure 5-7 Receivers: Reference channel of group 0

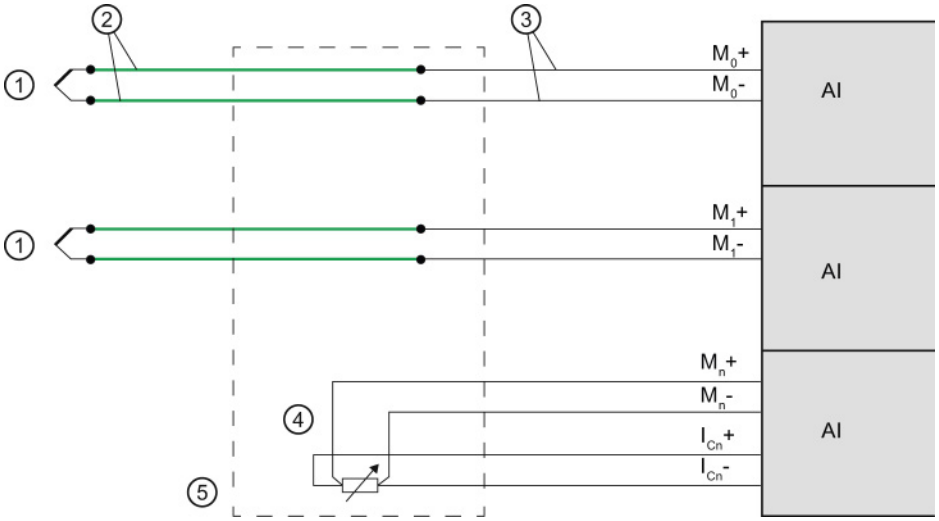
Connecting thermocouples and thermal resistors

The example below shows:

- An analog module with thermal resistor as reference temperature transmitter and
- Two analog modules with thermocouple as reference temperature receivers.

Connect the thermocouples to the supply lines at the reference junction, either directly or with compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.



① Thermocouple
② Compensating line (same material as thermocouple)
③ Copper supply cable, for example
④ Thermal resistor (RTD)
⑤ Reference junction

Figure 5-8 Example: Connecting thermocouples/thermal resistors for group 0 compensation

5.3.5 Compensation with fixed reference temperature

Function principle

With this type of compensation, the reference junction temperature is stored in the module as fixed value.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Fixed reference temperature".
7. Specify the temperature of the reference junction in the "Fixed reference temperature" area, for example, 20 °C.

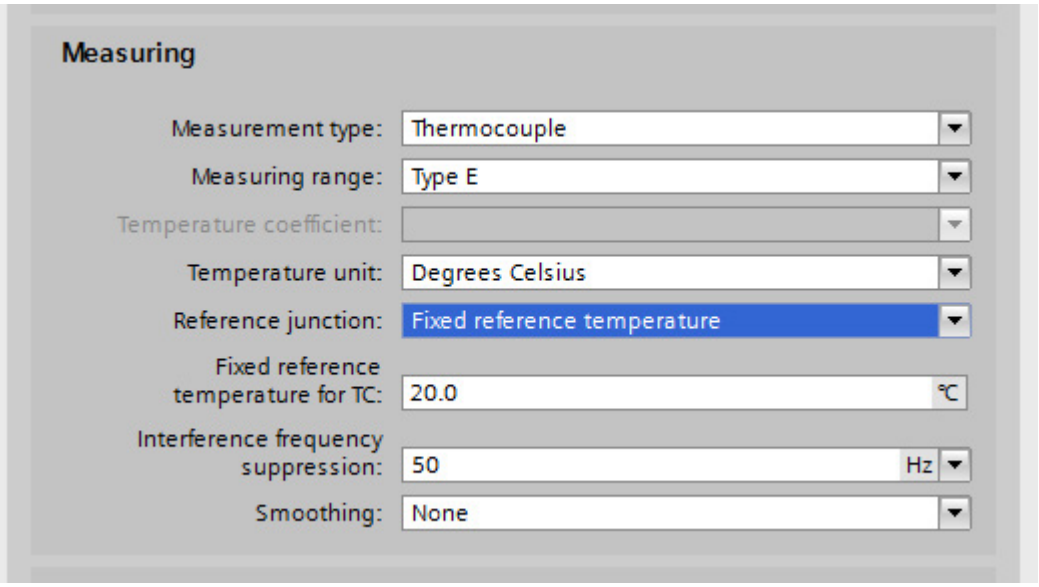
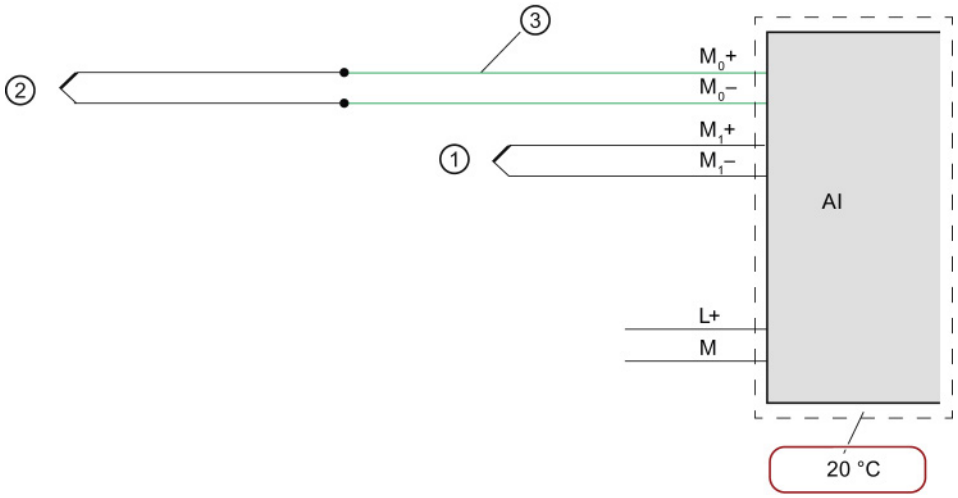


Figure 5-9 Fixed reference temperature

Temperature condition with "Fixed reference temperature" setting

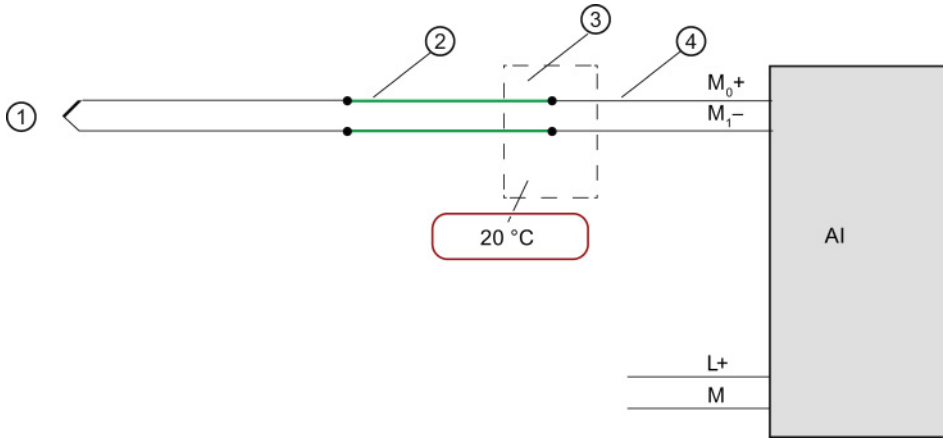
The figure below shows the connection options for thermocouples provided the temperature of the module is kept at a fixed reference temperature (20 °C), for example by installing it in an air-conditioned switch cabinet. The reference junction is in the module.



① Thermocouple without compensating line
② Thermocouple via compensating line
③ Compensating line (same material as thermocouple)

Figure 5-10 Example 1: Connecting a thermocouple to an analog module for compensation with "fixed reference temperature"

The figure below shows the connection options for thermocouples provided the temperature of the reference junction (outside the module) is kept at a fixed reference temperature (20 °C).



① Thermocouple with compensating line and supply line
② Compensating line (same material as thermocouple)
③ Reference junction
④ Copper supply cable, for example

Figure 5-11 Example 2: Connecting a thermocouple to an analog module for compensation with "fixed reference temperature"

5.3.6 Compensation by means of dynamic reference temperature

Function principle

This compensation type allows you to handle the reference junction temperature for temperature compensation in the user program. You can derive the temperature value from any other module of the station. The reference junction temperature is transferred via data records using the instruction **WRREC** (SFB 53).

The structure of the data records is detailed in the device manual for each module.

Requirement

STEP 7 project with the following contents:

- User program with WRREC (SFB 53) instruction for transferring the data records with reference temperature
- Analog module for acquisition of the process temperature using thermocouple (TC)
- Analog module for measuring the process temperature using thermal resistor (RTD)

Analog module for acquisition of the process temperature using thermocouple (TC)

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Dynamic reference temperature".

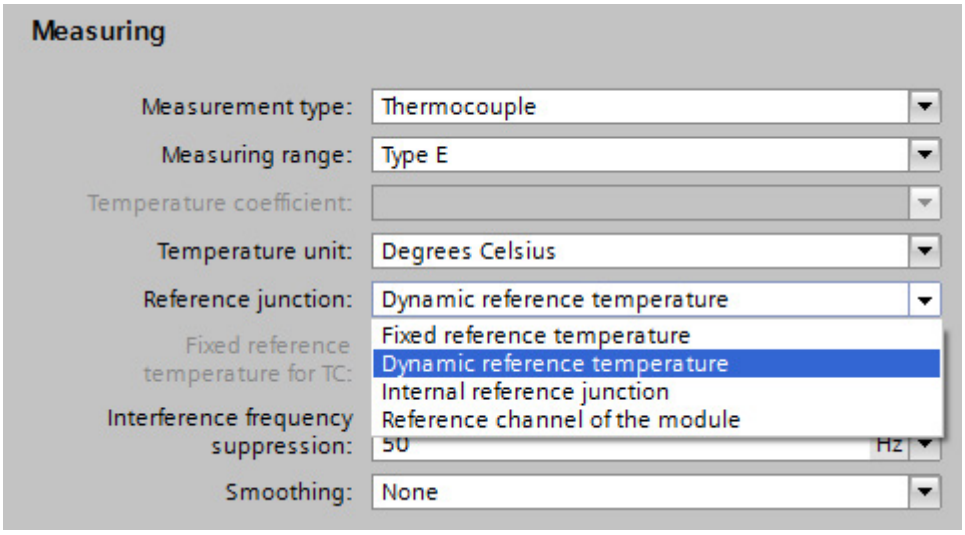


Figure 5-12 Dynamic reference temperature

Analog module for measuring the process temperature using thermal resistor (RTD)

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermal resistor (4-wire connection)" value as "Measurement type".

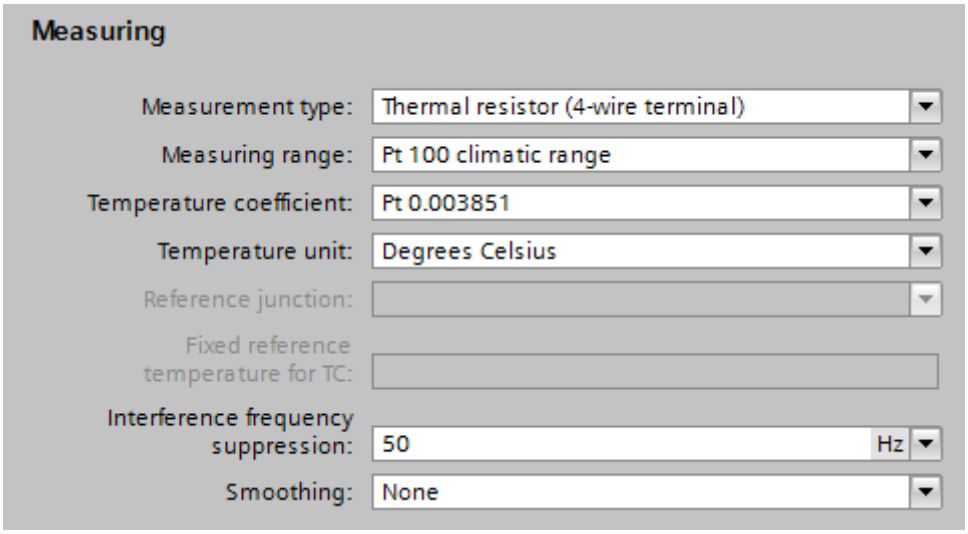
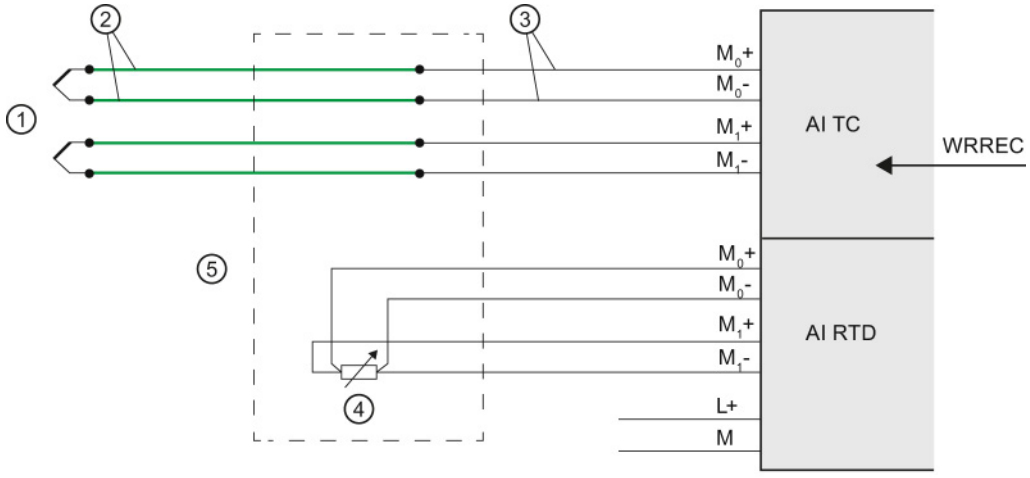


Figure 5-13 Settings for thermal resistor (RTD) type of measurement

Connecting thermocouples and thermal resistors

Connect the thermocouples, for example, to the module inputs using supply lines for temperature compensation with dynamic reference temperature. In this case, the temperature is acquired at the reference junction by means of a thermal resistor (RTD). This reference junction temperature determined in this way is transferred to the analog module with thermocouple via data records with the WRREC instruction.



① Thermocouple
② Compensating line (same material as thermocouple)
③ Copper supply cable, for example
④ Thermal resistor (RTD)
⑤ Reference junction

Figure 5-14 Example: Connecting thermocouples/thermal resistors for compensation by means of dynamic reference temperature

5.3.7 "None" or external compensation

Function principle

The reference junction temperature of the thermocouples is measured outside the analog input module, e.g., by means of a compensating box on the thermocouple. The temperature of the reference junction for this type of compensation is specified as 0° C.

The compensating box includes a bridge circuit that is calibrated for a specific reference junction temperature (compensation temperature). The connectors for the ends of the compensating line of the thermocouple form the reference junction. If the actual comparison temperature deviates from the compensation temperature, the temperature-dependent bridge resistor changes. A positive or negative compensation voltage is generated and added to the thermal voltage.

Note

Thermocouples of type B do not require a compensating box.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "Inputs" tab in the Inspector window of the selected module and the respective channel.
4. Select the "Thermocouple" value as "Measurement type" in the "Measuring" area.
5. As "Reference junction", select the value "None" or "External compensation" depending on the used module.

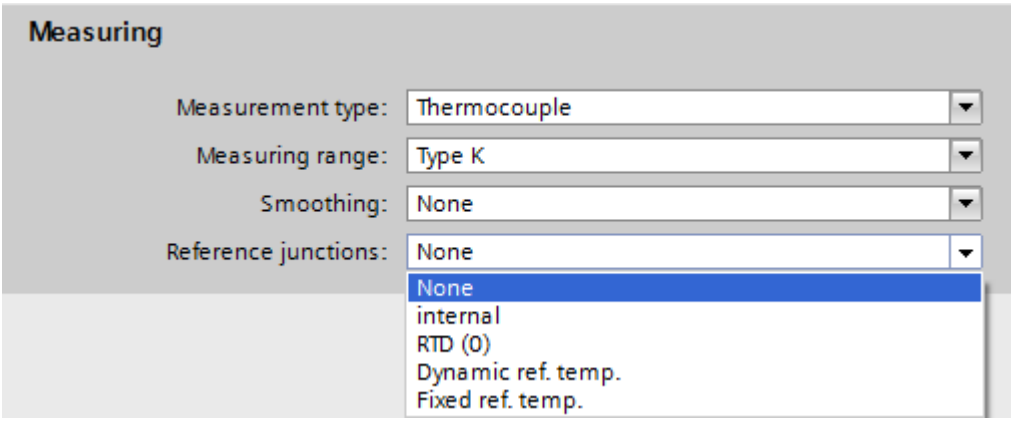


Figure 5-15 No reference junction

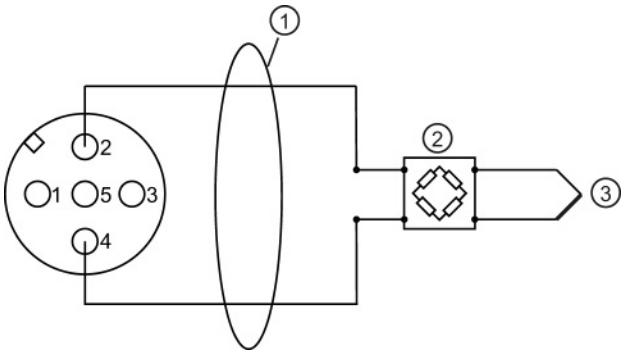
Connection of the compensating box

The compensating box is looped into the supply lines of an individual thermocouple. The compensating box must be supplied isolated. The power supply unit must have a sufficient noise filter, e.g., by means of a grounded shielding winding.

Each channel can use its own thermocouple type supported by the analog module regardless of the other channels. A separate compensating box is required for each channel.

Connection example "None" or external compensation

Connect the compensating box with the connection module of the analog input module using copper cables.



① Copper cables
② Compensating box (per channel), for example; thermocouple type B does not require a compensating box
③ Thermocouple

Figure 5-16 Connection example "No" compensation as reference junction

5.3.8 Compensation type RTD (0)

Function principle

The reference junction temperature is determined by means of the resistance value of a Pt 1000 at the clamping unit of the M12 compensation connector. The resistance measurement is only permitted at the X1 circular socket (channel 0). All of the module's channels with this type of compensation receive the same reference junction temperature.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "Inputs" tab in the Inspector window of the selected module.
4. Select the "Thermocouple" value as "Measurement type" in the "Measuring" area.
5. As "Reference junction", select the value "RTD (0)".

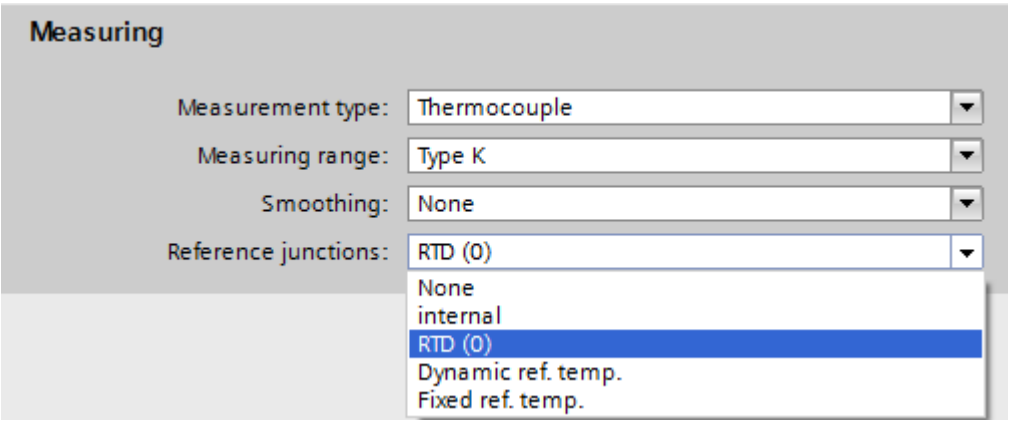


Figure 5-17 Compensation type RTD (0)

Connection example

Connection with M12 compensation connector

Connect the thermocouple to the M12 compensation connector directly or with compensating lines. Install the M12 compensation connector to the X1 circular socket (channel 0) of the CM IO 4 x M12 at the 4 AI TC High Feature.

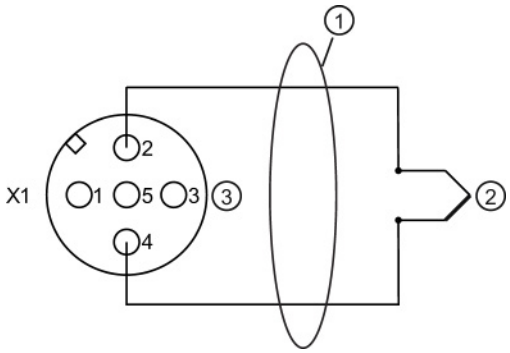
Connection without M12 compensation connector

To measure the referent junction temperature, connect an external Pt1000 (with α = 003851) to terminals 1 and 3 using copper cables. The thermal resistor Pt1000 must be positioned in the area of the reference junction. Connect the thermocouples to terminals 2 and 4 from the reference junction with copper cables.

Connecting additional thermocouples

You can connect additional thermocouples to the circular sockets X2 to X4 on the CM IO 4 x M12 of the 4 AI TC High Feature. The temperature of reference junction collected by measuring the resistance value at the X1 circular socket applies to all channels of the module that you have selected for this type of compensation.

The figure below shows a connection example "RTD (0)" as reference junction with M12 compensation connector and integrated thermal resistor Pt1000:



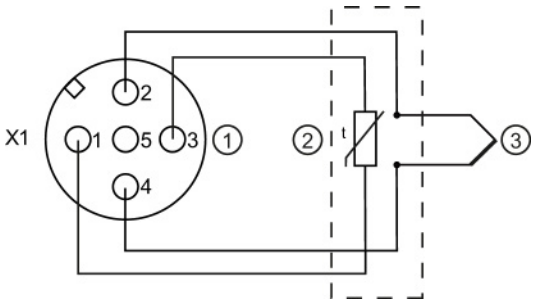
① Direct connection of the thermocouple or with compensating lines

② Thermocouple

③ M12 compensation connector (terminals 1 and 3 with internal Pt1000) only at X1 circular socket. The comparison value of the M12 compensation connector at circular socket X1 also applies to thermocouples at X2, X3 and X4.

Figure 5-18 Connection example "RTD (0)" as reference junction in the M12 compensation connector

The figure below shows a connection example "RTD (0)" as reference junction with external thermal resistor Pt1000:



① M12 connector only at X1 circular socket

② External Pt1000 (α = 0.003851) in the area of the reference junction with copper cables at terminals 1 and 3. The comparison value of the external Pt1000 at circular socket X1 also applies to thermocouples at X2, X3 and X4.

③ Thermocouple

Figure 5-19 Connection example "RTD (0)" as reference junction with external Pt1000

Wiring loads/actuators

6

6.1 Overview

Introduction

This chapter describes the basic procedure for wiring loads/actuators to analog outputs. Information on specific wiring options is available in the manual of each module.

For detailed information on cable routing and shielding, potential equalization, etc. please refer to the function manual Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

Abbreviations used in the figures

Key to the abbreviations in the figures below:

AQ	Analog output module
M	Ground connection
L+	Supply voltage connection
S_n+/S_n-	Sense line channel n
QV_n+/QV_n-	Voltage output channel n
QI_n+/QI_n-	Current output channel n
M_{ANA}	Reference point of the analog ground
U_{ISO}	Insulation voltage

Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

6.2 Wiring loads/actuators

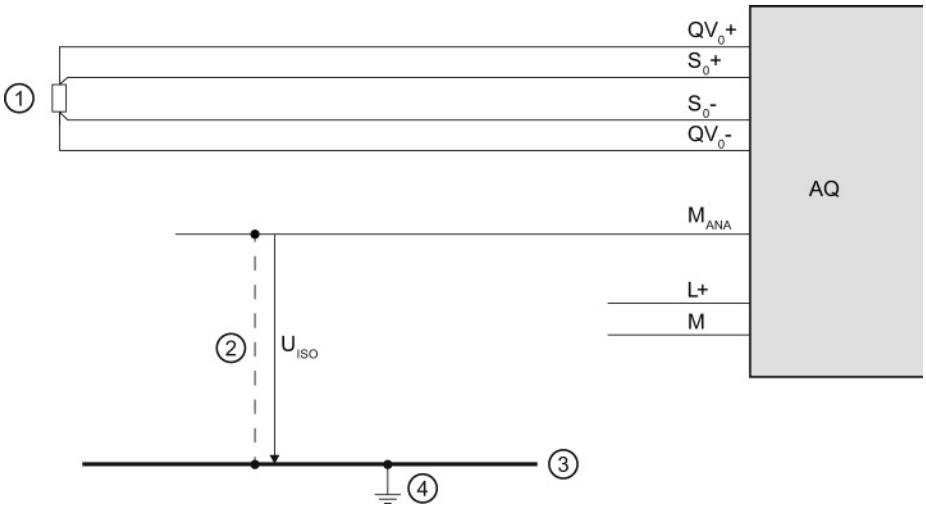
Reference potential for analog output modules with M_{ANA} connection

Analog output modules have no galvanic connection between the reference point of the analog ground M_{ANA} and the central ground.

Always verify that the admissible potential difference U_{ISO} between the reference point of the analog ground M_{ANA} and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum value U_{ISO} is not exceeded, wire terminal M_{ANA} and the central ground with an equipotential bonding cable.



① Load on the voltage output
② Equipotential bonding cable
③ Grounding bus cable
④ Central ground

Figure 6-1 Example: Reference potential for an analog output module with M_{ANA} connection

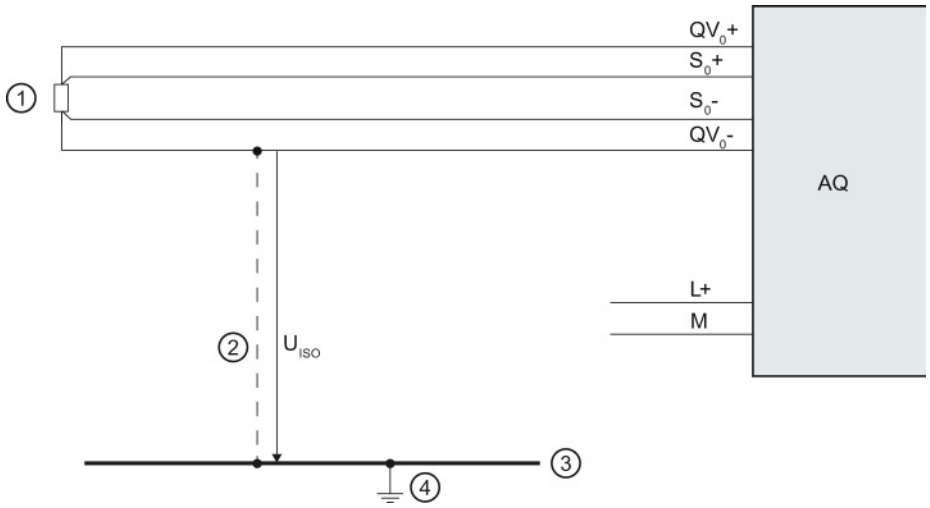
Reference potential for analog output modules without M_{ANA} connection

Analog output modules have no galvanic connection between the reference potential of the analog output circuits and central ground.

Always verify that the maximum potential difference U_{ISO} between the reference points of the analog output circuits and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum value U_{ISO} is not exceeded, interconnect each analog output circuit with the central ground using an equipotential bonding cable.



① Load on the voltage output
② Equipotential bonding cable
③ Grounding bus cable
④ Central ground

Figure 6-2 Example: Reference potential for an analog output module without M_{ANA} connection

Supported functions 7

7.1 Calibrating analog modules

7.1.1 Overview

Calibration

A calibration checks the process values measured by the analog input module and the process values output by the analog output module, determines the deviation from the actual values and compensates for any measurement and output errors.

Calibrating analog modules

The SIMATIC analog modules were calibrated before being shipped and have excellent long-term stability; calibration is therefore not required during runtime.

But certain regulations and directives, for example from the Food and Drug Administration (FDA), require regular calibration for all components in a measuring circuit. These components include analog input and output modules.

A calibration makes sense especially for plants in which sensors detect and process relatively small voltages or currents. The calibration compensates for influences on the measuring result by cables and/or temperature.

The calibration collects the new values and saves them retentively on the module. But the calibration values determined prior to delivery at the plant are not lost. You can return to these original calibration values at any time.

Note

The calibration saves the calibration values of each channel for the specific measuring range retentively on the module, which means the values apply to the same measuring range in which the user calibration took place.

If you reconfigure a channel with effective user calibration values to another type of measuring mode, the calibration values saved at the plant for this channel and for this measuring range will become effective.

But the user calibration values are not deleted. They are not overwritten until there is a new user calibration of the channel. If you set the original measuring range for this channel once again without new user calibration, the previously determined user calibration values will become effective.

The respective manual will include information whether or not your analog module supports the "Calibration" functionality.

Scope of functions

The "Calibration" group offers the following functions:

- Specifying the current calibration of all channels
- Calibrating a channel
- Canceling a running calibration
- Resetting the calibration of a channel to the factory settings

7.1.2 Calibrating analog modules

Manual calibration

The following requirements must be met to start manual calibration:

- An online connection exists between STEP 7, the respective CPU and the analog module to be calibrated.
- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The configuration reflects the actual structure of the station.
- No calibration process is busy on the module (if you want to launch calibration).
- A 24 V load voltage must be present at each module for the calibration.
- The last step was successfully completed (if you want to continue or conclude calibration).

Procedure

The basic mask for calibration opens once you start the "Calibration" function. The module reads the following general information data and calibration values after each new selection of a channel:

- **Calibration:** Indicates whether or not the currently effective calibration values are factory calibration values or user calibration values.
- **Measurement type:** Information about the selected measurement type
- **Measuring range:** Currently configured measuring range of the selected channel
- **Gain:** Currently effective gain correction of the analog-digital converter
- **Offset:** Currently effective offset correction of the analog-digital converter

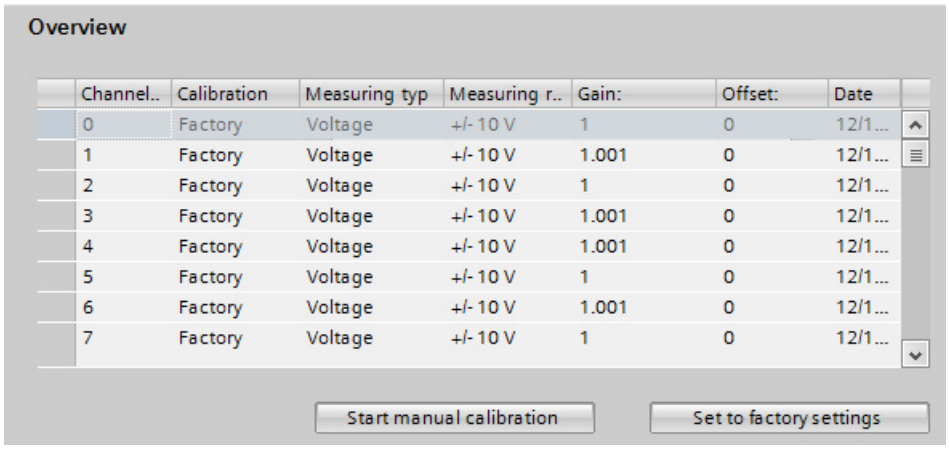


Figure 7-1 Calibration table

To start the calibration, follow these steps:

1. Select the line associated with the channel to be calibrated in the overview table.
2. Click the "Start manual calibration" button.
3. Now go through the steps in the "Manual calibration" section.
4. Follow the instructions in the "Command" field.
5. Click ""Next".

The required calibration values of the selected channel according to the measuring range configured for this channel are specified once again during the user calibration.

Note

The calibration can take place in RUN mode as well as STOP mode of the CPU. If the CPU is in RUN, the calibration value that was last collected prior to the start of the calibration is supplied for the duration of the calibration.

The module channel to be calibrated cannot process any new process values during the user calibration. All analog input values of the module are set to 0x7FFF ("Invalid analog value") until the end of the calibration. When the value status is enabled, the value status of the signal is set to "invalid" for the duration of the calibration.

You must provide a voltage and/or temperature during a user calibration. To do so, use the corresponding external wiring and an external voltage/temperature transducer. The field "Command" includes numbers of pins to which you can connect the calibration stimulus. The first pin number identifies the positive connector, the second pin number the negative connector. The accuracy of the calibration depends on the accuracy of the provided voltage/temperature.

Note

To ensure that the module retains the specified measuring accuracy after the user calibration, the provided voltage/temperature must be twice as accurate as specified for the module. Inaccurate voltages or temperature result in a faulty calibration.

The figure below shows an example of channel calibration with "Voltage" measurement, measuring range "+/- 10 V".

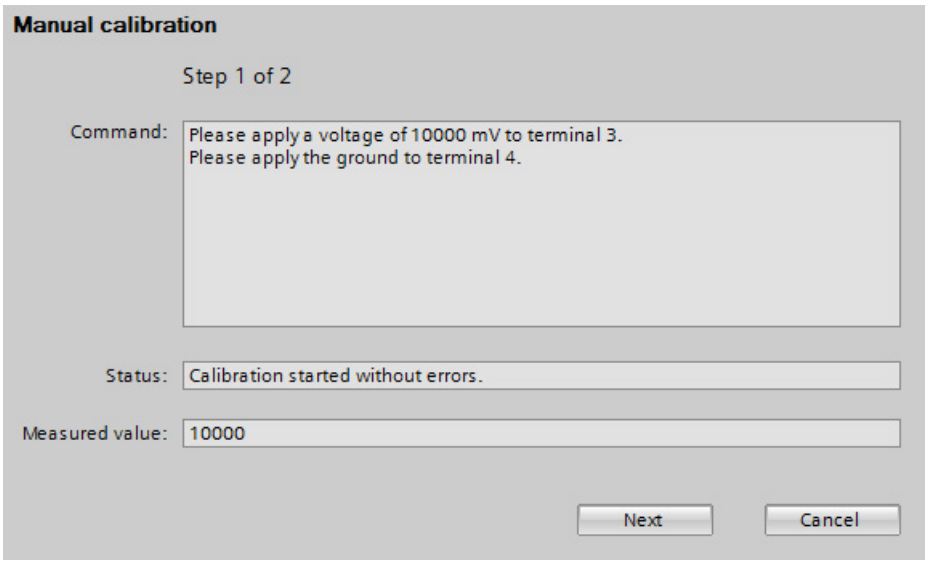


Figure 7-2 Manual calibration

- **Command:** The field "Command" indicates which actions the user has to execute during the current calibration step. Here you execute the specified actions and confirm them with the "Next" button. The module now executes all actions required for the current calibration step. If the calibration step was error-free, the next calibration step takes place.
  The instructions in the "Command" field are to be performed additively. For example, after you have applied the voltage/ground to the terminals 3/4, these connections must remain in place during the execution of the next calibration step.
- **Status:** Depending on the set type of measurement, several calibration steps are required for calibration of a channel. The field "Status" indicates whether or not the last calibration step included errors. If an error occurs during processing of a calibration step, the error is displayed here and calibration of the channel is aborted. All calibration values recorded up to this point are deleted. The calibration values that were in effect prior to the start of the user calibration are effective once again.

Note

Calibrators

If the "Wire break" diagnostics is activated for analog input modules, a test current is applied to the line for the measuring types "Resistance", "Thermistor" and "Thermocouple". This applied test current can result in inaccurate measured values in some calibrators. The wire break monitoring is therefore automatically disabled in some analog modules during the calibration.

To avoid the risk of inaccurate measured values, we recommend you disable the "Wire break" diagnostics during the calibration of analog input modules.

Result

Calibration sets new settings for the channel.

Error occurrence

If an error occurs during the calibration, the module cancels the calibration. All calibration values recorded up to this point are lost. The channel to be calibrated will then have the same settings as before the start of calibration.

7.1.3 Canceling a calibration

Requirement

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.
- A calibration is currently running on the analog module.

Procedure

Click the "Cancel" button to cancel an ongoing calibration.

Result

The active calibration is canceled. The channel to be calibrated will then have the same settings as before the start of calibration.

7.1.4 Resetting analog modules to factory settings

Requirement

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.

Procedure

Proceed as follows to reset the channel of an analog module to factory settings:

1. In the overview table, select the line of the channel to be calibrated.
2. Click the "Set to factory settings" button.

Result

The factory settings of the channel are restored.

Note

When you reset the current channel to the factory settings, the original calibration values that were saved in the delivery state of the module become effective once again. Any existing user calibration values of this channel are lost. You cannot restore these user calibration values.

High-speed analog modules

8

8.1 Basics

High-Speed analog modules (HS) are available for users with high demands regarding performance and speed. The main characteristics of these HS analog modules compared to Standard analog modules (ST) is their shorter cycle times. To achieve this goal, the input and output modules are equipped with components with extremely short throughput and conversion times. In addition, the entire architecture of the modules is designed for faster signal processing.

HS analog modules convert the output of measured values and output values at the same time. Each channel within the module has its own A/D or D/A converter. This means the cycle time is basically the conversion time and independent of the number of activated channels. This is true for analog input modules as well as analog output modules. This means HS modules can be used in fast isochronous mode.

Apart from isochronous mode, the HS analog modules also provide benefits in non-isochronous (free-running) mode. Due to the fast processing of the process signals, HS analog modules are able to detect changes in the process values more quickly and to respond to these events with the appropriate program blocks (for example, hardware interrupt or cyclic interrupt organization blocks). Additional information on the various organizational blocks can be found in the STEP 7 online help.

Isochronous mode

Isochronous mode refers to synchronous coupling:

- Of signal acquisition and output via the distributed I/O
- Of signal transmission via PROFIBUS or PROFINET
- Of program processing with the constant bus cycle time of PROFIBUS or PROFINET.

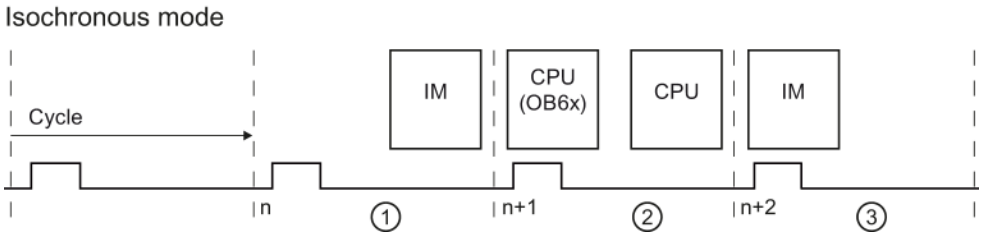
The result is a system that acquires its input signals in constant time intervals, processes them and outputs the output signals. Isochronous mode guarantees reproducible and defined process reaction times as well as equidistant and synchronous signal processing with distributed I/O.

The bus system and the I/O modules work synchronously with configured isochronous mode. The transmitted input and output data are linked to an "isochronous task" in the CPU. As a result, the data of a cycle are always consistent. All data of a process image belong together logically and in time. Jitter in the user program caused by the acquisition of outdated values is therefore almost impossible.

Even fast processes can be perfectly controlled by the exact timing reproducibility of all processes. Isochronous mode thus contributes to high control quality and hence to greater manufacturing precision. While possible fluctuations of the process reaction times are drastically reduced. The time-assured processing can be utilized to improve machine cycle times. Shorter cycle times increase the processing speed and help to lower production costs.

Send clocks

When you configure isochronous mode, the input and output data is synchronized within a send clock (cycle). The data of the input modules is acquired in cycle n and simultaneously transferred to the IM. The data is available in cycle n+1 in the CPU and can be processed. The CPU copies the data to the IM in the next cycle n+2. The output modules then output the data simultaneously in the same send clock. The acquisition – processing – output therefore takes place in three cycles. You can find more information on the configuration of isochronous mode in the STEP 7 online help.



① Measured values of the input modules are acquired and copied to the IM

② Measured values are processed and output values determined

③ Output values are copied to the IM and output by output modules

Figure 8-1 3-cycle model

Oversampling

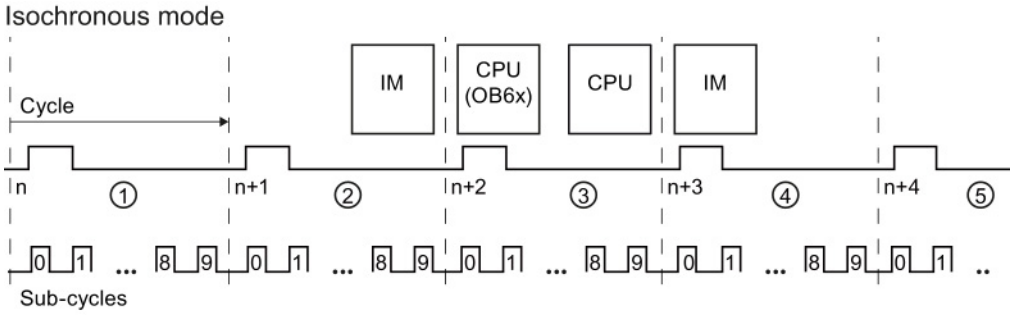
The use of the oversampling function in analog input or analog output modules requires an isochronous configuration.

With analog input modules, the set send clock is divided into time-equidistant sub-cycles. The send clocks can be subdivided into 2 to 16 sub-cycles. Each sub-cycle reads in a measured value. The read-in measured values of a data cycle are copied to the IM in the next send clock and are then available to the processing CPU one send clock later.

With analog output modules, the set send clock is also divided into time-equidistant sub-cycles. The send clocks can be subdivided into 2 to 16 sub-cycles. Each sub-cycle returns an output value. The output values are copied to the IM by the CPU within the same send clock and are written to the process one send clock later.

The read-in and output values are transmitted in the user data of the analog module. This way, the address space of the module is extended from 2 bytes of user data per channel to 16 x 2 bytes of user data per channel. If you subdivide the send clock into less than 16 sub-cycles, the unused addresses are assigned the error value 0x7FFF during input. For output, the values of the unused addresses are ignored.

Because the sub-cycles have to be within a send clock, oversampling needs an additional send clock to copy the data to the IM, unlike the 3-cycle model of isochronous mode. The result is a 5-cycle model.



① Send clock is divided into sub-cycles which record the measured value
② Measured values are copied to the IM
③ Measured values are processed and output values determined
④ Output values are copied by the CPU to the IM
⑤ Output values are written to the process

Figure 8-2 5-cycle model

Due to the configured modules, the send clock of an IO device has a minimum possible update time, which means the time interval within which an IO device/IO controller of the PROFINET IO system is supplied with new data. Modules with oversampling functionality, however, offer the option of further reducing the update time for their channels without having to shorten the send clock for the entire S7 station at the same time. The subdivision of the send clock into time-equidistant sub-cycles therefore enables an even faster signal processing speed.

Example

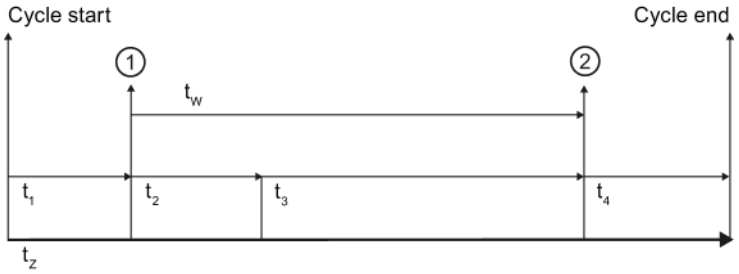
In practice, the use of oversampling makes sense when the isochronous system works with only one specific specific send clock (for example, 1 ms) due to the modules used and when faster sampling of the process values is required. By using oversampling and a subdivision of the send clock into 4 sub-cycles, for example, you can sample the process values in intervals of 250 µs.

Configuring oversampling

Enable the option "Isochronous mode" in the IO device used and set the corresponding parameters ("Send clock", etc.). You define the number of sub-cycles in the relevant distributed analog module with the "Sampling rate" parameter for analog input modules and the "Output rate" parameter for analog output modules. If, for example, you configure a "Sampling rate" of 4 "Values/cycle" for a "Send clock" of 1 ms, the send clock is subdivided into 4 sub-cycles and the process values are sampled in intervals of 250 µs.

Cycle time of an analog input module

If you have configured the system property "Isochronous mode" for HS modules, all analog input modules are synchronized to a shared time within the send clock (cycle) ①. The cycle time is made up of the following time intervals: $t_Z = t_1 + t_2 + t_3 + t_4$



① Synchronization time for all analog input modules in isochronous mode and simultaneously time of the converted input signal at the terminal in this cycle

② Digitalized input signal is transferred to the backplane bus

t_Z Cycle time

t_1 Time between cycle start and synchronization

t_2 Hardware-related runtime up to the analog-digital converter

t_3 Processing time of digitalized input data in the module

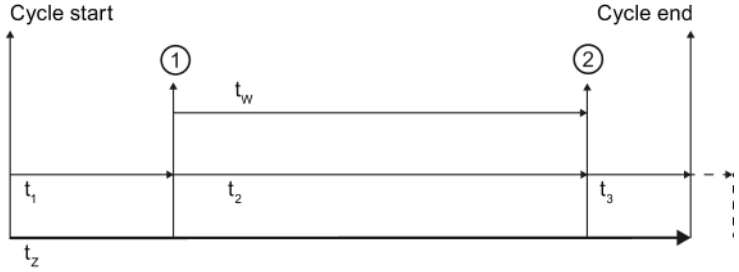
t_4 Transfer time of the backplane bus

t_W Conversion time of the module

Figure 8-3 Cycle time of the analog input module

Cycle time of an analog output module

The synchronization time for analog output modules refers to the output of the digital-analog converter ②. Because the impedance of the connected actuator including connection cable is unknown in output modules but has a significant impact on the signal run time, the settling time cannot be added as a fixed value. The respective manuals of the output modules specify the typical load settling times as reference point. But in practice, a measurement with an oscilloscope is required for a precise measurement of the settling time. The settling time may exceed the actual end of the cycle due to very short cycle times and very high capacitive loads. The cycle time is made up of the following time intervals: $t_Z = t_1 + t_2 + t_3$



① Output data is available in digital form in the module

② Synchronization time for all analog output modules in isochronous mode and simultaneously output time of data in the digital-analog converter

t_Z Cycle time

t_1 Transfer time of the backplane bus

t_2 Processing time of data in the module until output at digital-analog converter

t_3 Settling time of hardware until setpoint of output value

t_W Conversion time of the module

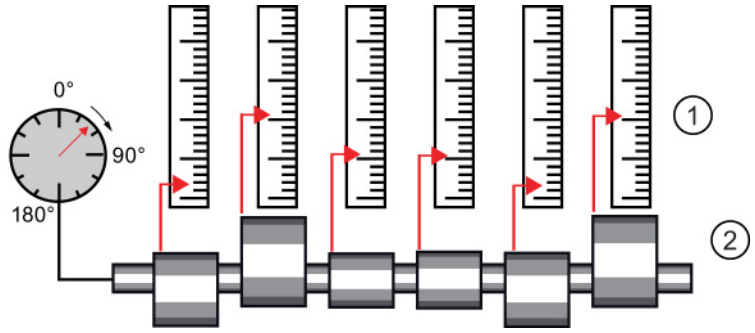
Figure 8-4 Cycle time of the analog output module

Typical applications

In principle, isochronous mode is worthwhile whenever measured values must be acquired synchronously, movements must be coordinated, and process reactions must be defined and executed at the same time. There are thus numerous areas in which isochronous mode can be used.

Typical applications include, for example, the acquisition of binary signals for quality assurance at specific times and positions. But hydraulic applications with position and pressure control can benefit as well from the equidistant and isochronous data transmission.

The following example shows the use of isochronous mode within the production process of camshafts. Precise measurements must be made at several measuring points for quality assurance.



① Measured values
② Camshaft

Figure 8-5 Measuring of camshafts

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously. The time required for measurement is reduced. Resultant workflow:

- Continuous machining of the camshaft
- During the continuous turning, measure the positions and cam excursion synchronously
- Process the next cam shaft

All camshaft positions and the corresponding measured values are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

8.2 ST modules vs HS modules

This section gives you an overview of other important distinctions between standard and high-speed analog modules. The specified numerical values are examples of selected modules. Keep in mind that the information can vary from module to module. The exact information of specific used analog module is available in the corresponding manual.

Conversion method

Instantaneous value conversion

Instantaneous value conversion if often used to convert analog signal into digital information in HS modules. In this type of conversion a very short sample is taken from the measured signal and converted into digital data. This digital information therefore represents an instantaneous value of the measured signal. Instantaneous value conversion is used to acquire fast changes of process values, such as in the area of motion control. The quickly changing physical quantities in this case must be acquired and processed quickly in cooperation with suitable transducers. Input areas are primarily voltage, current and resistance, the latter especially for position potentiometers.

Because the measured signal is converted within a short time, there is a risk of incorrect measurements in case of faulty signals. The analog inputs working with the instantaneous value conversion method cannot detect if the sampled signal value is the target signal or an overlaying disturbing pulse. They always convert the "instantaneously" detected value. This means the pending measurement task should be carefully examined with regard to time constraints.

Integrating conversion

ST modules usually work according to the integrating conversion principle. The integrating conversion involves the sampling of a measured signal across a specified time period (integration time). Although this method is slower than instantaneous value conversion, it returns a conversion with higher immunity to interference. When you select the time interval for the conversion so that it corresponds to one or several periods of the surrounding network frequency, the omnipresent interference that is possibly also overlaying the signal is basically suppressed. SIMATIC modules give you the option to set the network frequency at which the plant is operated by means of parameter assignment. The resolution and conversion times may change depending on the interference frequency suppression that is set. The technical specifications of the respective module define these dependencies.

Analog inputs with integrating methods can be used universally. Even though the cabling must also be carefully designed with these analog inputs, the requirements are much less than those for analog inputs with instantaneous value conversion due to their slower signal acquisition that is basically immune to interference.

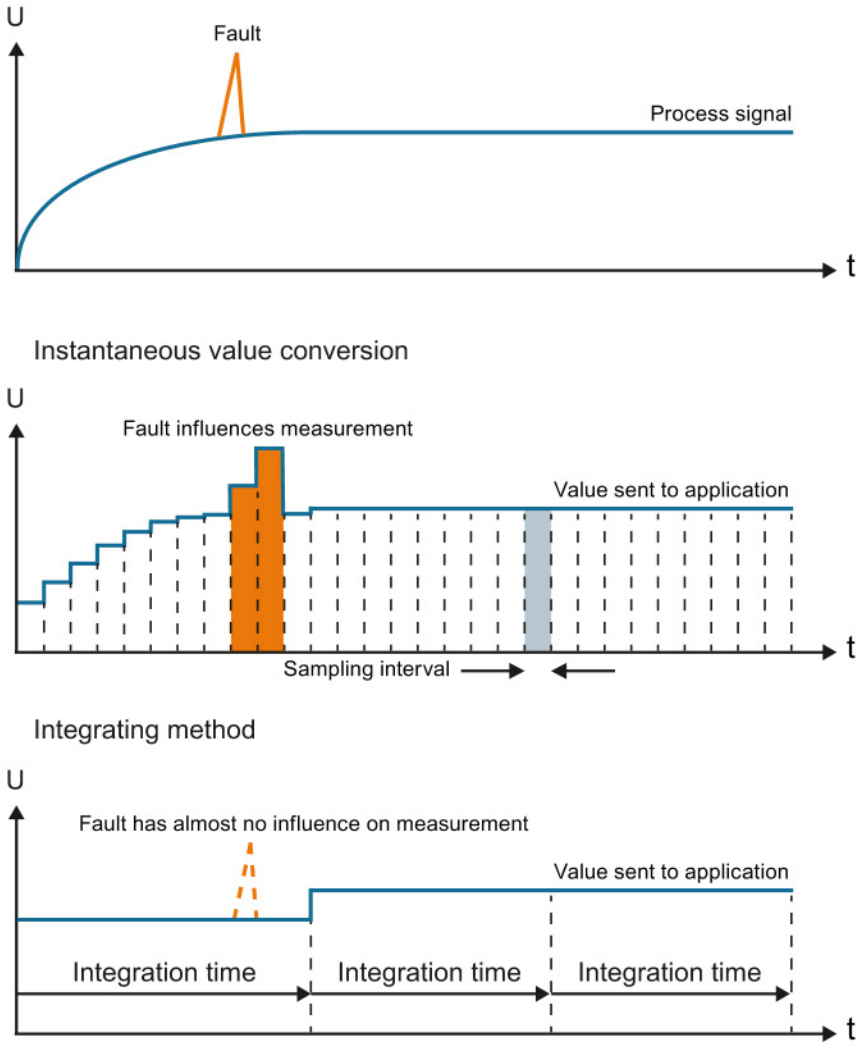


Figure 8-6 While an interference directly influences the value that is supplied to the application with instantaneous value encryption, its influence is negligible for the integrating method.

Electromagnetic compatibility

The entire architecture of HS modules is designed for fast processing of the signals. An interference-free design is therefore critical when using HS modules.

The following rules apply to the wiring of HS modules with sensors and actuators:

- Keep the cables as short as possible
- Use shielded and twisted pair cables
- Low-impedance connection of the cable shield at the respective shield supports
- Short cable loop between shield support and terminal connection

Note

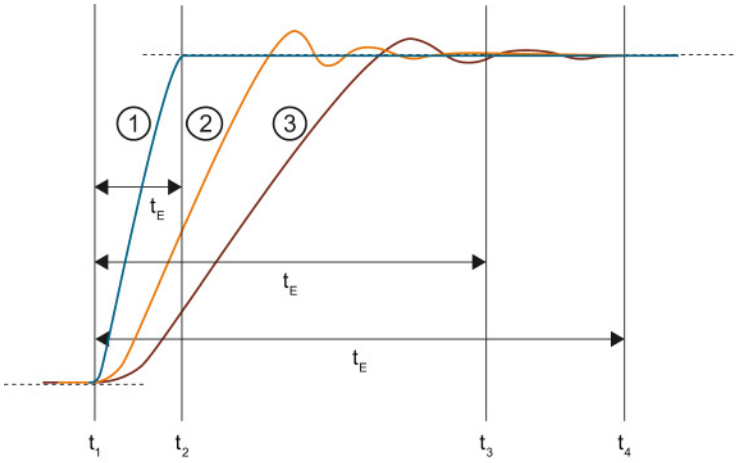
Interference-free design

Make sure that you pay close attention to the notes listed in the function manual Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) when using HS modules.

Effect of load on the settling time

The settling times to the setpoint achieved with analog output modules depend on the applied load, among other things. To take advantage of the faster conversion times, only small loads (e.g., max. 47 nF) are permitted in HS modules as specified in the technical specifications.

The type of load has an effect on the form of settling to the setpoint when using output modules. Capacitive loads reduce the rise time due to the charging process and can cause the output signal to overshoot. Inductive loads result in a delayed current increase due to remagnetization and therefore also a shorter rise time. The figure below shows the output signal with no/small ①, medium ② and high ③ capacitive load.



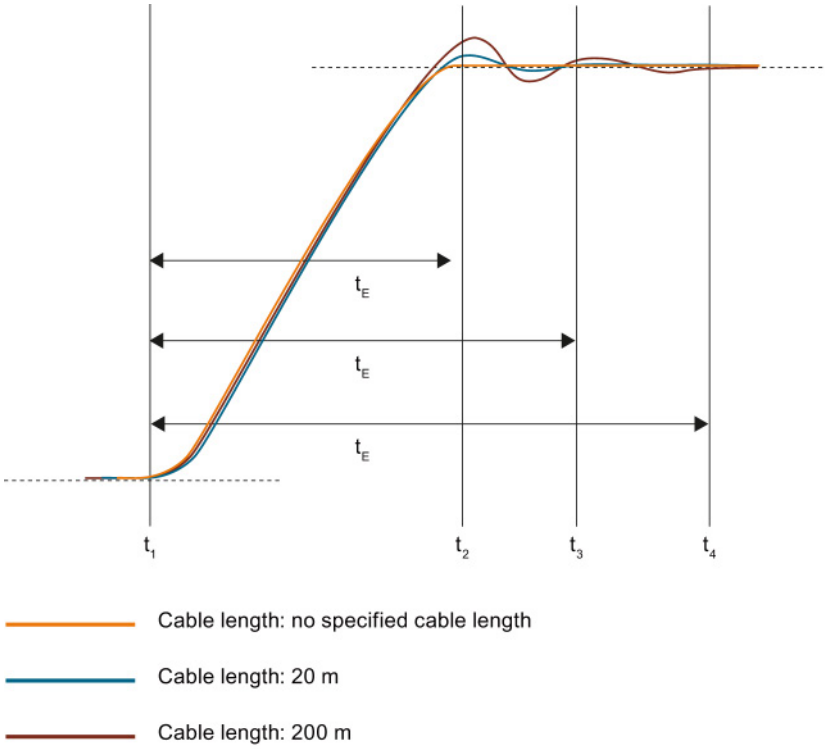
① Reference curve of a signal with no/small load capacity
② Signal with a load capacity of 47 nF
③ Signal with a load capacity of 100 nF
t_E Settling time
t_1 Module ends conversion at the terminal of the analog output channel and outputs the analog signal
t_2 Signal ① has settled and the specified analog output value has been reached (residual error 1 %)
t_3 Signal ② has settled and the specified analog output value has been reached (residual error 1 %)
t_4 Signal ③ has settled and the specified analog output value has been reached (residual error 1 %)

Figure 8-7 Effect of different loads on the settling time

Effect of the cable length on the settling time

Long cables between signal source and module are a target for interferences. You should therefore keep the cables as short as possible especially for HS modules. Cables have a capacitive and inductive component and therefore have an effect on the settling behavior of the signal.

The example below shows the jump of the output voltage of an HS output module with small, medium and long cable length. The overshoot of the input signal increases with the length of the cable and therefore the time until it reaches the setpoint.



t_E Settling time

t_1 Module ends conversion at the terminal of the analog output channel and outputs the analog signal

t_2 The signal running through a cable with short length has settled and the specified analog output value has been reached (residual error 1 %)

t_3 The signal running through a 20 m cable has settled and the specified analog output value has been reached (residual error 1 %)

t_4 The signal running through a 200 m cable has settled and the specified analog output value has been reached (residual error 1 %)

Figure 8-8 Effect of different cable lengths on the settling time

Effect of the value jump on the settling time

The figure below shows the effect of the height of the value jump between different output values on the settling time for analog output modules. The dotted line indicates the time when the signal has reached the setpoint. The higher the value jump, the later the signal reaches the setpoint.

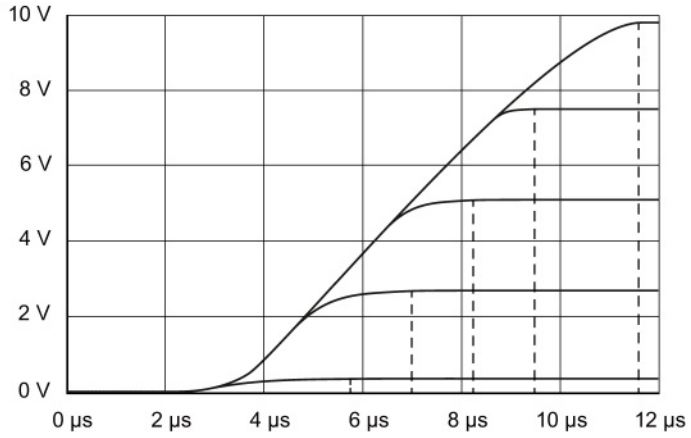


Figure 8-9 Settling time of five different analog signals with different value jumps

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SIMATIC

High-precision input/output with Time-based IO

Function Manual

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08/2014

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Preface

Purpose of the documentation

This function manual will support you when you use "Time-based IO" technology with the S7-1500, ET 200MP, and ET 200SP systems.

The documentation deals with the following topics:

- Using "Time-based IO" technology
- Functions of the "Time-based IO" technology
- Hardware and software requirements for "Time-based IO"
- Configuring the "Time-based IO" function with STEP 7 (TIA Portal)
- Diagnostics of the "Time-based IO" function

Basic knowledge required

The following knowledge is required in order to understand the Function manual:

- General knowledge of automation engineering
- Knowledge of the industrial automation system SIMATIC
- Proficiency with STEP 7 (TIA Portal)

Scope of the documentation

The following documentation is valid for all components of the S7-1500, ET 200MP and ET 200SP systems that support the "Time-based IO" technology.

Conventions

The following terms are used as synonyms in this documentation:

- **TIA Portal:** This term is used as synonym for the "STEP 7" configuration and programming software (TIA Portal)".
- **TIO module**: This term is used as synonym for I/O modules of the type:
  - IO-Link Master CM 4xIO-Link
  - ET 200MP TM Timer DIDQ 16x24V
  - ET 200SP TM Timer DIDQ 10x24V
- **TIO_Time**: This term is used as synonym for the shared time basis (relative time) of the TIO modules.
- **Jitter**: This is a general term that includes various time influences affecting accuracy. This means that:
  - for input data: Deviation of the measured time from the actual event.
  - for output data: Deviation of the actual switching time from the specified time.

This documentation contains pictures of the devices described. The pictures may differ slightly from the devices supplied.

You should also pay particular attention to notes such as the one shown below:

Note

The notes contain important information on the product, handling the product or on part of the documentation to which particular attention should be paid.

Additional support

You will find information about the technical support available in the appendix.

The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers a range of topics concerning your automation system.

The complete documentation for the S7-1500, ET 200MP, and ET 200SP systems consists of the respective system manuals, function manuals, and manuals for the specific device.

In addition, the TIA Portal (online help) information system supports you in configuring and programming your automation system.

Documentation for Time-based IO

The following table lists further documentation that you will need when using Time-based IO.

Table 1- 1 Documentation for Time-based IO

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning • Maintenance
	System Manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
	System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)	
PROFINET with TIA Portal	PROFINET with STEP 7 function manual (http://support.automation.siemens.com/WW/view/en/49948856)	• PROFINET basics • PROFINET functions • PROFINET IO Engineering • Diagnostics with PROFINET IO • Isochronous mode
CPU	Manuals (http://support.automation.siemens.com/WW/view/en/67295862/133300)	• Block diagram • Wiring • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimension drawings
IM	Manual IM 155-6 PN ST (http://support.automation.siemens.com/WW/view/en/59768173)	
	IM 155-6 PN HF manual (http://support.automation.siemens.com/WW/view/en/73184046)	

Topic	Documentation	Most important contents
	Manual IM 155-5 PN ST (http://support.automation.siemens.com/WW/view/en/59193106)	
	Manual IM 155-5 PN HF (http://support.automation.siemens.com/WW/view/en/89261636)	
TM	Manual Technology Module TM Timer DIDQ 16x24V (http://support.automation.siemens.com/WW/view/en/95153313)	• Wiring • Interrupts and diagnostic alarms • Parameter data set • Technical specifications • Dimension drawing
	Manual Technology Module TM Timer DIDQ 10x24V (http://support.automation.siemens.com/WW/view/en/95153951)	
IO-Link	SIMATIC IO-Link System function manual (http://support.automation.siemens.com/WW/view/en/65949252)	• Overview • Configuration
	Communication module IO-Link master CM 4xIO-Link manual (http://support.automation.siemens.com/WW/view/en/67328527)	• Block diagram • Wiring • Parameter assignment/addressing • Interrupts, diagnostics, error, and system messages • Technical specifications
Configuration with Port Configuration Tool	SIMATIC S7-PCT in the SIMATIC IO-Link System function manual (http://support.automation.siemens.com/WW/view/en/65949252)	• Description • Configuration
	SIMATIC S7-PCT online help	—
IO-Link sensors/actuators	SICK product information (http://www.sick.com/group/EN/home/products/technologies/smart_sensor_solutions/Pages/product_track_and_trace.aspx)	—
	Product documentation of halstrup-walcher (http://www.halstrup-walcher.de/en/produkte/positioniertechnik/index.php)	
System diagnostics	Diagnostics function manual (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostic evaluation
Isochronous mode	PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) function manual	• Benefits • Use • Parameter settings

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Software download for IO-Link

The Port Configuration Tool (SIMATIC S7-PCT) is available on the Internet (http://support.automation.siemens.com/WW/view/en/32469496).

You will find software downloads for the IO-Link Device with time stamp function on the Internet:

- SICK (http://www.sick.com/group/EN/home/products/technologies/smart_sensor_solutions/Pages/product_track_and_trace.aspx)
- halstrup-walcher (http://www.halstrup-walcher.de/en/downloads/index.php)

Time-based IO basics

2

2.1 Using Time-based IO

Many processes in a plant require a relatively precise reproducibility as far as time is concerned. The reproducibility can be optimized to a limited extent by shorter CPU cycle times. The use of high-precision input/output with Time-based IO provides a more accurate reproducibility than the one that can be achieved by optimizing the CPU cycle time. An additional advantage of Time-based IO is the independence from the minimum time scale of the application cycle.

Below is a selection of typical areas of application that can benefit from this technology.

Defined response times

An output signal that responds with a precise delay time that is independent of the application cycle can be output by adding a specified time to the time stamp of an edge at the digital input.

Length measurement

The length of a product passing by can be determined by the difference between two input time stamps and an associated travel speed.

Cam controller

The ongoing movement can be extrapolated from a synchronous position information (for example, from a counter module or an axis). Based on this result, the time of a switching position (cam position) is calculated and transferred to the TIO module (output). This way the switch event takes place at the required position.

Dosing

By specifying a switch-on and a switch-off edge to a time-controlled digital output, a valve can be opened for a specific time and the amount of liquid can be dosed accordingly.

2.2 Time behavior of Time-based IO

2.2.1 Time behavior of standard technology

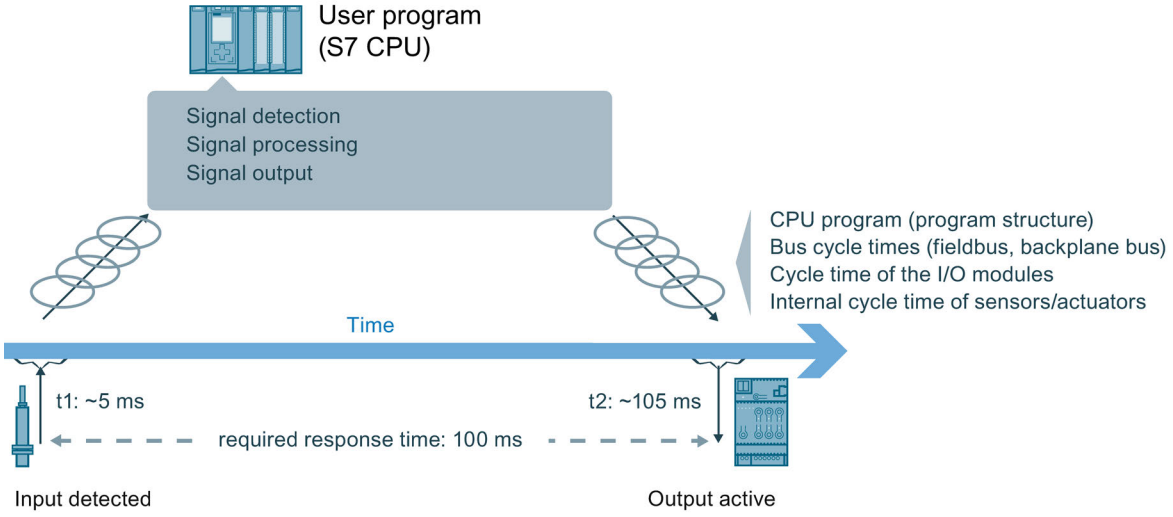
The time behavior of the inputs/outputs depends on the following factors for standard technology:

- CPU program (program structure)
- Bus cycle times (fieldbus, backplane bus)
- Cycle time of the I/O modules
- Internal cycle time of sensors/actuators

A deterministic statement as to

- when an input event (e.g., sensor signal) has taken place
- when the output event has an effect on the input event (e.g., output switches)

will become inaccurate due to the time factors listed above.

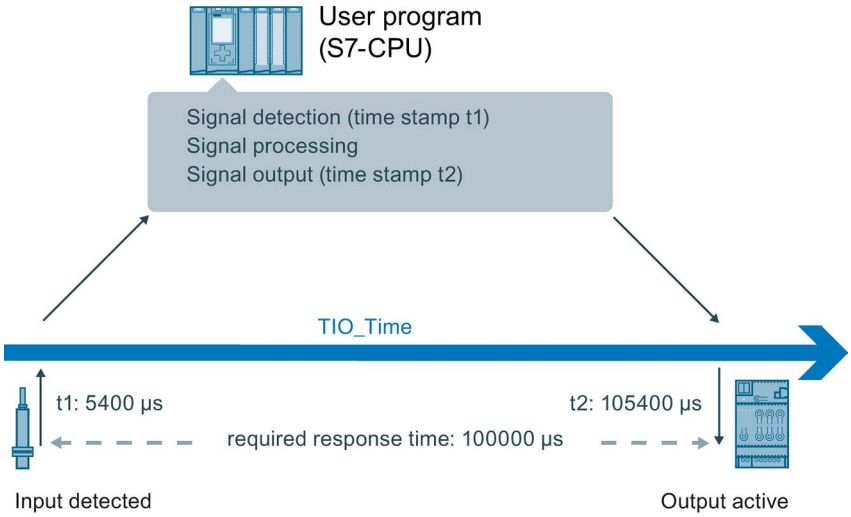


2.2.2 Time-based IO properties

Time-controlled I/O functionality

Time-based IO stands for time-based processing of I/O signals. All input signals are referred to one time (TIO_Time). The input signals receive the time stamp t1. After signal processing, the output event can also be linked with the TIO_Time and output at the required time. Output takes place at time t2.

Here an example for Time-based IO:



Independence and focus of Time-based IO

The shared time basis (TIO_Time) of all components involved is the basis for Time-based IO. By using TIO_Time, the accuracy of the output with Time-based IO does not depend on:

- CPU program (program structure)
- Bus cycle times (fieldbus, backplane bus)
- Cycle time of the I/O modules
- Internal cycle time of the IO-Link sensors/actuators

The focus of Time-based IO is not on the I/O response time but on the predictability (determinism) of I/O signals. With Time-based IO, it is possible to respond to an input signal with an output signal within a defined time. Keep in mind the system-dependent minimum response time when using Time-based IO.

Time-based IO stands for:

- I/O functionalities executed with high precision
- I/O processes with time stamp

Accuracy

Accuracy is crucial for the performance capability of Time-based IO.

Accuracy is a property of

- TIO module
- IO-Link sensor/ actuator

and indicates the deviation with which the required response is achieved. For Time-based IO, the accuracy and reproducibility of the response is in the millisecond range.

Response time

In addition to a very high accuracy, a minimum response time to an input event can result depending on the configuration.

The response time is the time between the input event and the required output event.

For the minimum response time:

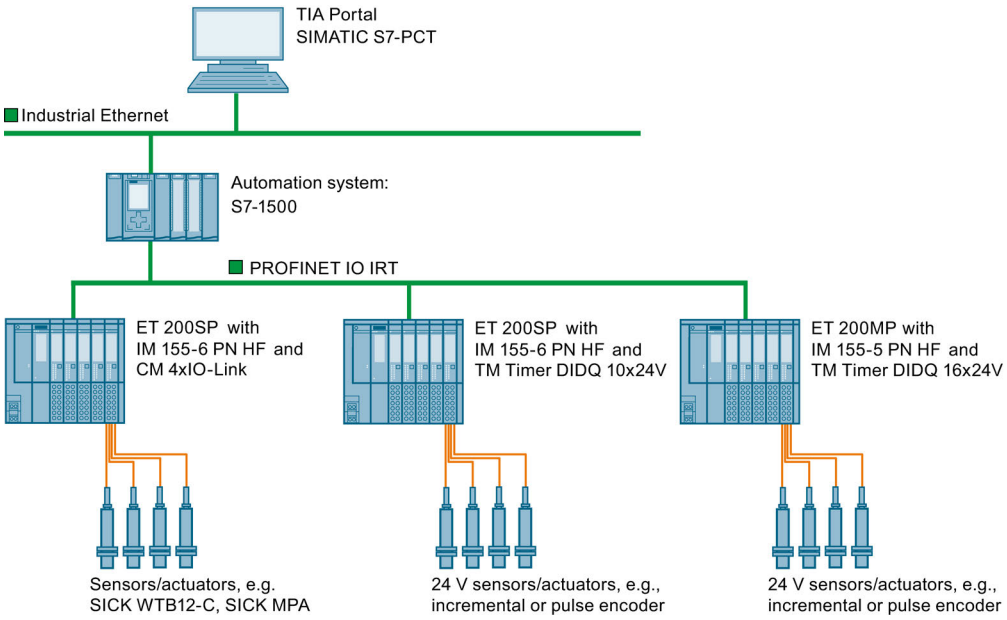
at least 3 * application cycle (T_{APP})

2.3 System environment

Introduction

Possible system configurations with PROFINET for the use of Time-based IO are shown below.

Use with TIA Portal



2.4 Hardware requirements

Introduction

The properties of the hardware components required for Time-based IO are listed below. You will also find specific modules as an example.

Requirements

Component	Properties	Examples
CPU	• Isochronous mode/ PROFINET IO IRT: provides defines response time and high-precision plant behavior.	• CPU 1511-1 PN
ET 200 interface module	• Supports isochronous mode	• ET 200SP with IM 155-6 PN HF (as of firmware V2.1) • ET 200MP with IM 155-5 PN HF
I/O module	• TIO module	• ET 200SP: CM 4xIO-Link (as of firmware V2.0) TM Timer DIDQ 10x24V • ET 200MP: TM Timer DIDQ 16x24V
IO-Link Device for CM 4xIO-Link	• supports IO-Link time stamp function	• SICK WTB12-C • halstrup-walcher PSE, PSS, PSW

2.5 Configuration software requirements

Introduction

Below please find a list of the software versions which support the "Time-based IO" function.

Requirements

Configuration software	Requirements	Supported hardware components	Additional information
STEP 7 (TIA Portal) as of V13	• PROFINET IO IRT • For CM 4xIO-Link: IO-Link technology	• S7-1500 automation system • ET 200SP and ET 200MP distributed I/O systems • CM 4xIO-Link • TM Timer DIDQ 16x24V (as of V13 Update 3) • TM Timer DIDQ 10x24V (as of V13 Update 3)	TIA Portal online help
S7-PCT as of V3.2	—	• CM 4xIO-Link	S7-PCT online help

TIO instructions

The TIO instructions are specific function blocks for use of Time-based IO. The following TIO instructions (Page 29) are available:

- TIO_SYNC
- TIO_IOLink_IN
- TIO_IOLink_OUT
- TIO_DI
- TIO_DQ

As of V13 Update 3, the TIO instructions are available as integrated instructions in TIA Portal.

2.6 Technical implementation

Introduction

The information below will help you better understand the core aspects of Time-based IO and find out which SIMATIC functions are used to implement the described aspects.

Synchronization of involved modules in PROFINET (shared time basis)

The Time-based IO technology uses isochronous mode for all involved PROFINET stations. Isochronous communication is made possible with PROFINET IRT (Isochronous Real-Time) and isochronous mode of the PROFINET stations.

Additional information on isochronous mode is available in the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) and Isochronous Mode (http://support.automation.siemens.com/WW/view/en/15218045) manuals.

Several TIO modules can be synchronized to a shared time basis by using the isochronous PROFINET. The basis of the shared time basis for the TIO modules is the relative time TIO_Time.

TIO_Time

The TIO_Time is the central time basis to which all time stamps refer.

TIO_Time has the following properties:

- Shared time basis for all TIO modules which are synchronized with the TIO instruction TIO_SYNC.
- The time starts counting again with each CPU startup.
- TIO_Time has the data type LTime (e.g., LT#14s830ms652us315ns).
- All valid time stamps refer to TIO_Time:
  - Input time stamps of the TIO modules are converted to TIO_Time in TIO instructions TIO_IOLink_IN and TIO_DI.
  - Output time stamps are converted to output time stamps of the TIO modules in TIO instructions TIO_IOLink_OUT and TIO_DQ.

TIO instructions in the "Synchronous Cycle" OB

The TIO instructions must be called in a "Synchronous Cycle" OB.

You can find additional information in the chapter Programming (Page 29).

Modes for updating the process image

In isochronous mode, you can influence the order of the update of the process image partition of the input and output data. In doing so, you can select the following program execution models:

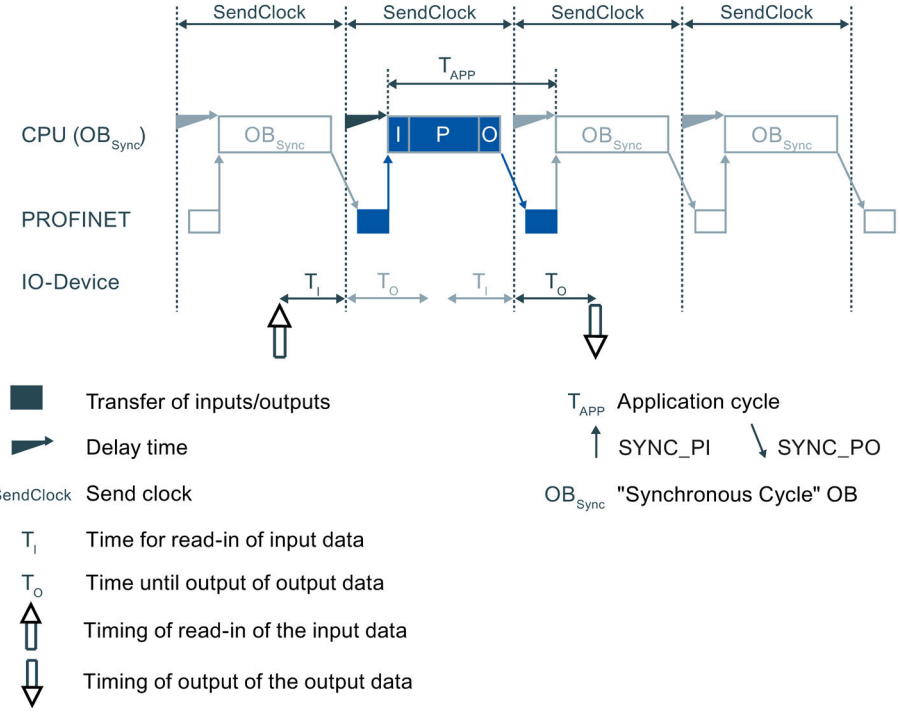
- IPO model (application cycle factor = 1)
- OIP model (application cycle factor >= 1)

The abbreviations I, P, O stand for the following processes: I = Input, P= Processing, O = Output.

Additional information on the application cycle factor is available in the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) Manual.

IPO model (application cycle factor = 1)

The user program is started after the delay time. Start by updating the corresponding process image partition of the inputs in the user program by calling the SYNC_PI system instruction. Processing is started next (for example, calculation of the time stamps). The corresponding process image partition of the outputs is updated at the end of the user program in the CPU by SYNC_PO.



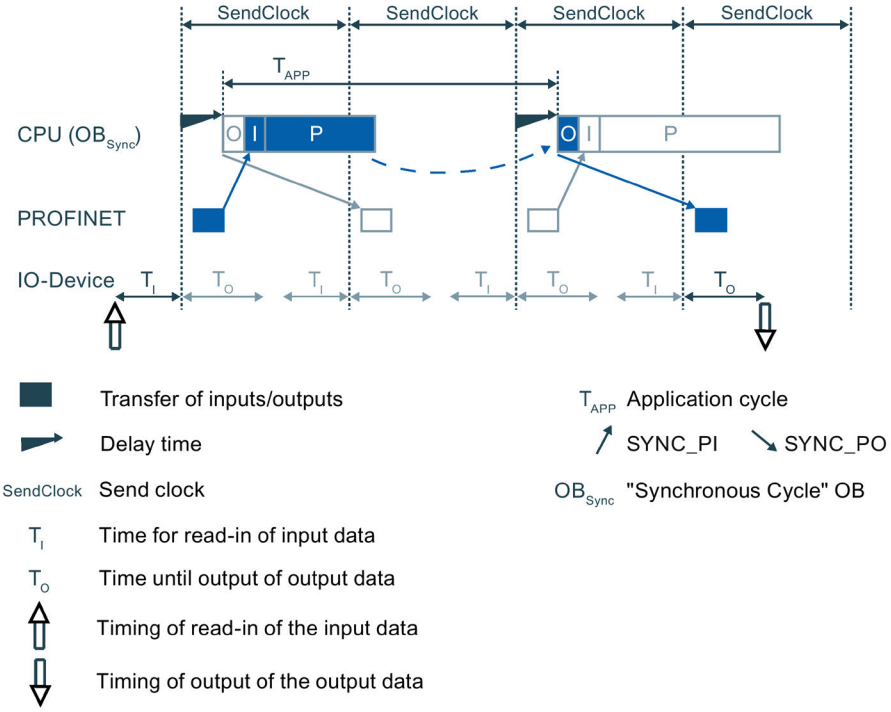
Properties of the IPO model:

- Supports shorter response times
- The application cycle may not be greater than the send clock.

  This gives the application less time than with the OIP model.

OIP model (application cycle factor >= 1)

The user program is started after the delay time. In PIP_Mode 0, the TIO_SYNC instruction updates the process image. In the other modes, you start by updating the corresponding process image partition of the outputs in the user program by calling the SYNC_PO system instruction. As a result, the output data that was calculated in the previous network cycle will become active during the next network cycle (T_O). Next the corresponding process image partition of the inputs is updated in the CPU by SYNC_PI. Processing starts after the data is transmitted (for example, calculation of the time stamps).



Properties of the OIP model:

- The response time is longer than with the IPO model.
- It is one application cycle longer than permitted by the send clock.

  This gives the application more time than with the IPO model.

Influence of accuracy

To estimate the accuracy you need the accuracy of

- TIO module
- Sensor/ actuator

Consult the data sheets of the respective module regarding the accuracy value.

You have to add the individual jitters of the TIO modules and the sensors/actuators. You can neglect any other influencing factors.

See also

Programming of Time-based IO (Page 30)

Configuring and parameter assignment 3

3.1 Requirements

Introduction

You need additional software components to use Time-based IO. You must also have created the standard configuration for your project.

Below you will learn more about the standard configuration for Time-based IO.

Requirements

In the TIA Portal:

- The project has been created.
- The CPU has been created and the parameters are assigned.
- ET 200 distributed I/O and modules have been created and the parameters are assigned.
- The connection has been created and the parameters are assigned via PROFINET.
- A "Synchronous Cycle" OB has been created.

In addition for IO-Link:

- S7-PCT is installed on the programming device/PC.
- IODD for IO-Link device (with time stamp function) are installed.

See also

System environment (Page 17)

Configuration software requirements (Page 19)

3.2 Settings for Time-based IO

Below you will find an overview of which settings have to be made for which components of Time-based IO.

Table 3- 1 Overview of settings for Time-based IO

Component	Can be set where (*)	Properties to be set	Additional information
PROFINET subnet	Properties of the PROFINET subnet > sync domain	Create sync domain or edit properties of sync domain • For example, set send clock (e.g., 2 ms)	• PROFINET with STEP 7 function manual (http://support.automation.siemens.com/WW/view/en/49948856) • Online help in the TIA Portal information system
		Specify devices of the sync domain: • Specify CPU as sync master. • Specify ET 200 interface module as sync slave with RT class "IRT".	
ET 200 station (with TIO module)	Properties of the PROFINET interface > isochronous communication	Assignment of the TIO modules to the isochronous PROFINET subnet	• PROFINET with STEP 7 function manual (http://support.automation.siemens.com/WW/view/en/49948856) • Manual Technology Module TM Timer DIDQ 16x24V (http://support.automation.siemens.com/WW/view/en/95153313) • Manual Technology Module TM Timer DIDQ 10x24V (http://support.automation.siemens.com/WW/view/en/95153951) • Online help in the TIA Portal information system
	Properties of the TIO module > isochronous mode	Activate isochronous mode	
TIO module	Properties of the TIO module > I/O addresses	A "Synchronous Cycle" OB has been assigned or created	
	Properties of the TIO module > I/O addresses	Assignment of I/O addresses to the process image partition (e.g., PIP1)	
	Properties of the TM Timer DIDQ > Basic parameters/Channel parameters	Parameter assignment for use of Timer DI and Timer DQ	
"Synchronous Cycle" OB	Properties of the "Synchronous Cycle" OB > Isochronous mode	Adjust application cycle, if necessary	
IO-Link Device (sensor/ actuator)	SIMATIC S7-PCT	Activate port of the IO-Link Device for Time-based IO	See chapter Configure IO-Link and activate Time-based IO (Page 27)

* Does not describe the exact location but the topic in the configuration software.

Setting for Time-based IO

If you have no special response time requirements, the following setting is suitable as a starting point:

- Send clock: 2 ms
- Application cycle: 4 ms
- Assignment to the process image partition: PIP1
- PIP_Mode: 0 (OIP model)

See also

Programming of Time-based IO (Page 30)

3.3 Configure IO-Link and activate Time-based IO

Introduction

For Time-based IO, the ports of the IO-Link Master must be set to the required operating mode and suitable sensors/actuators must be connected to the ports.

Requirements

- S7-PCT is installed on the programming device/PC.
- IODD for IO-Link Device (with time stamp function) are installed.

  You can find additional information on installation in the online help for S7-PCT.
- The project is open in network view in the TIA Portal.
- The hardware catalog is open.

Procedure

1. Right-click the IO-Link Master in the TIA Portal and select "Start Device Tool".

   The Port Configuration Tool (S7-PCT) opens.

2. Select the connected IO-Link Device (sensors/actuators with time stamp function) from the device catalog for the ports of the IO-Link Master in S7-PCT.

   Use drag-and-drop to insert the IO-Link Device to the matching Port of the IO-Link Master.

3. Adapt the settings of the ports to match their respective task in the application.

   Possible port settings:

   – IO-Link Time based IN: The input signals of the sensor are given a time stamp.

   – IO-Link Time based OUT: The signal is output at the specified time.

4. Save the settings.
5. Download the Port configuration to the IO-Link Master.
6. Close S7-PCT.

Result

The IO-Link Master is configured with the connected sensor and actuator information.

Programming

4

4.1 Overview of instructions

Introduction

Time-based IO is used with special instructions (TIO instructions). The TIO_SYNC TIO instruction is responsible for synchronizing all involved TIO modules and creates a unique time basis (TIO_Time) to which all actions are referenced.

Depending on the type of TIO module, additional instructions undertake the reading in of process input signals with associated time stamps and/or the time-controlled output of process output signals.

Note

The TIO instructions use the time stamp functions of the TIO modules. For the other functions of the respective TIO module, no use of instructions is necessary.

TIO instructions

Instruction	Can be used with TIO module	Short description
TIO_SYNC (Page 34)	• CM 4xIO-Link • TM Timer DIDQ 16x24V • TM Timer DIDQ 10x24V	Synchronizes the TIO modules and provides the time basis for Time-based IO
TIO_IOLink_IN (Page 38)	• CM 4xIO-Link	Reads the input signals with time stamp from the IO-Link Device (sensor)
TIO_DI (Page 42)	• TM Timer DIDQ 16x24V • TM Timer DIDQ 10x24V	Detects the edges at the digital input (Timer DI) and supplies the associated time stamp
TIO_IOLink_OUT (Page 47)	• CM 4xIO-Link	Outputs time-controlled output signals at the IO-Link Device
TIO_DQ (Page 52)	• TM Timer DIDQ 16x24V • TM Timer DIDQ 10x24V	Outputs time-controlled edges at the digital output (Timer DQ)

4.2 Programming of Time-based IO

Introduction

For use of Time-based IO, the TIO instructions must be called in a "Synchronous Cycle" OB. The application can also run in another OB. In this way, you can shorten the runtime of the "Synchronous Cycle" OB.

You need the following TIO instructions according to the required task:

TIO module	TIO instructions	
CM 4xIO-Link	• Per sensor, one TIO_IOLink_IN for read-in • Per actuator, one TIO_IOLink_OUT for output	One TIO_SYNC (for up to eight TIO modules)
TM Timer DIDQ	• Per digital input, one TIO_DI for read-in • Per digital output, one TIO_DQ for output	

This section below describes the programming of the CPU for Time-based IO.

Requirements

Hardware configuration in the TIA Portal:

- The TIO modules are assigned to an isochronous network.
- The TIO modules are assigned to a shared process image partition.
- The process image partition is assigned to a "Synchronous Cycle" OB.

Additional information on configuration of Time-based IO is available in the section Settings for Time-based IO (Page 26).

Procedure

1. Create a TIO_SYNC TIO instruction in the "Synchronous Cycle" OB.
2. Connect all TIO modules to be synchronized at the TIO_SYNC TIO instruction using parameters HWID_1 to HWID_8.

   The HWID is located in HWCN under the module properties.
3. Configure the send clock at the TIO_SYNC TIO instruction.

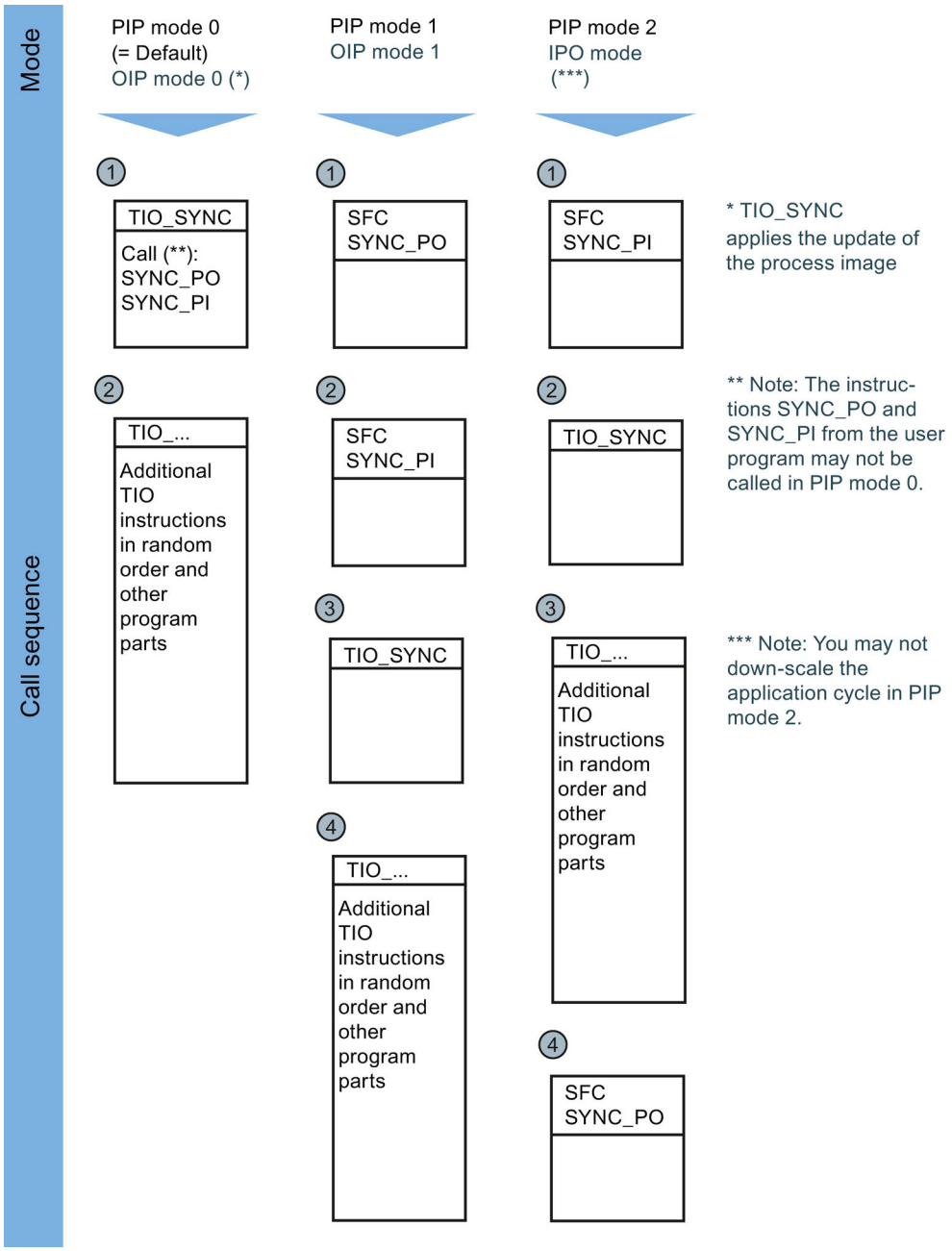
   The send clock is listed in the properties of the ET 200 station.

4. Set the data update mode at the TIO_SYNC instruction at the PIP_Mode input parameter.

   The description of the modes is available in the chapter Technical implementation (Page 20).

   The parameter assignment of the TIO_SYNC TIO instruction is complete.

5. For the following instructions, note the call sequence depending on the selected value for PIP_Mode:



6. Add the TIO instructions for data read-in/output required for your application in the "Synchronous Cycle" OB.

7. Connect the TIO_SYNC_Data input to the output of the same name at TIO_SYNC at each TIO instruction for read-in and output.
8. Assign the input parameters TO (see properties of the ET 200 station), HWID (see module properties in HWCN), and Port/Channel" for the TIO instructions for data read-in/output.

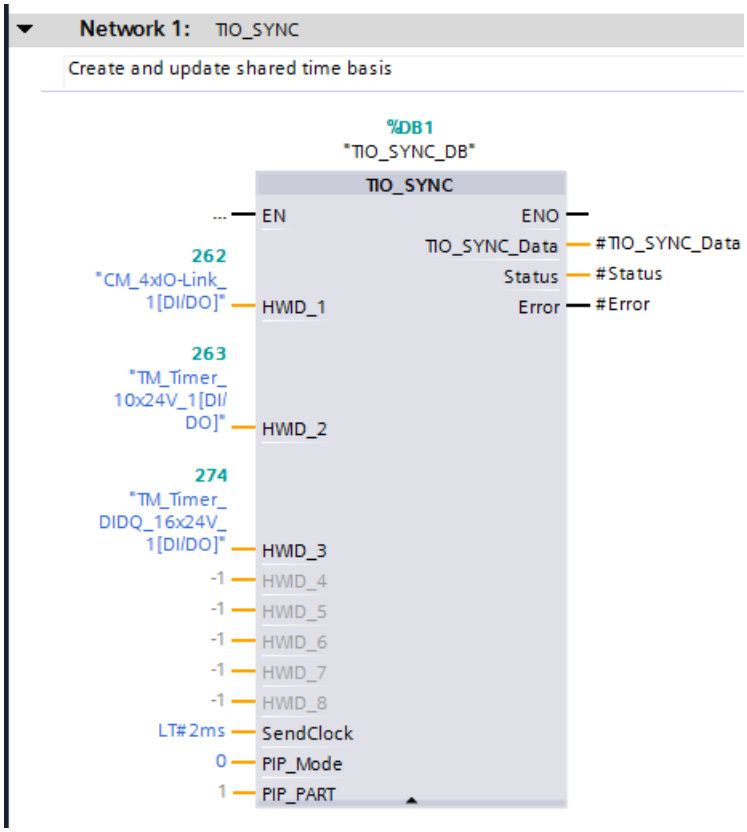
   Programming for the Time-based IO functionality is complete.
9. Connect the Time-based IO functionality with your application.
10. Compile and download the entire project to the CPU.

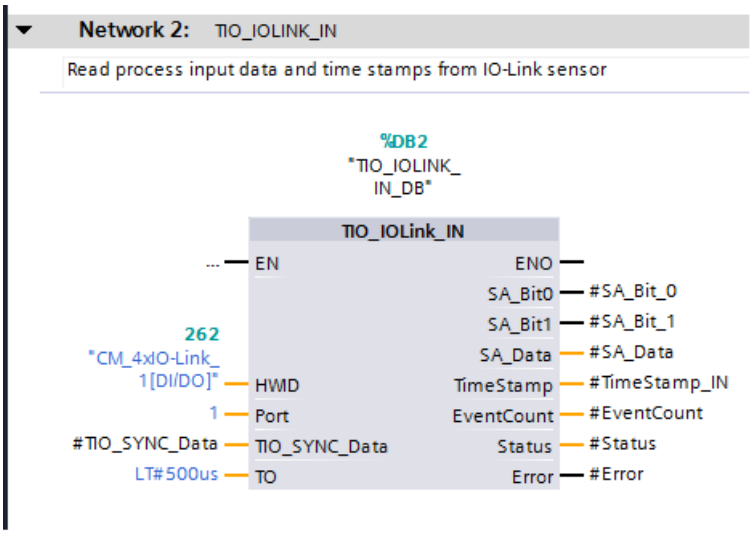
Result

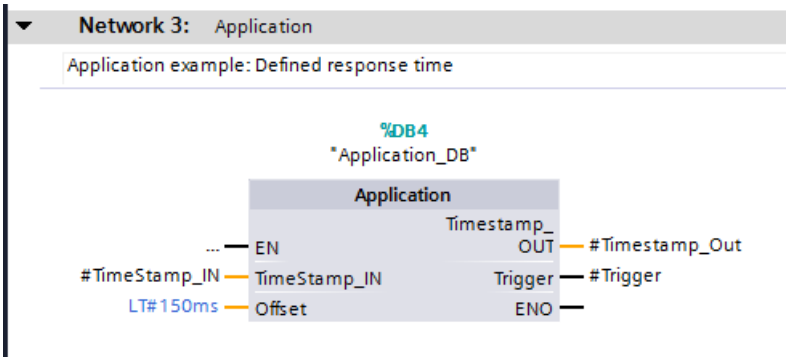
You have completed programming the use of Time-based IO.

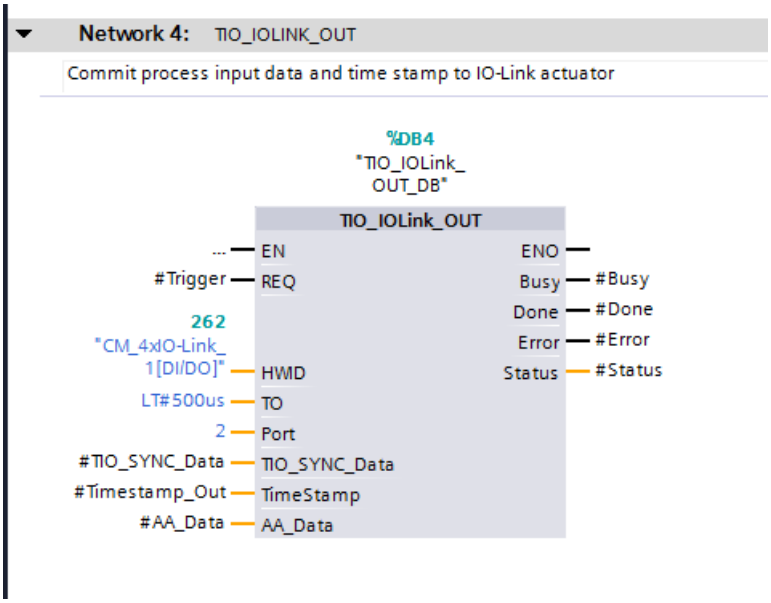
Example

Below you see an application example with a TIO_IOLink_IN and a TIO_IOLink_OUT.




Network 2: TIO_IOLINK_IN
Read process input data and time stamps from IO-Link sensor
%DB2
"TIO_IOLINK_
IN_DB"
TIO_IOLink_IN
EN
ENO
SA_Bit0
#SA_Bit_0
SA_Bit1
#SA_Bit_1
SA_Data
#SA_Data
262
"CM_4xIO-Link_
1[DI/DO]"
HWID
TimeStamp
#TimeStamp_IN
1
Port
EventCount
#EventCount
#TIO_SYNC_Data
TIO_SYNC_Data
Status
#Status
LT#500us
TO
Error
#Error


Network 3: Application
Application example: Defined response time
%DB4
"Application_DB"
Application
Timestamp_
EN
OUT
#Timestamp_Out
#TimeStamp_IN
TimeStamp_IN
Trigger
#Trigger
LT#150ms
Offset
ENO


Network 4: TIO_IOLINK_OUT
Commit process input data and time stamp to IO-Link actuator
%DB4
"TIO_IOLink_
OUT_DB"
TIO_IOLink_OUT
EN
ENO
#Trigger
REQ
Busy
#Busy
Done
#Done
262
"CM_4xIO-Link_
1[DI/DO]"
Error
#Error
HWID
Status
#Status
LT#500us
TO
2
Port
#TIO_SYNC_Data
TIO_SYNC_Data
#Timestamp_Out
TimeStamp
#AA_Data
AA_Data

4.3 Time-based IO

4.3.1 TIO_SYNC: Synchronizing TIO modules

Description

You can use Time-based IO with the TIO_SYNC instruction. TIO_SYNC synchronizes TIO modules to a shared time basis TIO_Time.

You can synchronize up to 8 TIO modules with TIO_SYNC. All TIO modules must be assigned to the same process image partition (PIP). If you select "0" for the input parameter PIP_Mode, you assign the number of the process image partition at the PIP_PART input parameter.

Startup characteristics

At the startup of the CPU, the TIO_SYNC instruction receives and checks the input parameters once and initializes the TIO_Time. If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Operating principle

In normal operation, the instruction ensures synchronization of all TIO modules configured at the HWID input.

The calculated TIO_Time for the instructions of the TIO modules is provided at the TIO_SYNC_Data output.

Reaction to error

The Error output indicates whether the instruction parameters are assigned correctly and whether an error has occurred. If the instruction was not processed successfully, the reasons for the errors are displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_SYNC instruction.

Parameter	Declaration	Data type S7-1500	Default	Description
HWID_1 ... HWID_8*	Input	HW_IO	-1	Hardware identifier for TIO module from HWCN
SendClock*	Input	LTime	LT#0ns	Send clock of the sync domain. Apply the send clock from the PROFINET configuration.
PIP_Mode*	Input	USInt	0	Mode for the data update**: • 0: OIP model with internal update of the process image by SYNC_PO and SYNC_PI. • 1: OIP model without internal update of the process image • 2: IPO model without internal update of the process image
PIP_PART*	Input	USInt	1	Only relevant if PIP_Mode = 0 Number of the process image partition which is to be updated isochronously.
TIO_SYNC_ Data	Output	"TIO_SYNC_ Data"		Calculated system time for the TIO instructions of the TIO modules and internal data used for synchronization. See UDT "TIO_SYNC_Data" (Page 57).
Status	Output	DWord	16#0	Status of the instruction: see description of Status parameter
Error	Output	Bool	False	If True, this output indicates that an error has occurred. For detailed information see Status parameter. Error is reset as soon as the error is remedied.

* Checked once at startup of the CPU

** The IPO model (PIP_Mode = 2) provides the shortest response times, but it also places the highest demands on system performance. Processing of all TIO instructions and other program sections must be completed within one send clock.

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Segment of the error code	Meaning
z0yywwww	Error of a system function: • during startup (z = 0) • during normal operation (z = 1) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The error information is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 0) • during normal operation (z = 1)

Table with error codes

Error code (DW#16#...)	Meaning	Remedy
00000000	No error.	—
1001xxxx	An error has occurred with system function RD_SINFO. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the TIA Portal information system. • Make sure that TIO_SYNC is called in a "Synchronous Cycle" OB.
10020000	The read cycle time of the isochronous OB is LT#0ms or has as negative value and is therefore invalid. The instruction can only be used without errors in an isochronous OB.	• Correct the value of the cycle time. • Make sure that TIO_SYNC is called in a "Synchronous Cycle" OB.
10030000	The TIO_SYNC instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB. Possible cause: The TIO_SYNC instruction was called in an "MC-Servo" or "MC-Interpolator" OB.	Make sure that TIO_SYNC is called in a "Synchronous Cycle" OB.
10040000	The assigned value at the PIP_Mode input parameter is outside the valid range of 0 to 2.	Correct the value at the PIP_Mode input parameter.
10050000	The assigned send clock is outside the permitted range of 0 < SendClock <= 4 ms and is therefore invalid.	Correct the value of the send clock.
0006xxxx	An error has occurred during execution of the SYNC_PI system function. The low word xxxx displays the error information of the RET_VAL return value from SYNC_PI.	Read the description of the SYNC_PI in the TIA Portal information system.
0007xxxx	An error has occurred during execution of the SYNC_PO system function. The low word xxxx displays the error information of the RET_VAL return value from SYNC_PO.	Read the description of the SYNC_PO in the TIA Portal information system.

Error code (DW#16#...)	Meaning	Remedy
10080000	Isochronous mode missing. Time-based IO cannot be used. Possible cause: Internal error during address calculation	Check the values of input parameters HWID_1 to HWID_8. Specify the hardware identifier of the TIO module from its module properties in HWCN.
10090000	TIO module HWID_1: Error during reading of HWID_1.	Check the value of the respective input parameter. Specify the hardware identifier of the TIO module in each case from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
100A0000	TIO module HWID_2: Error during reading of HWID_2.	
100B0000	TIO module HWID_3: Error during reading of HWID_3.	
100C0000	TIO module HWID_4: Error during reading of HWID_4.	
100D0000	TIO module HWID_5: Error during reading of HWID_5.	
100E0000	TIO module HWID_6: Error during reading of HWID_6.	
100F0000	TIO module HWID_7: Error during reading of HWID_7.	
10100000	TIO module HWID_8: Error during reading of HWID_8.	
10110000	The configured process image partition at input parameter PIP_PART is not within the valid range of 1 to 31.	Correct the value at the PIP_PART input parameter.
x0FF0000	General internal error.	—

4.3.2 TIO_IOLink_IN: Read process input signals with time stamps

Description

You can use the Time-based IO with the TIO_IOLink_IN instruction. TIO_IOLink_IN detects an event at the IO-Link Device and returns the process value including the associated time stamp.

The IO-Link Device must be equipped with the time stamp function and the Port must be in "IO-Link, Time based IN" mode.

Startup characteristics

During startup of the CPU, the instruction TIO_IOLink_IN applies the input parameters once and checks the following:

- Checking HWID
- Checking whether the Port number is in the range (1 to 4)
- Checking TIO_SYNC_Data.Error: Is an error present at TIO_SYNC?
- Checking T_o for a positive value
- Checking the setting to type IO-Link
- Checking Port mode regarding configuration for IO-Link Time based IN
- Checking whether the OB is a "Synchronous Cycle" OB
- Checking PortQualifier

If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Operating principle

In normal operation, the instruction detects the process data (SA_Data) of an IO-Link Device and the associated time stamp (time = TIO_Time) of the last valid change. Each valid change of the SA_Data with a correctly functioning port is accompanied by a valid time stamp.

You connect the input TIO_SYNC_Data with the output of the same name of the TIO_SYNC instruction. This ensures a shared time basis.

Reaction to error

The Error output indicates if the instruction was processed correctly. The reasons for the errors are displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_IOLink_IN instruction.

Parameter	Declaration	Data type S7-1500	Default	Description
HWID*	Input	HW_IO	0	Hardware identifier for TIO module from HWCN
Port*	Input	USInt	0	Port number (1 to 4) of the connected IO-Link Device
TIO_SYNC_ Data*	Input	"TIO_SYNC_ Data"		System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT "TIO_SYNC_Data" (Page 57). Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction.
TO*	Input	LTime	LT#0ns	T_o: Time for output of isochronous output data. Apply T_o from the ET 200 station (properties of the PROFINET interface).
SA_Bit0	Output	Bool	False	Display of a process data change (bit 0 of SA_Data). SA_Bit0 is event-oriented. As long as no valid time stamp has been acquired (EventCount = 0), the process data are invalid.
SA_Bit1	Output	Bool	False	Display of a process data change (bit 1 of SA_Data). SA_Bit1 is event-oriented. As long as no valid time stamp has been acquired (EventCount = 0), the process data are invalid.
SA_Data	Output	DWord	16#0	Process data SA_Data (Sensor Application Data)
TimeStamp	Output	LTime	LT#0ns	Time stamp: Time when a change of the process signal SA-Data took place at the IO-Link Device.
EventCount	Output	UInt	0	Counter: Is incremented with each new, valid time stamp. The counter is reset with each CPU startup.
Status	Output	DWord	16#0	Status of the instruction: see description of Status parameter
Error	Output	Bool	False	If True, this output indicates that an error has occurred. For detailed information see Status parameter. Error is reset as soon as the error is remedied.

* Checked once at startup of the CPU

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Segment of the error code	Meaning
z0yywwww	Error of a system function: • during startup (z = 0) • during normal operation (z = 1) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The system function is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 0) • during normal operation (z = 1)

Table with error codes

Error code (DW#16#...)	Meaning	Remedy
00000000	No error.	—
10010000	The assigned number at the Port input parameter is outside the valid range of 1 to 4.	Correct the value at the Port input parameter.
10020000	The TIO_IOLink_IN instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_IOLink_IN is called in a "Synchronous Cycle" OB.
10030000	An error occurred when reading the HWID input parameter.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0040000	The data in TIO_SYNC_Data is invalid/incorrect.	Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.
1005xxxx	An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the TIA Portal information system. • Make sure that TIO_IOLink_IN is called in a "Synchronous Cycle" OB.
10060000	Unable to find IO-Link Device. Possible cause: The module configured using the hardware identifier is not an IO-Link Master for Time-based IO.	• Make sure that the configured module is an IO-Link Master for Time-based IO. • Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN.

Error code (DW#16#...)	Meaning	Remedy
10070000	An internal error occurred during the address calculation.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
00080000	TIO module is not synchronized using the TIO_SYNC instruction.	Check the instruction TIO_SYNC.
10090000	The read cycle time of the isochronous OB is outside the permitted range of $0 < T_{APP} <= 16$ ms and is therefore invalid. The instruction can only be used without errors in an isochronous OB.	• Correct the cycle time. • Make sure that TIO_IOLink_IN is called in a "Synchronous Cycle" OB.
100A0000	The assigned time at the TO input parameter is outside the permitted range of $0 < T_o <= 4$ ms.	Correct the value at the TO input parameter.
100Bxxxx	An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.	Read the description of the RD_ADDR in the TIA Portal information system.
000C0000	The converted time stamp is invalid.	Check the connected sensor and the interaction between IO-Link Master and sensor (e.g., configuration).
000D0000	The value status PortQualifier of the IO-Link indicates that the process data is invalid.	Check the connected sensor and its configuration.
100E0000	The configured port mode of the IO-Link is incorrect.	Check the configuration of the connected sensor with S7-PCT.
x0FF0000	General internal error.	—

4.3.3 TIO_DI: Reading in edges at digital input and associated time stamps

Description

You can use the Time-based IO with the TIO_DI instruction. TIO_DI continuously detects the edges at a digital input of a TM Timer DIDQ and returns the associated time stamps.

Startup characteristics

During startup of the CPU, the instruction TIO_DI applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO_SYNC_Data.Error: Is an error present at TIO_SYNC?
- Checking T_o for validity (0 ms to 4 ms)
- Checking whether the OB is a "Synchronous Cycle" OB

If startup takes place without errors, the instruction changes to normal operation. The input parameter EdgeSel can be changed during normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Operating principle

In normal operation, the instruction detects the edges at a digital input and the associated time stamps (time = TIO_Time) of the last valid, defined edge pair. Use the input parameter EdgeSel to determine the edges for which time stamps are detected.

You connect the input TIO_SYNC_Data with the output of the same name of the TIO_SYNC instruction. This ensures a shared time basis.

Reaction to error

The Error output indicates if the instruction was processed correctly. The reasons for the errors are displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_DI instruction.

Parameter	Declaration	Data type S7-1500	Default	Description
HWID*	Input	HW_IO	0	Hardware identifier for TIO module from HWCN
Channel*	Input	UInt	0	Number (0 ... m) of the digital input of the connected TM Timer DIDQ
TIO_SYNC_Data*	Input	"TIO_SYNC_Data"		System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT "TIO_SYNC_Data" (Page 57). Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction.
EdgeSel	Input	UInt	3	Specify the edges for which time stamps are detected: 0_D: Reserved 1_D: Only at positive edges 2_D: Only at negative edges 3_D: Positive and negative edges (order depending on occurrence) 4_D: First positive, then negative edge 5_D: First negative, then positive edge 6 bis 255_D: Reserved
TO*	Input	LTime	LT#0ns	T_o: Time for output of isochronous output data. Apply T_o from the ET 200 station (properties of the PROFINET interface).
DI	Output	Bool	False	Status of digital input. If an inversion of the digital input is configured, this parameter is inverted as well.
TimeStampRE	Output	LTime	LT#0ns	Time stamp: Time at which a positive edge was detected. Exception: EdgeSel = 2_D: Time at which a negative edge was detected.
TimeStampFE	Output	LTime	LT#0ns	Time stamp: Time at which a negative edge was detected. Exception: EdgeSel = 1_D: Time at which a positive edge was detected.
EventCountRE	Output	UInt	0	Counter: Is incremented with each new, valid time stamp at a positive edge. The counter is reset with each CPU startup.
EventCountFE	Output	UInt	0	Counter: Is incremented with each new, valid time stamp at a negative edge. The counter is reset with each CPU startup.
LEC	Output	UInt	0	Counter: Number of edges for which no time stamp could be saved. The module can count a maximum of seven edges per application cycle. The counter is reset with each new application cycle.

Parameter	Declaration	Data type S7-1500	Default	Description
Status	Output	DWord	16#0	Status of the instruction: see description of Status parameter
Error	Output	Bool	False	If True, this output indicates that an error has occurred. For detailed information see Status parameter. Error is reset as soon as the error is remedied.

* Checked once at startup of the CPU

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Segment of the error code	Meaning
z0yywwww	Error of a system function: • during startup (z = 0) • during normal operation (z = 1) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The system function is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 0) • during normal operation (z = 1)

Table with error codes

Error code (DW#16#...)	Meaning	Remedy
00000000	No error.	—
10010000	The assigned number of the digital input at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).	Correct the value at the Channel input parameter.
10020000	The TIO_DI instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_DI is called in a "Synchronous Cycle" OB.
10030000	An error occurred when reading the HWID input parameter.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0040000	The data in TIO_SYNC_Data is invalid/incorrect.	Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.
1005xxxx	An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the TIA Portal information system. • Make sure that TIO_DI is called in a "Synchronous Cycle" OB.
10060000	Unable to find TM Timer DIDQ. Possible cause: The module configured using the hardware identifier is not a TM Timer DIDQ.	• Make sure that the configured module is a TM Timer DIDQ. • Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN.
10070000	An internal error occurred during the address calculation.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
00080000	TIO module is not synchronized using the TIO_SYNC instruction.	Check the instruction TIO_SYNC.
10090000	The read cycle time of the isochronous OB is outside the permitted range of $0 < T_{APP} <= 16$ ms and is therefore invalid. The instruction can only be used without errors in an isochronous OB.	• Correct the cycle time. • Make sure that TIO_DI is called in a "Synchronous Cycle" OB.
100A0000	The assigned time at the TO input parameter is outside the permitted range of $0 < T_o <= 4$ ms.	Correct the value at the TO input parameter.
100Bxxxx	An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.	Read the description of the RD_ADDR in the TIA Portal information system.

Error code (DW#16#...)	Meaning	Remedy
000C0000	The converted time stamp is invalid. Possible cause: Communication error	Check the PROFINET communication with the TIO module.
000D0000	The Quality Information of the digital input indicates that an error has occurred at the digital input.	Check the wiring of the digital input.
000E0000	The assigned number at the Channel input parameter is not a digital input configured as Timer DI.	• Check the channel configuration (only for TM Timer DIDQ 16x24V). • Check the operating mode of the digital input.
000F0000	The assigned value at the EdgeSel input parameter is outside the valid range of 1 to 5.	Correct the value at the EdgeSel input parameter.
10100000	The send clock is outside the permitted range of 0 < SendClock <= 4 ms and is therefore invalid. The error code can also indicate that • The data in TIO_SYNC_Data is invalid or does not exist. • The TIO_DI instruction is not called in an isochronous OB.	Correct the send clock.
x0FF0000	General internal error.	—

4.3.4 TIO_IOLink_OUT: Output time-controlled process output signals

Description

You can use Time-based IO with the TIO_IOLink_OUT instruction. TIO_IOLink_OUT lets you activate the output data of an IO-Link Device at a specified time.

The IO-Link Device must be equipped with the time stamp function and the Port must be in "IO-Link, Time based OUT" mode.

Startup characteristics

During startup of the CPU, the instruction TIO_IOLink_OUT applies the input parameters once and checks the following:

- Checking HWID
- Checking whether the Port number is in the range (1 to 4)
- Checking TIO_SYNC_Data.Error: Is an error present at TIO_SYNC?
- Checking T_o for a positive value
- Checking the setting to type IO-Link
- Checking Port mode regarding configuration for IO-Link Time based OUT
- Checking whether the OB is a "Synchronous Cycle" OB
- Checking PortQualifier

If startup takes place without errors, the instruction changes to normal operation. The input parameters REQ , Out_Mode, TimeStamp and AA_Data can be changed during normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Operating principle

In normal operation, the instruction sends the process data (AA_Data) to an IO-Link Device. The output data AA_Data are activated at the time defined at the input parameter TimeStamp.

You connect the input TIO_SYNC_Data with the output of the same name of the TIO_SYNC instruction. This ensures a shared time basis.

You start an output job with a positive edge at the "REQ" parameter. You can only start a new job when there is no error pending and no job is active. When starting the output job, the AA_Data (bit 0, 1) are activated on the IO-Link Device at a time defined by TimeStamp. The job is done when the last application cycle is executed before the output time is reached (Done). Status and Error are constantly being updated during the job runtime.

Note

Once the job has been started with a positive edge, you can adapt the output time with the input of a new TimeStamp without having to restart the job.

Constraint:

If the adapted time stamp is less than 16 ms before the output time (TimeStamp - TIO_Time < 16), the last valid time stamp is used.

If you specify the value 0 as TimeStamp, the output is written directly with the data specified at the input AA_Data. This gives you the option to implement a direct control from the TIO module without time stamp in manual mode. You can use the direct control to interrupt an ongoing job.

Reaction to error

The Error output indicates if the instruction was processed correctly. The reasons for the errors are displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_IOLink_OUT instruction.

Parameter	Declaration	Data type S7-1500	Default	Description
REQ	Input	Bool	False	Starts the job at a positive edge.
HWID*	Input	HW_IO	0	Hardware identifier for TIO module from HWCN.
TO*	Input	LTime	LT#0ns	T_o: Time for output of isochronous output data. Apply T_o from the ET 200 station (properties of the PROFINET interface).
Port*	Input	USInt	0	Port number (1 to 4) of the specified IO-Link Device
TIO_SYNC_Data*	Input	"TIO_SYNC_Data"		System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT "TIO_SYNC_Data" (Page 57). Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction.
TimeStamp	Input	LTime	LT#0ns	Time stamp: Time when the process data (AAE1, AAE2) are to be output.
AA_Data	Input	Word	16#0	Process output data: Date to be output (Word). Includes AAE1 and AAE2 on bit 0, 1.
Busy	Output	Bool	False	Busy = True: The job is not complete yet.
Done	Output	Bool	False	Done = True is displayed for one cycle: The job is signaled as "done, no errors".
Error	Output	Bool	False	If True, this output indicates that an error has occurred. In this case, BUSY and DONE are set to False. For detailed information see Status parameter. Error is reset as soon as the error is remedied.
Status	Output	DWord	16#0	Status of the instruction: see description of Status parameter

* Checked once at startup of the CPU

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Segment of the error code	Meaning
z0yywwww	Error of a system function: • during startup (z = 0) • during normal operation (z = 1) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The error information is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 0) • during normal operation (z = 1)

Table with error codes

Error code (DW#16#...)	Meaning	Remedy
00000000	No error.	—
10010000	The assigned number at the Port input parameter is outside the valid range of 1 to 4.	Correct the value at the Port input parameter.
10020000	The TIO_IOLink_OUT instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_IOLink_OUT is called in a "Synchronous Cycle" OB.
10030000	An error occurred when reading the HWID input parameter.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0040000	The data in TIO_SYNC_Data is invalid/incorrect.	Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.
1005xxxx	An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the TIA Portal information system. • Make sure that TIO_IOLink_OUT is called in a "Synchronous Cycle" OB.
10060000	Unable to find IO-Link Device. Possible cause: The module configured using the hardware identifier is not an IO-Link Master for Time-based IO.	• Make sure that the configured module is an IO-Link Master for Time-based IO. • Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN.

Error code (DW#16#...)	Meaning	Remedy
10070000	An internal error occurred during the address calculation.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
00080000	TIO module is not synchronized using the TIO_SYNC instruction.	Check the instruction TIO_SYNC.
10090000	The read cycle time of the isochronous OB is outside the permitted range of 0 < T_{APP} <= 16 ms and is therefore invalid. The instruction can only be used without errors in an isochronous OB.	• Correct the cycle time. • Make sure that TIO_IOLink_OUT is called in a "Synchronous Cycle" OB.
100A0000	The assigned time at the TO input parameter is outside the permitted range of 0 < T_o <= 4 ms.	Correct the value at the TO input parameter.
100Bxxxx	An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.	Read the description of the RD_ADDR in the TIA Portal information system.
000C0000	The time stamp at the TimeStamp input parameter is invalid.	Check the TimeStamp input parameter.
000D0000	The value status PortQualifier of the IO-Link indicates that the process data is invalid.	Check the connected sensor and its configuration.
100E0000	The configured port mode of the IO-Link is incorrect.	Check the configuration of the connected sensor with S7-PCT.
100F0000	The read cycle time of the "Synchronous Cycle" OB is too long. T_{APP} > 16 ms.	Configure a smaller multiple of the send clock as the cycle time.
x0FF0000	General internal error.	—

4.3.5 TIO_DQ: Output edges time-controlled at the digital output

Description

You can use Time-based IO with the TIO_DQ instruction. TIO_DQ switches the digital output of a TM Timer DIDQ at a specified time.

Startup characteristics

During startup of the CPU, the instruction TIO_DQ applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO_SYNC_Data.Error: Is an error present at TIO_SYNC?
- Checking T_o for validity (0 ms to 4 ms)
- Checking whether the OB is a "Synchronous Cycle" OB

If startup takes place without errors, the instruction changes to normal operation. The input parameters REQ , Out_Mode, TimeStampRE and TimeStampFE can be changed during normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Operating principle

The instruction outputs edges time-controlled at a digital output during normal operation.

- At the time defined at the TimeStampRE input parameter, a positive edge is output at the digital output.
- At the time defined at the TimeStampFE input parameter, a negative edge is output at the digital output.

Use the input parameter Out_Mode to determine if only one edge or both edges are output.

You connect the input TIO_SYNC_Data with the output of the same name of the TIO_SYNC instruction. This ensures a shared time basis.

You start an output job with a positive edge at the "REQ" parameter. You can only start a new job when there is no error pending and no job is active. When the output job is started, the digital output is switched at the times defined with TimeStampRE and TimeStampFE.

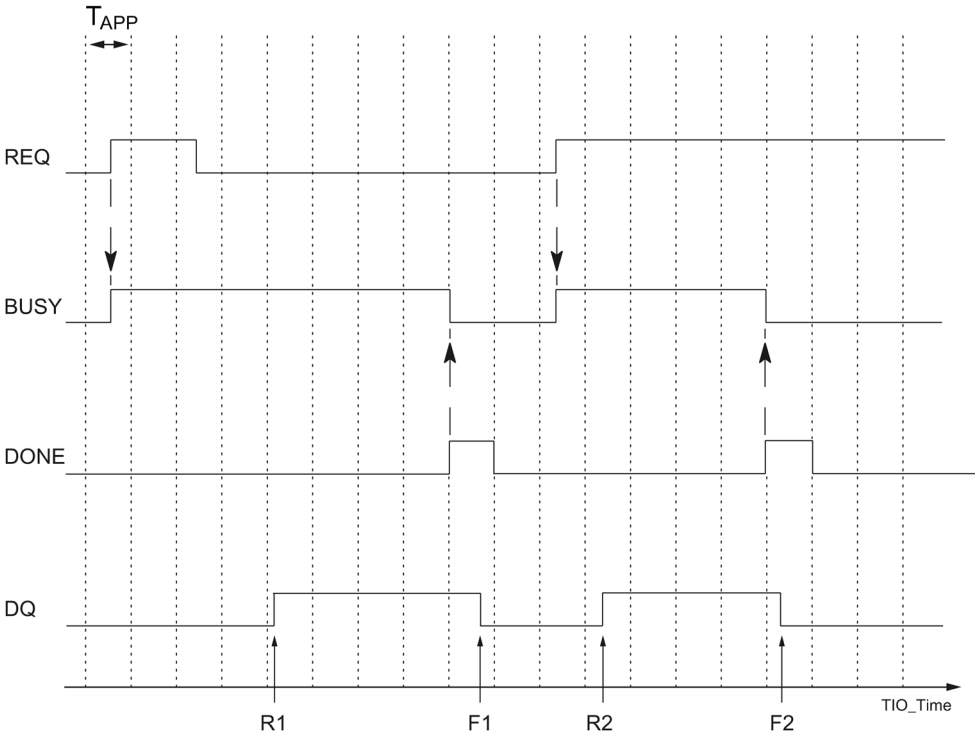
- If the digital output is already set at time TimeStampRE, the output job is not transferred to the module for the positive edge.
- If the digital output is not set at time TimeStampFE, the output job is not transferred to the module for the negative edge.

This means the digital output is not switched in both cases.

The job is done when the last application cycle is executed before the second output time is reached (DONE). Status and Error are constantly being updated during the job runtime.

The figure below shows an example for the reaction of the bits DONE and BUSY at the start of an output job under the following conditions:

- Out_Mode = 2
- The two time stamps are not adapted between the start of the job and the output.



T_{APP}	Application cycle
R1, R2	Specified times of a positive DQ edge
F1, F2	Specified times of a negative DQ edge

Note

Once the job has been started with a positive edge, you can adapt the output times with the input of TimeStampRE and TimeStampFE without having to restart the job.

Constraint:

If an adapted time stamp is less than two application cycles away from the output time (TimeStampRE - TIO_Time < 2*T_{APP} or TimeStampFE - TIO_Time < 2*T_{APP}), the last valid time stamp is used.

If you specify the value "0" as TimeStampRE or TimeStampFE, you can output the respective edge directly at the digital output with the input parameter Out_Mode = 3. This gives you the option to implement a direct control from the TIO module without time stamp in manual mode. You can use the direct control to interrupt an ongoing job.

Changes to the input parameters are not applied until the TIO_DQ instruction detects a startup of the CPU.

Reaction to error

The Error output indicates if the instruction was processed correctly. The reasons for the errors are displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_DQ instruction.

Parameter	Declaration	Data type S7-1500	Default	Description
REQ	Input	Bool	False	Starts the job at a positive edge.
HWID*	Input	HW_IO	0	Hardware identifier for TIO module from HWCN.
Channel*	Input	UInt	0	Number (0 ... m) of the digital output of the connected TM Timer DIDQ
TIO_SYNC_Data*	Input	"TIO_SYNC_Data"		System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT "TIO_SYNC_Data" (Page 57). Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction.
Out_Mode	Input	UInt	2	Specify the output mode for the edges at the digital output: 0_D: Output only positive edge (TimeStampRE). 1_D: Output only negative edge (TimeStampFE). 2_D: Both edges are output (TimeStampRE and TimeStampFE). 3_D: Each edge is output directly when TimeStampRE = 0 or TimeStampFE = 0. If both time stamps have the value "0" or if no time stamp has the value "0", no edge is output. 4 bis 255_D: Reserved
TO*	Input	LTime	LT#0ns	T_o: Time for output of isochronous output data. Apply T_o from the ET 200 station (properties of the PROFINET interface).
TimeStampRE	Input	LTime	LT#0ns	Time stamp: Time when a positive edge is to be output.
TimeStampFE	Input	LTime	LT#0ns	Time stamp: Time when a negative edge is to be output.
StatusDQ	Output	Bool	False	Actual status of the digital output. If an inversion of the digital output is configured, StatusDQ is inverted as well.
BUSY	Output	Bool	False	BUSY = True: The job is not complete yet.
DONE	Output	Bool	False	DONE = True is displayed for one cycle: The job is signaled as "done, no errors".
Status	Output	DWord	16#0	Status of the instruction: see description of Status parameter
Error	Output	Bool	False	If True, this output indicates that an error has occurred. In this case, BUSY and DONE are set to False. For detailed information see Status parameter. Error is reset as soon as the error is remedied.

* Checked once at startup of the CPU

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Segment of the error code	Meaning
z0yywwww	Error of a system function: • during startup (z = 0) • during normal operation (z = 1) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The error information is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 0) • during normal operation (z = 1)

Table with error codes

Error code (DW#16#...)	Meaning	Remedy
00000000	No error.	—
10010000	The assigned number of the digital output at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).	Correct the value at the Channel input parameter.
10020000	The TIO_DQ instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_DQ is called in a "Synchronous Cycle" OB.
10030000	An error occurred when reading the HWID input parameter.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0040000	The data in TIO_SYNC_Data is invalid/incorrect.	Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.
1005xxxx	An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the TIA Portal information system. • Make sure that TIO_SYNC is called in a "Synchronous Cycle" OB.
10060000	Unable to find TM Timer DIDQ. Possible cause: The module configured using the hardware identifier is not a TM Timer DIDQ.	• Make sure that the configured module is a TM Timer DIDQ. • Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN.

Error code (DW#16#...)	Meaning	Remedy
10070000	An internal error occurred during the address calculation.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in HWCN. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0080000	TIO module is not synchronized using the TIO_SYNC instruction. The error code can also indicate that: • A job was already present before the first run of the instruction. • The assigned number at the Channel input parameter is not a digital output.	Check the instruction TIO_SYNC.
10090000	The read cycle time of the isochronous OB is LT#0ms or has as negative value and is therefore invalid. Correct the value. The instruction can only be used without errors in an isochronous OB.	• Correct the cycle time. • Make sure that TIO_DQ is called in a "Synchronous Cycle" OB.
100A0000	The assigned time at the TO input parameter is outside the permitted range of 0 < T_o <= 4 ms.	Correct the value at the TO input parameter.
100Bxxxx	An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.	Read the description of the RD_ADDR in the TIA Portal information system.
000C0000	One or both time stamps at the TimeStampRE and TimeStampFE input parameters are invalid. The error is only signaled for the duration of one application cycle.	Check the TimeStampRE and TimeStampFE input parameters.
000D0000	The Quality Information of the digital output indicates that an error has occurred at the digital output.	• Check the parameter assignment of the digital output. • Check the wiring of the digital output for short-circuit, overload, and overtemperature.
000E0000	The assigned number at the Channel input parameter is not a digital output.	• Check the channel configuration (only for TM Timer DIDQ 16x24V). • Check the operating mode of the digital output.
100F0000	The read cycle time of the "Synchronous Cycle" OB is too long. T_{APP} > 16 ms.	Configure a smaller multiple of the send clock as the cycle time.
10100000	The send clock is outside the permitted range of 0 < SEND_CLOCK <= 4 ms and is therefore invalid. The error code can also indicate that • The data in TIO_SYNC_Data is invalid or does not exist. • The TIO_DQ instruction is not called in an isochronous OB.	Correct the send clock.

Error code (DW#16#...)	Meaning	Remedy
00110000	The assigned value at the Out_Mode input parameter is outside the valid range of 0 to 3.	Correct the value at the Out_Mode input parameter.
x0FF0000	General internal error.	—

4.3.6 UDT "TIO_SYNC_Data"

Description

The data type UDT "TIO_SYNC_Data" contains the central structure and data for synchronization of the modules and passing of the TIO_Time.

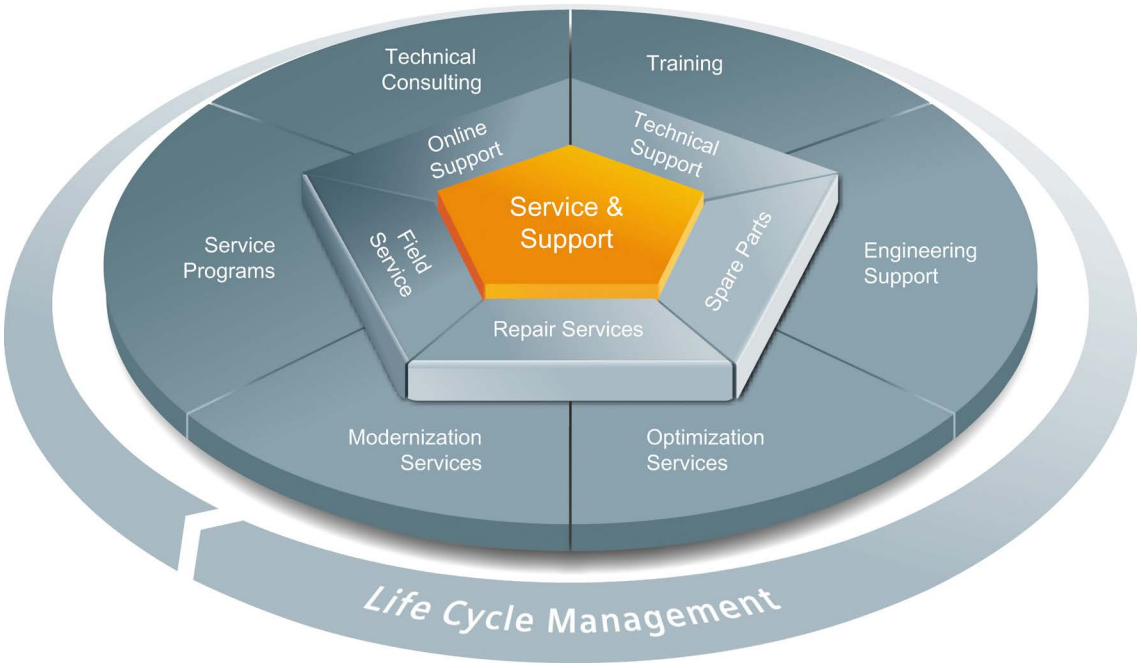
Parameter

Parameter	Data type S7-1500	Description
TIO_TIME_BASE	LTime	Internal use
TIO_TIME	LTime	Shared time basis (relative time) of the TIO modules.
PIP_MODE	USInt	Mode for data update (is forwarded by the PIP_Mode input parameter of the TIO_SYNC instruction)
APP_CYC	LTime	Application cycle of the "Synchronous Cycle" OB
SEND_CLOCK	LTime	Send clock of sync domain (is forwarded by the SendClock input parameter of the TIO_SYNC instruction)
TBase	LTime	Internal use
ERROR	Bool	Internal use

Service & Support

5

5.1 Service & Support



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SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL
Designing interference-free controllers

Function Manual

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Interference-free cable routing 3

Cable shielding 4

Equipotential bonding 5

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06/2014

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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GERMANY

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Preface

Purpose of the documentation

This documentation will support you in installing and commissioning programmable controllers.

Correct configuration is essential for fault-free operation of programmable controllers.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of VDE (German Association for Electrical, Electronic and Information Technologies) and EC regulations
- Knowledge of the rules for installing controllers and switchgear

Conventions

You should also pay particular attention to notes such as the one shown below:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation is valid for all products of the product series SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL.

The product series SIMATIC S7-1500, ET 200MP and ET 200SP are approved for IP20 degree of protection, i.e. the modules of these product series must be installed in a control cabinet.

The SIMATIC ET 200AL product series is approved for IP65/IP67 degree of protection, i.e. the modules need **not** be installed in a control cabinet.

Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version (version 01/2013):

- Extension of the scope of validity to the distributed I/O system ET 200AL
- Supplement to the section Connection of the cable shielding for ET 200AL
- Components for lightning protection potential equalization amended

Additional support

Additional information on SIMATIC products is available on the Internet. The associated documentation is also available on the Internet.

- The range of technical documentation for the individual SIMATIC products and automation systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200SP, ET 200MP and ET 200AL systems consists of the respective system manuals, function manuals and product manuals.

The STEP 7 information system (online help) also supports you when configuring and programming your automation system.

Overview of documentation on the subject of designing interference-free controllers

The following table lists additional documentation which supplements this description of designing interference-free controllers.

Table 1- 1 Documentation on the subject of designing interference-free controllers

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)	
	System Manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
	System manual Distributed I/O System ET 200AL (http://support.automation.siemens.com/WW/view/en/89254965)	

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Basic information on electromagnetic compatibility 2

2.1 Overview of possible interference

Introduction

SIMATIC products and their components have been developed for use in industrial environment and meet the legal EMC requirements (EMC - Electromagnetic Compatibility). However, you still need to conduct an EMC assessment before installing your controller in order to identify possible sources of interference and to include these in your considerations.

Electromagnetic compatibility

Electromagnetic compatibility describes the ability of an electrical device to function properly in its particular electromagnetic environment. Neither the environment itself nor the electrical device are influenced in an unacceptable manner.

Possible interference

Electromagnetic interference can influence an automation system in various ways. The most significant interferences and their causes are as follows:

- Electromagnetic fields having a direct influence on the system
- Interference coupling caused by bus signals (for example, PROFINET)
- Interference influencing the system via the process wiring
- Interference which reaches the system via the power supply and/or protective ground

The figure below shows the likely paths of electromagnetic interference.

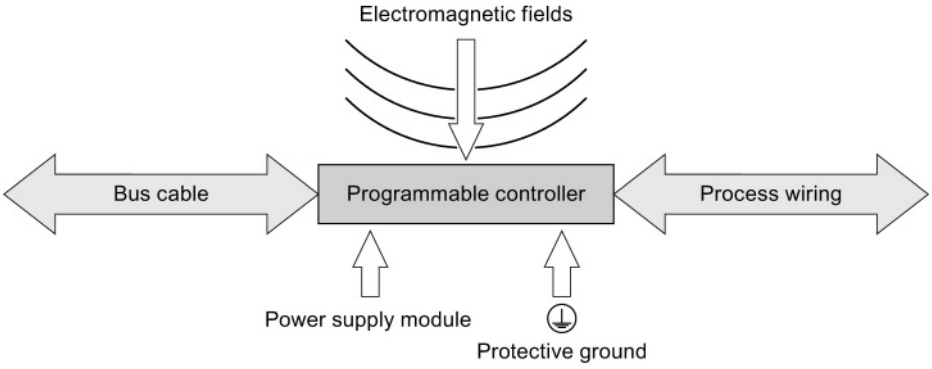


Figure 2-1 Electromagnetic interference

2.2 Coupling mechanisms

Depending on the emitting medium and the distance between the source of interference and the device, interference can reach the automation system via four different coupling mechanisms.

The following table shows possible causes and typical sources of interference for the various coupling mechanisms:

Table 2- 1 Coupling mechanisms

Coupling mechanism	Cause	Typical sources of interference
Galvanic coupling	Two electric circuits share the same cable	• Clocked devices (influence on the network due to converters and third-party power supply units) • Starting motors • Potential differences on component enclosures with shared power supply
Capacitive coupling	Potential difference between conductors	• Interference coupling due to parallel routing of signal cables • Static discharge of the operator
Inductive coupling	Mutual influencing of current-carrying conductor loops. The magnetic fields caused by the current flow induce interference voltages.	• Transformers, motors, electrical welding equipment • Power supply cables routed in parallel • Cables whose currents are switched • High-frequency signal cables • Unwired coils
Radiation coupling	Effect of an electromagnetic wave on a cable configuration. This wave induces currents and voltages.	• Neighboring transmitters (for example, walkie-talkies) • Spark gaps (spark plugs, collectors of electrical motors, welding devices)

Interference-free cable routing

3

This chapter describes the EMC-compatible classification of cables and cable routing for bus, data, signal and supply lines.

3.1 Classifying cables into cable categories

Classify the cables into cable categories according to their sensitivity to interference coupling and interference emission. The further away from one another cables of different cable categories are installed, the lower the mutual influence by capacitive and inductive coupling.

The following table shows the cable categories into which you can classify your cables accordingly.

Table 3- 1 Cable categories

Category A	• Signal lines to I/O modules • Bus and data lines (for example, PROFIBUS, PROFINET) • Lines to HMI devices • Supply lines for extra-low voltages (< 24V DC or < 60V AC)
Category B	• Supply lines with safe electrical isolation (SELV) • Supply voltages < 400 V
Category C	• Supply voltages > 400 V

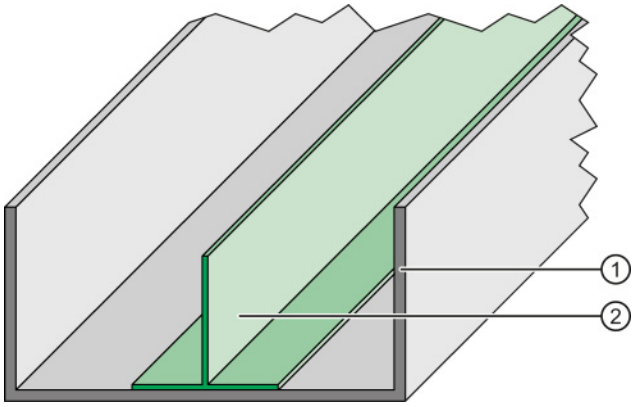
The following table shows the minimum clearance you must maintain when installing cables.

Table 3- 2 Combination of cable categories

	Category A	Category B	Category C
Category A	• In common bundles or cable channels	• In separate bundles or cable channels (no minimum clearance necessary)	• Inside cabinets in separate bundles or cable channels • Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance
Category B	• In separate bundles or cable channels (no minimum clearance necessary)	• In common bundles or cable channels	
Category C	• Inside cabinets in separate bundles or cable channels • Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance		• In common bundles or cable channels

If you install different cable categories in the same cable channel, use metallic cable channels with metallic partition.

The following figure show a schematic view of a cable channel with partition.



① Metallic cable channel
② Metallic partition

Figure 3-1 Cable channel with partition

3.2 Cable routing inside cabinets in buildings

Rule

Observe the following rules for proper cable routing inside of control cabinets:

- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Do not route cables coming into the cabinet from outside parallel to the shield supports.

3.3 Cable routing outside cabinets and inside buildings

Rule

Observe the following rules for proper cable routing outside control cabinets and inside buildings:

- Read the information in section Assigning cables to cable categories (Page 9).
- If you route the cables in metallic cable channels, you can rearrange the cable channels next to each other.
- Connect metallically conductive cable racks to the potential equalization of the building.
- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.

3.4 Cable routing outside buildings

If possible, lay the cables outside buildings on metallic cable holders. Connect the cable holder joints galvanically to each other and ground the cable holders.

Rule

Observe the following rules when laying cables outside of buildings:

- Use metallic auxiliary terminal boxes to connect cables coming from outside at the junction to cables inside the building. Ground these boxes.
- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Integrate bus cables installed outside of buildings into your lightning and overvoltage concept.

Lightning protection

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

Reference

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 26).

3.5 Underground cable routing

Rule

Observe the following rules for underground cable routing:

- Lay the cable at least 60 cm below the ground surface.
- Install equipotential bonding approximately 20 cm above the cable. You can use a zinc-plated ground strip, for example. The ground strips also serve as protection against lightning strikes.
- Protect the cable against mechanical damage by, for example, using a plastic pipe and/or a cable warning tape in the ground, approximately 40 cm above the cable.
- Separate the various cable categories in the ground using cable channels, for example.

The following figure shows the arrangement of cable warning tape, equipotential bonding and a cable.

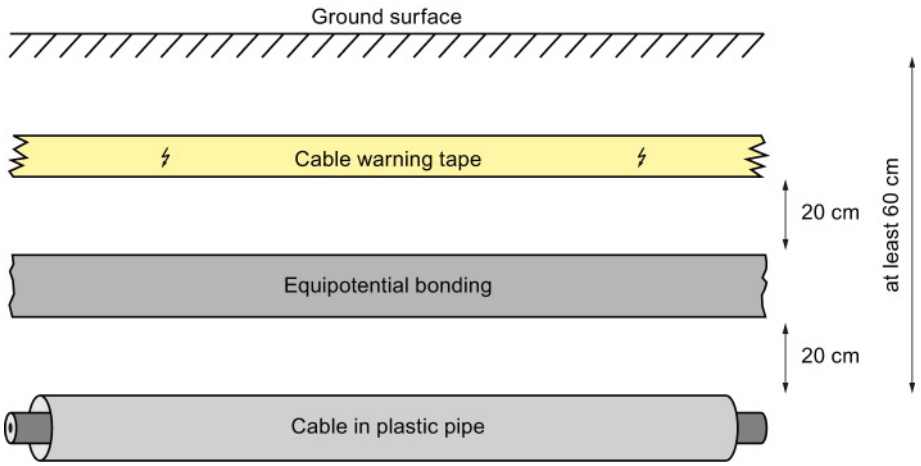


Figure 3-2 Arrangement underground

Lightning protection

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

Reference

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 26).

3.6 Bending radii and tensile strength of cables

Tensile strain

A high strain on the cables due to tensile forces leads to conductor material flow. The tensile forces thus cause a change in the structure of the material and lower the conductor cross-section. This decrease of the conductor cross-section leads, in turn, to a heating of the conductor and premature wear of the conductor insulation.

Use the supplied cable ties to relieve the terminal points on the plugs for the I/O modules of the product series SIMATIC S7-1500 and SIMATIC ET 200MP.

Bending radius

If you select too small bending radii when laying cables, this will cause the materials to stretch and compress and changes the mechanical structure of the cables. The electrical properties are impaired as a result.

Pay particular attention to the bending radii of fiber-optic cables. If the bending radii are too small, the optical properties of the fiber-optic cable are adversely affected. Reliable transmission is no longer guaranteed.

Cable shielding

4

Shielding is a measure to attenuate (dampen) magnetic, electrical or electromagnetic interference fields.

Interference currents on cable shields are diverted from the shield connection to ground. To avoid interference as a result of these currents, it is imperative to provide a low-impedance connection to the protective conductor.

Rules

Ideally, you should use cables equipped with a protective braided shield. The shield's contacting must be more than 80% at the contact point. Avoid tensile and compression strain on cables with a foil shield. This type of strain can damage the foil shield very slightly at the fastening point. The result is a reduced shielding effect.

Shield connection with grounding at both ends

Always connect the cable shields to the ground at both ends. Low and high frequency interference can be reduced only by connecting both ends of the shield to the ground.

Note

Laying an additional equipotential bonding cable

Whenever potential differences develop between the grounding points, an equalizing current flows on a shielding that is connected at both ends. In this case, lay an additional equipotential bonding cable. You can find more information on this topic in the chapter Equipotential bonding (Page 23).

Shield connection with capacitive grounding at one end

If you do not have the option of installing equipotential bonding (in plants covering a large area, for example), connect capacitive grounding to one end of your shield. In this case, only high-frequency interference will be reduced.

The following figure shows the capacitive grounding of a cable shield. The values indicated in the figure are indicative and will differ from system to system. The capacity diverts the high-frequency interference. This capacity provides high-impedance protection for the power frequency (50 or 60 Hz), thus preventing equalizing currents via the shield. A parallel switched high-impedance resistance prevents the capacity from loading a direct current.

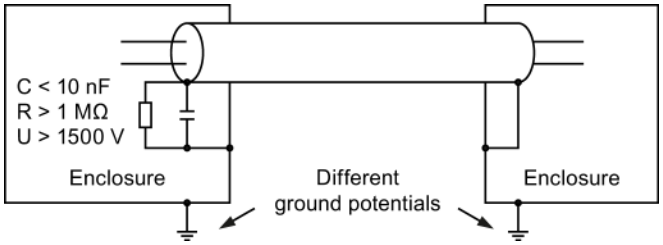


Figure 4-1 Capacitive grounding of the shield

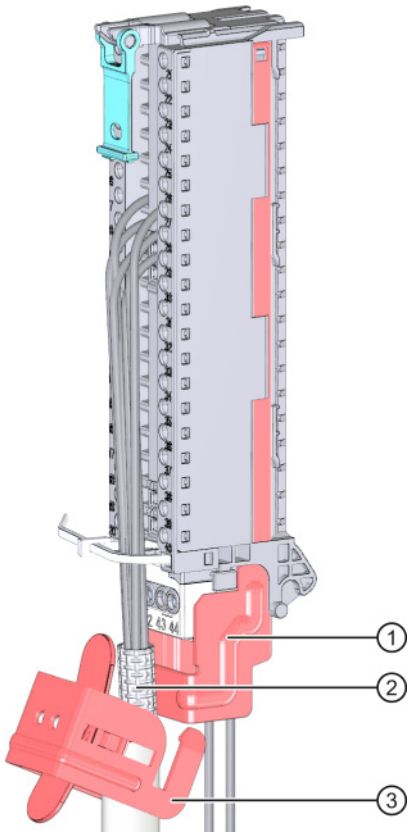
4.1 Connecting the cable shielding for S7-1500 and ET 200MP

A special shield design has been developed for the automation system S7-1500 and the distributed I/O system ET 200MP for the shield connection of the signal lines. The connection element for the cable shield consists of a shield clamp and a shield terminal.

If the front connector is located in the module, the interference currents which occur are diverted by the connection element to the ground via the module and mounting rail.

The shield clamp is a pluggable mount for the analog and technology modules. The shield clamp allows the low-impedance application of cable shields with minimum installation times.

The following figure shows a front connector with mounted shield clamp and associated shield terminal.



① Shield clamp
② Stripped cable shield
③ Shield terminal

Figure 4-2 Shield clamp and shield terminal on front connector

The shield clamp is inserted from below onto the front connector until the shield clamp latches audibly. The shield terminal is fastened to the shield clamp.

Additional information

For additional information on installing the shield clamp and shield terminal, refer to the "Connecting front connectors" chapter in the S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) or ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

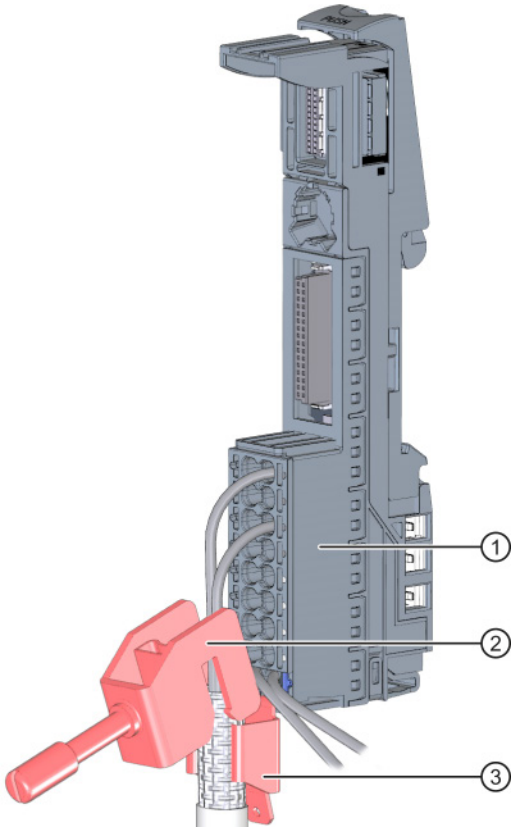
4.2 Connecting the cable shielding for ET 200SP

A special shield design has been developed for the shield connection of the signal lines of the ET 200SP distributed I/O system. The connection element for the cable shield consists of a shield terminal.

If the front connector is located in the module, the interference currents that occur are diverted by the connection element via BaseUnit and mounting rail to the ground.

The shield terminal is plugged into a mount of the BaseUnit. The shield terminal allows the low-impedance application of cable shields with minimum installation times. There is no need for the otherwise standard connection of the cable shield at the cabinet entry.

The following figure shows a BaseUnit with shield terminal and shield support.



① BaseUnit of ET 200SP
② Shield terminal
③ Shield support with flat plug for terminal sockets

Figure 4-3 BaseUnit with shield terminal

Additional information

For more information on mounting the shield terminal, refer to the "Connecting cable shields" chapter of the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Connecting the cable shielding for ET 200AL

Each module of the ET 200AL distributed I/O system features a functional ground connection.

Use only shielded cables for connection of analog signals, PROFINET and PROFIBUS signals and for the ET-Connection. If you have screwed the plug in correctly, the interference currents that occur are diverted to the metal parts and functional ground.

If you attach an ET 200AL module to a **conductive**, grounded base, the lower mounting bolt establishes a conductive connection to the earth potential.

If you attach an ET 200AL module to a **non-conductive** base, connect the lower mounting bolt to the ground wire at the same time.

The following figure shows how to connect the functional ground via a ground wire, using the IM 157-1 PN interface module as an example.

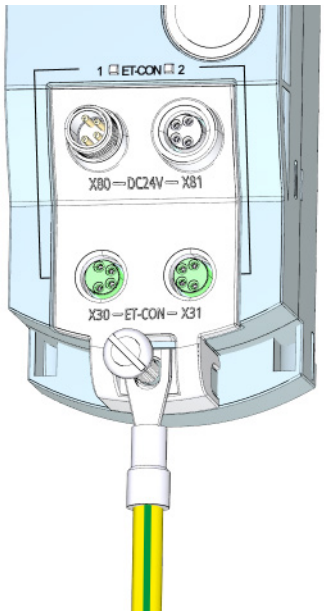


Figure 4-4 Connect functional ground via a ground wire

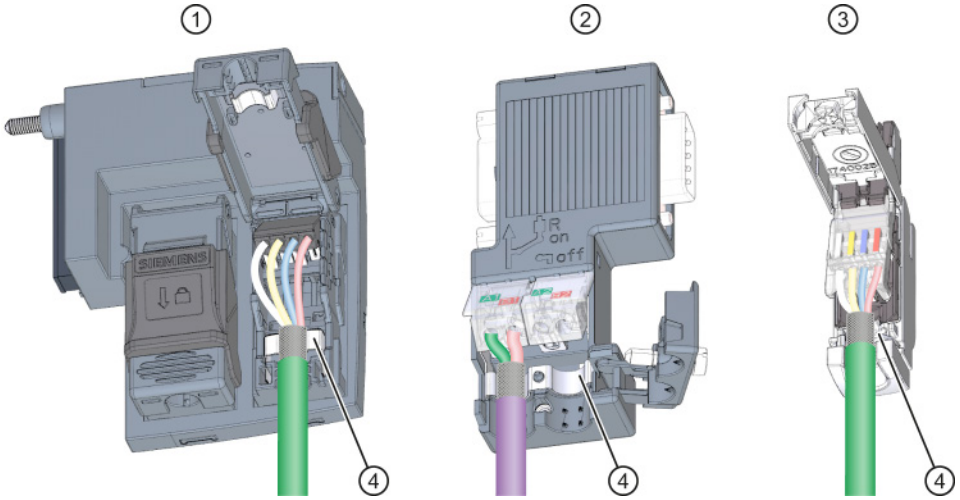
Additional information

You can find more information on installing ET 200AL modules in the Installing Modules section of the system manual Distributed I/O System ET 200AL (http://support.automation.siemens.com/WW/view/en/89254965).

4.4 Connecting the cable shield for bus cables

In the S7-1500, ET 200MP and ET 200SP systems, the cable shields of PROFIBUS and PROFINET cables are connected to the existing bus connection elements. Cable shield and shield support are thus galvanically connected to each other. If the connector is plugged into the module, the coupled interferences are diverted via the module carrier to the ground. There is no need for the otherwise standard connection of the shield at the cabinet entry.

The following figure shows examples of the shield connection for various bus connection elements.



① BusAdapter BA 2xRJ45 for ET 200SP
② PROFIBUSconnector, 9-pin D-Sub
③ PROFINETconnector RJ45
④ Shield support of respective connector

Figure 4-5 Shield connection for bus connection elements

Reference

For more information on installing the connectors, refer to the "Connecting PROFINET IO BusAdapter BA 2xRJ45 to the interface module" chapter of the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) and to the supplied product information.

4.5 Connecting the cable shield for other components

The following procedures for connecting the shield to devices that do not have any special shield terminals have proven themselves in practice.

Rule

Note the following points when handling the shield:

- Always use metal clamps to mount the protective braided shields of the cables. The clamps must cover a large area of the shield and provide appropriate contact force.
- Attach the shield to a shielding bus directly after the point where the cable enters the cabinet. If you route the shield further to the module, do not connect the shield again in front of the module, as this would create ground loops.

The following figure shows standard types of shield fastening.

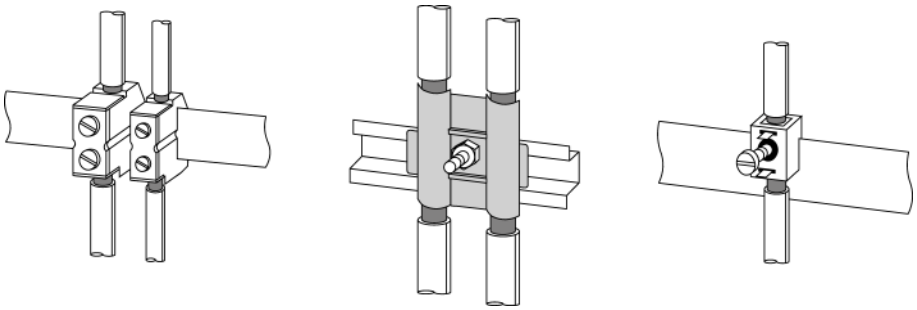


Figure 4-6 Cable shielding

Equipotential bonding

5

Definition according to DIN VDE 0100

Equipotential bonding is an electrical connection which brings the bodies of electrical equipment and external conductive parts to the same, or nearly the same, potential.

Equipotential bonding is divided into:

- Main equipotential bonding
- Additional local equipotential bonding

Both versions of equipotential bonding are of great importance not only for protection against electric shock, but also for EMC.

Main equipotential bonding

Main equipotential bonding is required by DIN VDE 0100 Part 410 as a protective measure and is mandatory, regardless of other measures for protection against direct and indirect contact.

Additional local equipotential bonding

Additional local equipotential bonding is required if:

- Unfavorable grounding conditions exist between plant parts due to different conductivity of the soil (for example, sandy or stony ground)
- Cables bridge a large distance
- Electrical energy is fed in from various power supplies (for example, in the case of multiple substations)
- Considerable electrical power is used (for example, welding robots, large drives)

Measures

In such cases, an additional equipotential bonding cable between the individual potentials can solve the problem. The equipotential bonding cable must also be able to divert large currents and carry lightning stroke current. The following equipotential bonding systems have proven themselves in practice:

- 16 mm^2 for copper equipotential bonding cables up to 200 m long
- 25 mm^2 for copper equipotential bonding cables over 200 m long

To prevent ground loops, equipotential bonding cables are installed in parallel and, whenever possible, near to the signal/bus cable. This allows the area between the two cables to be kept as small as possible.

The following figure shows a schematic view of the installation of an equipotential bonding cable.

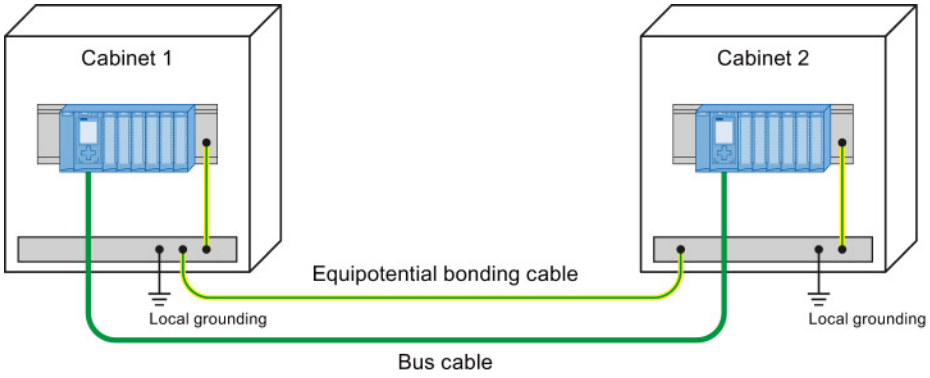


Figure 5-1 Installation of equipotential bonding cables

Rule

Note the following issues regarding equipotential bonding:

- The lower the impedance of an equipotential bonding cable, the more effective is equipotential bonding. The impedance of the additionally installed equipotential bonding cable should not exceed 10% of the shield impedance.
- Connect the equipotential bonding cables to a large area of the grounding system.
- Protect the connection points against corrosion.
- Avoid ground loops.
- Install the equipotential bonding cables in such a way as to minimize the areas enclosed between the equipotential bonding cables and signal lines.

Special measures for interference-free operation

6

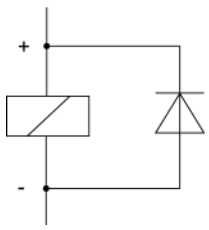
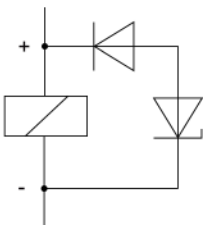
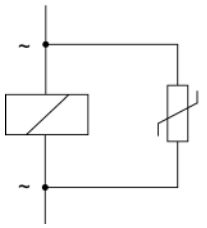
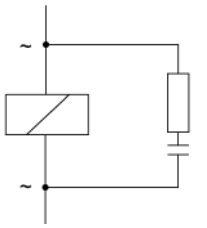
Connecting inductances to quenching elements

Ideally, the inductances (for example, contactor or relay coils) controlled by SIMATIC do not require any wiring to external quenching elements. The required quenching elements are already integrated into the modules.

If the SIMATIC output circuit can also be switched off by built-in contacts (such as relay contacts for EMERGENCY OFF), the module's integrated quenching elements are no longer effective. In this case, the inductances must be wired to quenching elements.

Wire inductances to freewheeling diodes, varistors or RC elements, for example.

Table 6- 1 Wiring inductances

Wiring DC-operated inductances		Wiring AC-operated inductances	
with diode	with Z diode	with varistor	with RC element
			

Programming devices

Provide a socket in each cabinet for the supply of the programming devices. The sockets are supplied from the distribution board to which the protective conductor for the cabinet is also connected.

Observe the following points during the installation of the socket in the control cabinet:

- Include the grounding of the socket in your consideration of the equipotential bonding.
- The common star point of the two ground potentials (cabinet and socket) must be close to the two end points.
- An equipotential bonding cable is not permitted as communication cable between programming device and controller.

Lightning protection and overvoltage protection 7

7.1 What is lightning and overvoltage protection?

Introduction

The term "Lightning and overvoltage protection" covers both the concept and system for the protection of structural systems (such as buildings or electrical equipment). This concept also includes the protection of people and animals.

Overvoltages are most frequently caused by lightning strikes.

Lightning protection system

The lightning protection system is the complete system used to reduce physical damage to a structural system as a result of direct lightning strikes and overvoltages. The lightning protection system is divided into external and internal lightning protection.

External lightning protection

External lightning protection is part of the lightning protection system and comprises an interception device, an arrester and a grounding system. In the event of a lightning strike, the external lightning protection serves to divert the lightning current safely to the ground. This measure most frequently prevents fire damage.

Internal lightning protection

Internal lightning protection is part of the lightning protection system and comprises lightning protection equipotential bonding and/or electrical isolation with respect to the external lightning protection. In the event of a lightning strike, the internal lightning protection reduces the damage caused by overvoltages resulting from the lightning.

Even at larger distances of up to 1.5 km, lightning strikes can sometimes still cause damage. You obtain effective lightning protection by expanding the external lightning protection into an overall protection system. This system includes equipotential bonding and surge protection devices.

7.2 Lightning protection zone concept

Introduction

Each building requires a coordinated protection zone concept. The grading of the protection is of key importance for this. Sufficient protection can only be guaranteed if this grading requirement is satisfied.

The lightning protection zone concept described in the standards IEC 62305-4 and DIN EN 62305-4 is used for this purpose. The lightning protection zone concept groups devices and areas that have the same risk potential and can be wired to arresters of the same type.

Use overvoltage protection devices at the transitions of the lightning protection zones based on the requirements. Install the overvoltage protection devices at an appropriate location such as the main or sub-distribution board.

Principle of the lightning protection zone concept

The principle behind the lightning protection zone concept is the division of the areas to be protected from overvoltages, for example buildings, into lightning protection zones based on EMC considerations.

Schematic diagram of the lightning protection zone concept

The following is a schematic diagram of the lightning protection zone concept in a physical structure.

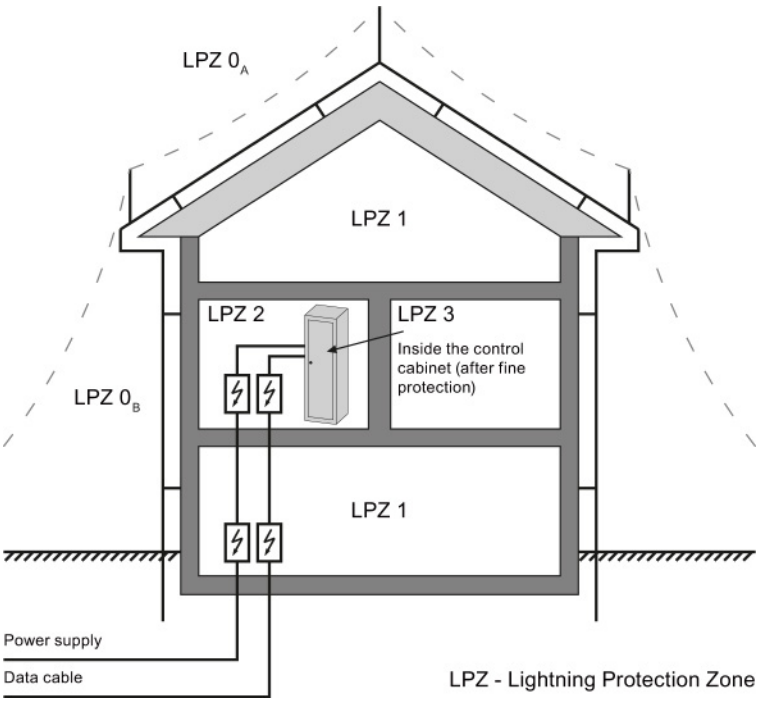


Figure 7-1 Division of a structural system into lightning protection zones

Division of lightning protection zones

The various lightning protection zones (LPZ - Lightning Protection Zone) are limited spatially as follows and not necessarily by physical boundaries, such as walls or floors.

The following table explains the division into various lightning protection zones.

Table 7- 1 External and internal lightning protection zones

Lightning protection zones	
External lightning protection zones:	
LPZ 0_A	• Risk from direct lightning strikes • Risk from the full electromagnetic field of the lightning
LPZ 0_B	• Protected against direct lightning strike • Risk from the full electromagnetic field of the lightning
Internal lightning protection zones:	
LPZ 1	• Protected against direct lightning strike • Attenuated electromagnetic field of the lightning
LPZ 2	• Protected against direct lightning strike • Reduced leakage currents and electromagnetic fields compared to LPZ 1 • Protected terminal devices
LPZ 3	• Protected against direct lightning strike • Protected area inside the terminal device • Local equipotential bonding

Effects of the lightning strike

Direct lightning strikes occur in the lightning protection zone LPZ 0_A. Effects of the lightning strike are high-energy lightning currents and strong electromagnetic fields. These effects are reduced from one lightning protection zone to the next through suitable lightning current or overvoltage arrester/shielding measures.

Frequent damage caused by lightning strikes includes:

- Injury to people and animals, which may in worst cases lead to death
- Damage to buildings
- Fire caused by strong heat development of a lightning strike

Overvoltages

Electromagnetic fields of the lightning channel can be reduced with appropriate shielding measures. Overvoltages due to inductions can be reduced to a safe level starting in lightning protection zone LPZ 0_B with overvoltage arresters.

7.3 Rules and components for the transitions between lightning protection zones

Introduction

This chapter provides you with information on the rules for transitions between lightning protection zones. Measures must be taken to reduce the surge current load and the magnetic fields at the transitions between the lightning protection zones.

Each zone-penetrating metallic/electrical system is incorporated into the equipotential bonding at the zone transition.

The metallic systems include channels, structural parts, and pipes (for water, gas, and heat, for example).

Electrical systems include power and IT cables and wires (for example, power cables and bus cables).

Transitions between lightning protection zones

Overvoltage protection must be provided at the transitions between lightning protection zones (LPZ - Lightning Protection Zone) in accordance with DIN EN 62305. The protection levels are defined at the transitions and implemented by means of overvoltage protection devices (SPD - Surge Protective Device).

- SPD Type 1 - Coarse protection for the transition from LPZ 0 to LPZ 1
- SPD Type 2 - Medium protection for the transition from LPZ 1 to LPZ 2
- SPD Type 3 - Fine protection for the transition from LPZ 2 to LPZ 3

The following figure illustrates the lightning protection zones and the type classes from the supply line to the consumer.

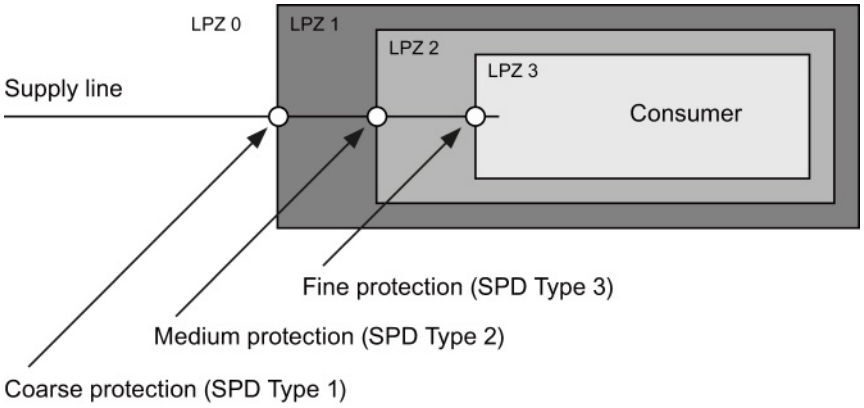


Figure 7-2 Lightning protection zone transitions

Rule for transition from lightning protection zone 0_A to 1

Lightning protection equipotential bonding is required at the transition from lightning protection zone 0_A to 1. The following applies to the transition at the interface of lightning protection zone 0_A to 1:

- Use of lightning arresters prevents introduction of partial lightning currents into structural systems
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

Components for lightning protection equipotential bonding from lightning protection zone 0_A to 1

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0_A to 1.

Table 7- 2 Components for transition from lightning protection zone 0_A to 1

Seq. no.	Cables for ...	Connection at the 0_A interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	Article number
1	Three-phase TN-C system	DEHNventil® DV M TNC 255	951 300
		DEHNventil® DV M TNC 255 FM *	951 305 *
2	Three-phase TN-S system	DEHNventil® DV M TNS 255	951 400
		DEHNventil® DV M TNS 255 FM *	951 405 *
3	Three-phase TT system	DEHNventil® DV M TT 255	951 310
		DEHNventil® DV M TT 255 FM *	951 315 *
4	AC TN-S system	DEHNventil® DV M TN 255	951 200
		DEHNventil® DV M TN 255 FM *	951 205 *
5	AC TT system	DEHNventil® DV M TT 2P 255	951 110
		DEHNventil® DV M TT 2P 255 FM *	951 115 *
6	Supply U_N = 24 V DC	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 B 180 (I_L = 1.2 A) (2-wire)	920 211
7	Supply U_N = 24 V DC	DEHNbloc® M, DB M 1 150	961 110
		DEHNbloc® M, DB M 1 150 FM * (2 pieces required)	961 115 *
8	Bus cable MPI RS 485, RS 232 (V.24)	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 B 180 (2-wire)	920 211
9	Inputs/outputs of digital modules U_N = 24 V DC	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML4 B 180 (I_L = 1.2 A) (4-wire)	920 310
10	Inputs/outputs of digital modules U_N = 230 V AC	DEHNbloc® M, DB M 1 255	961 120
		DEHNbloc® M, DB M 1 255 * (2 pieces required)	961 125 *

Seq. no.	Cables for ...	Connection at the 0_A interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	Article number
11	Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module (I_L = 1.2 A) (4-wire)	920 310
* Version with remote indication contact Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de) **Components can be ordered directly from:** DEHN+SÖHNE GMBH+CO.KG. Hans-Dehn-Straße 1 D-92318 Neumarkt			

Rule for the transition from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3

The transition from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3 prevents strong electromagnetic coupling and serves as overvoltage protection. The following applies to the transition at the interface from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3:

- Use of power cables with surge current-carrying cable shields or twisted-pair IT cables
- Laying cables and lines
  - In continuous, surge current-carrying metal pipes that are grounded at both ends
  - In reinforced concrete channels capable of carrying surge current with grounding at both ends
  - On closed metal cable racks that are grounded at the beginning and end
- Use of fiber-optic cables without a metal shield if such a transmission is intended
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

Additional measures

If the actions listed above cannot be implemented, protection by means of overvoltage arresters must be provided. The following sections contain tables with overvoltage arresters that are very suitable for protecting the plant.

Components for lightning protection equipotential bonding from lightning protection zone 0_B to 1 and 1 to 2

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0_B to 1 and 1 to 2.

Table 7- 3 Components for transition from lightning protection zone 0_B to 1 and 1 to 2

Seq. no.	Cables for ...	Connection at the 0_B interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	Article number
1	Three-phase TN-C system	DEHNguard® DG M TNC 275	952 300
		DEHNguard® DG M TNC 275 FM *	952 305 *
2	Three-phase TN-S system	DEHNguard® DG M TNS 275	952 400
		DEHNguard® DG M TNS 275 FM *	952 405 *
3	Three-phase TT system	DEHNguard® DG M TT 275	952 310
		DEHNguard® DG M TT 275 FM *	952 315 *
4	AC TN-S system	DEHNguard® DG M TN 275	952 200
		DEHNguard® DG M TN 275 FM *	952 205 *
5	AC TT system	DEHNguard® DG M TT 2P 275	952 110
		DEHNguard® DG M TT 2P 275 FM *	952 115 *
6	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24	918422
7	Bus cable MPI/DP RS 485	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 BD HFS 5	920 271
8	Bus cable RS 232 (V.24)	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 BE S 12	920 222
9	Industrial Ethernet	DEHNpatch® DPA M CLE RJ45B 48	929 121
10	Inputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK E 60 (I_L = 0.5 A)	919 990
11	Outputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK D 5 24 (I_L = 10.0 A)	919 986
12	Inputs/outputs of digital modules U_N = 230 V AC	DEHNguard® DG S 275	952 070
		DEHNguard® DG S 275 FM *	952 090 *
		N-PE arrester in the TT system	
		DEHNgap® C S, DGP C S	952 030
		DEHNgap® C S, DGP C S FM *	952 035 *
13	Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)	DEHNconnect® RK, DCO RK E 60 (I_L = 0.5 A)	919 990

Seq. no.	Cables for ...	Connection at the 0_B interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	Article number
14	Inputs/outputs of the fail-safe modules (24 V DC)	DEHNconnect® RK, DCO RK D 5 24	919 986
* Version with remote indication contact Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de) **Components can be ordered directly from:** DEHN+SÖHNE GMBH+CO.KG. Hans-Dehn-Straße 1 D-92318 Neumarkt			

Components for lightning protection equipotential bonding from lightning protection zone 2 to 3

The following table shows components for lightning protection equipotential bonding from lightning protection zone 2 to 3 that you can use for S7-1500/ET 200MP and ET 200SP.

Table 7- 4 Components for transition from lightning protection zone 2 to 3 (for S7-1500/ET 200MP and ET 200SP)

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:			
		S7-1500/ET 200MP	Article number	ET 200SP	Article number
1	Three-phase TN-S, TT system	DEHNrail® DR M 4P 255	953 400	DEHNguard® DG M TNS 275	952 400
				DEHNguard® DG MOD 275	952 010
		DEHNrail® DR M 4P 255 FM * (I_L = 25.0 A)	953 405 *	DEHNguard® DG M TT 275	952 310
				DEHNguard® DG MOD 275	952 010
				DEHNguard® DG MOD NPE	952 050
2	AC TN-S, TT system	DEHNrail® DR M 2P 255	953 200	DEHNguard® DG M TN 275	952 200
				DEHNguard® DG MOD 275	952 010
		DEHNrail® DR M 2P 255 FM * (I_L = 25.0 A)	953 205 *	DEHNguard® DG M TT 2P 275	952 110
				DEHNguard® DG MOD 275	952 010
				DEHNguard® DG MOD NPE	952 050
3	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24	918 422	BLITZDUCTOR® VT, BVT AVD 24 ® VT	918 422
4	Bus cable MPI/DP RS 485	BLITZDUCTOR® XT, base section BXT BAS	920 300	---	---
		BLITZDUCTOR® XT, module BXT ML2 BD HFS 5	920 271	---	---
5	Bus cable RS 232 (V.24)	BLITZDUCTOR® XT, base section BXT BAS	920 300	---	---
		BLITZDUCTOR® XT, module BXT ML2 BE S 12	920 222	---	---
6	Industrial Ethernet	DEHNpatch® DPA M CLE RJ45B 48	929 121	---	---
7	Inputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK E60 (I_L = 0.5 A)	919 990	BLITZDUCTOR® XT, BXT ML4 BD 24 (I_L < 1 A)	920 344

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:			
		S7-1500/ET 200MP	Article number	ET 200SP	Article number
				BLITZDUCTOR® XT, base section BXT BAS (I_L < 1 A)	920 300
8	Outputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK D 5 24 (I_L = 10.0 A)	919 986	BLITZDUCTOR® XT, BXT ML4 BD 24 (I_L < 1 A)	920 344
				BLITZDUCTOR® XT, base section BXT BAS (I_L < 1 A)	920 300
				DEHNconnect® SD2, DCO SD2 E 48 (I_L < 10 A)	917 989
9	Inputs/outputs of digital modules U_N = 230 V AC	DEHNguard® DG S 275	952 070	DEHNguard® DG S 275	952 070
				DEHNguard® DG MOD 275	952 010
		DEHNguard® DG S 275 FM *	952 090 *	---	---
		N-PE arrester in the TT system			
		DEHNgap® C S, DGP C S	952 030	---	---
		DEHNgap® C S, DGP C S FM *	952 035 *	---	---
10	Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)	DEHNconnect® RK, DCO RK E 60 (I_L = 0.5 A)	919 990	BLITZDUCTOR® XT, BXT ML4 BD 24 (I_L < 1 A)	920 344
				BLITZDUCTOR® XT, base section BXT BAS (I_L < 1 A)	920 300
11	Inputs/outputs of the fail-safe modules (24 V DC)	---	---	DEHNconnect® RK, DCO RK D 5 24	919 986
				DEHNconnect® RK, DCO RK E 60	919 990

* Version with remote indication contact

Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de)

Components can be ordered directly from:
DEHN+SÖHNE GMBH+CO.KG.
Hans-Dehn-Straße 1
D-92318 Neumarkt

The following table shows components for lightning protection equipotential bonding from lightning protection zone 2 to 3 that you can use for ET 200AL.

Table 7- 5 Components for transition from lightning protection zone 2 to 3 (for ET 200AL)

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:	
		ET 200AL	Article number
1	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24 ® VT	918 422
Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de) **Components can be ordered directly from:** DEHN+SÖHNE GMBH+CO.KG. Hans-Dehn-Straße 1 D-92318 Neumarkt			

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S7-1500 Motion Control V3.0 in the TIA Portal V14

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Appendix A

TIA Portal V14

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- For the path settings in the project navigation it is presumed that the "Technology objects" object is opened in the CPU subtree. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".

- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type

- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

Note

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Further support

- The range of technical documentation for the individual SIMATIC products and systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the online ordering system is available on the Internet (http://mall.industry.siemens.com).

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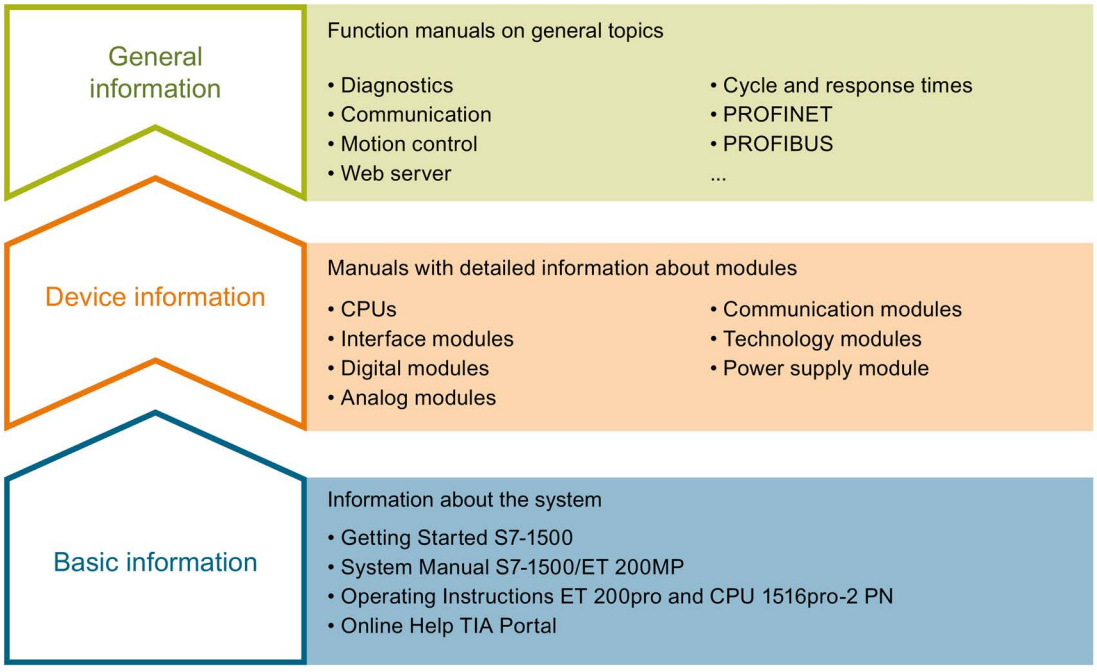
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, the CPU 1516pro-2 PN based on SIMATIC S7-1500 and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems.
For CPU 1516pro-2 PN you use the corresponding operating instructions. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, motion control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86140384).

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86630375).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the PROFINET network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Introduction

2

2.1 Integrated Motion Control functionality

S7-1500 Motion Control supports controlled positioning and moving of axes and is an integral part of every CPU S7-1500 as well as every CPU S7-1500SP.
The S7-1500T Technology CPUs provide enhanced functions.

The Motion Control functionality supports the following technology objects:

- Speed axis
- Positioning axis
- Synchronous axis
- External encoder
- Measuring input
- Output cam
- Cam track
- Cam (S7-1500T)

Drives with PROFIdrive capability and drives with analog setpoint interface are controlled by means of standardized Motion Control instructions according to PLCopen.

The axis control panel and comprehensive online and diagnostic functions support easy commissioning and optimization of drives.

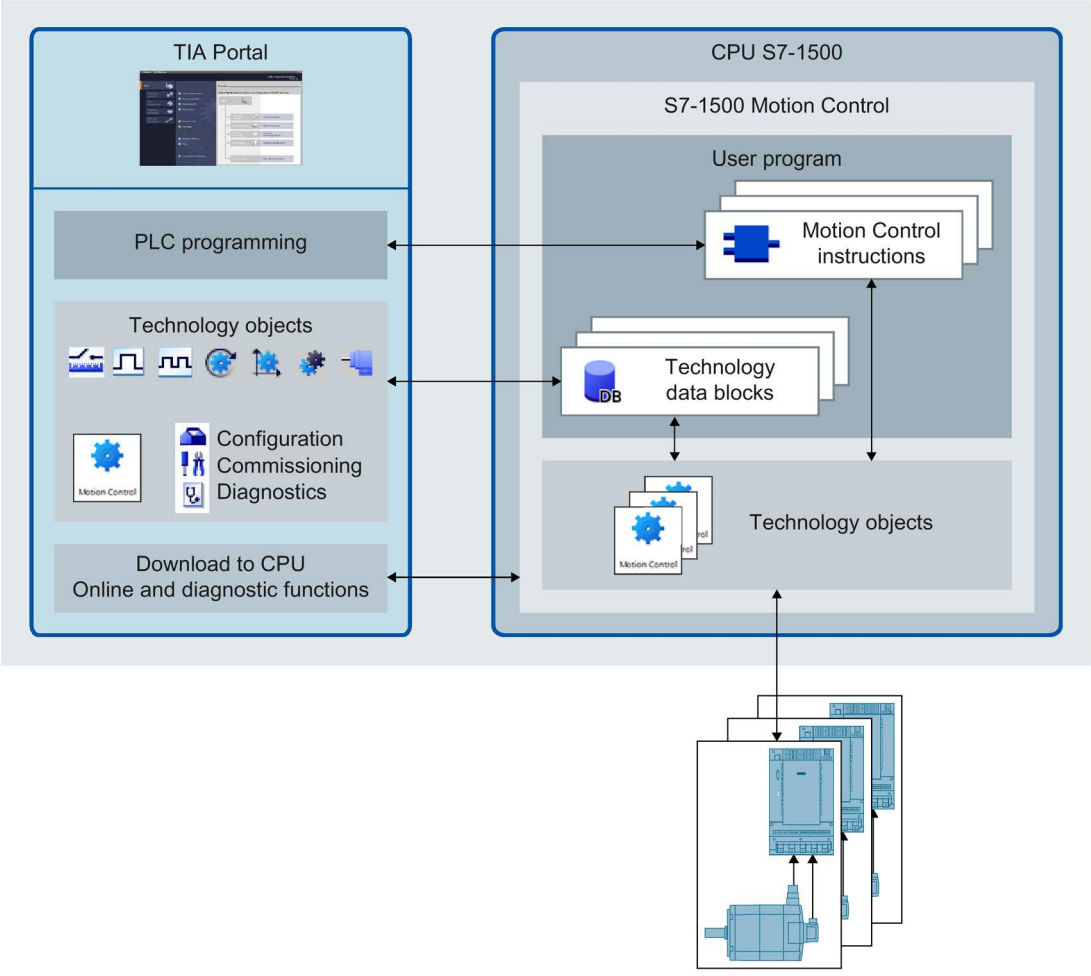
S7-1500 Motion Control is fully integrated into the system diagnostics of the S7-1500 CPU.

2.2 Principle of operation of S7-1500 Motion Control

Overview

You create a project, configure technology objects, and download the configuration to the CPU with the TIA Portal. The Motion Control functionality is processed in the CPU.
You control the technology objects with the Motion Control instructions in your user program.
The TIA Portal provides additional functions for commissioning, optimization (Page 326) and diagnostics (Page 341).

The following figure provides a schematic representation of the user interfaces and the integration of Motion Control into the S7-1500 CPU. The concepts are then briefly explained:



TIA Portal

The TIA Portal supports you in the planning and commissioning of Motion Control functionality:

- Integrating and configuring hardware
- Creating and configuring technology objects
- Creating the user program
- Downloading to CPU
- Commissioning of axes
- Optimization of drives
- Diagnostics

You use the TIA Portal to configure the hardware, the technology objects as well as your user program. You download the program you created to the CPU. You test your user program and diagnose the hardware with the online and diagnostic functions of the TIA Portal.

Technology objects

Technology objects represent real objects (e.g. a drive) in the controller. You call the functions of the technology objects by means of Motion Control instructions in your user program. The technology objects provide open- and closed-loop control of the movement of the real objects, and report status information (e.g. the current position).

The configuration of the technology objects represents the properties of the real object. The configuration data is stored in a technology data block.

The following technology objects are available for Motion Control:

- **Speed axis technology object**

  The speed axis technology object ("TO_SpeedAxis") is used to specify the speed for a drive. You program the motion of the axis with motion control instructions.

- **Positioning axis technology object**

  The positioning axis technology object ("TO_PositioningAxis") is used to position a drive with closed-loop position control. You issue positioning jobs to the axis with Motion Control instructions in your user program.

- **Synchronous axis technology object**

  The synchronous axis technology object ("TO_SynchronousAxis") includes all functions of the positioning axis technology object. The axis can also be interconnected with a leading value so that the axis follows the position change of a leading axis in synchronous operation.

- **External encoder technology object**

  The external encoder technology object ("TO_ExternalEncoder") detects a position and makes it available to the controller. The detected position can be evaluated in the user program.

- **Measuring input technology object**

  The measuring input technology object ("TO_MeasuringInput") detects actual positions quickly, accurately and event triggered.

- **Output cam technology object**

  The output cam technology object ("TO_OutputCam") generates switching signals depending on the position of an axis or external encoder. You can evaluate the switching signals in the user program or feed them to digital outputs.

- **Cam track technology object**

  The cam track technology object ("TO_CamTrack") generates a switching signal sequence depending on the position of an axis or external encoder. In this process, up to 32 individual cams are superimposed and the switching signals are output as a track. You can evaluate the switching signals in the user program or feed them to digital outputs.

- **Cam technology object (S7-1500T)**

  The cam technology object ("TO_Cam") defines a function f(x) by means of interpolation points and/or segments. Missing function ranges are interpolated.

Technology data block

The properties of real objects are configured by means of the technology objects and saved in a technology data block (Page 294). The technology data block contains all configuration data, setpoint and actual values, and status information of the technology object.
The TIA Portal automatically creates the technology data block when the technology object is created. You access the data of the technology data block (read/write access) with your user program.

Motion Control instructions

With the Motion Control instructions you perform the desired functionality in the technology objects. The Motion Control instructions are available in the TIA Portal under "Instructions > Technology > Motion Control".

The Motion Control instructions conform to PLCopen (version 2.0).

User program

The Motion Control instructions and the technology data block represent the programming interfaces for the technology objects. You use Motion Control instructions to start Motion Control jobs for technology objects in your user program. You track the status of running jobs via the output parameters of the Motion Control instructions. You access status information of the technology object and change specific configuration parameters during runtime using the technology data block.

Drives and encoders

Drives ensure the motion of the axis. They are integrated in the hardware configuration.

When you execute a Motion Control job in your user program, the technology object takes over the control of the drive and the reading in of values of encoders.

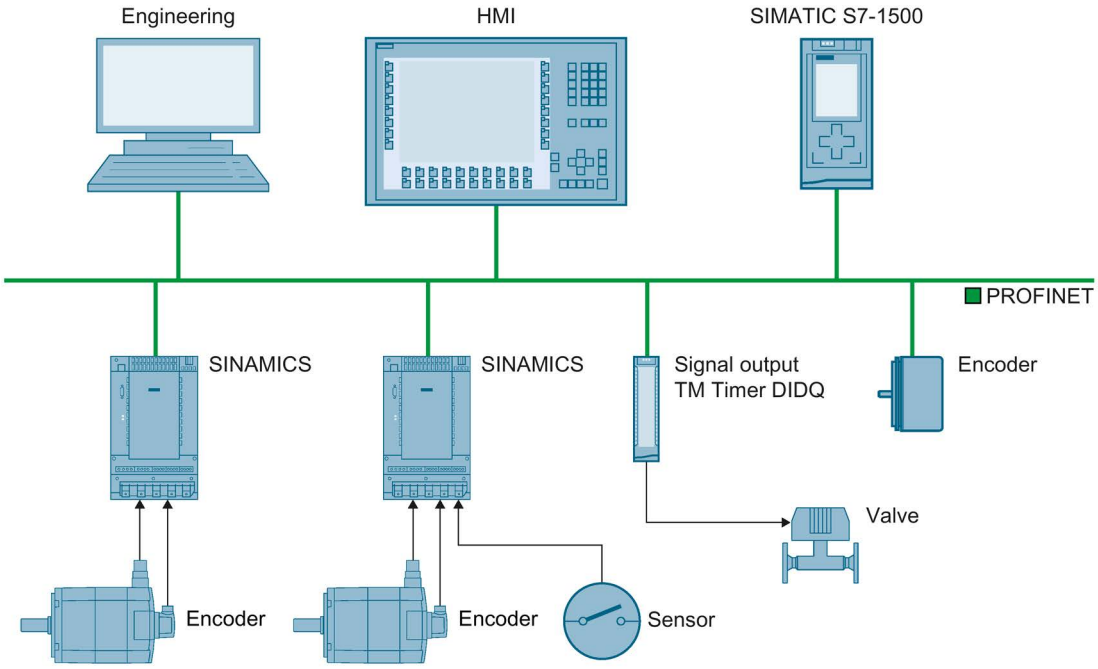
Drives and encoders with PROFIdrive capability are connected by means of PROFIdrive telegrams. The following connections are possible:

- PROFINET IO
- PROFIBUS DP
- Technology module (TM)

Drives with analog setpoint interfaces are connected using an analog output (AQ) and an optional enable signal. Analog inputs and outputs are made available by means of corresponding I/O modules.

A drive is also called an actuator, and an encoder is also called a sensor.

The figure below shows an example configuration in which all components are connected to the CPU by means of PROFINET IO:



2.3 Functions

2.3.1 Functions - Axes

You execute the functions of the speed axis, positioning axis and synchronous axis technology objects using Motion Control instructions in your user program or using the TIA Portal (under "Technology object > Commissioning").

The following table shows the functions that are supported by technology objects:

Function	Technology object		
	Speed axis (Page 105)	Positioning axis (Page 106)	Synchronous axis (Page 107)
Motion Control instructions (user program)			
"MC_Power (Page 371)" Enable, disable technology objects	X	X	X
"MC_Home (Page 379)" Home technology objects, set home position	-	X	X
"MC_MoveJog (Page 402)" Move axes in Jog mode	X	X	X
"MC_MoveVelocity (Page 397)" Move axes at predefined velocity	X	X	X
"MC_MoveRelative (Page 393)" Relative positioning of axes	-	X	X
"MC_MoveAbsolute (Page 389)" Absolute positioning of axes	-	X	X
"MC_MoveSuperimposed (Page 406)" Positioning axes overlapping	-	X	X
"MC_GearIn (Page 434)" Start gearing	-	-	X
"MC_Halt (Page 385)" Halt axes	X	X	X
"MC_TorqueLimiting (Page 410)" Limit torque using torque reduction	X	X	X
"MC_Reset (Page 376)" Acknowledge alarms, restart technology objects	X	X	X

Function	Technology object		
	Speed axis (Page 105)	Positioning axis (Page 106)	Synchronous axis (Page 107)
TIA Portal			
"Axis control panel (Page 329)" Move and home axes using the TIA Portal	X	X	X
"Optimization (Page 334)" Optimization of closed loop position control	-	X	X

2.3.2 Functions - Other technology objects

You execute the functions of the other technology objects by means of Motion Control instructions in your user program.

The following table shows the Motion Control instructions that are supported by the technology objects:

Motion Control instruction	Technology object			
	External encoder (Page 113)	Measuring input (Page 115)	Output cam (Page 129)	Cam track (Page 145)
Motion Control instructions (user program)				
"MC_Power (Page 371)" Enable, disable technology objects	X	-	-	-
"MC_Home (Page 379)" Home technology objects, set home position	X	-	-	-
"MC_MeasuringInput (Page 416)" Start measuring job once	-	X	-	-
"MC_MeasuringInputCyclic (Page 420)" Start cyclic measuring job	-	X	-	-
"MC_AbortMeasuringInput (Page 425)" End measuring job	-	X	-	-
"MC_OutputCam (Page 426)" Activate/deactivate output cam	-	-	X	-
"MC_CamTrack (Page 430)" Activate/deactivate cam track	-	-	-	X
"MC_Reset (Page 376)" Acknowledge alarms, restart technology objects	X	X	X	X

Technology objects

3

3.1 Configuration limits

Motion Control resources

Each CPU offers a defined set of Motion Control resources. For information on the available Motion Control resources, refer to the technical specifications of the utilized CPU.

Each technology object uses Motion Control resources:

Technology object	Motion Control resources used
Speed axis	40
Positioning axis	80
Synchronous axis	160
External encoder	80
Measuring input	40
Output cam	20
Cam track	160

You can find an overview of the Motion Control resources of a CPU in the TIA Portal under "Tools > Resources".

Cam technology object (S7-1500T)

A cam technology object does not use Motion Control resources. For information on the maximum number of cams that can be used in addition to the Motion Control resources, refer to the technical specifications of the relevant CPU.

Application cycle

As the number of technology objects used increases, the computing time needed by CPU to process the technology objects increases. The Motion Control application cycle (Page 97) can be adapted according to the number of technology objects used.

3.2 Basics - Axes

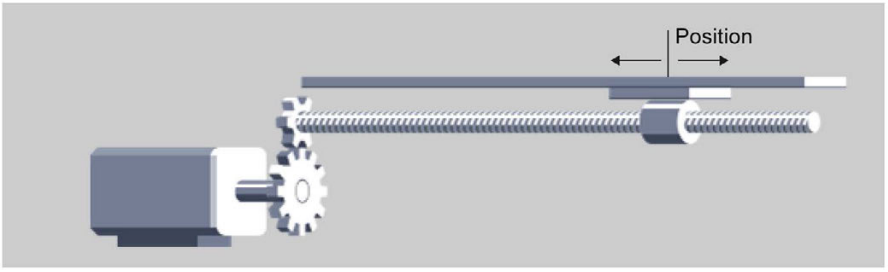
3.2.1 Axis types

Axes can be configured with different axis types:

- Positioning and synchronous axes can be configured as rotary or linear axis.
- Speed axes are always rotary axes.

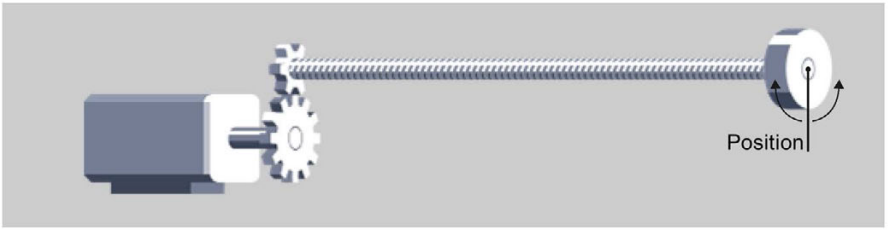
Depending on the execution of the mechanics, an axis is implemented as a linear axis or rotary axis:

- **Linear axis**



For linear axes, the position of the axis is specified as a linear measure, e.g. millimeters (mm).

- **Rotary axis**



For rotary axes, the position of the axis is specified as an angular measure, e.g. degrees (°).

3.2.2 Measuring units

The supported measuring units for speed (revolutions per time unit) are 1/s, 1/min and 1/h.

The table below shows the supported measuring units for position and velocity:

Position	Velocity
nm, µm, mm, m, km	mm/s, mm/min, mm/h, m/s, m/min, m/h, km/min, km/h
in, ft, mi	in/s, in/min, ft/s, ft/min, mi/h
°, rad	°/s, °/min, rad/s, rad/min

The acceleration is set accordingly as the position measuring unit/s².

The jerk is set accordingly as the position measuring unit/s³.

The table below shows the supported measuring units for force and torque:

Force	Torque
N, kN	Nm, kNm
lbf, ozf, pdl	lbf in, lbf ft, ozf in, ozf ft, pdl in, pdl ft

The measuring unit for time is permanently specified for the following technology objects:

Technology object	Time
Speed axis, positioning/synchronous axis, external encoder	s
Output cam, cam track, measuring input	ms

Note

When setting or changing the measuring units, take into consideration the effect on the display of parameter values and the user program:

- Display of parameter values in the technology data block
- Assignment of parameters in the user program
- Input and display of the position and velocity in the TIA Portal
- Setpoint settings by leading axes in synchronous operation

All information and displays correspond to the selected measuring unit.

The set units are displayed in the tag structure of the technology object <TO>.Units.
The tag structure is described in the Appendix (Page 442) under the tags of the respective technology object.

3.2.3 Modulo setting

For the positioning axis, synchronous axis and external encoder technology objects, the "Modulo" setting can be activated.

When an axis moves in only one direction, the position value continually increases. To limit the position value to a recurring reference system, you can activate the "Modulo" setting.

When the "Modulo" setting is activated, the position value of the technology object is mapped onto a recurring modulo range. The modulo range is defined by the start value and the length.

For example, to limit the position value of a rotary axis to a full rotation, the modulo range can be defined with start value = 0° and length = 360°. As a result, the position value is mapped onto the modulo range 0° to 359.999°.

3.2.4 Drive and encoder connection

3.2.4.1 Brief description

A drive is assigned to the "Speed axis" technology object.
A drive and one to four encoders are assigned to the "Positioning axis" and "Synchronous axis" technology objects.
An encoder is assigned to the "External encoder" technology object.

The setpoint for the drive is specified either with PROFIdrive telegrams or using an analog output.

The following connection options are available for an encoder:

- Encoder connected to drive
- Encoder to technology module
- PROFIdrive encoder connected directly to PROFIBUS DP / PROFINET IO

The actual encoder value is transmitted exclusively via PROFIdrive telegrams.

PROFIdrive

PROFIdrive is the standardized drive technology profile for connecting drives and encoders via PROFIBUS DP and PROFINET IO.

Drives that support the PROFIdrive profile are connected according to the PROFIdrive standard.

Communication between the controller and drive/encoder is performed using various PROFIdrive telegrams. Each of the telegrams has a standardized structure. You can select the appropriate telegram according to the application. Control words and status words as well as setpoints and actual values are transmitted in the PROFIdrive telegrams.

The PROFIdrive profile likewise supports the "Dynamic Servo Control" (DSC) control concept. DSC uses rapid closed loop position control in the drive. This can be used to solve highly dynamic positioning tasks.

Analog drive connection

Drives with analog setpoint interfaces are connected using an analog output and an optional enable signal. The speed setpoint is specified via an analog output signal (e.g. from -10 V to +10 V) from the PLC.

Stepper motors

Drives with a stepper motor interface are connected using telegram 3 and with the help of PTO (Pulse Train Output) pulse generators.

For functional support of stepper motor operation, quantization of the control deviation can be set.

Through the specification of a quantization, a range around the target position is defined in which no correction of the actual position is to be made. This prevents a possible oscillation of the stepper motor around the target position. Two types of quantization can be set:

- Quantization of the control deviation corresponding to the encoder resolution

  (<TO>.PositionControl.ControlDifferenceQuantization.Mode = 1)

  This prevents oscillation of the stopped motor between two increment values, for example. This mode is especially helpful when using encoders. With this setting, the quantization is adapted appropriately at an encoder switchover.

- Direct specification of a value for quantization of the control deviation.

  (<TO>.PositionControl.ControlDifferenceQuantization.Mode = 2, value setting in <TO>.PositionControl.ControlDifferenceQuantization.Value)

  This mode is helpful for stepper motors with encoders in which the resolution of the encoder is greater than the step size of the stepper motor.

3.2.4.2 PROFIdrive telegrams

PROFIdrive telegrams are used to transfer setpoints and actual values, control and status words and other parameters between the controller and drive/encoder.

When a PROFIdrive telegram is used for connection, the drives and encoders are handled and switched on in accordance with the PROFIdrive profile.

The following table shows the possible PROFIdrive telegrams for various technology objects.

Technology object			Possible PROFIdrive telegrams
Speed axis			• 1, 2 • 3, 4, 5, 6, 102, 103, 105, 106 (actual encoder value is not evaluated)
Positioning axis/synchronous axis			
	Setpoint and actual encoder value in one drive telegram		3, 4, 5, 6, 102, 103, 105, 106
	Setpoint and actual encoder value separately		
		Setpoint in drive telegram	1, 2, 3, 4, 5, 6, 102, 103, 105, 106
		Actual value from telegram	81, 83
External encoder			81, 83
Measuring input [1)]			391, 392, 393

1) When using SINAMICS drives (measuring using SINAMICS measuring input)

Telegram types

The following table shows the supported PROFIdrive telegram types for the assignment of drives and encoders:

Telegram	Brief description
Standard telegrams	
1[1)]	• Control word STW1, status word ZSW1 • Speed setpoint 16 bit (NSET), actual speed value 16 bit (NACT)
2	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT)
3	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2)
4	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) • Actual encoder value 2 (G2_XIST1, G2_XIST2)
5	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Dynamic Servo Control (DSC)[2)]
6	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Actual encoder value 2 (G2_XIST1, G2_XIST2) • Dynamic Servo Control (DSC)[2)]

Telegram	Brief description
SIEMENS telegrams (with torque limiting)	
102	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) • Torque limiting
103	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) • Actual encoder value 2 (G2_XIST1, G2_XIST2) • Torque limiting
105	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Dynamic Servo Control (DSC)[2)] • Torque limiting
106	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Actual encoder value 2 (G2_XIST1, G2_XIST2) • Dynamic Servo Control (DSC)[2)] • Torque limiting

Telegram	Brief description
SIEMENS telegrams (measuring input) [3]	
391	• Control word STW1, status word ZSW1 • Measuring input control word (MT_STW), measuring input status word (MT_ZSW) • Measuring input time stamp of negative (MT1…2_ZS_F) or positive edges (MT1…2_ZS_S) • Digital output 16 bit, digital input 16 bit
392	• Control word STW1, status word ZSW1 • Measuring input control word (MT_STW), measuring input status word (MT_ZSW) • Measuring input time stamp of negative (MT1…6_ZS_F) or positive edges (MT1…6_ZS_S) • Digital output 16 bit, digital input 16 bit
393	• Control word STW1, status word ZSW1 • Measuring input control word (MT_STW), measuring input status word (MT_ZSW) • Measuring input time stamp of negative (MT1…8_ZS_F) or positive edges (MT1…8_ZS_S) • Digital output 16 bit, digital input 16 bit • Analog input 16 bit
Standard telegrams - encoder	
81	• Control word STW2_ENC, status word ZSW2_ENC • Actual encoder value 1 (G1_XIST1, G1_XIST2)
83	• Control word STW2_ENC, status word ZSW2_ENC • Actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2)

1) Isochronous mode is not possible.

2) For use of Dynamic Servo Control (DSC), the motor encoder (first encoder in the telegram) of the drive must be used as the first encoder for the technology object.

3) When using SINAMICS drives (measuring using SINAMICS measuring input)

See also

Data connection of drive/encoder via data block (Page 49)

3.2.4.3 Actual values

Brief description

For position-controlled motion and positioning, the controller must know the actual position value.

The actual position value is provided by a PROFIdrive telegram.

The actual values are represented as incremental or absolute values in the PROFIdrive telegram. The actual values are normalized in the controller to the technological unit taking into account the configuration of the mechanics. The reference to a physical position of the axis or external encoder is established by homing.

The controller supports the following types of actual values (encoder types):

- Incremental actual value
- Absolute actual value with the setting absolute (measuring range > traversing range of the axis)
- Absolute actual value with the setting absolute (measuring range < traversing range of the axis)

Actual value calculation with virtual axis

You calculate the time delay from actual value to setpoint for a virtual axis (T_t) as follows:

- With precontrol: $T_t = T_{ipo} + T_{servo} + T_{vtc}$
- Without precontrol, without DSC: $T_t = T_{ipo} + 1/kv$
- Without precontrol, with DSC $T_t = T_{ipo} + T_{servo} + 1/kv$

(kv from <TO>.PositionControl.Kv, T_{vtc} from <TO>.DynamicAxisModel.VelocityTimeConstant)

Incremental actual value

The actual value in the PROFIdrive telegram is based on an incremental value.

After POWER ON, position zero is displayed. A transition of the CPU to RUN mode starts the actual value update. The actual value is then also updated in CPU STOP mode. The relationship between the technology object and the mechanical position must be re-established by means of homing.

Absolute actual value

The actual value in the PROFIdrive telegram is based on an absolute value.

After POWER ON, position zero is displayed. The first transition of the CPU to RUN mode starts the actual value update. The actual value is then also updated in CPU STOP mode. The supplied absolute value is assigned to the associated mechanical axis position by means of the absolute encoder adjustment. The absolute encoder adjustment must be performed once. The absolute value offset is retentively saved beyond the switching on/off of the controller.

Differentiation of absolute values:

- The measuring range of the encoder is larger than the traversing range of the axis:

  Absolute value with setting absolute

- The measuring range of the encoder is smaller than the traversing range of the axis:

  Absolute value with setting cyclic absolute

Absolute actual value with setting absolute (measuring range > traversing range)

The axis position results directly from the current actual encoder value. The traversing range must be within an encoder measuring range. This means that the zero passage of the encoder must not be located in the traversing range.

When the controller is switched on, the axis position is determined from the absolute actual encoder value.

Absolute actual value with setting cyclic absolute (measuring range < traversing range)

The encoder supplies an absolute value within its measuring range. The controller includes the traversed measuring ranges and thus determines the correct axis position beyond the measuring range.

When the controller is switched off, the traversed measuring ranges are saved in the retentive memory area of the controller.
At the next power-on, the saved traversed measuring ranges are taken into account in the calculation of the actual position value.

NOTICE
Movements of the axis while the controller is switched off can skew the actual value
If the axis or the encoder is moved by more than half of the encoder measuring range while the controller is switched off, then the actual value in the controller is no longer in accord with the mechanical axis position.

See also

Absolute value adjustment (Page 86)

Tags

The tags named in the Homing (Page 88) section are relevant for adapting actual values.

3.2.4.4 Automatic transfer of drive and encoder parameters in the device

Identical reference values for the drive and encoder connections must be set in the controller and in the drive and encoder for the operation.

The speed setpoint NSET and the actual speed value NACT are transferred in the PROFIdrive telegram as a percentage of the reference speed. The reference value for the speed must be set identically in the controller and in the drive.

The resolution of the actual value in the PROFIdrive telegram must likewise be set identically in the controller and in the drive and encoder modules

Automatic transfer of parameters

For SINAMICS drives as of V4.x and PROFIdrive encoders as of product version A16, the drive and encoder parameters can be automatically applied in the CPU.

The corresponding parameters are transferred after the (re-)initialization of the technology object and (re)start of the drive and the CPU. Changes in the drive configuration are transferred after restart of the drive or technology object.

Successful transfer of the parameters can be checked in the controller in the tags of the technology objects <TO>.StatusDrive.AdaptionState = 1 and <TO>.StatusSensor[n].AdaptionState = 1.

Parameters

The controller settings are made in the TIA Portal under "Technology object > Configuration > Hardware interface > Data exchange with the drive/encoder".

The drive and encoder settings are made in the configuration or the respective hardware.

The following table compares the settings in the TIA Portal, in the controller and the corresponding drive/encoder parameters:

Setting in the TIA Portal	Controller tag in the technology data block	Drive parameter	Automatic transfer
Drive			
Telegram number	Telegram input address <TO>.Actor.Interface.AddressIn	Telegram number P922	-
	Telegram output address <TO>.Actor.Interface.AddressOut		
Reference speed in [1/min]	<TO>.Actor.DriveParameter.Reference-Speed	(SINAMICS drives: P2000)	X
Maximum speed of motor in [1/min]	<TO>.Actor.DriveParameter.MaxSpeed	(SINAMICS drives: P1082)	X
Reference torque in [NM]	<TO>.Actor.DriveParameter.Reference-Torque	(SINAMICS drives: P2003)	X
Encoder			
Telegram	<TO>.Sensor[n].Interface.AddressIn	P922	-
	<TO>.Sensor[n].Interface.Addressout		
Encoder type	<TO>.Sensor[n].Type 0: incremental 1: absolute 2: cyclic absolute	P979[5] Encoder 1 P979[15] Encoder 2	-
Measuring system	<TO>.Sensor[n].System 0: linear 1: rotary	P979[1] Bit0 Encoder 1 P979[11] Bit0 Encoder 2	X
Resolution (linear encoder) The grid spacing is specified on the nameplate of the encoder as a separation distance of the marks on the linear measuring system.	<TO>.Sensor[n].Parameter.Resolution	P979[2] Encoder 1 P979[12] Encoder 2	X
Steps per revolution (rotary encoder)	<TO>.Sensor[n].Parameter.StepsPer-Revolution	P979[2] Encoder 1 P979[12] Encoder 2	X
Number of bits for fine resolution XIST1 (cyclic actual encoder value, linear or rotary encoder)	<TO>.Sensor[n].Parameter.Fine-ResolutionXist1	P979[3] Encoder 1 P979[13] Encoder 2	X
Number of bits for fine resolution XIST2 (absolute encoder value, linear or rotary encoder)	<TO>.Sensor[n].Parameter.Fine-ResolutionXist2	P979[4] Encoder 1 P979[14] Encoder 2	X
Differentiable encoder revolutions (rotary absolute encoder)	<TO>.Sensor[n].Parameter. DeterminableRevolutions	P979[5] Encoder 1 P979[15] Encoder 2	X

3.2.4.5 Safety functions in the drive

Safety functions ("Safety Integrated Basic Functions") in the SINAMICS drive are safety-oriented, internal drive functions with the goal of shutting down the respective drive safely. In addition, additional safety functions are available to monitor definable limits ("Safety Integrated Extended Functions"). The goal of these safety functions is to monitor that the respective limit is maintained, to signal the violation or to subsequently shut down the drive safely. To prevent the monitoring function from being triggered, it is necessary to switch the axis to the monitored operating mode with the user program or to keep it in this mode.

The cooperation of the safety functions in the drive and the SIMATIC S7-1500 and S7-1500T are necessary to ensure fault-free plant operation.

The technology objects speed axis, positioning axis and synchronous axis support the "Safety Integrated Basic Functions" of the drive. The technology object detects that the Basic Safety function is triggered and displays a corresponding warning (technology alarm 550 - alarm response: Track setpoints) or alarm (technology alarm 421 - alarm response: Remove enable).

No additional response must take place in the user program, especially for technology alarm 550, at the "Enable" input of the Motion Control instruction "MC_Power" in the sense of a "shutdown". Shutdown of the Motion Control instruction "MC_Power" by the user after technology alarm 421 is possible but not necessary.

After acknowledgment and release of the drive by the actual safety function, the technology alarm can also be acknowledged at the respective technology object with the Motion Control instruction "MC_Reset". The technology object is then enabled automatically, if "MC_Power.Enable" is still "TRUE".

The "Safety Integrated Extended Functions" are **not** supported by the technology object independently.

To prevent the extended safety functions from being triggered and thus preventing a disruption in plant operation, we recommend that you evaluate the status of the safety functions. This evaluation can take place in the user program by using or evaluating the status information of the "Safety Info Channels" (SIC). With the help of the corresponding Motion Control instruction, the axis can now stay within the monitored limit or reach it before a deviation is detected.

If a safety function is applied to a following axis in active synchronous operation, one of the following two responses is required:

- End synchronous operation
- Adjust velocity of the leading axis accordingly

Four status words are available in the SIC:

- S_ZSW1B
- S_ZSW2B
- S_ZSW3B
- S_V_LIMIT_B

Two predefined PROFIdrive telegrams are available for transmission:

- Tel. 700 (contains the status words S_ZSW1B & S_V_LIMIT_B)
- Tel. 701 (contains all four status words and two additional control words)

Additional information on the safety functions in SINAMICS drives and on the SIC is available in the SINAMICS S120 Safety Integrated Function Manual (https://support.industry.siemens.com/cs/ww/en/view/99668646).

The tables below provide an overview of the four SIC status words and the required response for each to prevent faults in plant operation.

S_ZSW1B

S_ZSW1B		Meaning		Recommended response of the respective axis in the user program
Bit	Assignment			
0	STO (active)	1	Safe Torque Off active	MC_Power can remain enabled (waiting).
		0	Not active	None
1	SS1 (active)	1	Safe Stop 1 active	Drive brakes autonomously and goes into STO. MC_Power remains enabled until STO.
		0	Not active	None
2	SS2 (active)	1	Safe Stop 2 active	Drive brakes autonomously and goes into SOS. MC_Power remains enabled.
		0	Not active	None
3	SOS (active)	1	Safe Operating Stop active	MC_Power remains enabled. The drive must not move (monitoring takes place in the drive)
		0	Not active	None
4	SLS (active)	1	Safety-Limited Speed active	MC_Power remains enabled. Velocity must be less than active velocity limit (see "Active SLS stage" or S_V_LIMIT_B).
		0	Not active	None
5	SOS (selected)	1	Safe Operating Stop selected	MC_Power remains enabled. Braking with MC_Halt within the time permitted by SOS.
		0	Deselected	None
6	SLS (selected)	1	Safety-Limited Speed selected	Drop below velocity limit within the time specified by SLS. For example, by specifying an override or a new dynamic limit (restriction with synchronous motion).
		0	Deselected	None
7	Internal event	1	Group alarm that a safety function was selected or became active	Additional evaluation of the status words required to determine the triggering safety function. The bit indicates that a safety function is active. (See also "Safety alarm")
		0	No event	None
8	Reserved	-		-
9	Active SLS level	SLS velocity limit Display bit 0		Additional information on SLS (bit 6) – shows active velocity limit for SLS in levels (1… 4). This limit can be evaluated in the program to limit the current velocity of the axis as needed.
10		SLS velocity limit Display bit 1		

S_ZSW1B		Meaning		Recommended response of the respective axis in the user program
Bit	**Assignment**			
11	Reserved	-		-
12	SDI positive	1	Safe Direction positive selected	Reaching standstill or the positive velocity of the actual value of the axis (when SDI negative = 0) within the time specified by SDI.
		0	Deselected	None monitoring for positive direction.
13	SDI negative	1	Safe Direction negative selected	Reaching standstill or the negative velocity of the actual value of the axis (when SDI positive = 0) within the time specified by SDI.
		0	Deselected	None monitoring for negative direction.
14	ESR retraction	1	Extended stop and retraction required (not a Safety function)	To be considered individually. You can find additional information in the SINAMICS S120 Safety Integrated Function Manual (https://support.industry.siemens.com/cs/ww/en/view/-99668646).
		0	Not requested	None
15	Safety alarm	1	Effective	If necessary, evaluate bit as group alarm to see whether a Safety alarm is pending in the alarm buffer.
		0	Not effective	None

S_V_LIMIT_B

S_V_LIMIT_B		Meaning	Explanation
Bit	**Assignment**		
0 … 31	Velocity set-point limit	SLS Speed limit (32-bit resolution with sign)	Additional information on SLS (S_ZSW1B bit 6) Shows the selected / active velocity limit for SLS. If necessary, the velocity limit can be evaluated in the program to limit the current velocity of the axis as needed.

S_ZSW2B

S_ZSW2B		Meaning		Recommended response of the respective axis
Bit	Assignment			
0 … 3	Reserved	-		-
4	SLP selected position area	1	SLP area 2 selected	Safe position in the area 2. Do not change the position using the user program any longer.
		0	SLP area 1 selected	Safe position in the area 1. Do not change the position using the user program any longer.
5, 6	Reserved	-		-
7	SLP selected and user approval set	1	Safety-Limited Position selected and user approval is set	Status message (if required in the user program) Application-dependent evaluation (means that the SLP is selected and the safe position was confirmed by the user – see "Safe homing")
		0	SLP not selected or user approval missing	Application-dependent evaluation
8	SDI positive	1	Safe Direction positive selected	Reaching standstill or the positive velocity of the actual value of the axis within the time specified by SDI. (when SDI negative = 0)
		0	Deselected	None monitoring for positive direction
9	SDI negative	1	Safe Direction negative selected	Reaching standstill or the negative velocity of the actual value of the axis within the time specified by SDI. (when SDI positive = 0)
		0	Deselected	None monitoring for negative direction
10, 11	Reserved	-		-
12	Test stop active	1	Test stop active	Status message (if required in the user program) Application-dependent evaluation
		0	Not active	None
13	Test stop required	1	Test stop required	Perform test stop
		0	Not required	None
14, 15	Reserved	-		-

S_ZSW3B

S_ZSW3B		Meaning		Recommended response of the respective axis
Bit	Assignment			
0	Brake test	1	Brake test selected	MC_Power remains enabled. Do not start travel motion with user program.
		0	Deselected	None – brake test is inactive (normal plant operation)
1	Setpoint value specification drive / external	1	Specification for drive	The speed setpoint is specified by the SBT function. Application-dependent evaluation
		0	External specification (control)	The "normal" speed setpoint is in effect. Application-dependent evaluation – setpoint value specification through user program required
2	Active brake	1	Test brake 2 active	Status message (if required in the user program) Application-dependent evaluation
		0	Test brake 1 active	Status message (if required in the user program) Application-dependent evaluation
3	Brake test active	1	Test active	Status message (if required in the user program) Application-dependent evaluation
		0	Inactive	None
4	Brake test result	1	Test required	Status message (if required in the user program) Application-dependent evaluation
		0	With error(s)	Status message (if required in the user program) Application-dependent evaluation, test must usually be successful to guarantee safety of the brake.
5	Brake test complete	1	Run test	Status message (if required in the user program) Application-dependent evaluation
		0	Incomplete	Status message (if required in the user program) Application-dependent evaluation, usually test is repeated
6	External brake request	1	Closing the brake	Closing external brake (when controlled by user program) Application-dependent evaluation
		0	Opening the brake	Opening external brake (when controlled by user program) Application-dependent evaluation
7	Current load sign	1	Negative sign	Status of the load sign if required in the user program Application-dependent evaluation
		0	Positive sign	
8 … 13	Reserved	-		-
14	Acceptance test SLP(SE) selected	1	Acceptance test SLP(SE) selected	Status message (if required in the user program) Application-dependent evaluation
		0	Deselected	None
15	Acceptance test mode selected	1	Acceptance test mode selected	Status message (if required in the user program) Application-dependent evaluation
		0	Deselected	None

3.2.4.6 Virtual axis/simulation

S7-1500 Motion Control offers the option to move axes in simulation mode. This allows speed, positioning and synchronous axes to be simulated in the CPU without the drive and encoder. An axis can be configured as virtual axis or axis in simulation for this purpose. The drive and encoder do not have to be configured.

Real axis

A real axis has motion control as well as drive and encoder connection.

Virtual axis

A virtual axis has motion control but does not need drive or encoder connection, which means it does not control a real drive. The "Virtual axis" configuration can only be changed by a new download to the CPU (in STOP mode) (<TO>.VirtualAxis.Mode).

Application:
A virtual axis is most often used as an auxiliary axis, for example, to generate the setpoints for multiple real following axes in synchronous operation.

Axis in simulation

An axis in simulation has motion control, but initially does not need drive or encoder connection. The "Simulation" configuration can be changed during runtime of the user program (<TO>.Simulation.Mode). A valid drive and encoder connection is required when exiting the simulation.

Application:
An axis is simulated for programming of the machine application, for example, and is later assigned to the configured hardware for commissioning.

When the tags of the technology object <TO>.VirtualAxis.Mode and <TO>.Simulation.Mode are both set, the "Simulation" configuration cannot be changed during runtime.

Characteristics in simulation mode

An axis in simulation/virtual axis does not output setpoints to the drive and does not read actual values. Hardware limit switches and home position switches have no effect.

The technology objects measuring input (with signal detection via TM_Timer_DIDQ or SINAMICS measurement sensing input), output cam and cam track can also be used for axes in simulation/virtual axes.

The following table shows Motion Control instructions with adapted behavior in simulation mode.

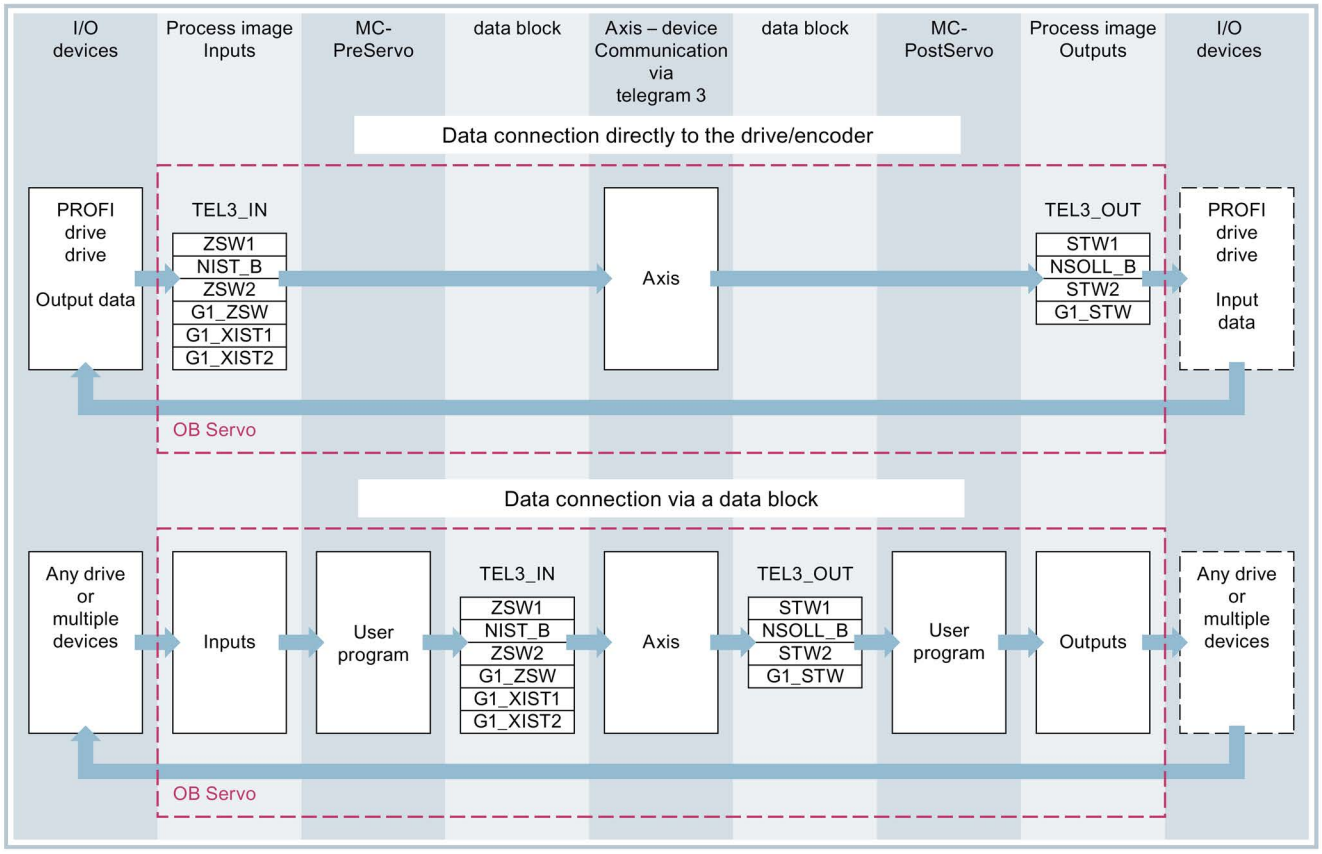
Motion Control instruction	Characteristics in simulation mode
MC_Power	The axis is enabled immediately without waiting for feedback from the drive.
MC_Home	Homing jobs are executed immediately without simulated axis motion.
MC_TorqueLimit	The specified torque is not output to the drive.

3.2.4.7 Data connection of drive/encoder via data block

The data connection of PROFIdrive drives and encoders occurs either directly via the PROFIdrive telegram or via a data block.

Use the tags of the PROFIdrive telegrams generated by the system to evaluate the telegram contents.

Use the connection via data block if you want to influence or evaluate telegram contents in the user program for process-specific reasons.



Principle of data connection via data block

Generally, at the start of closed loop position control of the axis (by MC-Servo [OB91]), the input area of the drive or encoder telegram is read.

At the end of closed loop position control, the output area of the drive or encoder telegram is written.

To influence or evaluate telegram contents for process-specific reasons, a data interface via a data block must be connected in between before and after the closed loop position control.

- The input area of the telegram can be edited using the MC-PreServo [OB67] organization block. The MC-PreServo is called before the MC-Servo.
- The input area of the telegram can be edited using the MC-PostServo [OB95] organization block. The MC-PostServo is called after the MC-Servo.

The data block must be created by the user and contain a data structure of data type "PD_TELx" for the data connection. Here, "x" stands for the telegram number of the drive or encoder configured in the device configuration.

The organization blocks MC-PreServo and MC-PostServo can be programmed by the user and must be added with the command "Add new block". The connection to the I/O via telegram must be programmed in this organization block.

Creating the data block for data connection

1. Create a new data block of type "Global DB".
2. Select the data block in the project tree and select "Properties" from the shortcut menu.
3. Under Attributes, disable the following attributes and confirm with OK
   "Only store in load memory"
   "Data block write-protected in the device"
   "Optimized block access"
4. Open the data block in the block editor.
5. Insert a tag structure of type "PD_TELx" textually in the block editor.

This tag structure contains the "Input" tag structure for the input area of the telegram and the "Output" tag structure for the output area of the telegram.

Note

"Input" and "Output" relate to the view of the closed loop position control. For example, the input area contains the actual values of the drive and the output area contains the setpoints for the drive.

The data block may contain the data structures of multiple axes and encoders and other contents.

Configuring data connection via a data block

1. Open the configuration window "Hardware interface > Drive" or "Hardware interface > Encoder".
2. In the Data block drop-down list, select "Data block".
3. In the "Data block" field, select the previously created data block.
   Open this data block and select the tag name defined for the drive and encoder.

Adding a PLC tag for telegram access

1. Open the "PLC tags" folder in the project tree and have all tags displayed.
2. Add a new tag and assign a unique name, made up for example from the name of the axis or the encoder, the telegram type and the address area.
3. Enter the type "PD_TELx_IN" textually in the "Data type" column.
4. Enter the telegram input address of the drive/encoder in the "Address" column.
   You can find the address in the device configuration of the drive or encoder.

Follow the same procedure for the PLC tag of the output area and select "PD_TELx_OUT" as the data type and the telegram output address of the drive/encoder as the address.

Programming MC-PreServo and MC-PostServo

1. Assign the previously defined PLC tag of the input range of the data block to MC-PreServo .
2. Assign the previously defined PLC tag of the output range of the data block to MC-PostServo.

NOTICE
Machine damage Improper manipulation of drive and encoder telegrams may result in unwanted drive motions. Check your user program for consistency in the drive and encoder connection.

See also

PROFIdrive telegrams (Page 33)

Organization Blocks for Motion Control (Page 97)

3.2.4.8 Tags

The following technology object tags are relevant for the drives and encoder connections:

Drive telegram	
<TO>.Actor.Interface.AddressIn	Input address for the PROFIdrive telegram
<TO>.Actor.Interface.AdressOut	Output address for the PROFIdrive telegram or the analog setpoint
<TO>.Actor.DriveParameter.Reference Speed	Reference value (100%) for the speed setpoint (NSET) of the drive
<TO>.Actor.DriveParameter.MaxSpeed	Maximum value for the speed setpoint of the drive (NSET)
<TO>.Actor.DriveParameter.Reference Torque	Reference torque for the torque transferred as a percentage
Encoder telegram	
<TO>.Sensor[n].Interface.AddressIn	Input address for the PROFIdrive telegram
<TO>.Sensor[n].Interface.AdressOut	Output address for the PROFIdrive telegram
<TO>.Sensor[n].System	Encoder system linear or rotary
<TO>.Sensor[n].Type	Encoder type, incremental, absolute or cyclic absolute
<TO>.Sensor[n].Parameter.Resolution	Resolution for linear encoder The grid spacing corresponds to the distance between two marks.
<TO>.Sensor[n].Parameter.StepsPer Revolution	Steps per revolution for rotary encoder
<TO>.Sensor[n].Parameter.Determinable Revolutions	Number of differentiable encoder revolutions for a multi-turn absolute encoder
Fine resolution	
<TO>.Sensor[n].Parameter.Fine ResolutionXist1	Number of bits for fine resolution XIST1 (cyclic actual encoder value)
<TO>.Sensor[n].Parameter.Fine ResolutionXist2	Number of bits for fine resolution XIST2 (absolute value of encoder)
Simulation mode	
<TO>.Simulation.Mode	Simulation mode 0: No simulation, normal operation 1: Simulation mode

3.2.5 Mechanics

3.2.5.1 Brief description

For the display and processing of the technology object's position, the decisive factor is whether the position is represented as a unit of length (linear axis) or a unit of angle (rotary axis).

Examples of units of length: mm, m, km

Examples of units of angle: °, rad

For the determination of the physical position from an actual encoder value, the system must know the various properties and configurations of the mechanics.

Positioning axis/synchronous axis

The following configuration options for mechanics are supported:

- Load gear
- Leadscrew pitch (linear axes only)
- Encoder mounting type:
  - Motor side (before the load gear)
  - Load side (after the load gear and as applicable the leadscrew)
  - External (e.g. odometer)
- Inversion of drive direction
- Inversion of encoder direction

External encoder

The following configuration options for mechanics are supported:

- Measuring gear (for rotary encoders)
- Leadscrew pitch (only with linear system of units and rotary encoders)
- Inversion of encoder direction

Speed axis

The following configuration options for mechanics are supported:

- Load gear
- Inversion of drive direction

3.2.5.2 Tags

The following technology object tags are relevant for the setting of the mechanics:

Type of motion	
<TO>.Properties.MotionType	Indication of linear or rotary motion 0: Linear motion 1: Rotary motion
Load gear	
<TO>.LoadGear.Numerator	Load gear numerator
<TO>.LoadGear.Denominator	Load gear denominator
Leadscrew pitch	
<TO>.Mechanics.LeadScrew	Leadscrew pitch
Encoder mounting type	
<TO>.Sensor[n].MountingMode	Encoder mounting type
<TO>.Sensor[n].Parameter.DistancePerRevolution	Load distance per encoder revolution with an externally mounted encoder
Inversion	
<TO>.Actor.InverseDirection	Setpoint inversion
<TO>.Actor.Efficiency	Efficiency of leadscrew pitch
<TO>.Sensor[n].InverseDirection	Actual value inversion
Modulo	
<TO>.Modulo.Enable	Enable modulo
<TO>.Modulo.Length	Modulo length
<TO>.Modulo.StartValue	Modulo start value

3.2.6 Traversing range limitation

3.2.6.1 Brief description

Hardware and software limit switches limit the permissible traversing range and operating range of the positioning axis/synchronous axis. Before use, they must be enabled in the configuration or in the user program.

The following figure shows the relationship between the operating range, maximum traversing range and limit switches:

① Mechanical endstop
② Hardware limit switches
③ Software limit switches
④ Maximum traversing range
⑤ Operating range

3.2.6.2 Hardware limit switches

Hardware limit switches are limit position switches that limit the maximum permissible traversing range of the axis.

Select the positions of the hardware limit switches so that there is adequate braking distance for the axis when needed. The axis should come to a standstill before a mechanical endstop.

Approaching the hardware limit switches

In the monitoring of range limitation, no distinction is made as to whether the switches are reached or crossed.

If a hardware limit switch is reached, technology alarm 531 is output, and the technology object is disabled (alarm response: remove enable).

Exception

If the hardware limit switches are used as reversing cams or reference cams during homing, then the monitoring of the hardware limit switches has no effect.

When hardware limit switches are used as reversing cams, the axis is braked with the deceleration configured in the dynamic defaults.

This must be taken into account when planning the distance of the hardware limit switch to the mechanical endstop.

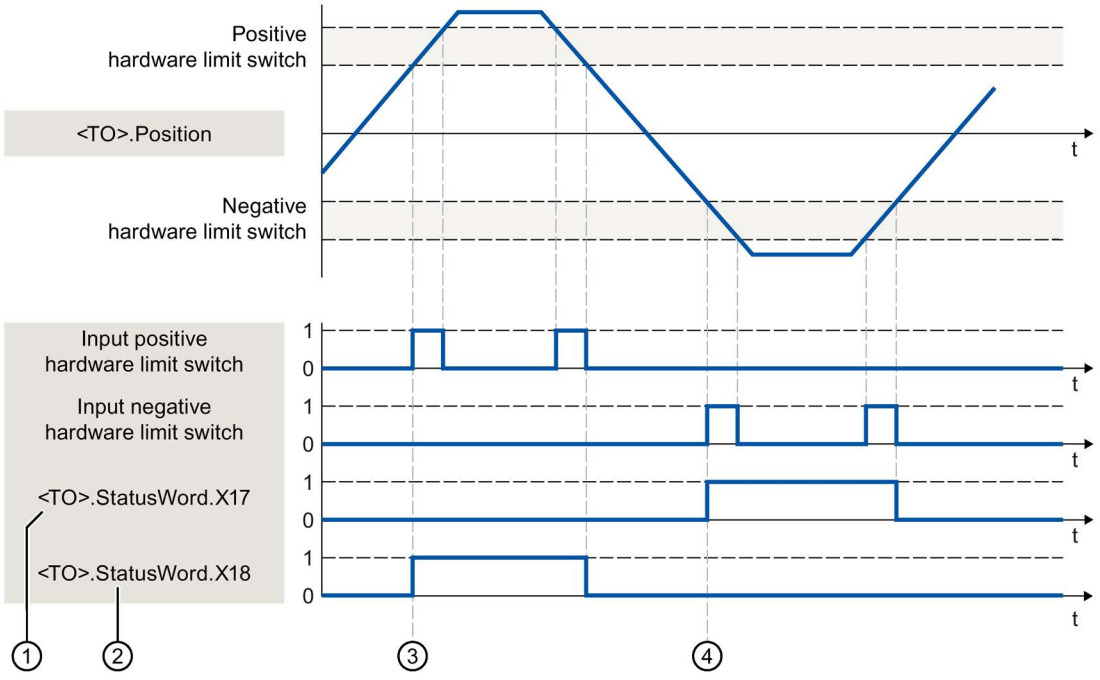
Retracting

The position of the axis when the hardware limit switch is detected is stored internally on the CPU. The status of the reached hardware limit switch is reset only after the hardware limit switch is left and the axis is once again in the maximum traversing range.

To retract the axis after it reaches the hardware limit switch and to reset the status of the hardware limit switch, follow the steps below:

1. To enable motion in the retraction direction, acknowledge the technology alarm.
2. Traverse the axis in the retraction direction until the hardware limit switch is left.
   The axis must then be within the maximum traversing range.
   If you move the axis opposite the retraction direction before the hardware limit switch is left, the monitoring will be triggered again.

The following chart shows the behavior of the status word when the hardware limit switch is reached and when the axis is retracted:



① <TO>.StatusWord.X17 (HWLimitMinActive)
0: Negative hardware limit switch not reached
1: Negative hardware limit switch reached or overtraveled

② <TO>.StatusWord.X18 (HWLimitMaxActive)
0: Positive hardware limit switch not reached
1: Positive hardware limit switch reached or overtraveled

③ The position of the axis when the **positive** hardware limit switch is detected is saved internally in the CPU. To reset the status of the hardware limit switch, the axis position must fall short of this position.

④ The position of the axis when the **negative** hardware limit switch is detected is saved internally in the CPU. To reset the status of the hardware limit switch, the axis position must go past this position.

3.2.6.3 Software limit switch

The operating range of the axis is limited with software limit switches. Relative to the traversing range, always position the software limit switches within the hardware limit switches. Since the positions of the software limit switches can be flexibly configured, the operating range of the axis can be individually adapted in accordance with the current velocity profile.

Software limit switches are only in effect when there is a valid actual value after homing the technology object. The monitoring of the software limit switches is relative to the setpoint.

Modulo enabled

With modulo enabled, the modulo position is monitored.

The software limit switches are configured and activated in the axis configuration.
The software limit switches can be activated or deactivated in the user program using the <TO>.PositionLimits_SW.Active tag, If the positions of both software limit switches are outside the modulo range, the monitoring has no effect. No check is made to determine whether the positions of the software limit switches are within the modulo range.

Approaching the software limit switches

The axis continually checks the position of the software limit switch during motion and brakes to exactly this position, if necessary.

If the software limit switches are reached, then technology alarm 533 is output, and the axis is stopped with the maximum dynamic values (alarm response: Stop with maximum dynamic values). The technology object remains enabled.

Overrun of the software limit switches

If a software limit switch is crossed, technology alarm 534 is output, and the technology object is disabled (alarm response: remove enable).

Retracting

To retract the axis after violation of the software limit switch, follow the steps below:

1. Acknowledge the technology alarm.
2. Move the axis in the retraction direction until the software limit switch is left.

   If you move the axis opposite the retraction direction before the software limit switch is left, the monitoring with be triggered again.

3.2.6.4 Tags

The following technology object tags are relevant for software limit switches:

Status indicators	
<TO>.StatusWord.X15 (SWLimitMinActive)	Negative software limit switch is active
<TO>.StatusWord.X16 (SWLimitMaxActive)	Positive software limit switch is active
<TO>.ErrorWord.X8 (SWLimit)	An alarm is pending, that a software limit switch was violated
Control bits	
<TO>.PositonLimits_SW.Active	Enables / disables the monitoring of the software limit switches
Position values	
<TO>.PositonLimits_SW.MinPosition	Position of the negative software limit switch
<TO>.PositonLimits_SW.MaxPosition	Position of the positive software limit switch

The following technology object tags are relevant for hardware limit switches:

Status indicators	
<TO>.StatusWord.X17 (HWLimitMinActive)	Negative hardware limit switch is active
<TO>.StatusWord.X18 (HWLimitMaxActive)	Positive hardware limit switch is active
<TO>.ErrorWord.X9 (HWLimit)	An alarm is pending; a hardware limit switch was violated
Control bits	
<TO>.PositonLimits_HW.Active	Enables / disables the monitoring of the hardware limit switches
Parameters	
<TO>.PositonLimits_HW.MinSwitchLevel	Level selection for activation of the low hardware limit switch: FALSE: At low level, the signal is active TRUE: At high level, the signal is active
<TO>.PositonLimits_HW.MinSwitchAddress	Byte number of the I/O address of the hardware limit switch for the low or minimum position
<TO>.PositonLimits_HW.MaxSwitchLevel	Level selection for activation of the high hardware limit switch: FALSE: At low level, the signal is active TRUE: At high level, the signal is active
<TO>.PositonLimits_HW.MaxSwitchAddress	Byte number of the I/O address of the hardware limit switch for the high or maximum position

3.2.7 Motion control and limits for dynamics

3.2.7.1 Brief description

Motion control of the axis occurs by means of velocity profiles (Page 60). The velocity profiles are calculated in accordance with the specifications for dynamics. A velocity profile defines the behavior of the axis during approach, braking and changes in velocity.
During positioning a velocity profile is calculated, that moves the axis to the target point.

Maximum values for velocity, acceleration and jerk result from the properties of the drive and the mechanics. These maximum values can be configured in the limits for dynamics.
The limits for dynamics are in effect as limits for every motion generated by means of the technology object. The dynamic limits have no effect on a following axis in synchronous operation.

The configurable emergency stop deceleration (Page 61) is triggered by the Motion Control instruction MC_Power or by a technology alarm.

The jerk limit reduces the mechanical load during an acceleration ramp or deceleration ramp. A "smoothed" velocity profile results.

3.2.7.2 Velocity profile

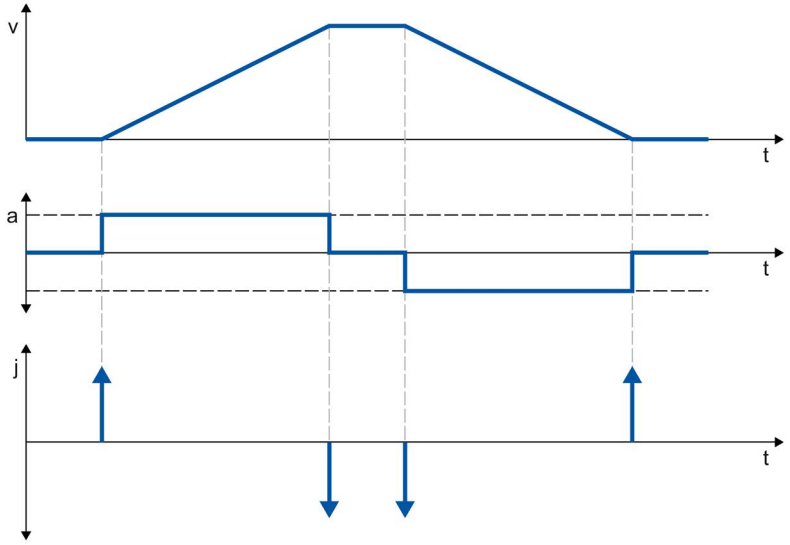
Velocity profiles with or without jerk limitation are supported for motion control of the axis.

The dynamic values for the motion are specified in the Motion Control job. Alternatively the values of the dynamic defaults can be used. The defaults and the limits for velocity, acceleration, deceleration and jerk are set in the configuration.

To influence velocity, a velocity override can override the current traversing velocity.

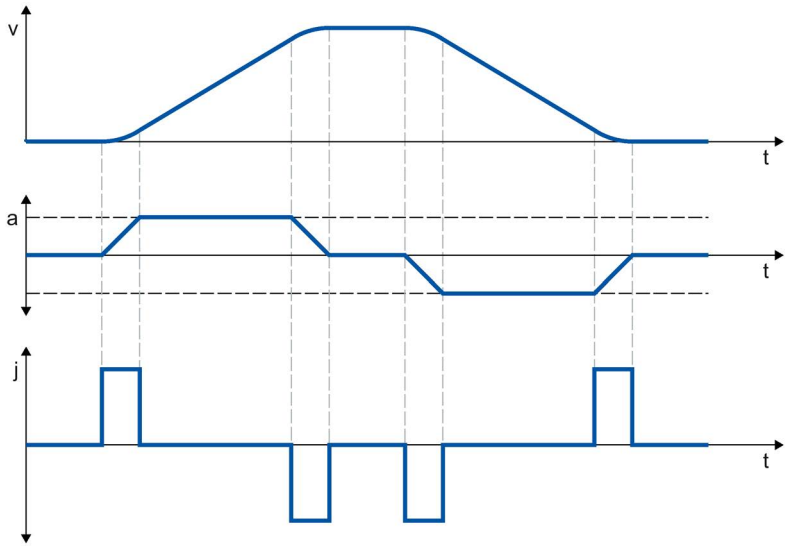
Velocity profile without jerk limitation

The following figure shows velocity, acceleration and jerk:



Velocity profile with jerk limitation

The following figure shows velocity, acceleration and jerk:



A velocity profile with jerk limitation is employed for a continuous acceleration and deceleration sequence. The jerk can be specified.

3.2.7.3 Emergency stop deceleration

When stopping with the emergency stop ramp, the axis is braked to a standstill without a jerk limit, using the configured emergency stop deceleration.

In the following cases the configured emergency stop deceleration is in effect:

- For an emergency stop ramp that has been enabled via the Motion Control instruction "MC_Power" with parameter "StopMode" = 0.
- For a technology alarm with the local alarm response "Stop with emergency stop ramp".

This emergency stop deceleration can be set greater than the maximum deceleration. If the emergency stop deceleration is set lower than this, it may occur that the axis does not stop until after the limit switch in the case of "Stop at software limit switch" and the occurrence of a technology alarm with the local alarm response "Stop with emergency stop ramp".

3.2.7.4 Dynamic limits in synchronous operation with MC_GearIn

Leading axis

The dynamic limits configured for the technology object are always in effect for the leading axis.

Following axis

If a synchronous axis is operated as a following axis in synchronous operation with MC_GearIn, the following dynamic limits apply depending on the phase of the synchronous operation.

- **Synchronization**

  During the synchronizing phase, dynamic limits configured for the technology object apply to the following axis.

- **Synchronous motion**

  When the synchronous axis is moving synchronously to the leading axis as a following axis, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). The dynamics of the following axis results from the synchronous operation function.

  If the dynamic limits configured for the following axis are exceeded, this will be indicated in the technology object tag <TO.>StatusSynchronizedMotion.StatusWord.

  If the following axis cannot follow the leading value, this results in a following error, which is monitored by the following error monitoring.

- **Synchronous operation override**

  As soon as synchronous operation has been overridden, the dynamic limits configured for the technology object apply to the following axis again. With the start of the overriding job, the active dynamics is transitioned (smoothed) to the configured dynamic limits and the specifications for the Motion Control instruction.

See also

StatusSynchronizedMotion tags (synchronous axis) (Page 484)

Override response of Motion Control commands V3 (Page 439)

3.2.7.5 Force/torque limiting

Adjustable force/torque limiting is available for the speed axis, positioning axis and synchronous axis technology objects.

The force/torque limiting can be activated and deactivated before and during a motion job.

To use force/torque limiting, the drive and the PROFIdrive telegram must support torque reduction. A telegram 10x can be used.

The limiting value can be configured as a default value during configuration of the axis or it can be defined in the user program using Motion Control instruction "MC_TorqueLimiting".

The following interconnection is required in the SINAMICS drive:

- P1522 must be interconnected to a fixed value of + 100%,
- P1523 to a fixed value of -100% (e.g. through interconnection to fixed value parameter P2902[i]).

The user specifies the limiting values in the configured measuring unit for force or torque. The measuring units are defined in the "Basic parameters" configuration window.

The following configuration options are available for force/torque limiting.

- **"Rotary" axis type**
  - Torque limiting is active on load side or motor side
- **Axis type "Linear"**
  - Torque limiting is active on the motor side of the rotary motor
  - Force limiting is active on the load side

The force/torque limit defined by the user in accordance with the specification in the PROFIdrive telegrams 10x are transferred internally to the drive as a percentage torque reduction. The reference torque set in the "Data exchange with the drive" configuration dialog must match the reference torque set for the drive.

User-defined force limiting on the load side is converted to torque limiting by the technology. If the limiting relates to the load side, the gear and leadscrew parameters defined in the "Mechanics" configuration dialog are taken into consideration. If the gear and leadscrew efficiency is crucial, this can be set in the <TO>.Actor.Efficiency tag.

The defined limiting values act as an absolute value and thus in the same way for positive and negative forces/torques.

Positioning and following error monitoring with active force/torque limiting

As a result of force/torque limiting, a larger setpoint-actual value difference can build up for position-controlled axes, which may cause unwanted activation of the positioning and following error monitoring.

Therefore, in the "Torque limiting" configuration window, the positioning and following error monitoring of the axis can be set as deactivated by default when force/torque limiting is active. If necessary, the positioning and following error monitoring can also be kept active even when force/torque limiting is active.

Typical response of a positioning or synchronous axis with active force/torque limiting

With active force/torque limiting, a larger setpoint-actual value difference can build up than during motion without force/torque limiting.

Given a constant setpoint, the axis makes repeated attempts to reduce the following error.

When the limiting values are increased or limiting is deactivated during active closed loop position control, the axis can accelerate briefly to reduce the following error. If the axis is switched to non-position-controlled operation, e.g. using "MC_MoveVelocity" with "PositionControlled" = FALSE, the following error is no longer in effect. To prevent compensation of the following error, the velocity setpoint of 0.0 must also be specified in "MC_MoveVelocity".

Stopping an axis with active force/torque limiting

- When stopping an axis in position-controlled mode with "MC_Halt", the position setpoint and the velocity setpoint are used as basis. Torque limiting still remains active and any accumulated following error is retained and will be reduced. The axis is at a standstill when the actual velocity is "0.0" and the minimum dwell time in the standstill window has expired. The axis remains enabled.
- When stopping an axis with "MC_Power" and an emergency stop ramp, the actual position value and the actual velocity are used as a basis. The axis is braked with the configured emergency stop deceleration without any jerk limit and brought to a standstill. The axis is then disabled when at a standstill.

See also

Fixed stop detection (Page 65)

MC_TorqueLimiting: Activate and deactivate force/torque limit / fixed stop detection (Page 410)

Automatic transfer of drive and encoder parameters in the device (Page 40)

3.2.7.6 Fixed stop detection

With the Motion Control instruction "MC_TorqueLimiting", you activate and monitor a fixed stop detection.

Together with a position-controlled motion job, a "Travel to fixed stop" can be realized. The operation is also referred to as clamping.

"Travel to fixed stop" can be used, for example, to move quills against the workpiece with a specified torque.

The fixed stop detection is configured in the configuration window "Extended parameters" > "Limits" > "Fixed stop detection".

The fixed stop detection is only possible in position-controlled operation of the axis.

If the drive and telegram support force/torque limiting, this is active during travel to fixed stop and for clamping.

Detection of the fixed stop using following error

If the drive is stopped by a mechanical fixed stop during a motion job, the following error is increased. When the following error configured in the configuration window "Extended parameters" > "Limits" > "Fixed stop detection" is exceeded, this is regarded as the fixed stop having been reached.

When following error monitoring is activated, the configured following error must be greater than the following error for fixed stop detection.

Clamping at the mechanical endstop

When the fixed stop is reached, the active position-controlled motion job is aborted with CommandAborted. The setpoint is no longer changed and the following error remains constant. The closed loop position control remains active and the monitoring of the configured "Positioning tolerance" is activated The drive is in "Clamping" state.

If the drive and frame support force/torque limiting, this continues to be active with active fixed stop detection. During clamping, the clamping force or clamping torque can be changed. The value in input parameter "Limit" of the Motion Control instruction "MC_TorqueLimiting" can be changed for this.

Monitoring of the clamping

If the actual position changes by a value greater than the configured "Positioning tolerance" during active clamping, this is regarded as the breaking away or turning back of the fixed stop. An alarm is triggered; the axis is disabled and the drive is stopped according to its configuration.

If the position setpoint is within the configured "Positioning tolerance", the breaking away or turning back of the fixed stop cannot be detected.

The configured position tolerance must be less than the configured following error for detection of clamping.

Retracting

Retracting from the fixed stop is only possible with a position-controlled motion job in the opposite direction to the fixed stop.

The "Travel to fixed stop" or "Clamping" function is ended when the "Positioning tolerance" is left in the retraction direction.

See also

Force/torque limiting (Page 63)

MC_TorqueLimiting: Activate and deactivate force/torque limit / fixed stop detection (Page 410)

Configuration - Fixed stop detection (Page 216)

3.2.7.7 Tags

The following technology object tags are relevant for motion control:

Status	
<TO>.StatusWord	Status indicator for an active motion
<TO>.Position	Position setpoint
<TO>.Velocity	Velocity setpoint / speed setpoint
<TO>.ActualPosition	Actual position
<TO>.ActualVelocity	Actual velocity
<TO>.ActualSpeed	Actual speed of the motor (only with PROFIdrive drive type)
<TO>.Acceleration	Setpoint acceleration
<TO>.ActualAcceleration	Actual acceleration
<TO>.StatusSynchronizedMotion.StatusWord.X0 (MaxVelocityExceeded)	Set to value TRUE when the maximum velocity configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X1 (MaxAccelerationExceeded)	Set to value TRUE when the maximum acceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X2 (MaxDecelerationExceeded)	Set to value TRUE when the maximum deceleration configured for the following axis is exceeded during synchronous operation.
Override	
<TO>.Override.Velocity	Velocity override
Dynamic limit values	
<TO>.DynamicLimits.MaxVelocity	Dynamic limitation for maximum velocity
<TO>.DynamicLimits.MaxAcceleration	Dynamic limitation for maximum acceleration
<TO>.DynamicLimits.MaxDeceleration	Dynamic limitation for maximum deceleration
<TO>.DynamicLimits.MaxJerk	Dynamic limitation for maximum jerk
Dynamic defaults	
<TO>.DynamicDefaults.Velocity	Default velocity
<TO>.DynamicDefaults.Acceleration	Default acceleration
<TO>.DynamicDefaults. Deceleration	Default deceleration
<TO>.DynamicDefaults.Jerk	Default jerk
<TO>.DynamicDefaults. EmergencyDeceleration	Emergency stop deceleration

Torque limiting	
<TO>.TorqueLimiting.LimitDefaults.Torque	Limiting torque
<TO>.TorqueLimiting.LimitDefaults.Force	Limiting force
<TO>.TorqueLimiting.LimitBase	Torque limiting motor or drive side 0: Motor side 1: Load side
<TO>.TorqueLimiting.PositionBased Monitorings	Deactivate or keep active the positioning and following error monitoring 0: Deactivate 1: Keep active
Fixed stop detection	
<TO>.Clamping.FollowingErrorDeviation	Value of the following error starting from which the fixed stop is detected
<TO>.Clamping.PositionTolerance	Position tolerance for the clamping monitoring

3.2.8 Homing

3.2.8.1 Brief description

With homing, you create the relationship between the position in the technology object and the mechanical position. The actual position value in the technology object is assigned to a homing mark at the same time. This homing mark represents a known mechanical position.

With incremental actual values this process is called homing; with absolute actual values it is called absolute encoder adjustment.

Homing is a requirement for display of the correct position for the technology object and for absolute positioning.

Homing is activated with the Motion Control instruction "MC_Home".

Homing status

The technology object tag <TO>.StatusWord.X5 (HomingDone) indicates whether the axis or external encoder technology object is homed.

Type of homing

Homing can occur by means of an independent homing motion (active homing), the detection of a homing mark during a motion initiated on the user side (passive homing) or a direct position assignment.

A distinction is made between the following types of homing:

- **Active homing**

  Active homing initiates a homing movement and performs the necessary homing mark approach. When the homing mark is detected, the actual position is set to the value specified in MC_Home. It is possible to specify a home position offset. Retraction to the home position offset occurs automatically during the home position approach.

  When active homing starts, current traversing movements are aborted.

- **Passive homing**

  The homing job does not perform its own homing motion. When the homing mark is detected during a motion initiated on the user side, the actual position is set to the value specified in "MC_Home".

  Passive homing is also called homing on the fly.

- **Direct homing**

  With the homing job, the actual position is set directly to the value specified in "MC_Home" or is offset by this value.

- **Absolute encoder adjustment**

  The absolute encoder adjustment compares the existing absolute actual value with the value specified in "MC_Home".

Homing mode

Depending on the type of homing mark and homing mark search, a distinction is made among the following homing modes (Page 72):

- **Homing with zero mark via PROFIdrive telegram and reference cam**
- **Homing with zero mark via PROFIdrive telegram**
- **Homing with digital input**

3.2.8.2 Terms

Homing mark

A homing mark is an input signal, on whose occurrence a known mechanical position can be assigned to the actual values.

A homing mark can be:

- **A zero mark**

  The zero mark of an incremental encoder or an external zero mark is used as a homing mark.

  The zero mark is detected at the drive module or encoder module and transmitted in the PROFIdrive frame. Perform the setting and evaluation as an encoder zero mark or external zero mark at the drive module and encoder module.

- **An edge at the digital input**

  The negative or positive edge at a digital input is used as a homing mark.

Reference cam

If there are several zero marks in the traversing range, the reference cam is used to select a specific zero mark before or after the reference cam.

Homing mark position

This is the position assigned to the homing mark.

The homing mark position corresponds to the home position minus the home position offset.

Home position

At the end of the active homing motion, the axis arrives at the home position.

Home position offset

The difference between the home position and the homing mark position is the home position offset.

A home position offset only has an effect with active homing. The offset is traversed after the synchronization of the axis using the Motion Control instruction "MC_Home". For axes with modulo setting, the home position offset is always traversed with the direction setting for the shortest path.

Direction reversal at the hardware limit switch (reversing cam)

Hardware limit switches can be used as reversing cams in active homing. If the homing mark was not detected or was approached from the wrong side, the motion continues in the opposite direction after the reversing cam.

3.2.8.3 Homing mode

Various homing modes are available for the positioning axis/synchronous axis and external encoder technology objects with incremental encoders. The homing mode is set in the configuration.

Homing with zero mark via PROFIdrive telegram and reference cam

The system checks for when the reference cam is reached. After the reference cam has been reached and left again in the assigned homing direction, zero mark detection is enabled via the PROFIdrive telegram.

When the zero mark is reached in the pre-selected direction, then the actual position of the technology object is set to the homing mark position.

Homing with zero mark via PROFIdrive telegram

The system enables zero mark detection, as soon as the actual value of the technology object moves in the assigned homing direction.

When the zero mark is reached in the specified homing direction, the actual position of the technology object is set to the homing mark position.

Homing with digital input

The system checks the state of the digital input, as soon as the actual value of the axis or encoder moves in the assigned homing direction.

When the homing mark is reached (setting of the digital input) in the specified homing direction, the actual position of the technology object is set to the homing mark position.

Note

The digital inputs must be placed into the process image partition "PIP OB Servo".

The filter time of the digital inputs must be set smaller than the duration of the input signal at the reference point switch.

See also

Homing SINAMICS drives with external zero marks (Page 572)

3.2.8.4 Active homing with zero mark and reference cam

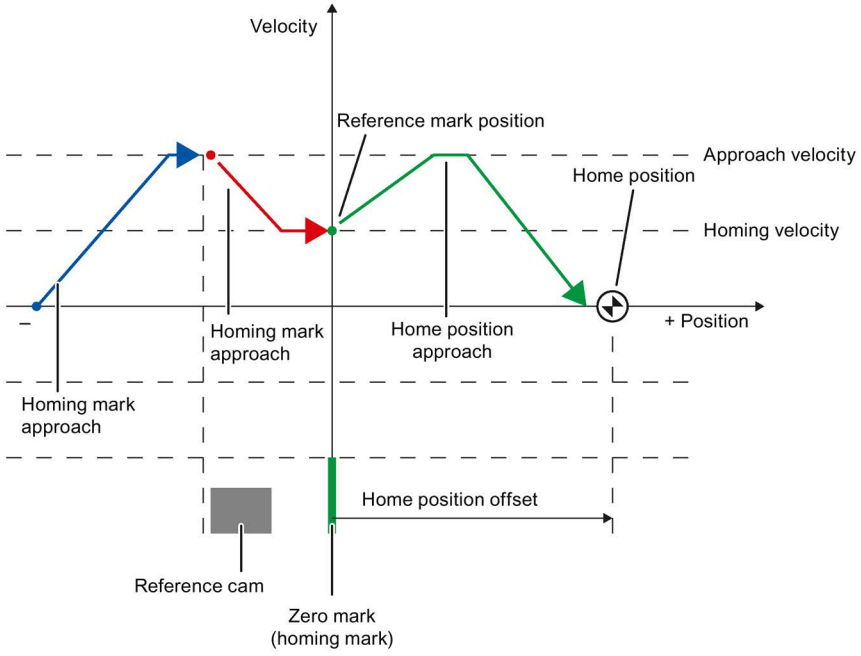
The following examples show homing motions in the positive and negative directions.

Example of homing in the positive direction

The approach to the homing mark and the home position occurs in the positive direction.

The following figure shows the homing motion with the following settings:

- Active homing with zero mark and reference cam
- Approach in the positive direction
- Homing in the positive direction
- Positive home position offset

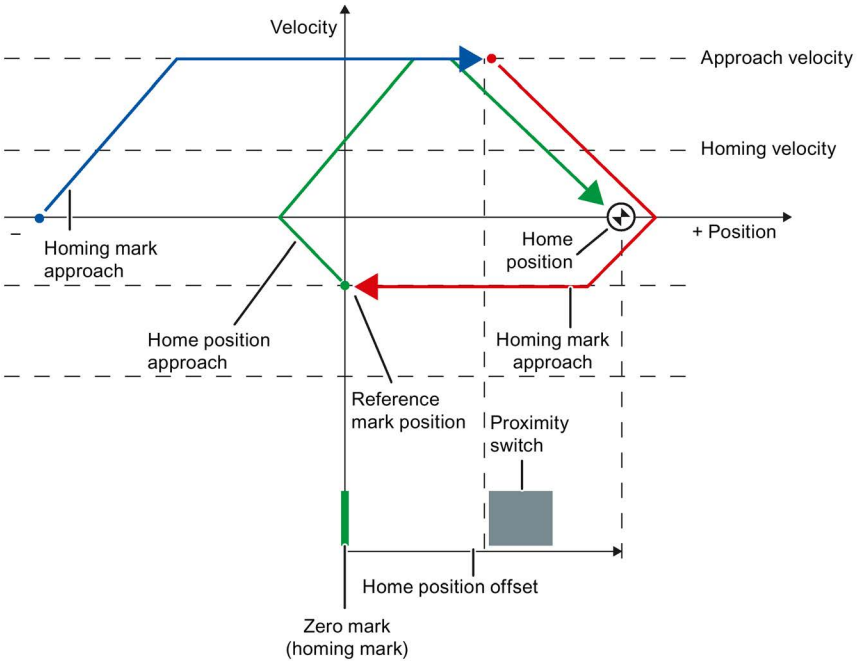


Example of homing in the negative direction

The approach to the homing mark occurs in the negative direction by means of a direction reversal during the homing process. The approach to home position causes another direction reversal and occurs in the positive direction.

The following figure shows the homing motion with the following settings:

- Active homing with zero mark and reference cam
- Approach in the positive direction
- Homing in the negative direction
- Positive home position offset



Motion sequence

The motion occurs in the following sequence:

1. **Start of active homing via the Motion Control instruction "MC_Home"**
2. **Approach to reference cam**
3. **Detection of the reference cam in the homing direction and travel with homing velocity**
4. **Departure from the reference cam and travel to the homing mark**

   With the departure from the reference cam, the detection of the homing mark is enabled.
5. **Detection of the homing mark**

   When the homing mark is detected, the position of the technology object is set depending on the configured mode:

   – Parameter "Mode" in "MC_Home" = 3

     Position = value in parameter "Position" minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   – Parameter "Mode" in "MC_Home" = 5

     Position = value in the tag <TO>.Homing.HomePosition minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   Note

   Parameter "MC_Home.Mode"

   The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).
6. **Approach to home position**

   – Parameter "Mode" in "MC_Home" = 3

     The axis moves to the position that is specified in the "Position" parameter.

   – Parameter "Mode" in "MC_Home" = 5

     The axis moves to the position that is specified in the <TO>. Homing.HomePosition tag.

   Note

   If the velocity cannot be reduced to the reference velocity between detection of the reference cam and the zero mark, homing is performed at the velocity present when the zero mark is crossed.

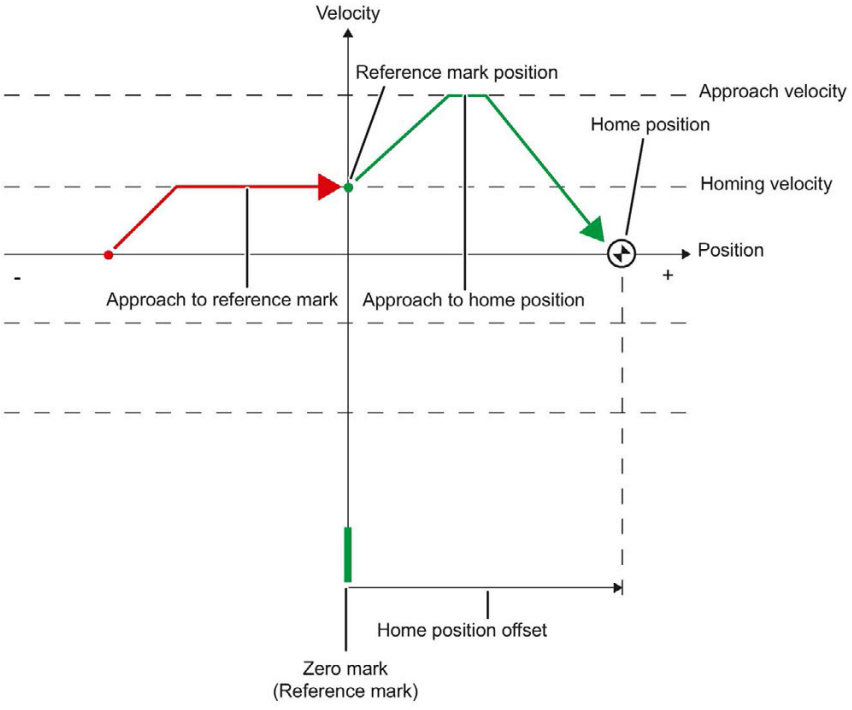
See also

Homing SINAMICS drives with external zero marks (Page 572)

3.2.8.5 Active homing with zero mark

The following figure shows an example of the homing motion with the following settings:

- Active homing with zero mark
- Homing in the positive direction
- Positive home position offset



Motion sequence

The motion occurs in the following sequence:

1. **Start of active homing via the Motion Control instruction "MC_Home"**
2. **Move to the homing mark in the homing direction with the homing velocity**

3. **Detection of the homing mark**

   When the homing mark is detected, the position of the axis or encoder is set depending on the configured mode:

   – Parameter "Mode" in "MC_Home" = 3

     Position = value in parameter "Position" minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   – Parameter "Mode" to "MC_Home" = 5

     Position = value in the tag <TO>.Homing.HomePosition minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   Note

   Parameter "MC_Home.Mode"

   The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

4. **Approach to home position**

   – Parameter "Mode" in "MC_Home" = 3

     The axis moves to the position that is specified in the "Position" parameter.

   – Parameter "Mode" to "MC_Home" = 5

     The axis moves to the position that is specified in the <TO>. Homing.HomePosition tag.

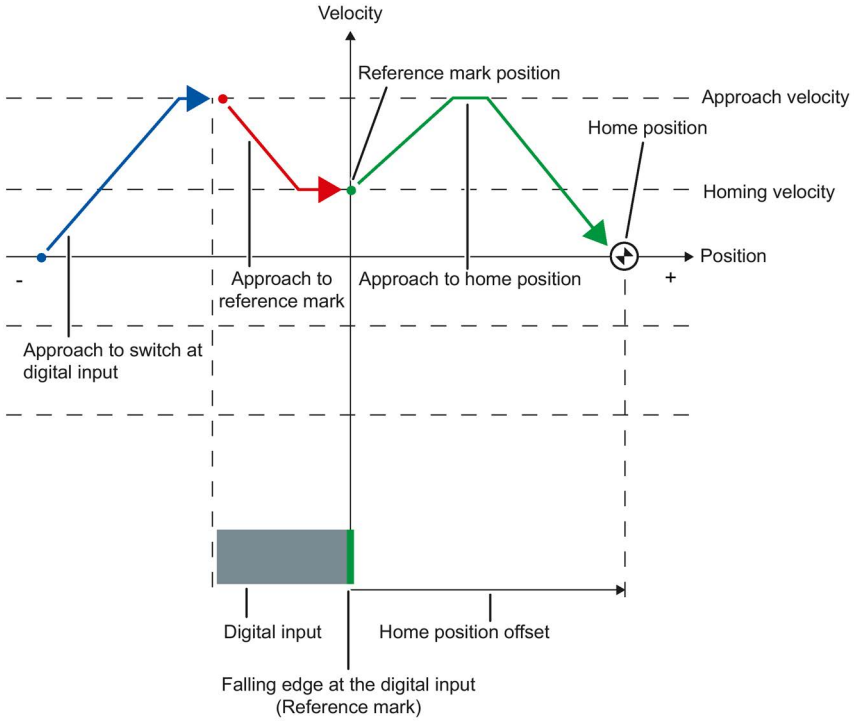
See also

Homing SINAMICS drives with external zero marks (Page 572)

3.2.8.6 Active homing with digital input

The following figure shows an example of the homing motion with the following settings:

- Active homing with digital input
- Approach in the positive direction
- Homing mark on the positive side of the digital input
- Positive home position offset



Motion sequence

The motion occurs in the following sequence:

1. **Start of active homing via the Motion Control instruction "MC_Home"**
2. **Detection of the positive edge at the digital input, while moving with homing velocity**
3. **Approach to the homing mark**
4. **Detection of the homing mark**

   In the example, the negative edge of the switch at the digital input represents the homing mark.

   When the homing mark is detected, the position of the axis or encoder is set depending on the configured mode:

   – Parameter "Mode" in "MC_Home" = 3

     Position = value in parameter "Position" minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   – Parameter "Mode" in "MC_Home" = 5

     Position = value in the tag <TO>.Homing.HomePosition minus <TO>.Sensor[n].ActiveHoming.HomePositionOffset

   Note

   Parameter "MC_Home.Mode"

   The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

5. **Approach to home position**

   – Parameter "Mode" in "MC_Home" = 3

     The axis moves to the position that is specified in the "Position" parameter.

   – Parameter "Mode" in "MC_Home" = 5

     The axis moves to the position that is specified in the <TO>.Homing.HomePosition tag.

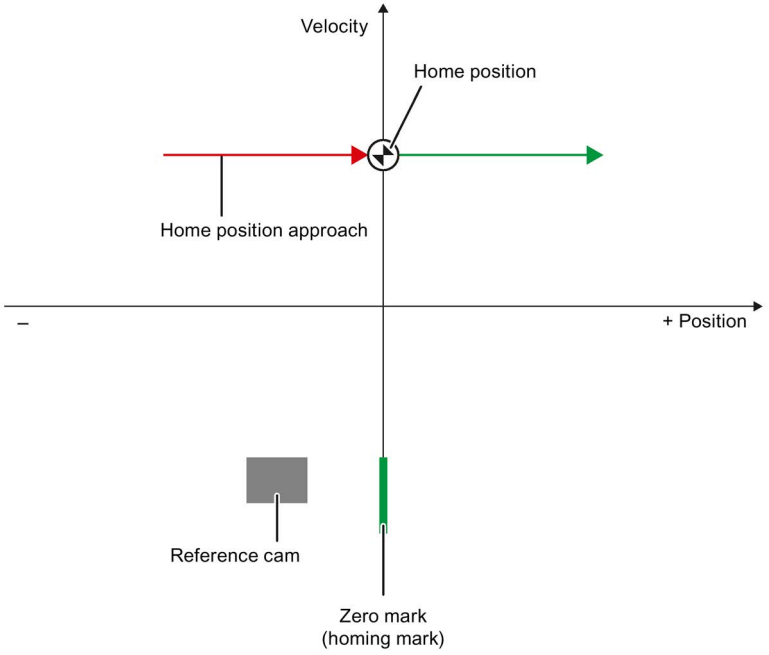
   Note

   If the velocity on the span from the detection of the positive edge to the negative edge cannot be reduced to the homing velocity, then homing occurs at the velocity that exists when the homing mark is traversed.

3.2.8.7 Passive homing with zero mark and reference cam

The following figure shows an example of the homing motion with the following settings:

- Passive homing with zero mark and reference cam
- Homing in the positive direction



Motion sequence

The motion occurs in the following sequence:

1. **Activation of passive homing using the Motion Control instruction "MC_Home".**
2. **Motion due to a Motion Control job by the user**

   The detection of the reference cam and homing mark is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.
3. **Detection of the reference cam**
4. **Departure from the reference cam**

   The departure from the reference cam enables the detection of the homing mark.
5. **Detection of the homing mark**

   When the homing mark is detected, the position of the axis or encoder is set depending on the configured mode:

   – Parameter "Mode" in "MC_Home" = 2, 8

     Position = value in parameter "Position"

   – Parameter "Mode" in "MC_Home" = 10

     Position = value in tag <TO>.Homing.HomePosition

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

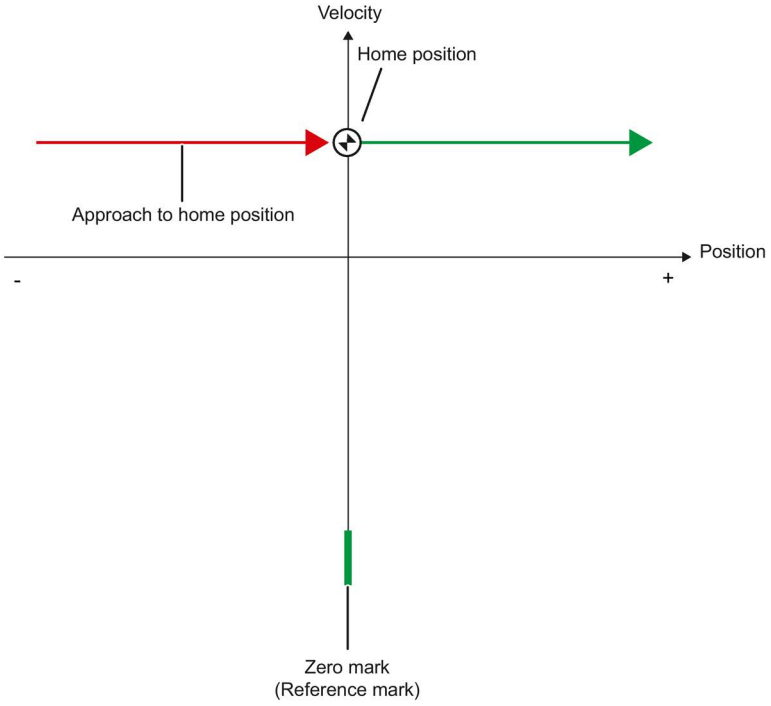
Note

If the motion direction changes after departure from the reference cam and before detection of the homing mark, the reference cam must be detected again.
The Motion Control instruction "MC_Home" remains enabled.

3.2.8.8 Passive homing with zero mark

The following figure shows an example of the homing motion with the following settings:

- Passive homing with zero mark
- Homing in the positive direction



Motion sequence

The motion occurs in the following sequence:

1. **Enablement of passive homing via the Motion Control instruction "MC_Home".**
2. **Motion due to a Motion Control job from the application**

   The detection of the homing mark is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.
3. **Detection of the homing mark**

   When the homing mark is detected, the position of the axis or encoder is set depending on the configured mode:

   – Parameter "Mode" to "MC_Home" = 2, 8

     Position = value in parameter "Position"

   – Parameter "Mode" to "MC_Home" = 10

     Position = value in tag <TO>.Homing.HomePosition

Note

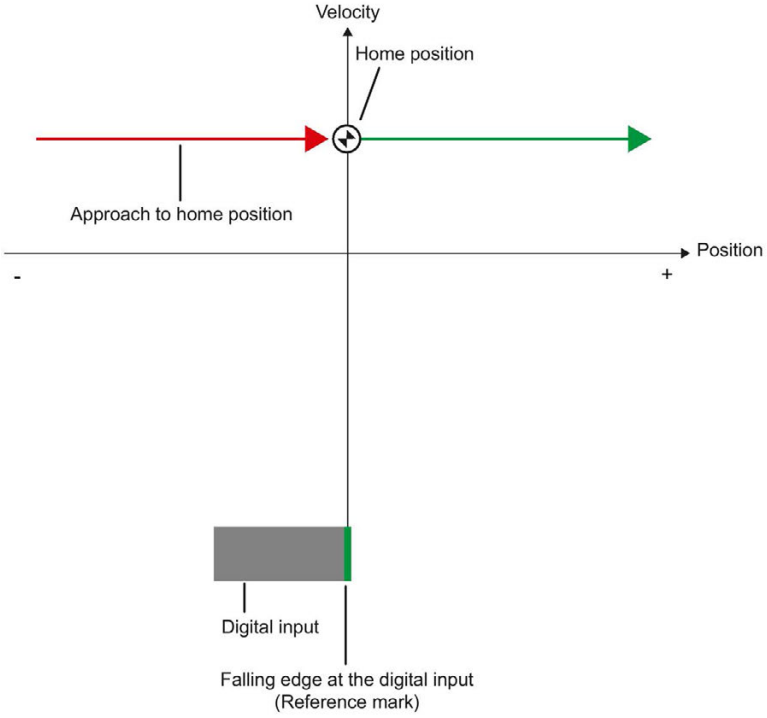
Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

3.2.8.9 Passive homing with digital input

The following figure shows an example of the homing motion with the following settings:

- Passive homing with digital input
- Homing in the positive direction
- Homing mark on the positive side of the digital input



Motion sequence

The motion occurs in the following sequence:

1. **Enablement of passive homing via the Motion Control instruction "MC_Home".**
2. **Motion due to a Motion Control job from the application**

   The detection of the homing mark at the digital input is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.
3. **Detection of the homing mark**

   In the example, the falling edge of the switch at the digital input represents the homing mark.

   When the homing mark is detected, the position of the axis or encoder is set depending on the configured mode:

   – Parameter "Mode" to "MC_Home" = 2, 8

     Position = value in parameter "Position"

   – Parameter "Mode" to "MC_Home" = 10

     Position = value in tag <TO>.Homing.HomePosition

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

3.2.8.10 Direction reversal at the hardware limit switch (reversing cam)

During active homing, the hardware limit switch can optionally be used as a reversing cam. If the homing mark is not detected or the motion was not in the homing direction, the motion continues in the opposite direction with the approach velocity after the reversing cam.

When the hardware limit switch is reached, the default settings for dynamics take effect. Deceleration with the emergency stop deceleration does not occur.

NOTICE

Avoid moving to a mechanical endstop

Ensure by one of the following measures, that in a direction reversal the machine does not move to a mechanical endstop.

- Keep the approach velocity low.
- Increase the configured acceleration / deceleration.
- Increase the distance between the hardware limit switch and the mechanical endstop.

3.2.8.11 Direct homing

Depending on the configured mode, the position of the positioning axis/synchronous axis or external encoder technology objects can be absolutely or relatively set with "MC_Home".

Set position absolutely

Proceed as follows to set the position absolutely:

1. In the Motion Control instruction "MC_Home", enter the absolute position in the "Position" parameter.
2. Call the Motion Control instruction "MC_Home" with parameter "Mode" = 0.

The position is set to the value specified in the "Position" parameter.

Set position relatively

Proceed as follows to set the position relatively:

1. In the Motion Control instruction "MC_Home", enter the relative position in the "Position" parameter.
2. Call the Motion Control instruction "MC_Home" with parameter "Mode" = 1.

The position is set to the current position plus the value specified in the "Position" parameter.

3.2.8.12 Absolute value adjustment

In absolute value adjustment, Motion Control determines an absolute value offset, that is retentively stored on the CPU.

Depending on the configured mode, the position of the axis or the encoder is absolutely or relatively set in the "MC_Home" Motion Control instruction.

- Parameter "Mode" = 7 (absolute specification of position)

  Position = value in parameter "Position"

- Parameter "Mode" = 6 (relative specification of position)

  Position = current position + value in parameter "Position"

3.2.8.13 Resetting the "Homed" status

Incremental encoder

In the following cases, the "Homed" status is reset, and the technology object must be rehomed.

- Error in sensor system/encoder failure
- Initiation of active homing with the Motion Control instruction "MC_Home" with "Mode" = 3, 5 (after successful completion of the homing process, the status "Homed" is set again.)

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

- Initiation of passive homing with the Motion Control instruction "MC_Home" with "Mode" = 2, 8, 10 (after successful completion of the homing process, the status "Homed" is set again.)
- Replacement of the CPU
- Replacement of the SIMATIC Memory Card
- POWER OFF
- Memory reset
- Modification of the encoder configuration
- Restart of the technology object
- Restoration of the CPU factory settings
- Transfer of a different project into the controller

Absolute encoder

In the following cases, the "Homed" status is reset, and the technology object must be rehomed.

- Error in sensor system/encoder failure
- Replacement of the CPU
- Modification of the encoder configuration
- Restoration of the CPU factory settings
- Transfer of a different project into the controller

Resetting the memory of the CPU or upgrading a project does not require another absolute value adjustment.

3.2.8.14 Tags

The following technology object tags are relevant for homing:

Status indicators	
<TO>StatusWord.X11 (HomingCommand)	Homing job running
<TO>StatusWord.X5 (HomingDone)	Technology object is homed
<TO>ErrorWord.X10 (HomingFault)	Error occurred during homing
Approach to reference cam	
<TO>.Homing.ApproachDirection	Start direction or approach direction for the approach to the reference cam
<TO>.Homing.ApproachVelocity	Velocity for the approach to the reference cam
Approach to the homing mark	
<TO>.Sensor[n].ActiveHoming.Direction	Homing direction
<TO>.Homing.ReferencingVelocity	Velocity for the approach to the homing mark
Approach to home position	
<TO>.Homing.ApproachVelocity	Velocity for the approach to the home position
Positions	
<TO>.Homing.AutoReversal	Reversal at the hardware limit switches
<TO>.Homing.HomePosition	Home position
<TO>.StatusSensor[n].AbsEncoderOffset	Calculated offset after the absolute encoder adjustment
Parameters for active homing	
<TO>.Sensor[n].ActiveHoming.Mode	Homing mode
<TO>.Sensor[n].ActiveHoming.SideInput	Side of the digital input
<TO>.Sensor[n].ActiveHoming.Direction	Homing direction or approach direction
<TO>.Sensor[n].ActiveHoming.DigitalInput Address	Byte number of the I/O address of the digital input
<TO>.Sensor[n].ActiveHoming.HomePosition Offset	Offset of the homing mark from the home position
Parameters for passive homing	
<TO>.Sensor[n].PassiveHoming.Mode	Homing mode
<TO>.Sensor[n].PassiveHoming.SideInput	Side of the digital input
<TO>.Sensor[n].PassiveHoming.Direction	Homing direction or approach direction
<TO>.Sensor[n].PassiveHoming.DigitalInput Address	Byte number of the I/O address of the digital input

Note

Evaluation of the bits in StatusWord, ErrorWord and WarningWord

Read the information provided in section Evaluate StatusWord, ErrorWord and WarningWord (Page 298).

3.2.9 Position monitoring functions

3.2.9.1 Brief description

The following functions are available in the positioning axis/synchronous axis technology object for monitoring positioning and motion:

- Positioning monitoring (Page 90)

  The actual position value must reach a positioning window within a specified time, and remain in this positioning window for a minimum dwell time.

- Following error monitoring (Page 91)

  The following error is monitored based on a velocity-dependent following error limit. The permissible maximum following error depends on the setpoint velocity.

If monitored conditions are violated, then technology alarms are output.
The technology object responds in accordance with the alarm response.

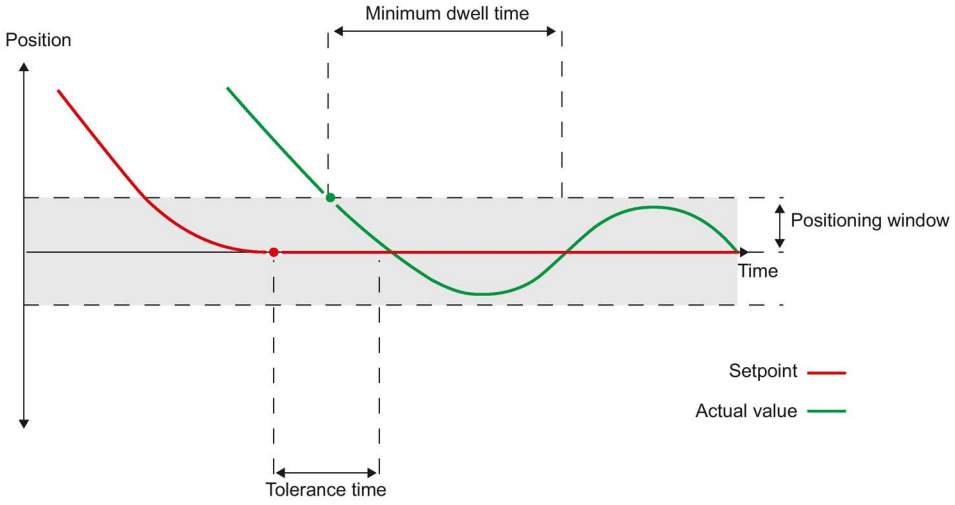
3.2.9.2 Positioning monitoring

Positioning monitoring monitors the behavior of the actual position at the end of the setpoint calculation.

As soon as the velocity setpoint reaches the value zero, the actual position value must be located in the positioning window within a tolerance time. The actual value must not exit the positioning window during the minimum dwell time.

If the actual position is reached at the end of a positioning motion within the tolerance time and remains in the positioning window for the minimum dwell time, then <TO>.StatusWord.X6 (Done) is set in the technology data block. After expiration of the minimum dwell time, the "Done" parameter of the corresponding Motion Control instruction is also set. This completes a motion job.

The following figure shows the chronological sequence and the positioning window:



Positioning monitoring does not make any distinction between how the setpoint interpolation was completed. The end of setpoint interpolation can for example be reached as follows:

- by reaching of the target position on the part of the setpoint
- by position controlled stopping during the motion by the Motion Control instruction "MC_Halt"

Violation of positioning monitoring

In the following cases, technology alarm 541 is output by the positioning monitoring, and the technology object is disabled (alarm reaction: remove enable).

- The actual value does not reach the positioning window during the tolerance time.
- The actual value exits the positioning window during the minimum dwell time.

3.2.9.3 Following error monitoring

The following error in the positioning axis/synchronous axis technology object is monitored based on a velocity-dependent following error limit. The permissible following error depends on the velocity setpoint.

A constant permissible following error can be specified for velocities lower than an adjustable velocity low limit.

Above this low velocity limit, the permissible following error increases in proportion to the velocity setpoint. The configurable maximum permissible following error is the maximum velocity limit.

Calculation of the following error

The following error is the difference between the position setpoint and the actual position value. The transmission times of the setpoint to the drive, and of the actual position value to the controller, are taken into account in the calculation of the following error, i.e. subtracted out.

Warning limit

A warning limit can be specified for the following error. The warning limit is input as a percentage value and operates relative to the current permissible following error.
If the warning limit of the following error is reached, then technology alarm 522 is output. This is a warning and contains no alarm response.

Violation of the permissible following error

If the permissible following error is exceeded, then technology alarm 521 is output, and the technology object is disabled (alarm response: remove enable).

When force/torque limiting is activated, the monitoring of the permissible following error can be deactivated.

3.2.9.4 Standstill signal

When the actual velocity reaches the standstill window and remains there for the minimum dwell time, the standstill of the axis is indicated.

3.2.9.5 Tags

The following technology object tags are relevant for positioning monitoring:

Status indicators	
<TO>.StatusWord.X7 (Standstill)	Set to the value TRUE when the actual velocity reaches the standstill window and does not exit it within the minimum dwell time. The standstill signal is only present for the positioning axis/synchronous axis.
<TO>.StatusWord.X6 (Done)	**Positioning axis/synchronous axis** Set to the value TRUE, when the actual velocity value reaches the positioning window within the tolerance time and remains in the window for the minimum dwell time. **Speed axis** Set to TRUE, when the motion is complete and thus the speed setpoint is equal to zero.
<TO>.ErrorWord.X12 (PositioningFault)	A positioning error has occurred.
Positions and times	
<TO>.PositioningMonitoring.ToleranceTime	Maximum permissible time until positioning window is reached The time is started with the end of the setpoint interpolation.
<TO>.PositioningMonitoring.MinDwellTime	Minimum dwell time in the positioning window
<TO>.PositioningMonitoring.Window	Positioning window
Standstill signal	
<TO>.StandstillSignal.VelocityThreshold	Velocity threshold for the standstill signal
<TO>.StandstillSignal.MinDwellTime	Minimum dwell time below the velocity threshold

The following technology object tags are relevant for following error monitoring:

Status indicators	
<TO>.StatusPositioning.FollowingError	Current following error
<TO>.ErrorWord.X11 (FollowingErrorFault)	Status indication, that the following error is too large
<TO>.WarningWord.X11 (FollowingErrorWarning)	Status indication, that the following error warning limit has been reached
Control bits	
<TO>.FollowingError.EnableMonitoring	Enabling / disabling following error monitoring
Limit values	
<TO>.FollowingError.MinVelocity	Lower velocity setpoint for the characteristic curve of the maximum following error
<TO>.FollowingError.MinValue	Permissible following error below the <TO>.FollowingError.MinVelocity
<TO>.FollowingError.MaxValue	Maximum permissible following error at maximum axis velocity
<TO>.FollowingError.WarningLevel	Warning limit as a percentage value relative to the maximum permissible following error (velocity-dependent in accordance with the characteristic curve)

3.2.10 Closed-loop control

3.2.10.1 Brief description

The position controller of the positioning axis/synchronous axis is a closed-loop P controller with velocity precontrol.

If the drive supports Dynamic Servo Control (DSC), then a closed-loop position controller in the drive can optionally be used.

Dynamic Servo Control (DSC)

In drives that support Dynamic Servo Control (DSC), you can optionally use the closed-loop position controller in the drive. The position controller in the drive is usually implemented with a rapid speed-control cycle. This improves the control performance for digitally coupled drives.

The following requirements must be met to use DSC:

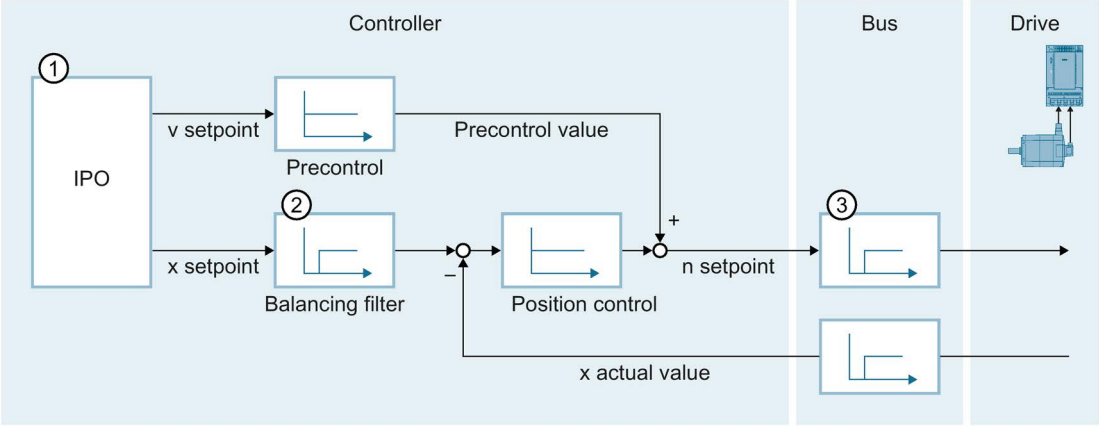
- The motor encoder (first encoder in the telegram) of the drive is used as the first encoder for the technology object.
- One of the following PROFIdrive telegrams is used for the drive:
  - Standard telegram 5 or 6
  - SIEMENS telegram 105 or 106

See also

PROFIdrive telegrams (Page 33)

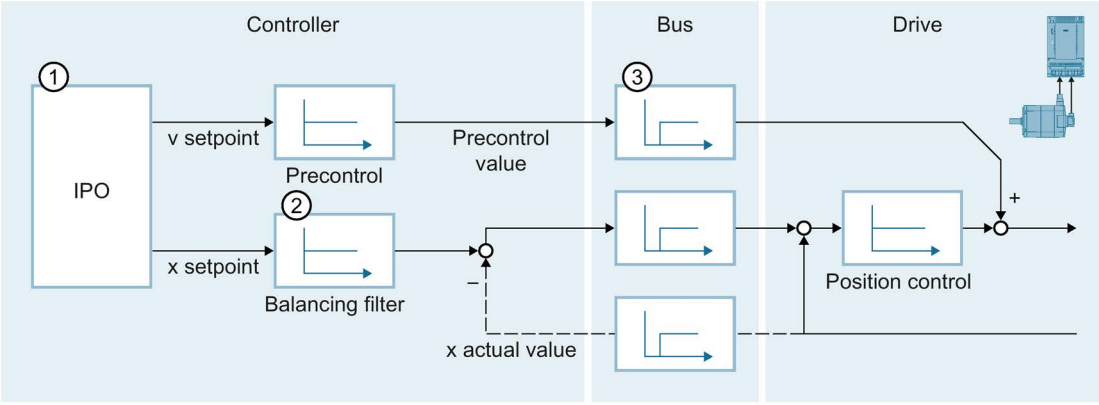
3.2.10.2 Control structure

The following figure shows the effective closed loop control structure **without** DSC:



① Interpolator with motion control
② Internal consideration of signal propagation times and the speed control loop substitute time
③ Communication between controller and drive

The following figure shows the effective closed loop control structure **with** DSC:



① Interpolator with motion control
② Internal consideration of the speed control loop substitute time
③ Communication between controller and drive

See also

Configuration - Control loop (Page 232)

3.2.10.3 Tags

The following technology object tags are relevant for the closed-loop control:

Parameters	
<TO>.PositionControl.Kv	Proportional gain of the closed loop position control
<TO>.PositionControl.Kpc	Velocity precontrol of the closed loop position control (in %)
<TO>.PositionControl.EnableDSC	Enable DSC
<TO>.DynamicAxisModel.VelocityTime Constant	Speed control loop substitute time [s]
<TO>.PositionControl.ControlDifference-Quantization.Mode	Type of quantification Configuration of a quantization when a drive with stepper motor interface is connected 0: No quantification 1: Quantization corresponding to encoder resolution 2: Quantization to a direct value (value input in <TO>.PositionControl.ControlDifferenceQuantization.-Value) (configuration is performed using the parameter view (data structure))
<TO>.PositionControl.ControlDifference-Quantization.Value	Value of quantification Configuration of a value for quantization to a direct value (<TO>.PositionControl.ControlDifferenceQuantization.-Mode = 2) The quantization value is specified in the position unit of the axis. (configuration is performed using the parameter view (data structure))

3.2.11 Process response

3.2.11.1 Organization Blocks for Motion Control

Description

When you create a technology object, organization blocks are automatically created for processing the technology objects. The Motion Control functionality of the technology objects creates its own execution level, and is called according to the Motion Control application cycle.

The following blocks are created:

- **MC-Servo [OB91]**

  Calculation of the position controller

- **MC-Interpolator [OB92]**

  Evaluation of the Motion Control instructions, generation of setpoints and monitoring functionality

The organization blocks are protected (know-how protection).
The program code cannot be viewed or changed.

The frequency relationship of the two organization blocks to one another is always 1:1. MC-Servo [OB91] is always executed before MC-Interpolator [OB92].

You can set the application cycle and the priority of the organization blocks according to your requirements for control quality and system load.

MC-PreServo [OB67] and MC-PostServo [OB95]

In addition, you can create the organization blocks MC-PreServo [OB67] and MC-PostServo [OB95].

The organization blocks MC-PreServo [OB67] and MC-PostServo [OB95] can be programmed. They are called in the configured application cycle. This means you can use the organization blocks MC-PreServo [OB67] and MC-PostServo [OB95] for consistent data processing or time-critical events, such as starting of motions or homing functions for the process that may have to run synchronously with the application cycle.

Application cycle

You can set the application cycle in which the MC-Servo [OB91] is called in the properties of the organization block in "General > Cycle Time":

- **Synchronous to the bus**

  MC-Servo [OB91] is called synchronously with or at a reduced ratio to a bus system. You set the send clock in the properties of the selected bus system. In the "Distributed I/O" drop-down list, you can select the following bus systems:

  – Isochronous PROFIBUS DP

  – Isochronous PROFINET IO

  You cannot call the MC-Servo [OB91] synchronously with a bus system that is connected to the CPU via a communications processor/communications module (CP/CM).

- **Cyclic**

  The MC-Servo [OB91] is called cyclically with the specified application cycle.

The selected application cycle must be long enough to be able to process the technology objects in one cycle. If the processing time of the technology objects is longer than the application cycle, overflows (Page 100) will occur.

You can check the runtime of MC-Servo [OB91] and MC-Interpolator [OB92] with the expanded instruction "RT_INFO".

The current application cycle (information in µs) of the organization blocks MC-PreServo [OB67] and MC-PostServo [OB95] can be read using the start information.

Reduction ratio (CPU V1.5 and higher)

You can reduce the application cycle of the MC-Servo [OB91] relative to the send clock of an isochronous PROFINET IO system. You can set an integer multiple of the send clock as the factor. Values up to 14 times the send clock (maximum 32 ms) are possible for the application cycle.

If you call an isochronous mode interrupt OB and the MC-Servo [OB91] synchronously with the same PROFINET IO system, you must set the same application cycle for both organization blocks.

Priority

You can configure the priority of the organization blocks as needed in their properties under "General > Properties > Priority":

- **MC-Servo [OB91]**

  Priority 17 to 26 (default value 25)

- **MC-Interpolator [OB92]**

  Priority 16 to 25 (default value 24)

The priority of MC-Servo [OB91] must be at least one higher than the priority of MC-Interpolator [OB92].

The priority of the organization blocks MC-PreServo [OB67] and MC-PostServo [OB95] correspond to the priority of the MC-Servo [OB91]. MC-PreServo [OB67] is called immediately before MC-Servo [OB91]. MC-PostServo [OB95] is called immediately after MC-Servo [OB91].

See also

Data connection of drive/encoder via data block (Page 49)

3.2.11.2 Process image partition "OB Servo PIP"

The process image partition "OB Servo PIP" is made available in isochronous mode for Motion Control when MC-Servo [OB91] is called. All drives and encoders used by Motion Control are assigned to this process image partition.

Because the organization blocks MC-PreServo [OB67] and MC-PostServo [OB95] are called automatically by the MC-Servo [OB91], the process image partition is also available automatically.

Additionally, you should assign all I/O modules used by Motion Control to this process image partition (e.g. hardware limit switches). The assignment results in chronologically synchronous processing with the technology object.

The input process image partition is also updated in STOP mode.

Process image partition in the user program

As of CPU version V1.5, you can access the process image partition "OB Servo PIP" in your user program. This makes it possible to evaluate the process image partition using the trace function.

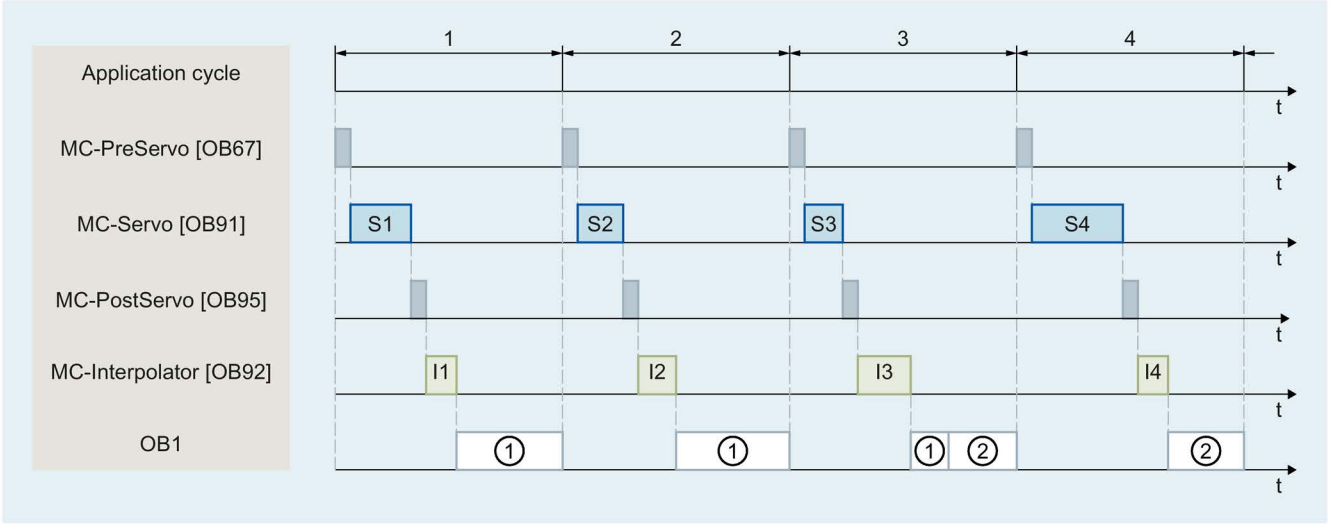
3.2.11.3 Operational Sequence and Timeouts

When processing the Motion Control functionality, the organization blocks MC-Servo [OB91] and MC-Interpolator [OB92] are called and processed in each application cycle.
The remaining cycle time is available for the processing of your user program.

For error-free program execution, keep to the following rules:

- In each application cycle, MC-Servo [OB91] must be started and executed completely.
- In each application cycle, the relevant MC-Interpolator [OB92] must at least be started.

The following figure shows an example of the error-free operational sequence for the processing of organization block OB1:



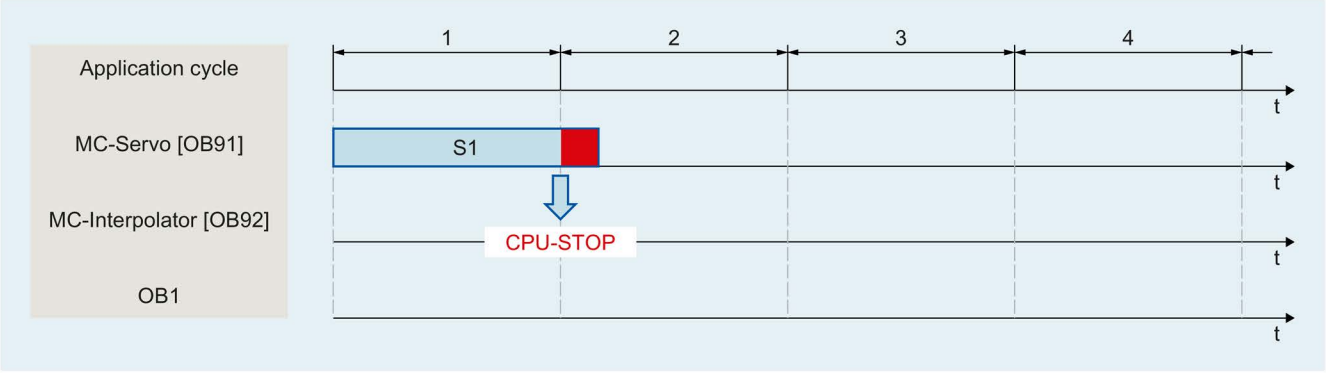
① First OB1 cycle
② Second OB1 cycle

Overflows

If the configured application cycle is not adhered to, for example because additional technology objects or programs are added in the MC-PreServo [OB67] or MC-PostServo [OB95], overflows can occur. The application cycle must be adapted in this case to prevent overflows.

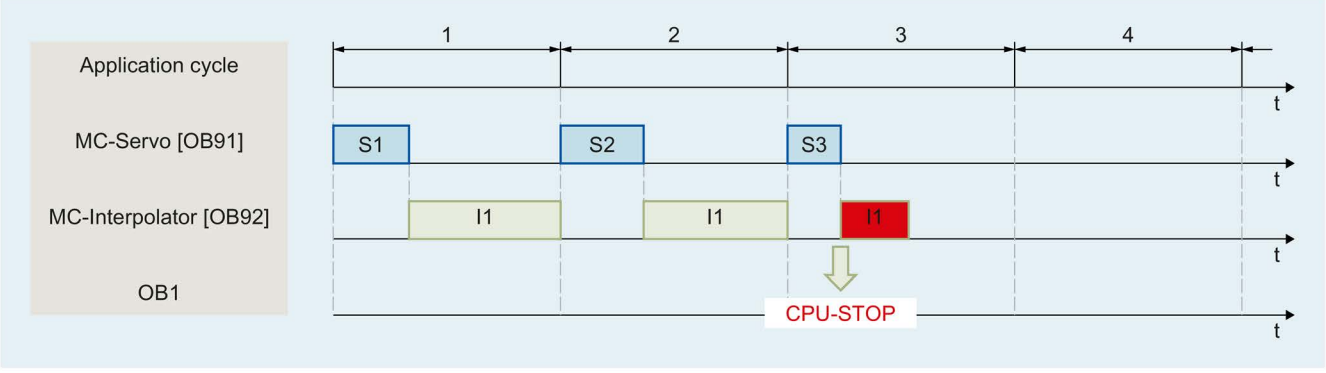
The CPU will not tolerate overflow of MC-Servo [OB91]. An overflow will cause the CPU to change to STOP mode.

The following figure shows the operational sequence if there is an overflow of MC-Servo [OB91]:



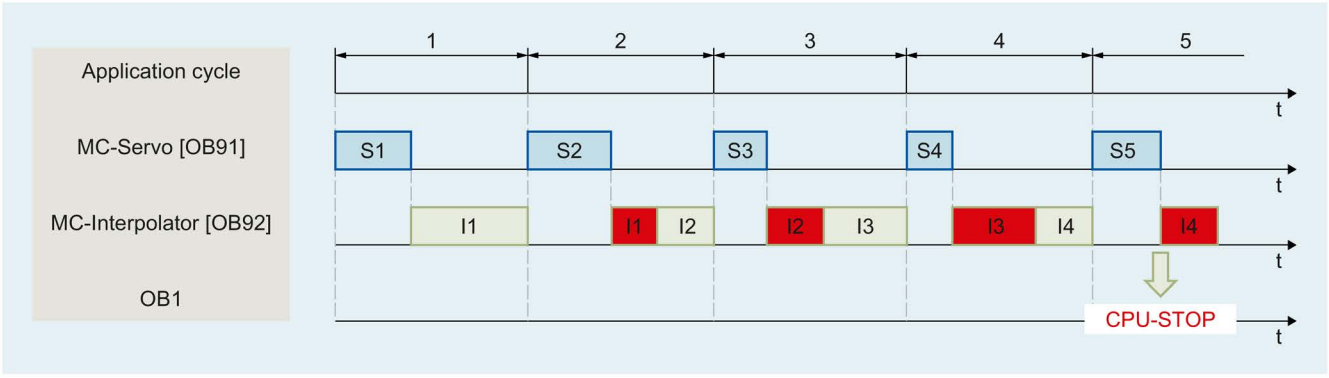
The execution of an MC-Interpolator [OB92] may only be interrupted by an MC-Servo [OB91] call. If more interruptions occur, the CPU switches to STOP mode.

The following figure shows the operational sequence when an MC-Interpolator [OB92] is interrupted over two time slices:



The CPU tolerates a maximum of three consecutive overflows of MC-Interpolator [OB92]. If more overflows occur, the CPU switches to STOP mode.

The following figure shows the operational sequence if there are four consecutive individual overflows of MC-Interpolator [OB92]:



3.2.11.4 Operating modes

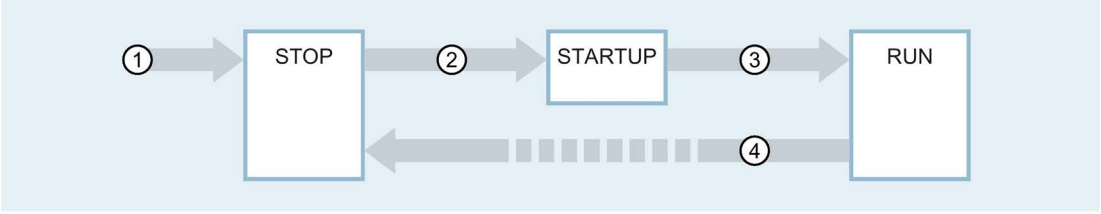
This section examines the behavior of the Motion Control in the respective operating modes and in the transitions between operating modes. A general description of the operating modes can be found in the S7-1500 System Manual

Operating modes and transitions

The CPU has three operating modes:

- STOP
- STARTUP
- RUN

The following figure shows the operating modes and the operating mode transitions:



Operating mode transitions

The following table shows the behavior of the Motion Control in the transitions between the operating modes:

No.	Operating mode transition	Behavior
①	POWER ON → STOP	The CPU performs a restart of the technology objects. The technology objects are reinitialized with the values from the load memory.
②	STOP → STARTUP	Not relevant for Motion Control.
③	STARTUP → RUN	The process outputs are enabled.
④	RUN → STOP	When the CPU changes from RUN mode to STOP mode, all technology objects are disabled in accordance with the alarm response "remove enable". Active Motion Control jobs are aborted. If restart-relevant data has been changed for technology objects in RUN, the CPU performs a restart of the corresponding technology objects.

STOP mode

In STOP mode the user program is not processed and all process outputs are disabled. Thus no Motion Control jobs are executed.

The technology data blocks are updated.

STARTUP mode

Before the CPU starts processing of the cyclical user program, the startup OBs are processed one time.

In STARTUP mode, the process outputs are disabled. Motion Control jobs are rejected.

The technology data blocks are updated.

RUN mode

The user program is processed in RUN mode.

In RUN mode, the programmed Motion Control jobs are cyclically called and processed.

The technology data blocks are updated.

3.3 Speed-controlled axis technology object

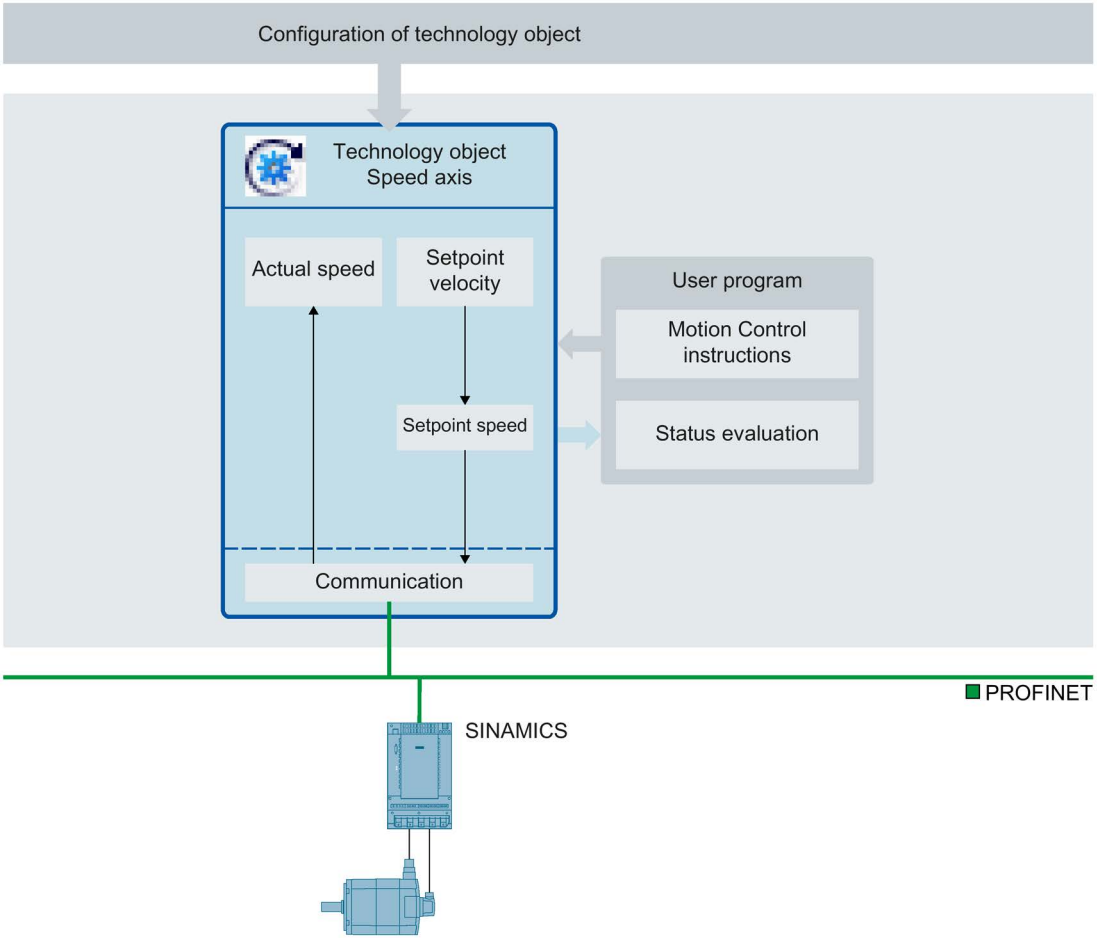
The speed axis technology object calculates speed setpoints, taking into account the dynamic settings, and outputs them to the drive. All motions of the speed axis take place as speed-controlled motions. An existing load gear is taken into account on the system side.

You can find an overview of the functions of the speed axis technology object in the Functions (Page 26) section.

A drive is assigned to each speed axis by means of a PROFIdrive telegram or an analog setpoint interface.

The speed is specified in revolutions per unit of time.

The following figure shows the basic principle of operation of the speed axis technology object:



3.4 Positioning axis technology object

The positioning axis technology object calculates position setpoints, taking into account the encoderc settings, and outputs corresponding speed setpoints to the drive.
In position-controlled mode, all movements of the positioning axis take place as position-controlled movements. For absolute positioning, the physical position must be known to the positioning axis technology object.

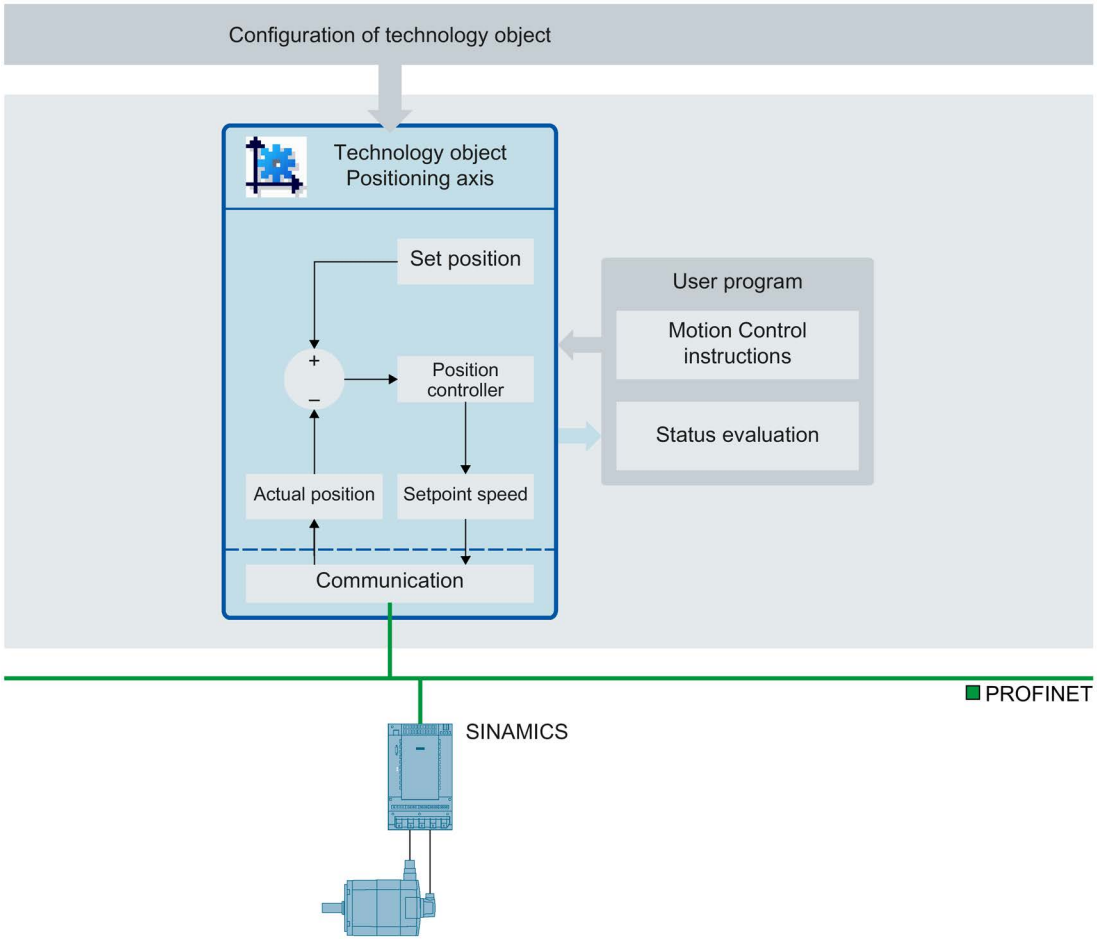
You can find an overview of the functions of the positioning axis technology object in the Functions (Page 26) section.

Each positioning axis is assigned a drive by means of a PROFIdrive telegram or an analog setpoint interface as well as an encoder by means of a PROFIdrive telegram.

The relationship between the encoder values and a defined position is established by the parameter assignment of the mechanical properties and encoder settings and by a homing operation. The technology object can also perform movements without a position relationship, and relative position movements, even without being in a homed status.

A positioning axis can be configured as a linear axis or rotary axis (Page 29), depending on the design of the mechanics.

The figure below shows the basic principle of operation of the positioning axis technology object:



3.5 Synchronous axis technology object

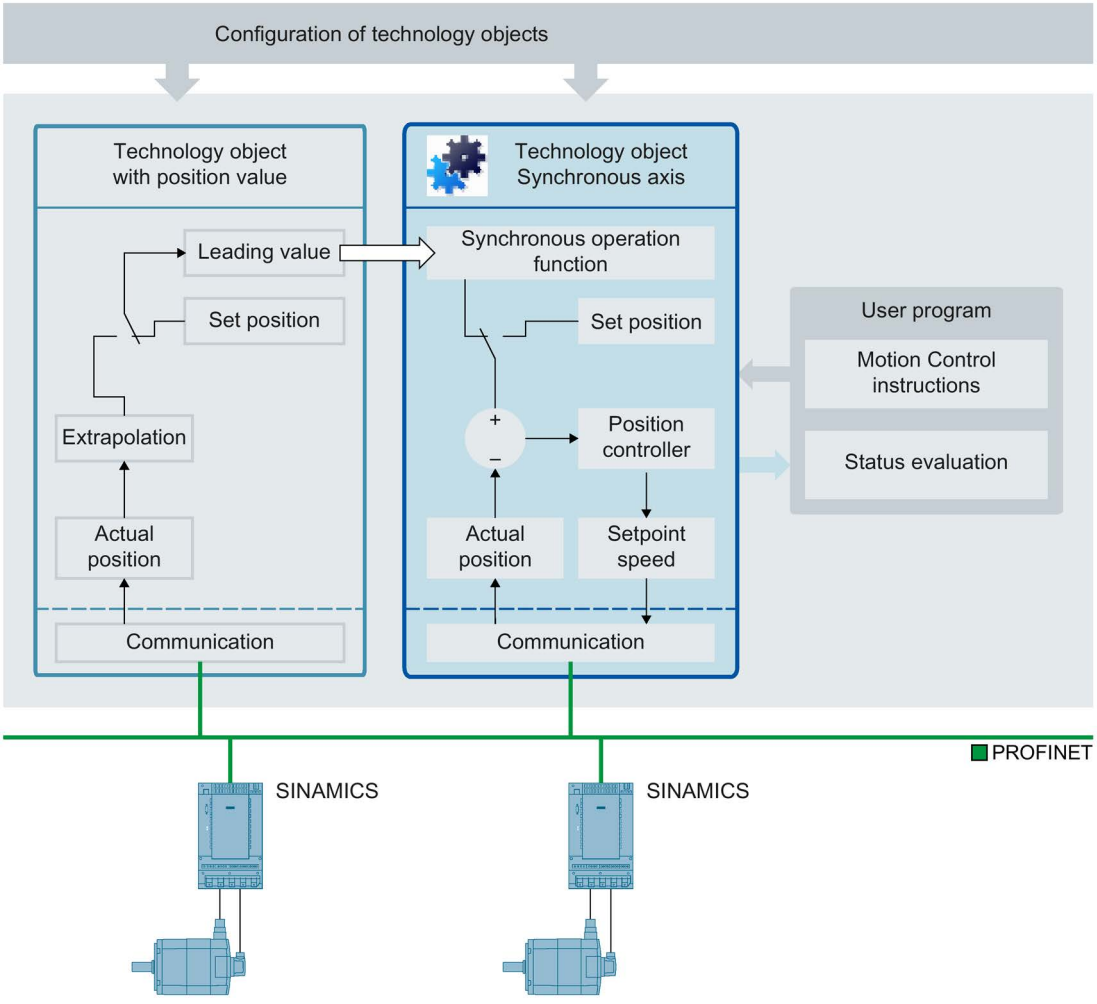
3.5.1 Brief description

The synchronous axis technology object includes all functions of the positioning axis technology object.

A synchronous axis can also follow the motions of a leading axis. The synchronous operation relationship between the leading and following axes is specified by a synchronous operation function.

You can find an overview of the functions of the synchronous axis technology object in the Functions (Page 26) section.

The figure below shows the basic principle of operation of the synchronous axis technology object:



See also

Axis types (Page 29)

3.5.2 Synchronous operation phases

By means of synchronous operation, a following axis can be linked to a leading axis and move synchronously with it.

The synchronous operation proceeds in the following phases:

- **Synchronization**

  The following axis is synchronized to the leading value.

- **Synchronous motion**

  The following axis follows the position of the leading axis according to the synchronous operation function.

- **Synchronous operation override**

  An active synchronous operation is overridden by motion jobs (e.g. MC_Halt) issued to the following axis.

During these phases the dynamic limits apply as described in section Dynamic limits in synchronous operation (Page 62).

Avoid homing the leading axis during an active synchronous operation. Homing the leading axis during synchronous operation corresponds to a setpoint step change on the following axis. The following axis compensates for the step change according to the synchronous operation function and limited only to the maximum speed of the drive.

Note

The leading values and following values are coupled without conversion into the relevant configured user unit. If, for example, a linear leading axis moves by 10 mm, a rotary following axis moves by 10° with at a gear ratio of 1:1.

3.5.3 Leading value coupling

3.5.3.1 Brief description

The leading value for synchronous operation is provided by a leading axis. The leading value is specified and coupled in the user program with the call of the corresponding Motion Control instruction for synchronous operation. The leading value is switched when you call the Motion Control instruction again specifying a different leading axis.

The following rules apply to the leading value coupling:

- A leading axis can output the leading value to several following axes.
- The synchronous axis can be interconnected with different leading values.
  All interconnections required during operation must be set up during configuration of the technology object.
- Only one leading value at a time is coupled and evaluated.

3.5.3.2 Setpoint coupling

With setpoint coupling, the position setpoint of the leading axis is used as the leading value for synchronous operation.

The position setpoint of the following technology objects can be interconnected as the leading value for synchronous operation:

- Positioning axis
- Synchronous axis

3.5.4 Gearing with MC_GearIn

During gearing the position of the following axis results from the position of the leading axis multiplied by the gear ratio. You specify the gear ratio as a ratio of two integers. The result is a linear synchronous operation function.

Synchronous operation with MC_GearIn begins after synchronization when the following axis has reached the velocity and acceleration of the leading axis, taking into account the gear ratio.

Synchronization

Synchronization begins with the start of an "MC_GearIn (Page 434)" job.
When a synchronous axis is synchronizing to a leading value, this is indicated in the technology object tag <TO>.StatusWord.X21 (Synchronizing). Active motion jobs are overridden. The dynamic values (acceleration, delay, jerk) of the following axis for the synchronization are specified at "MC_GearIn".

The synchronization duration and distance are dependent on the following parameters:

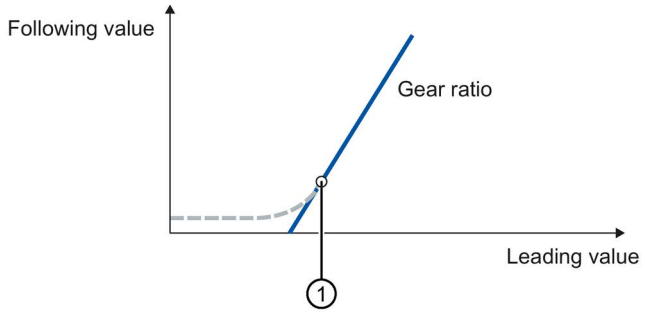
- Start time of the "MC_GearIn" job
- Dynamics of the following axis at the start time
- Dynamic value settings for "MC_GearIn"
- Dynamics of the leading axis

When the following axis has reached the velocity and acceleration of the leading axis, taking into account the gear ratio, the following axis is synchronized. The following axis travels synchronously with the leading axis.

Synchronous motion

When a synchronous axis is synchronized to a leading value, the "Synchronous" status is indicated by parameter "MC_GearIn.InGear" = TRUE as well as in the technology object tag <TO>.StatusWord.X22 (Synchronous). The following axis follows the dynamics of the leading axis according to the gear ratio.

The response characteristic during gearing is expressed by a linear relationship between the leading value and following value.



Gear ratio	Slope of line/transmission ratio Gear ratio = MC_GearIn.RatioNumerator/MC_GearIn.RatioDenominator
- - - - -	Synchronization
①	Position starting from which the leading and following axes move synchronously Position ① is dependent on the above-named parameters (see Synchronization).

The following value is calculated according to the following function:

Position of following axis (following value) = Position ① of following axis + gear ratio × (Position of leading axis - Position ① of leading axis)

Direction

The numerator of the gear ratio is specified as positive or negative.
This yields the following behavior:

- **Positive gear ratio:**
  The leading and following axes move in the same direction.
- **Negative gear ratio**:
  The following axis moves in the opposite direction of the leading axis.

See also

MC_GearIn: Start gear synchronization V3 (Page 434)

3.5.5 Tags for synchronous operation

The following technology object tags are relevant for synchronous operation:

Status indicators	
<TO>.StatusSynchronizedMotion.ActualMaster	When a synchronous operation job is started, the number of the technology data block of the currently used leading axis is displayed. "ActualMaster" = 0 when synchronous operation is inactive
<TO>.StatusWord.X21 (Synchronizing)	Set to value TRUE when the synchronous axis synchronizes to a leading value.
<TO>.StatusWord.X22 (Synchronous)	Set to value TRUE when the synchronous axis is synchronized and moves synchronously to the leading axis,
<TO>.ErrorWord.X14 (SynchronousError)	Error during synchronous operation The leading axis specified in the Motion Control instruction was not configured as a possible leading axis.
<TO>.StatusSynchronizedMotion.StatusWord.X0 (MaxVelocityExceeded)	Set to value TRUE when the maximum velocity configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X1 (MaxAccelerationExceeded)	Set to value TRUE when the maximum acceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X2 (MaxDecelerationExceeded)	Set to value TRUE when the maximum deceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.PhaseShift	Current absolute leading value shift in synchronous operation

3.6 Technology object external encoder

The external encoder technology object detects a position, and makes it available to the controller.

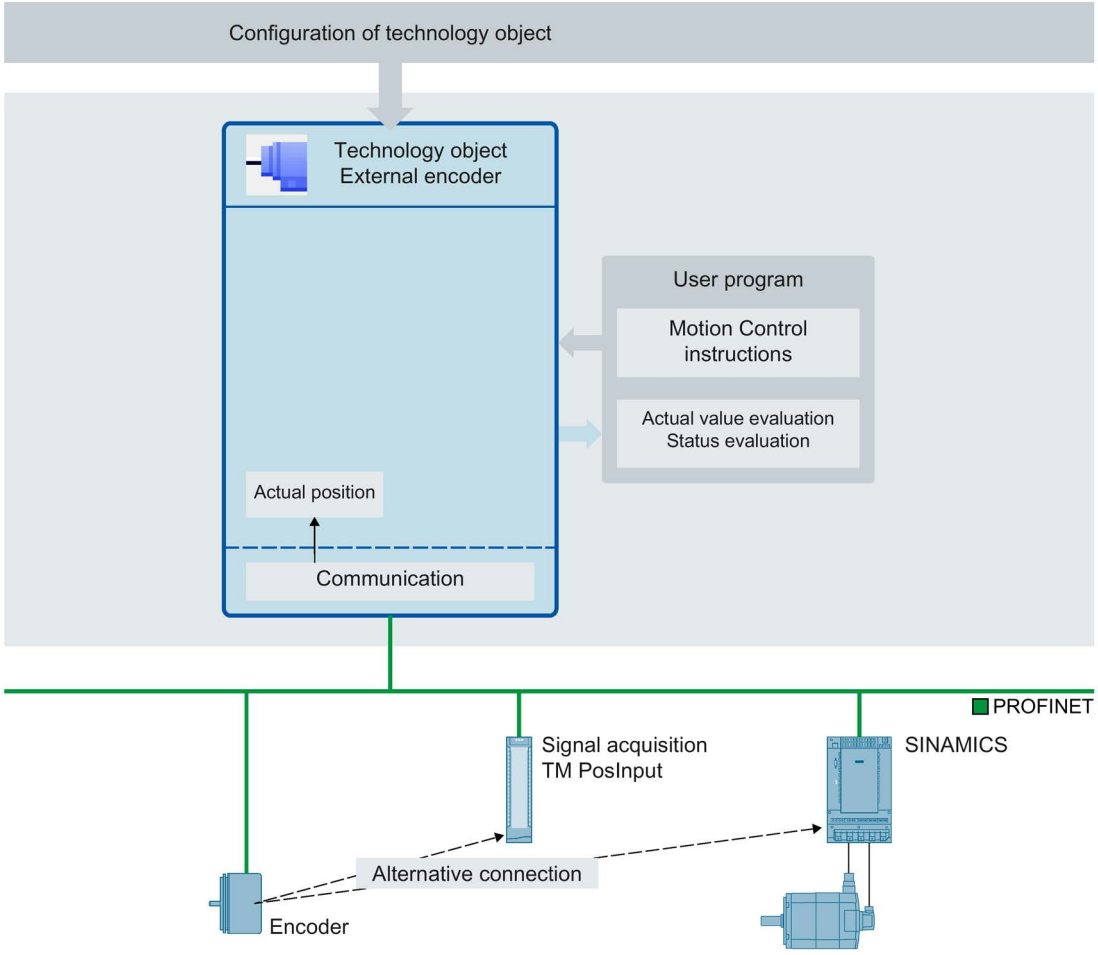
The actual position detected by the external encoder can be used for the following functions, for example:

- Measured value acquisition by a measuring input
- Position-dependent generation of switching signals and switching signal sequences by output cam and cam track with actual value reference.
- As a leading value of a synchronous axis (S7-1500T)

You can find an overview of the functions of the external encoder technology object in the Functions (Page 26) section.

The relationship between the encoder values and a defined position is established by the parameter assignment of the mechanical properties and encoder settings and by a homing operation.

The following figure shows the basic principle of operation of the external encoder technology object:



Specification of the position occurs according to the selected system of units:

- **Linear system of units**

  The position is specified as a linear measure, e.g. millimeters.

- **Rotary system of units**

  The position is specified as an angular measure, e.g. degrees.

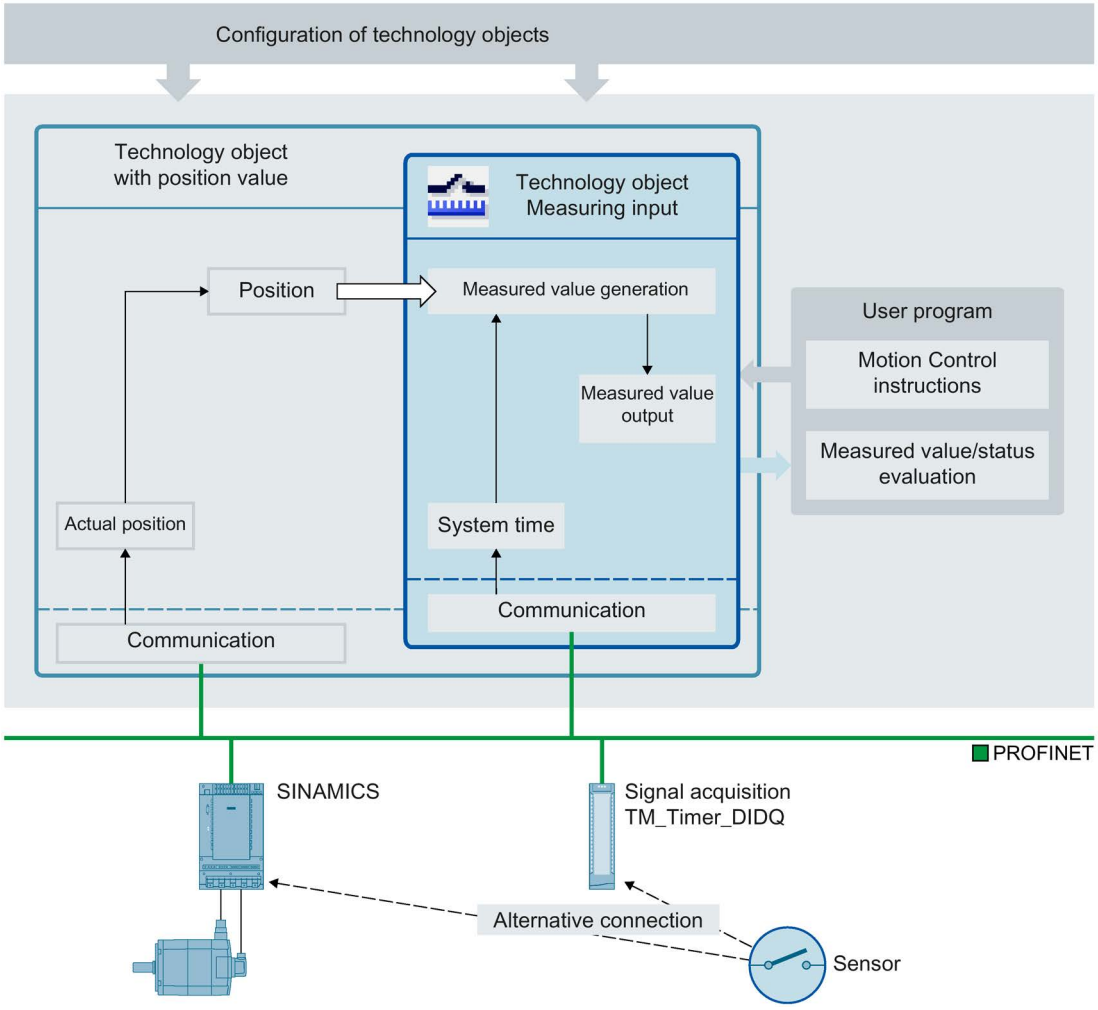
3.7 Technology object measuring input

3.7.1 Brief description

The measuring input technology object acquires the actual position of an axis or external encoder at a signal change at the measuring input.

You can find an overview of the functions of the measuring input technology object in the Functions (Page 26) section.

The figure below shows the basic principle of operation of the measuring input technology object:



Measurement types

Two types of measurement can be performed:

- One-time measurement (Page 118)

  Up to two measured values are acquired with edge accuracy with one measuring job.
  A one-time measuring job is started with "MC_MeasuringInput".

- Cyclic measuring (Page 119)

  With cyclic measuring, up to two measured values are acquired with edge accuracy in each position control cycle.

  A cyclic measuring job is started with "MC_MeasuringInputCyclic".
  The measurements are continued cyclically until they are ended per command.

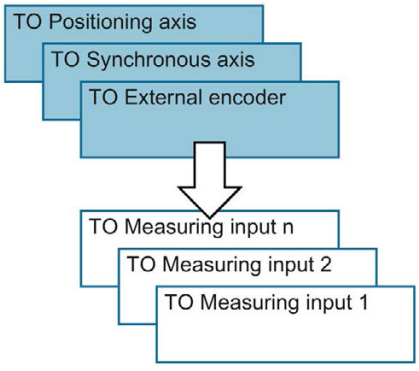
The edges to be detected are selected when starting the measurement using Motion Control instruction "MC_MeasuringInput" or "MC_MeasuringInputCyclic".

Assignment

The measuring input technology object must always be assigned to another technology object whose position will be evaluated by the measuring input.

The measuring input technology object can be assigned to the following technology objects:

- Synchronous axis
- Positioning axis
- External encoder



Exactly one axis or one external encoder can be assigned to a measuring input technology object.

An axis or external encoder can be assigned multiple measuring input technology objects.

Measured value determination

The position can be detected using support from the hardware in one of the following ways:

- Measuring using TM Timer DIDQ (time-based)
- Measuring with SINAMICS measuring input (time-based)
- Measuring using PROFIdrive telegram (drive or external encoder)

A measuring job is activated using Motion Control instruction "MC_MeasuringInput" or "MC_MeasuringInputCyclic".

With time-based measuring ("TIME_BASED"), a signal change of the external trigger signal for the measurement is detected via a corresponding module such as TM Timer DIDQ or SINAMICS Drive. The time stamp is transferred to the controller and the associated actual position is determined in the technology object.

With direct position detection ("PROFIDRIVE"), the measurement input is connected to the drive device and the measurement is implemented in the drive. The drive or encoder module directly supplies the acquired position value to the technology object via the PROFIdrive telegram.

The resulting measured value is indicated at the respective output of the Motion Control instruction "MC_MeasuringInput" or "MC_MeasuringInputCyclic".

Cyclic measuring is only possible when measuring using TM Timer DIDQ. One-time measuring is always possible.

Measuring using TM Timer DIDQ requires isochronous mode.

For measuring using a PROFIdrive telegram, only one measuring input at a time can be active on an actual value or encoder in the PROFIdrive telegram. A maximum of two measuring inputs via PROFIdrive can be configured on an actual value or encoder in the PROFIdrive telegram Refer to Automatic transfer of drive and encoder parameters in the device (Page 40).

Correction time

The time of the measurement can be corrected by setting a correction time (<TO>.Parameter.CorrectionTime) for the measuring input technology object.

Corrections may be required for the following examples:

- Times for mechanical displacement of the measuring input
- Times for the generation of the measured signal before the input at the measurement module
- Filter times at the input or filter times for the measurement inputs on the SINAMICS drive unit

The correction time is calculated by the measuring input technology object for time-based measured value acquisition ("TIME_BASED") and for direct position detection ("PROFIDRIVE").

Also note the time delay when measuring on a virtual axis. See section Brief description (Page 37).

3.7.2 Measuring

3.7.2.1 One-time measurement

With one-time measurement, up to two edges can be detected with one measuring job. The associated actual positions are signaled back in the function block and in the technology DB and can be further processed in the user program.

Measuring job

A measuring job is started using the Motion Control instruction "MC_MeasuringInput". The <TO>.Status tag in the technology data block changes to "WAITING_FOR_TRIGGER". The technology object activates the measurement when the selected edge is detected.

The measurement occurs at the measurement input in the form of up to two system times. Based on the times, the associated position is determined and output, taking into consideration a correction time, if present.

With direct position detection, the detected position value is supplied directly from the drive or encoder module to the technology object via the PROFIdrive telegram.

The measurement is then finished. An additional measurement must be restarted using Motion Control instruction "MC_MeasuringInput".

Table 3- 1 Mode and display of the results of measurement results when using one-time measurement

Configured "Mode" parameter in Motion Control instruction "MC_MeasuringInput"	Output of Motion Control instruction "MC_MeasuringInput"	
	MeasuredValue1	MeasuredValue2
Measure positive edge only	Actual position at the time of the edge	–
Measure negative edge only		
Measure the next two edges	Actual position at the time of the first edge	Actual position at the time of the second edge
Measure the next two edges starting with the positive edge	Actual position at the time of the positive edge	Actual position at the time of the negative edge
Measure the next two edges starting with the negative edge	Actual position at the time of the negative edge	Actual position at the time of the positive edge

The last detected values are set in the technology data block. If a new job is initiated with the function block, the outputs of the function block are initialized. The technology data block is not initialized. After detecting the first valid measuring cycle, the values in the technology data block and function block are consistent with one another.

The finished measuring command is indicated in the function block in "MC_MeasuringInput.DONE" = TRUE or in the technology data block in <TO>.Status = "TRIGGER_OCCURRED".

See also

MC_MeasuringInput: Start measuring once V3 (Page 416)

3.7.2.2 Cyclic measuring

With cyclic measuring, up to two measuring events can be acquired by the system in each position control cycle of the technology object and the associated measuring positions can be displayed. The measurements are continued cyclically until they are ended per command.

The determined measured values are displayed and can be read by the user program.

Cyclic measuring requires the measured value to be determined using the following type of hardware support: "Measuring using Timer DIDQ".

Measuring edges at which a measured value could not be determined are indicated in a lost edge counter in the technology DB as well as in function block "MC_MeasuringInputCyclic".

Measuring job

A cyclic measuring job is started with Motion Control instruction "MC_MeasuringInputCyclic", and the measuring job is issued to the corresponding technology module. Depending on the functionality of the technology module, up to two measuring events and thus measuring times can be captured with edge reference in each position control cycle and then forwarded to the technology object. The technology object determines the measuring positions for the measuring times taking into consideration any specified correction times.

The technology data block tag "<TO>.Status" changes from "INACTIVE" to "WAITING_FOR_TRIGGER" and remains in this status as long as additional events are awaited.

The mode set in the Motion Control instruction specifies the edges for which the measured values are to be acquired. At most, the following edges can be detected in each position control cycle:

- Two positive edges when detecting positive edges
- Two negative edges when detecting negative edges
- One positive edge and one negative edge when detecting positive and negative edges

Measured values and counters

With a positive edge at the input MC_MeasuringInputCyclic.Execute, outputs MeasuredValue1Counter and MeasuredValue2Counter are reset to "0". As a result, new events can be tracked immediately and new measured value entries can be detected.

All measuring event occurrences of the measuring job are incremented by "1" in the corresponding event counters <TO>.MeasuredValues.MeasuredValue1Counter and <TO>.MeasuredValues.MeasuredValue2Counter of the technology data block.

The acquired measured values are continuously captured in the technology data block irrespective of individual jobs and the values are only reset to "0" at power-up or restart of the technology object.

After a completed measurement, the measured values are output in the function block. The counters of the function block are set to "0" at a new measuring job. The measured value output in the technology data block always indicates the last acquired measured value.

Lost edge counter (LEC)

If more than two edges to be detected occur within one position control cycle, a measured value cannot be evaluated for the other edges to be detected. The number of lost edges is recorded in the LEC.

The lost edges that are recorded in the LEC depend on the mode set in the Motion Control instruction. For example, if only positive edges are to be measured, the LEC records only the non-measured positive edges.

A maximum of seven lost edges can be counted and displayed in the LEC.

The number of lost edges is indicated in the function block and in the technology data block in:

- LostEdgeCounter1

  Lost cleared edges from the position control cycle in which MeasuredValue1 was acquired.

  ⇒ The displayed value in LostEdgeCounter1 is updated when counter MeasuredValueCounter1 is incremented.

- LostEdgeCounter2

  Lost cleared edges from the position control cycle in which MeasuredValue2 was acquired.

  ⇒ The displayed value in LostEdgeCounter2 is updated when counter MeasuredValueCounter2 is incremented.

Display of measurement results when using cyclic measuring

Edges selected in the command	Display per position control cycle			
	MeasuredValue1	MeasuredValue2	LostEdgeCounter1	LostEdgeCounter2
Detect positive edges only "MC_MeasuringInputCyclic.-Mode" = 0	Actual position at the time of the first positive edge	Actual position at the time of the second positive edge	Number of positive or negative edges in excess of two in the position control cycle of acquisition of MeasuredValue1 and MeasuredValue2. The following applies here: • If a MeasuredValue1 **and** a MeasuredValue2 are acquired, the number of acquired and lost edges indicated in LostEdgeCounter1 and LostEdgeCounter2 are the same. • If **only** one MeasuredValue1 is acquired, the LostEdgeCounter1 is reset to "0". The value in LostEdgeCounter2 remains changed.	
Detect negative edges only "MC_MeasuringInputCyclic.-Mode" = 1	Actual position at the time of the first negative edge	Actual position at the time of the second negative edge		
Detect positive and negative edges "MC_MeasuringInputCyclic.-Mode" = 2	Actual position at the time of the first positive edge in the position control cycle	Actual position at the time of the first negative edge in the position control cycle	Number of edges in excess of two in the position control cycle of acquisition of MeasuredValue1 and MeasuredValue2. The following applies here: • If a MeasuredValue1 **and** a MeasuredValue2 are acquired, the number of acquired and lost edges indicated in LostEdgeCounter1 and LostEdgeCounter2 are the same. • If **only** one MeasuredValue1 is acquired, the LostEdgeCounter1 is reset to "0". The value in LostEdgeCounter2 remains changed. • If **only** one MeasuredValue2 is acquired, the LostEdgeCounter2 is reset to "0". The value in LostEdgeCounter1 remains changed.	

The following figures show examples of divergence of MeasuredValue1Counter and MeasuredValue2Counter as a result of lost edges.

Example of measurement at positive edges (Mode = 0)

Processing cycle clock TO Measuring input	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Measuring input											
MeasuredValue1Counter	...	6	7	7	8	9	9	10	11	12	13
LostEdgeCounter1	...	0	0	0	0	0	0	1	0	1	0
MeasuredValue2Counter	...	6	7	7	7	7	7	8	8	9	9
LostEdgeCounter2	...	0	0	0	0	0	0	1	1	1	1

Example of measurement at negative edges (Mode = 1)

Processing cycle clock TO Measuring input	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Measuring input											
MeasuredValue1Counter	...	6	7	8	9	10	10	11	11	12	13
LostEdgeCounter1	...	0	0	0	1	0	0	1	1	1	0
MeasuredValue2Counter	...	6	7	7	8	8	8	9	9	10	10
LostEdgeCounter2	...	0	0	0	1	1	1	1	1	1	1

Example of measurement at positive and negative edges (Mode = 2)

Processing cycle clock TO Measuring input	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Measuring input											
MeasuredValue1Counter	...	6	7	7	8	9	9	10	11	12	13
LostEdgeCounter1	...	0	2	2	0	0	0	3	0	4	0
MeasuredValue2Counter	...	6	7	8	8	9	10	11	12	13	14
LostEdgeCounter2	...	0	2	0	0	0	0	3	0	4	0

See also

MC_MeasuringInputCyclic: Start cyclic measuring V3 (Page 420)

3.7.3 Measuring with measuring range

A measuring job can be activated directly or restricted to a defined measuring range.

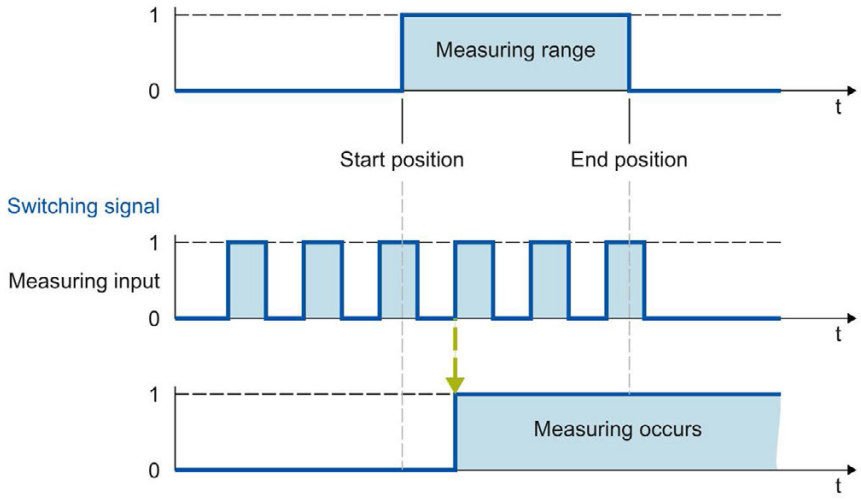
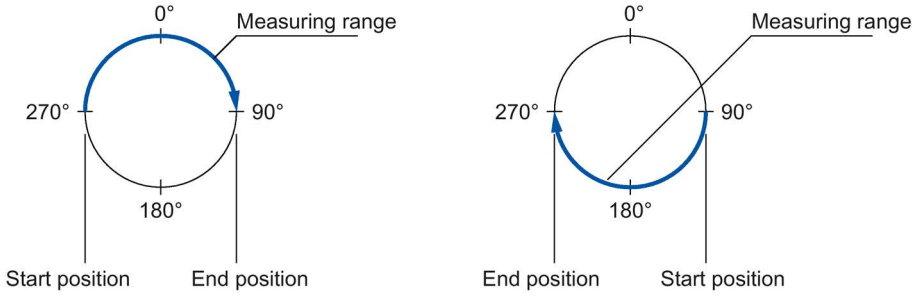


Figure 3-1 Example of measuring with measuring range in Mode = 0 (measurement of next positive edge)

Only measured values within the measuring range are displayed for the technology object.

- If no measuring edge within the measuring range is detected during a one-time measurement, the measuring job is canceled and an alarm is triggered.
- Cyclic measuring remains active even if no measuring edge within the measuring range was detected.

For axes without modulo function, it is immaterial in which order the start and end positions are specified. If the start position is greater than the end position, the two values are interchanged in the application. If the start position for an axis with modulo function is greater than the end position, the measuring range is extended from the start position past the modulo transition of the axis to the end position.



The measuring range positions are specified in Motion Control instruction MC_MeasuringInput or MC_MeasuringInputCyclic.

Activation time for the measuring range

The measuring function must be active at the measurement input when the start of the measuring range is reached. To compensate for the communication time for activation in the TM Timer DIDQ or drive, for example, the activation of the measurement in the technology object begins earlier then the measuring range start by the amount of the activation time.

The activation time for measuring with measuring range is divided up as follows:

- The activation time allocation defined and active on the system side is indicated in the <TO>.Parameter.MeasuringRangeActivationTime tag.
- An additional activation time can also be set by the user with the <TO>.Parameter.MeasuringRangeAdditionalActivationTime tag.

3.7.4 Time-related boundary conditions

Depending on the hardware configuration and selection of edges to be detected, different system-inherent requirements apply to the time allowed after calling the Motion Control instruction "MC_MeasuringInput" or "MC_MeasuringInputCyclic" until a measurement occurs and the results are displayed.

The following times must be distinguished here:

- Time until the measuring event can be captured
- Time until the measurement result is displayed or the measurement is finished.

The times calculated taking into account the current settings are indicated in configuration window "Extended parameters" of a measuring input.

Measuring using TM Timer DIDQ / Measuring using SINAMICS measuring input

- Time from output of an MC_MeasuringInput job until measuring event detection becomes effective:
  - MeasuringRangeActivationTime: 2 x T_{servo}
- Minimum time after measuring event until measured value is available in the controller:
  - One-time measurement: 2 x T_{servo} + T_{dp}
  - Cyclic measuring: T_{servo} + T_{dp}
- Activation time for a measurement with measuring range:
  - MeasuringRangeActivationTime + MeasuringRangeAdditionalActivationTime

Measuring using PROFIdrive telegram (drive or external encoder)

- MeasuringRangeActivationTime: 4 x T_{servo}
- Time from output of an MC_MeasuringInput job until measuring event detection becomes effective:
  - Measuring a positive/negative edge or two edges:

    MeasuringRangeActivationTime + 2 x T_{servo}
  - Measuring two dedicated edges:

    MeasuringRangeActivationTime + 3 x T_{servo}
- Minimum time after measuring event until measured value is available in the controller:
  - Measuring an edge: 7 x T_{servo}
  - Measuring two edges: 13 x T_{servo}
- Activation time for a measurement with measuring range:
  - Measuring a positive/negative edge or two edges:

    MeasuringRangeActivationTime + MeasuringRangeAdditionalActivationTime + 2 x T_{servo}
  - Measuring two dedicated edges:

    MeasuringRangeActivationTime + MeasuringRangeAdditionalActivationTime + 3 x T_{servo}

Definition of tags:

- T_{servo} = Call interval of the technology object in the servo cycle clock [ms]
- T_{dp} = Bus cycle clock (on PN) [ms]
- MeasuringRangeActivationTime = See section Measuring with measuring range (Page 123)

To prevent asynchronous processing from overwriting a measured value that was just determined, a new one-time measuring job cannot be started until the active measurement has concluded. The sum of the activation time and the time until display or conclusion must be taken into account for this.

With cyclic measuring, evaluation or temporary storage of the measurement results in the synchronous MC-PostServo [OB95] is recommended from the user perspective.

3.7.5 Tags

Status display	
<TO>.Status	Measuring input function status 0: Measurement is not active ("INACTIVE") 1: The measuring input is waiting for a measuring event ("WAITING_FOR_TRIGGER") 2: The measuring input has acquired one or more measured values ("TRIGGER_OCCURRED"). 3: Error during the measurement ("MEASURING_ERROR")
<TO>.InputState	Measuring input input status
Parameters	
<TO>.Parameter.MeasuringInputType	Measuring input type
<TO>.Parameter.PROFIdriveProbe-Number	Number of the measuring input to be used for a measurement using PROFIdrive telegram
<TO>.Parameter.MeasuringRange-ActivationTime	System-defined activation time allocation [ms]
<TO>.Parameter.MeasuringRange-AdditionalActivationTime	Additional user-defined activation time allocation [ms]
<TO>.Parameter.CorrectionTime	User-defined correction time for the measurement result [ms]
Interface	
<TO>.Interface.Address	I/O address for the digital measuring input
Units	
<TO>.Units.LengthUnit	Unit of the length data
<TO>.Units.TimeUnit	Unit of the time data
MeasuredValues	
<TO>.MeasuredValues.Measured-Value1	First measured value
<TO>.MeasuredValues.Measured-Value2	Second measured value (when measuring two or more edges in one position control cycle)
<TO>.MeasuredValues.Measured-Value1Counter	Count value for the first measured value
<TO>.MeasuredValues.Measured-Value2Counter	Count value for the second measured value
<TO>.MeasuredValues.LostEdge-Counter1	Lost edges in the cycle clock of the first measured value acquisition (zero in the case of one-time measurement)
<TO>.MeasuredValues.LostEdge-Counter2	Lost edges in the cycle clock of the second measured value acquisition (zero in the case of one-time measurement)

StatusWord	
<TO>.StatusWord.X0 (Control)	The technology object is in operation.
<TO>.StatusWord.X1 (Error)	An error occurred at the technology object.
<TO>.StatusWord.X2 (RestartActive)	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart.
<TO>.StatusWord.X3 (OnlineStartValuesChanged)	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object.
<TO>.StatusWord.X5 (CommunicationOk)	The measuring input is synchronized with the measuring module and can be used.
ErrorWord	
<TO>.ErrorWord.X0 (SystemFault)	A system-internal error has occurred.
<TO>.ErrorWord.X1 (ConfigFault)	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program.
<TO>.ErrorWord.X2 (UserFault)	Error in user program at a Motion Control instruction or its use.
<TO>.ErrorWord.X3 (CommandNotAccepted)	Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
<TO>.ErrorWord.X13 (PeripheralError)	Error accessing a logical address.
ErrorDetail	
<TO>.ErrorDetail.Number	Alarm number
<TO>.ErrorDetail.Reaction	Effective alarm reaction 0: No reaction 6: End measuring input processing

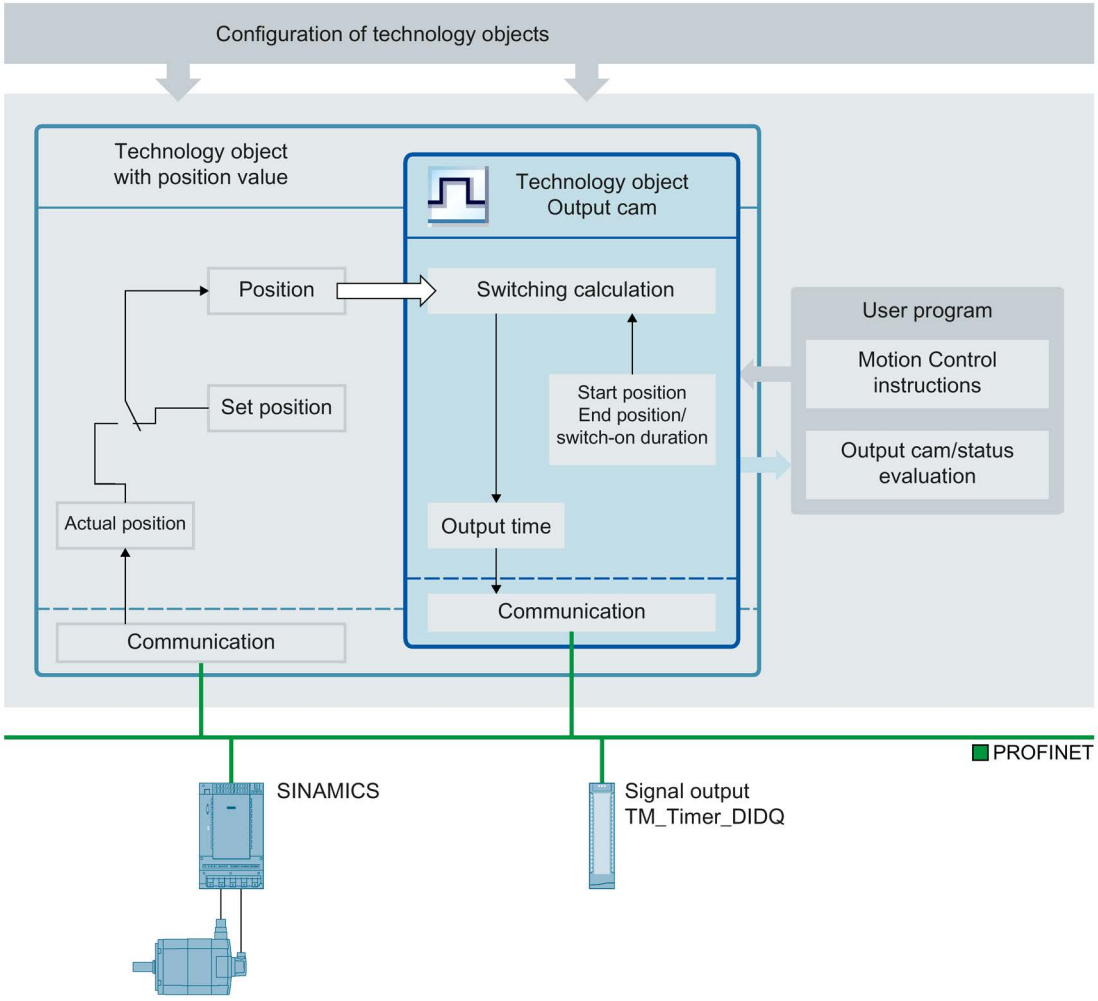
3.8 Technology object output cam

3.8.1 Brief description

The output cam technology object generates switching signals depending on the position of an axis or external encoder. The switching states can be evaluated in the user program and fed to digital outputs.

You can find an overview of the functions of the output cam technology object in the Functions (Page 26) section.

The figure below shows the basic operating principle of the output cam technology object:



Output cam types

The following output cam types can be used:

- Distance output cam (Page 133)

  Distance output cams switch on between the start position and end position. Outside this range, the distance output cam is switched off.

- Time-based output cam (Page 135)

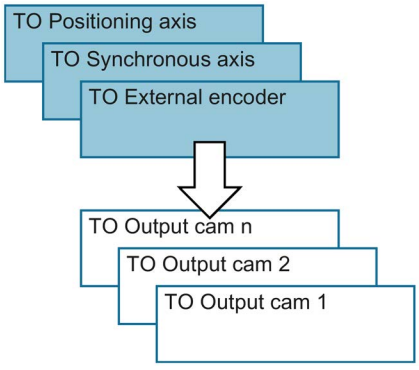
  Time-based output cams switch on for a defined time period when the start position is reached.

Assignment

The output cam technology object must always be assigned to another technology object whose position will be evaluated.

The output cam technology object can be assigned to the following technology objects:

- Synchronous axis
- Positioning axis
- External encoder



Exactly one axis or one external encoder can be assigned to an output cam.

Multiple output cams can be assigned to one axis or external encoder.

Output cam calculation and output cam output

The output cam technology object calculates the exact switching time, thereby ensuring exact adherence to the switching positions. The switching time is calculated two position control cycles before the output.

The following output options are available for the digital cam output:

- TM Timer DIDQ

  Digital output with high degree of accuracy and reproducibility in the microsecond range on ET 200MP TM Timer DIDQ 16x24V and ET 200SP TM Timer DIDQ 10x24V time-based IO modules

  Output by TM Timer DIDQ requires isochronous mode. Isochronous mode is only possible with PROFINET interface modules.

- Digital output module

  Digital output with switching accuracy depending on the output cycle of the I/O used

When output is deactivated, the output cam status is not output at the hardware output. The output cam status can be used internally in the user program by evaluating the relevant "<TO>.CamOutput" tag.

Inverted output

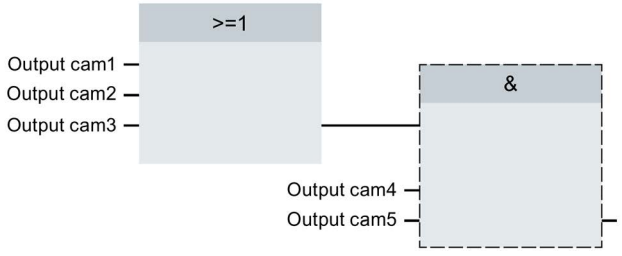
In the case of the inverted output, the range in which the cam output is switched on and the range in which it is switched off are swapped.

The inverted output is set in Motion Control instruction "MC_OutputCam" and is active when the instruction is enabled.

The inverted output can be used for both distance output cams and time-based output cams.

Output of multiple output cams to one output

The output of multiple output cams to one output is performed with either an AND or OR logic operation of the output cam signals to the output.



Display of the switching state

The switching state of the output cam is displayed in the associated technology DB in "<TO>.CamOutput".

Position reference

The switching points of the output cams can be referenced to the following positions, depending on the interconnected technology object.

- Actual position of a synchronous axis/positioning axis
- Position setpoint of a synchronous axis/positioning axis
- Position of an external encoder

Homing the interconnected technology object

A change to the position of an axis or external encoder using Motion Control instruction "MC_Home" is regarded as a sudden position change.

- Distance output cams are either skipped or correspondingly output.
- Time-based output cams are skipped. A time-based output cam is switched on only when the start position is crossed and remains switched on for the on-load factor.
- Switched time-based output cams are not canceled by a homing operation.

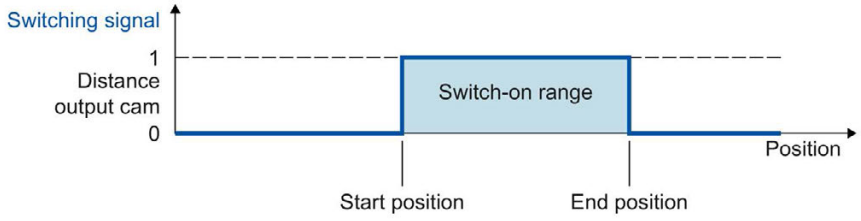
3.8.2 Distance output cam

Switch-on range

The switch-on range of distance output cams is basically defined by the start position and end position.

Start position smaller than end position

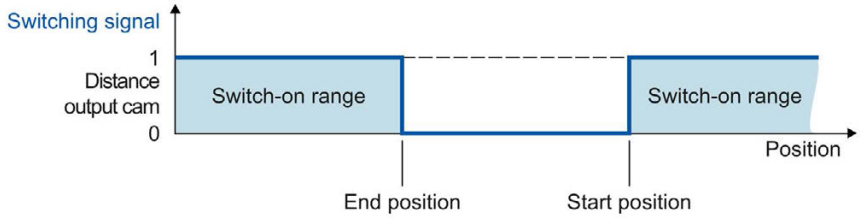
When the start position is less than the end position, the switch-on range begins with the start position and ends with the end position.



Start position greater than end position

When the start position is greater than the end position, there are two switch-on ranges as follows:

- Switch-on range beginning with the start position and ending with the positive range end (e.g. positive software limit switch, end of modulo range)
- Switch-on range beginning with the negative range end (e.g. negative software limit switch, start of modulo range) and ending with the end position



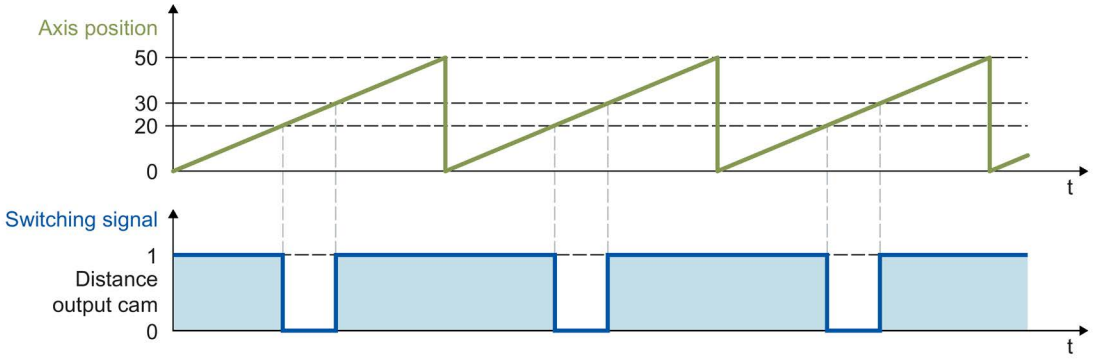
Mapping to an axis with modulo function

With active modulo function of the interconnected technology object, the start and end positions of the output cam are automatically mapped to values within the modulo range.

Example

- Modulo range = 0° to 50°
- Output cam start position = 80°
- Output cam end position = 220°

⇒ The distance output cam switches on at 30° and switches off again at 20°.



Switching characteristics

After activation, a distance output cam switches on in the following cases:

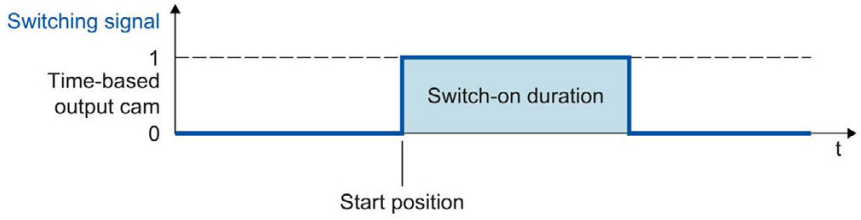
- The position of the interconnected technology object reaches the start or end position in the activation direction configured in Motion Control instruction "MC_OutputCam".
- The position of the interconnected technology object is moved into the switch-on range of the output cam (e.g. during homing) in the activation direction configured in Motion Control instruction "MC_OutputCam". If both activation directions are enabled in Motion Control instruction "MC_OutputCam", the output cam switches on even when the interconnected technology object is at a standstill.
- The output cam is switched on permanently using Motion Control instruction "MC_OutputCam" with "Mode" = 3.

An active distance output cam switches off in the following cases:

- The position is outside the switch-on range of the output cam.
- The position value is moved outside the switch-on range of the output cam.
- Motion Control instruction "MC_OutputCam" is set to "Enable" = FALSE.
- The motion direction of the interconnected technology object is reversed and no longer agrees with the enabled activation direction.

3.8.3 Time-based output cam

A time-based output cam switches on at the start position and remains set for the on-load factor.



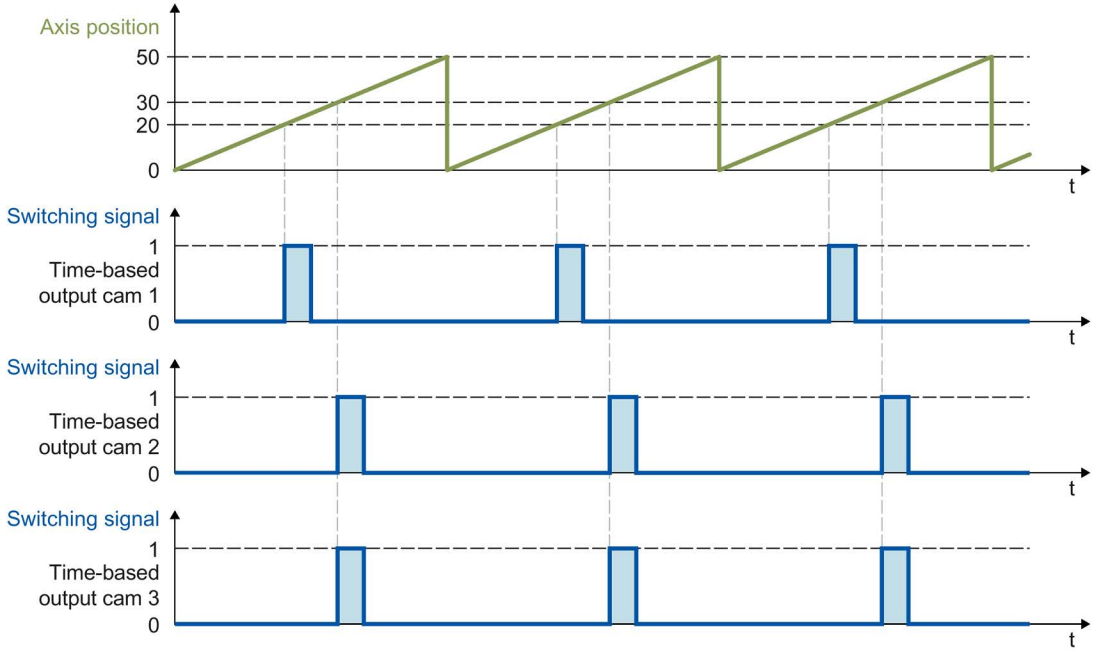
Mapping to an axis with modulo function

In the case of active modulo function of the interconnected technology object, the start position of the output cam is automatically mapped to the value within the modulo range.

Example

- Modulo range = 0° to 50°
- Output cam start positions:
  - Output cam 1 = 20°
  - Output cam 2 = 30°
  - Output cam 3 = 80°

⇒ The time-based output cam 1 switches on at 20°, the time-based output cams 2 and 3 switch on at 30°. All three output cams remain active the set on-load factor in each case.



Switching characteristics

A time-based output cam switches on in the following cases:

- The start position has been reached and the motion direction of the interconnected technology object corresponds to the effective direction enabled by the instruction.

Note

- If the start position is reached again while an output cam is switched on, the on-load factor is not re-triggered.
- If due to the Motion Control instruction "MC_Home", the position value of the interconnected technology object is placed directly on or behind the start position of the output cam during the motion, the output cam does not switch on.

A time-based output cam switches off in the following cases:

- The configured on-load factor has expired.
- Motion Control instruction "MC_OutputCam" is set to "Enable" = FALSE.

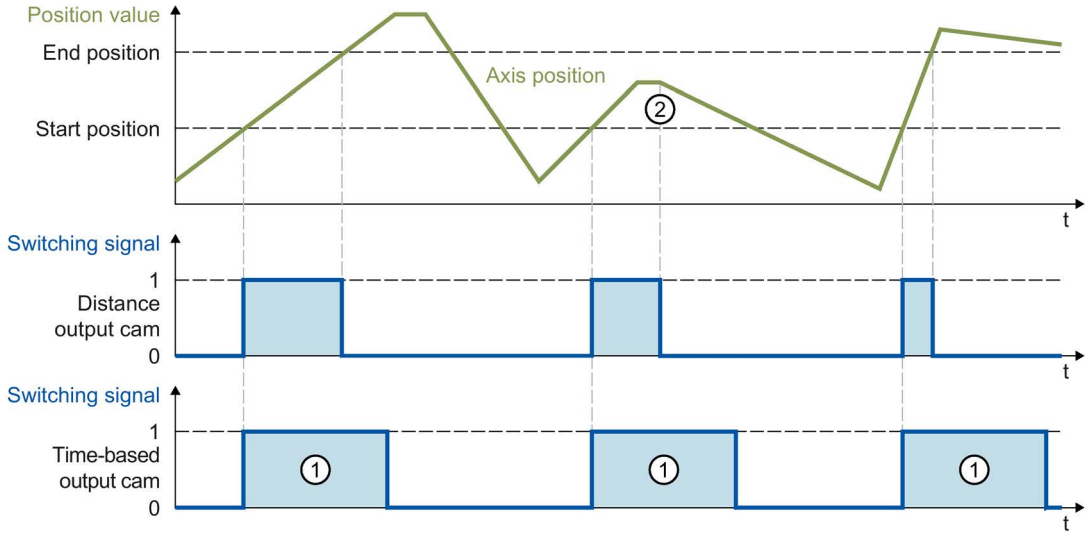
3.8.4 Activation direction of cam

An output cam can be switched depending on the motion direction of the interconnected technology object. It is possible to output an output cam with positive or negative motion direction only or even independent of direction.

The effective direction is set in "MC_OutputCam.Direction".

The following examples show the behavior of the output cam as a function of the effective direction setting.

Example of "positive" effective direction ("Direction" = 1)



Distance output cam

The output cam switches on when the switch-on range is reached in the **positive** direction. At a direction reversal ②, the output cam switches off.

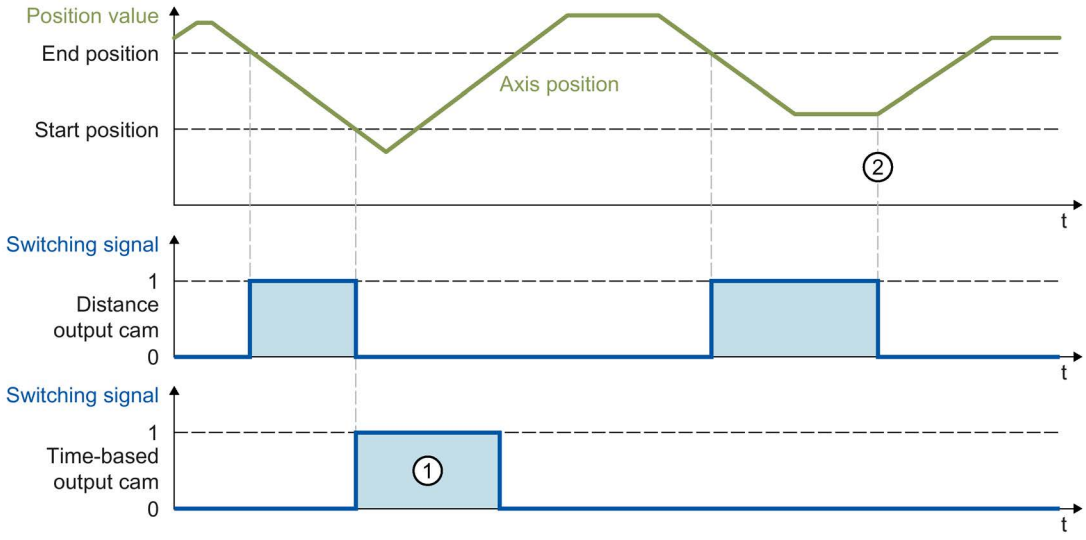
If the position value is moved into the switch-on range of the output cam, the cam switches on when there is positive motion direction of the interconnected technology object. The output cam remains switched off when the interconnected technology object is at a standstill.

Time-based output cam

The output cam switches on when the start position is reached in the **positive** direction. At a direction reversal, the output cam remains switched on for the specified on-load factor ①.

If during the homing motion, the position value of the interconnected technology object is directly on or behind the start position of the output cam, the output cam does not switch on.

Example of "negative" effective direction ("Direction" = 2)



Distance output cam

The output cam switches on when the switch-on range is reached in the **negative** direction. At a direction reversal ②, the output cam switches off.

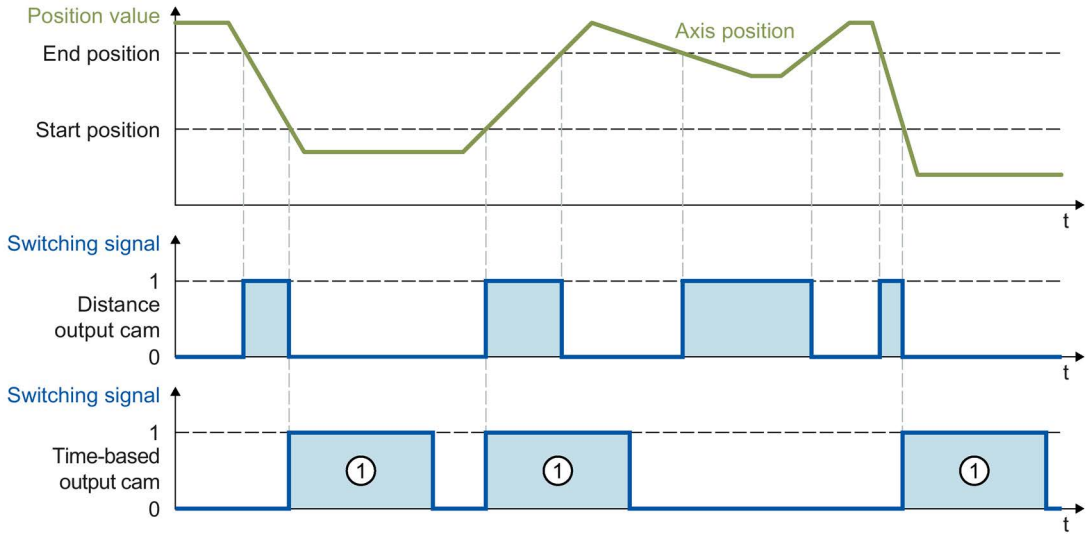
If the position value is moved into the switch-on range of the output cam, the output cam switches on when there is negative motion direction of the interconnected technology object. The output cam remains switched off when the interconnected technology object is at a standstill.

Time-based output cam

The output cam switches on when the start position is reached in the **negative** direction. At a direction reversal, the output cam remains switched on for the specified on-load factor ①.

If during the homing motion, the position value of the interconnected technology object is directly on or behind the start position of the output cam, the output cam does not switch on.

Example of "both directions" effective direction ("Direction" = 3)



Distance output cam

The output cam switches on when the position of the interconnected technology object is within the switch-on range.

If the position value of the interconnected technology object is moved into the switch-on range of the output cam, the cam switches on even when the interconnected technology object is at a standstill.

Time-based output cam

The output cam switches on when the start position is reached. At a direction reversal, the output cam remains switched on for the specified on-load factor ①.

If during the homing motion, the position value of the interconnected technology object is directly on or behind the start position of the output cam, the output cam does not switch on.

3.8.5 Hysteresis

Possible variations in the actual position/position setpoint can result in unwanted switch-on and switch-off of cams.

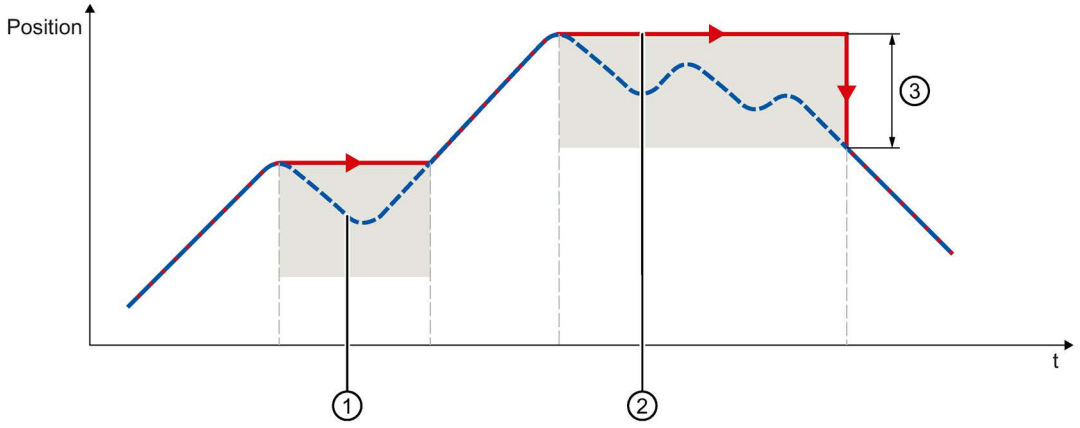
Minimal changes of the actual value of an axis at standstill can result in switch-on or switch-off of an actual value output cam with specified positive or negative effective direction. Even minimal changes of the setpoints of a switched-off axis in follow-up mode can result in switch-on or switch-off of an actual value output cam with specified positive or negative effective direction. Such unwanted switching states can be prevented by configuring a hysteresis (> 0.0). The configuration of a hysteresis value (> 0.0) is recommended in particular with reference to the actual position.

The hysteresis is a position tolerance within which the position values may vary without changing the switching state of the output cam. Changes of direction detected within the hysteresis are ignored.

The hysteresis is set for the technology object in <TO>.Parameter.Hysteresis.

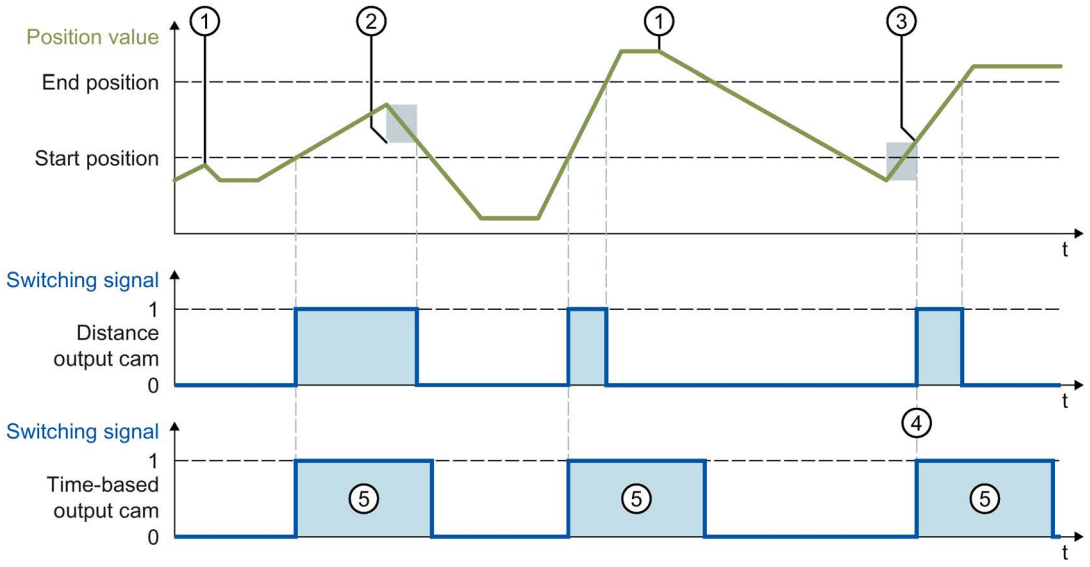
Behavior

- The hysteresis is activated at a direction reversal.
- The following applies within the hysteresis:
  - The switching state of distance output cams is not changed.
  - The motion direction is not determined again.
  - If the start position of a time-based output cam is within the hysteresis, the time-based output cam is switched on when leaving the hysteresis with the corresponding effective direction.
  - The on-load factor of time-based output cams remains unchanged.
- After the hysteresis range is exited, distance output cams are set according to the output cam settings.



① Actual position
② Effective position
③ Hysteresis range

The following examples show the effects of the hysteresis on the switching behavior of output cams with positive activation direction.



① Direction reversal without hysteresis effect
② Hysteresis in effect
③ The switch-on position of the distance output cam is influenced according to the direction reversal and hysteresis.
④ The start position of the time-based output cam is located within the hysteresis. The time-based output cam is switched on when leaving the hysteresis with the corresponding effective direction.
⑤ Switch-on duration

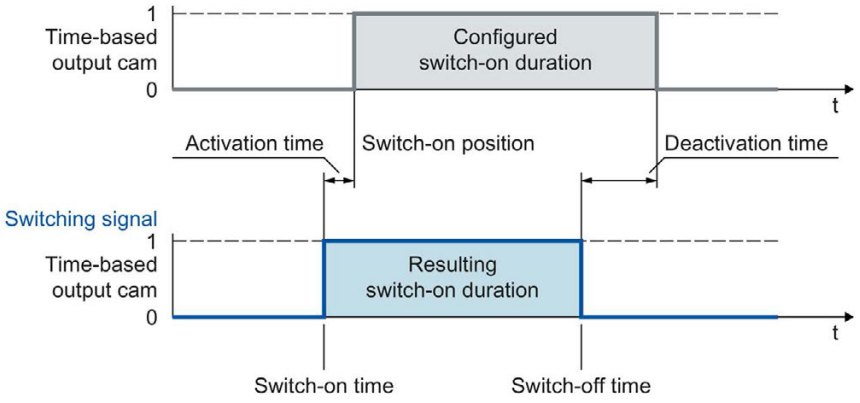
Hysteresis range

The maximum size of the hysteresis range in the system is as follows: for an axis with modulo function, one quarter of the modulo range; for an axis without modulo function, one quarter of the operating range.

3.8.6 Compensation of actuator switching times

Switching times of the output and the connected actuator (e.g. valve) can be compensated for using the activation time or deactivation time of the output cam technology object.

The activation time is specified as the lead time for the switch-on edge, and the deactivation time as the lead time for the switch-off edge.



The activation time is set in the technology object <TO>.OnCompensation.

The deactivation time is set in the technology object <TO>.OffCompensation.

Note

- The following must be met for the times:

  On-load factor > deactivation time - activation time

  (The on-load factor for distance output cams is determined by the switching positions and the current velocity)
- If the output cam has been switched taking the lead times into consideration, this action has taken place from the system perspective and will not be restarted in response to any subsequent variation in the actual speed.
- System-dependent runtimes are automatically taken into consideration when output by TM Timer DIDQ is used.

  When the output with a digital output module is used, system-dependent runtimes are not taken into consideration and must be set as correction times in the activation time or deactivation time.

3.8.7 Tags

Status display	
<TO>.CamOutput	The output cam is switched.
Parameters	
<TO>.Parameter.OutputCamType	Output cam type 0: Distance output cam 1: Time-based output cam
<TO>.Parameter.PositionType	Position reference 0: Position setpoint 1: Actual position
<TO>.ParameterOnCompensation	Activation time (lead time for the switch-on edge)
<TO>.Parameter.OffCompensation	Deactivation time (lead time for the switch-off edge)
<TO>.Parameter.Hysteresis	Hysteresis value
Interface	
<TO>.Interface.EnableOutput	Activation of the output cam output FALSE: No output TRUE: Output
<TO>.Interface.Address	I/O address of the output cam
<TO>.Interface.LogicOperation	Logical operation of the output cam signals at the output 0: OR operation 1: AND operation
Units	
<TO>.Units.LengthUnit	Unit of the length data
<TO>.Units.TimeUnit	Unit of the time data
StatusWord	
<TO>.StatusWord.X0 (Control)	The technology object is in operation.
<TO>.StatusWord.X1 (Error)	An error occurred at the technology object.
<TO>.StatusWord.X2 (RestartActive)	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart.
<TO>.StatusWord.X3 (OnlineStartValuesChanged)	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object.
<TO>.StatusWord.X4 (OutputInverted)	The output cam output is inverted.
<TO>.StatusWord.X5 (CommunicationOk)	The cam is synchronized with the output module and available for use.

ErrorWord	
<TO>.ErrorWord.X0 (SystemFault)	A system-internal error has occurred.
<TO>.ErrorWord.X1 (ConfigFault)	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program.
<TO>.ErrorWord.X2 (UserFault)	Error in user program at a Motion Control instruction or its use.
<TO>.ErrorWord.X3 (CommandNotAccepted)	Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
<TO>.ErrorWord.X13 (PeripheralError)	Error accessing a logical address.
ErrorDetail	
<TO>.ErrorDetail.Number	Alarm number You can find a list of the technology alarms and alarm reactions in the Technology Alarms (Page 530) appendix.
<TO>.ErrorDetail.Reaction	Effective alarm reaction 0: No reaction 6: Output cam processing is complete. You can find a list of the technology alarms and alarm reactions in the Technology Alarms (Page 530) appendix.

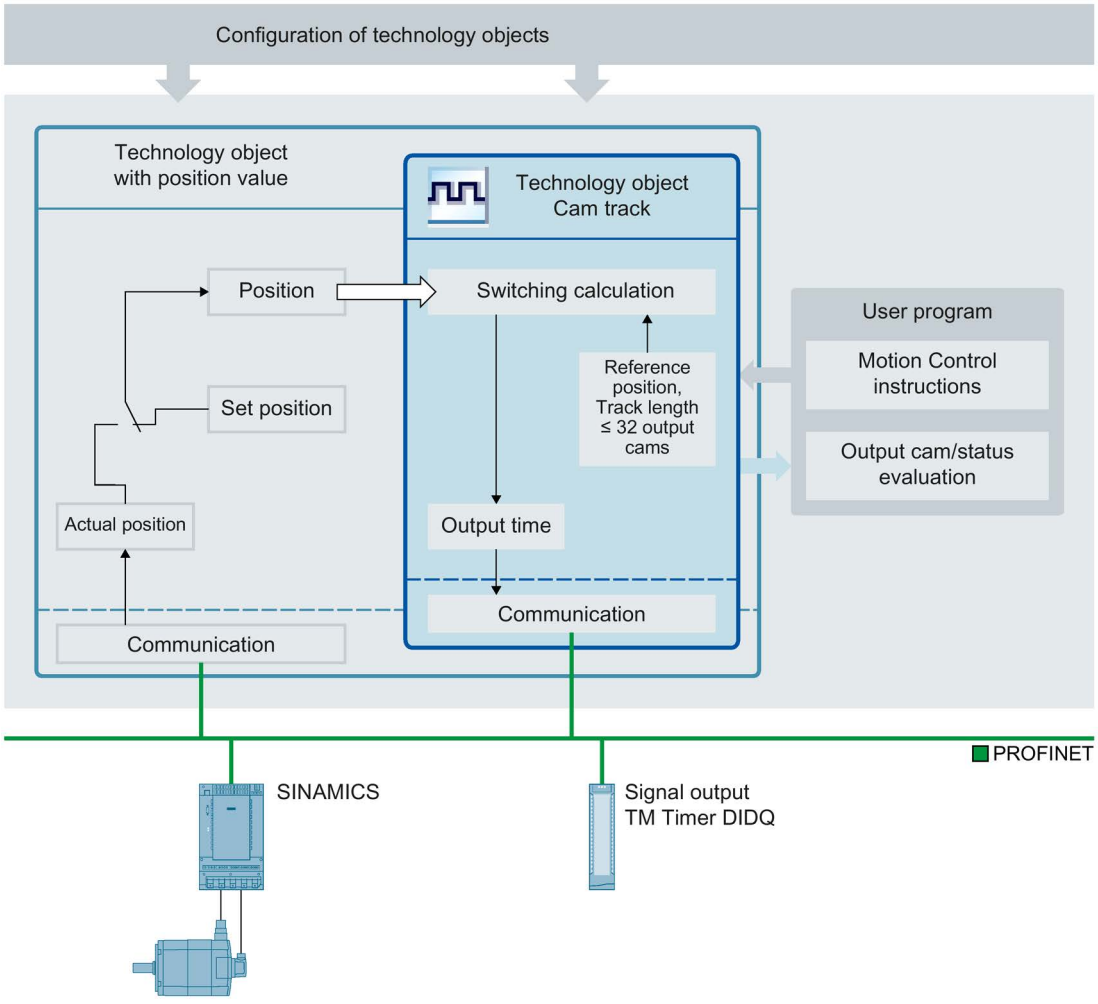
3.9 Cam track technology object

3.9.1 Brief description

The cam track technology object generates a switching signal sequence dependent on the position of an axis or external encoder. A cam track can consist of up to 32 individual output cams and be output to one output. The switching states can be evaluated in the user program or fed to digital outputs.

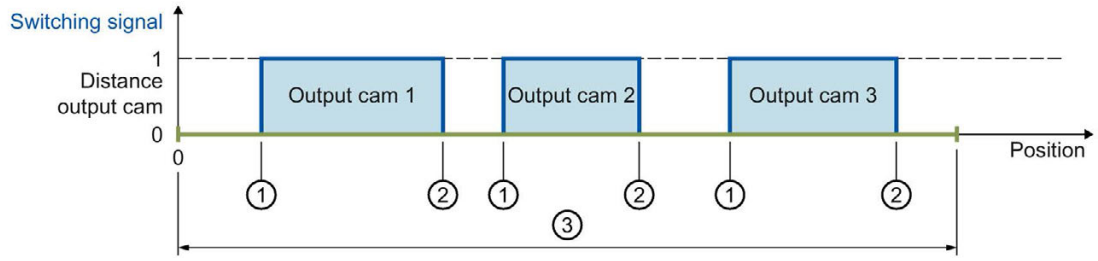
You can find an overview of the functions of the cam track technology object in the Functions (Page 26) section.

The figure below shows the basic principle of operation of the cam track technology object:



Definition of cam track

A cam track consists of up to 32 individual output cams that are specified within an adjustable track length.



① Start position
② End position
③ Cam track length

Figure 3-2 Cam track with distance output cam

The output cam positions are defined relative to the cam track. The start of the cam track is always 0.0. The output cam positions on the cam track are thus always positive.

When the cam track is processed, the output cams with start position within the track length are taken into consideration.

If the end of a cam track is crossed, connected output cams behave as follows within the cam track:

- Time-based output cams remain switched on for the set on-load factor.
- Distance output cams whose end position lie outside the cam track are switched off when the cam track is left.

Output cams whose start and end positions lie outside the cam track length are not taken into consideration. They become active only if the cam track length is increased so that at least the respective start position of an output cam is within the new track length.

Mapping of the cam track to the position of an axis or external encoder.

The start of the cam track is placed at the specified reference position of the interconnected technology object. Thus, the switching positions result from the cam track positions mapped onto the interconnected technology object starting from the reference position.
The cam track is continued in both directions of the interconnected technology object.

The setting for the reference position can be either positive or negative.

Example

- Axis range = -1000 mm to +1000 mm
- Desired switching points of the output cam with reference to axis position:
  - Start position = -200 mm
  - End position = -100 mm
- Cam track length = 2000 mm
- Definition of output cam on the track:
  - Start position = 800 mm
  - End position = 900 mm

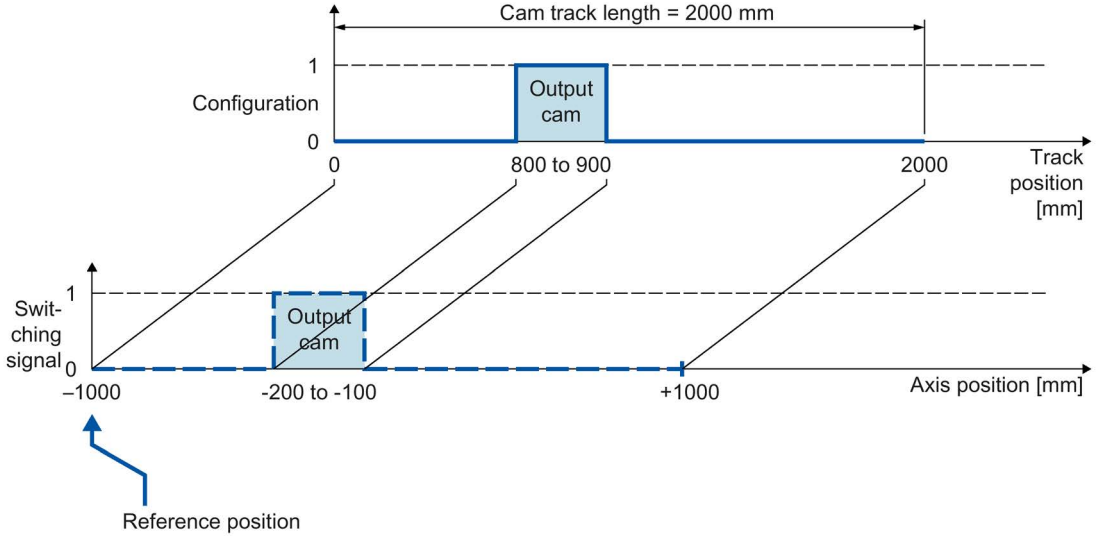


Figure 3-3 Cam track with output cam output at negative axis position

Processing of a cam track

The processing of a cam track occurs cyclically.

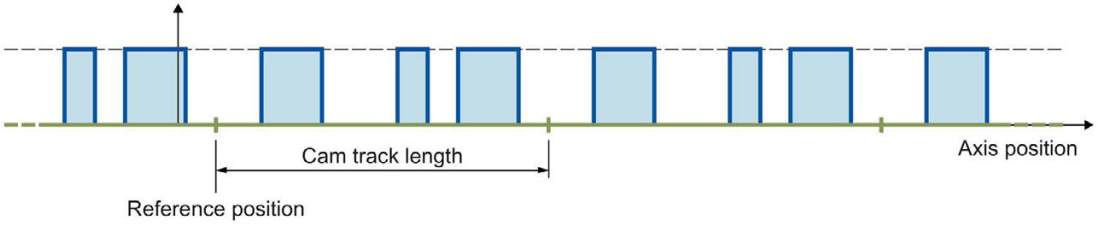


Figure 3-4 Cyclic mapping of a cam track

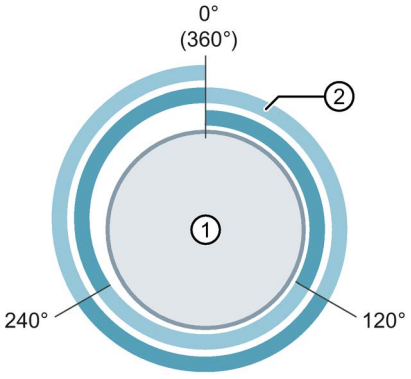
The cam track is mapped onto the position of the interconnected technology object starting from the reference position and is continued cyclically in both directions.

Track length and mapping to an axis with modulo function

When a cam track is mapped onto an axis with modulo function, a reference position specified outside the modulo range is mapped within the modulo range.

The track length can be less than or greater than the modulo length of the axis. In order for the cam track to be mapped without offset in the modulo range and to prevent unwanted overrides, an integer ratio of modulo length to track length, and vice versa, is required.

Example Mapping without offset



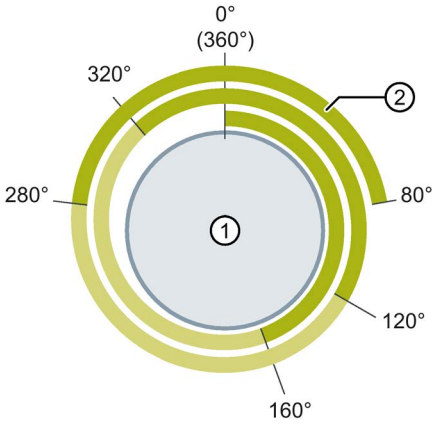
① Axis with modulo length 360°

② Cam track with track length 120°

⇒ Ratio = 360° / 120° = **3**

The cam track is output 3 times on a modulo length.

Example Mapping with offset



① Axis with modulo length 360°

② Cam track with track length 160°

⇒ Ratio = 360° / 160° = **2.25**

The cam track is output 2.25 times on the first modulo length and continued correspondingly in the other modulo lengths.

During cyclic processing of the cam track, the continued reference position of the current cam track is displayed in the <TO>.MatchPosition tag. The continued reference position is independent of direction and always the position of the left boundary of the cam track. The unique detection and output of the position is only possible when the assigned technology object is in motion. The distance to the current reference position of the current cam track (<TO>.MatchPosition) is displayed in the <TO>.TrackPosition tag.

Output cam types

The following output cam types are used:

- Distance output cam
- Time-based output cam

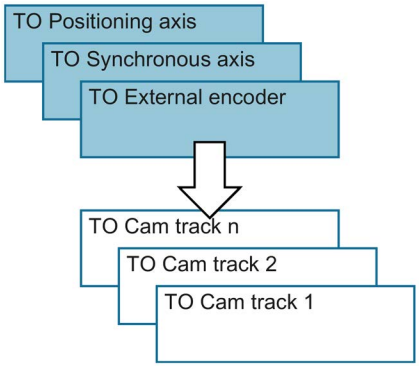
The output cams of the cam track can be set as distance output cams or time-based output cams, whereby only one of the two output cam types can be used in one cam track.

Assignment

The cam track technology object must always be assigned to another technology object whose position is evaluated.

The cam track technology object can be assigned to the following technology objects:

- Synchronous axis
- Positioning axis
- External encoder



Exactly one axis or one external encoder can be assigned to a cam track.

Multiple cam tracks can be assigned to one axis or external encoder.

Position reference

The switching points of the output cams of a cam track can be referenced to the following positions, depending on the interconnected technology object.

- Actual position of a synchronous axis/positioning axis
- Position setpoint of a synchronous axis/positioning axis
- Position of an external encoder

Homing the interconnected technology object

A change to the position of an axis or external encoder using Motion Control instruction "MC_Home" is regarded as a sudden position change. An enabled cam track is referenced to the changed position and processed further from there.

- For axes with modulo function, homing also has an effect on the current position of the cam track (<TO>.TrackPosition). The position is formed again as quickly as possible due to the offset.
- Distance output cams are either skipped or correspondingly output.
- Time-based output cams are skipped. A time-based output cam is switched on only when the start position is crossed and remains switched on for the on-load factor.
- Switched time-based output cams are not canceled by a homing operation.

We recommend locking the cam track before or during homing.

Output of a cam track

The following output options are available for the digital cam track output:

- TM Timer DIDQ

  Digital output with high degree of accuracy and reproducibility in the microsecond range on ET 200MP TM Timer DIDQ 16x24V and ET 200SP TM Timer DIDQ 10x24V time-based IO modules

  Output by TM Timer DIDQ requires isochronous mode. Isochronous mode is only possible with PROFINET interface modules.

- Digital output module

  Digital output with switching accuracy depending on the output cycle of the I/O used

A maximum of two edges (by TM Timer DIDQ, positive and negative) or one edge (via digital output module, positive or negative) can be output per position control cycle clock. If multiple switch-on edges or switch-off edges are transmitted in one position control cycle clock, the last written values in each case are valid.

Masking of individual output cams of a cam track

In order for output cams to processed, they must be configured as valid in the technology data block with "<TO>.Parameter.Cam[1 … 32].Existent" = TRUE. In addition, output cams of a cam track configured as valid can be masked in the user program using bit masking ("<TO>.Parameter.CamMasking"). In the default setting, all valid output cams are enabled ("<TO>.Parameter.CamMasking" = 0xFFFFFFFF). The cam track itself is activated/deactivated using the Motion Control instruction "MC_CamTrack".

3.9.2 Effective direction

The cam track is always active for both directions of the position of the interconnected technology object.

Output of a cam track with distance output cam

Distance output cams are switched when the switch-on range is overtraveled.

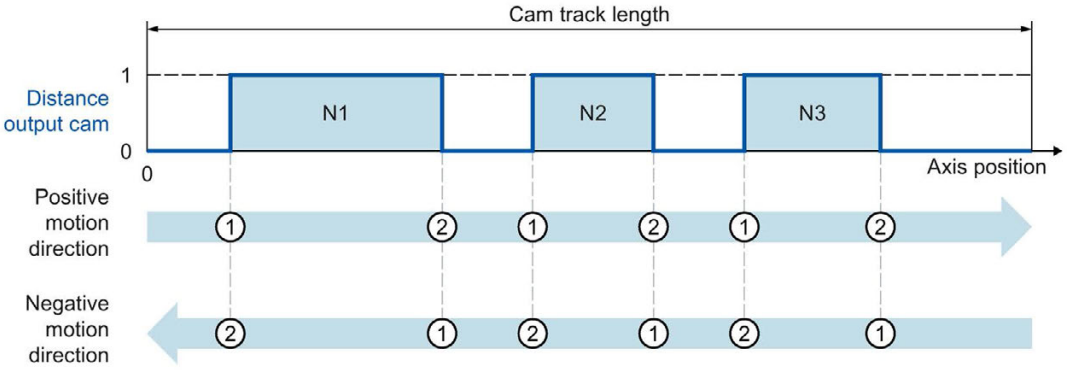


Figure 3-5 Executing a cam track with distance output cams dependent on the motion direction of the axis

- With positive motion direction, the output cams of the cam track are output in the order Output Cam N1, Output Cam N2, Output Cam N3
- In the case of negative motion direction, the output cams of the cam track are output in the order Output Cam N3, Output Cam N2, Output Cam N1
- The distance output cams switch on at ① and switch off at ②

Output of a cam track with time-based output cam

The time-based output cams are switched when the start position is crossed.

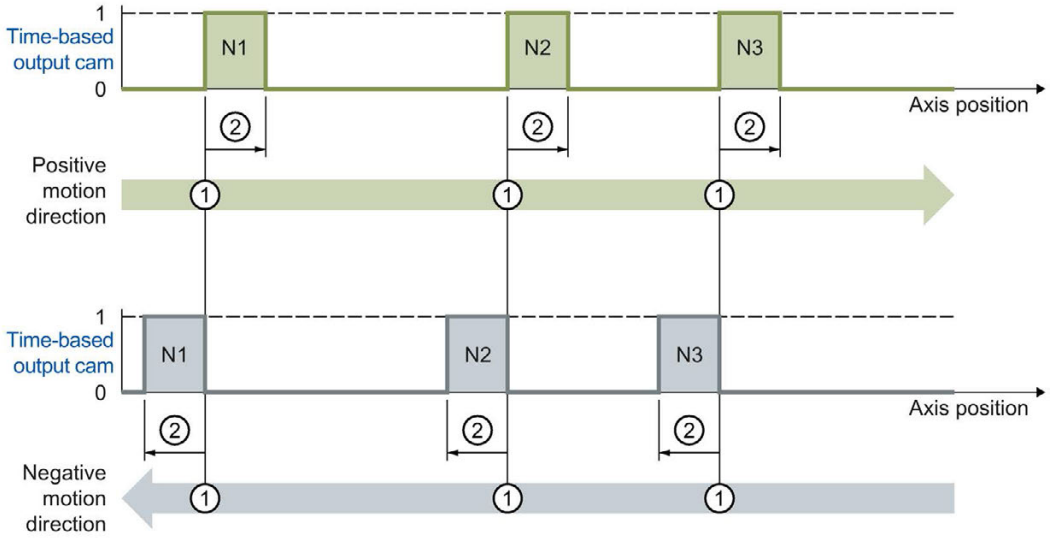


Figure 3-6 Executing a cam track with time-based output cams dependent on the motion direction of the axis

- With positive motion direction, the output cams of the cam track are output in the order Output Cam N1, Output Cam N2, Output Cam N3
- In the case of negative motion direction, the output cams of the cam track are output in the order Output Cam N3, Output Cam N2, Output Cam N1
- The time-based output cams switch on at ① and remain switched on for the set switch-on duration ②

3.9.3 Changing the cam track data during operation

The data of a cam track and the parameters of the associated Motion Control instruction "MC_CamTrack" can be changed while track processing is enabled. The active Motion Control instruction "MC_CamTrack" is not aborted. The modified parameters, however, only take effect at the next call of Motion Control instruction "MC_CamTrack".

The following parameters can be changed during operation and are in effect after another call of Motion Control instruction "MC_CamTrack".

- Cam track data in technology data block
  - Reference position (<TO>.Parameter.ReferencePosition)
  - Track length (<TO>.Parameter.CamTrackLength)
  - Bit masking of individual output cams (<TO>.Parameter.CamMasking)
  - Activation time (<TO>.Parameter.OnCompensation)
  - Deactivation time (<TO>.Parameter.OffCompensation)
  - Hysteresis value (<TO>.Parameter.Hysteresis)
  - Output cam data (<TO>.Parameter.Cam[1 … 32])
- Parameters in the function block
  - Enable (MC_CamTrack.Enable)
  - Mode (MC_CamTrack.Mode)
  - Inverted output (MC_CamTrack.InvertOutput)

Note the different activation behavior (Page 155) when changing the cam track data.

3.9.4 Activation behavior

A cam track is activated by the call of Motion Control instruction "MC_CamTrack" with "Enable" = TRUE. A distinction must be made here between:

- A first-time activation of the cam track
- The call after a change of the cam track data during active cam track processing

The difference relates to how the cam track data is applied. Depending on the set mode ("MC_CamTrack.Mode"), the configuration (cam track data, data in the function block) is applied at different times.

- **First-time switch-on of a cam track**

  The call of Motion Control instruction "MC_CamTrack" with "Enable" = TRUE activates the cam track immediately (<TO>.Status changes to 1) and configured cam track data takes effect immediately. This behavior is the same when "MC_CamTrack.Mode" = 0 and "MC_CamTrack.Mode" = 1.

- **Change of cam track data of an already activated cam track**(<TO>.Status = 1)

  – With the call of Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and "Mode" = 0, the modified cam track data takes effect immediately.

    Previously activated distance output cams are aborted if their track signal is not still set due to the changed cam track data. Previously activated time-based output cams are always aborted.

  – With the call of Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and "Mode" = 1, the cam track continues to be output with the prior configuration up to the cam track end. Modified cam track data takes effect at the end of the current track cycle.

Changing cam track data when modulo length is not a multiple of the track length

For the switching times to be set correctly, we recommend the following procedure for changes:

- Enter changes as soon as possible after start of a new cam track
- Enter a new reference position (<TO>.Parameter.ReferencePosition) for the changed cam track. The new reference position is composed as follows depending on the direction:

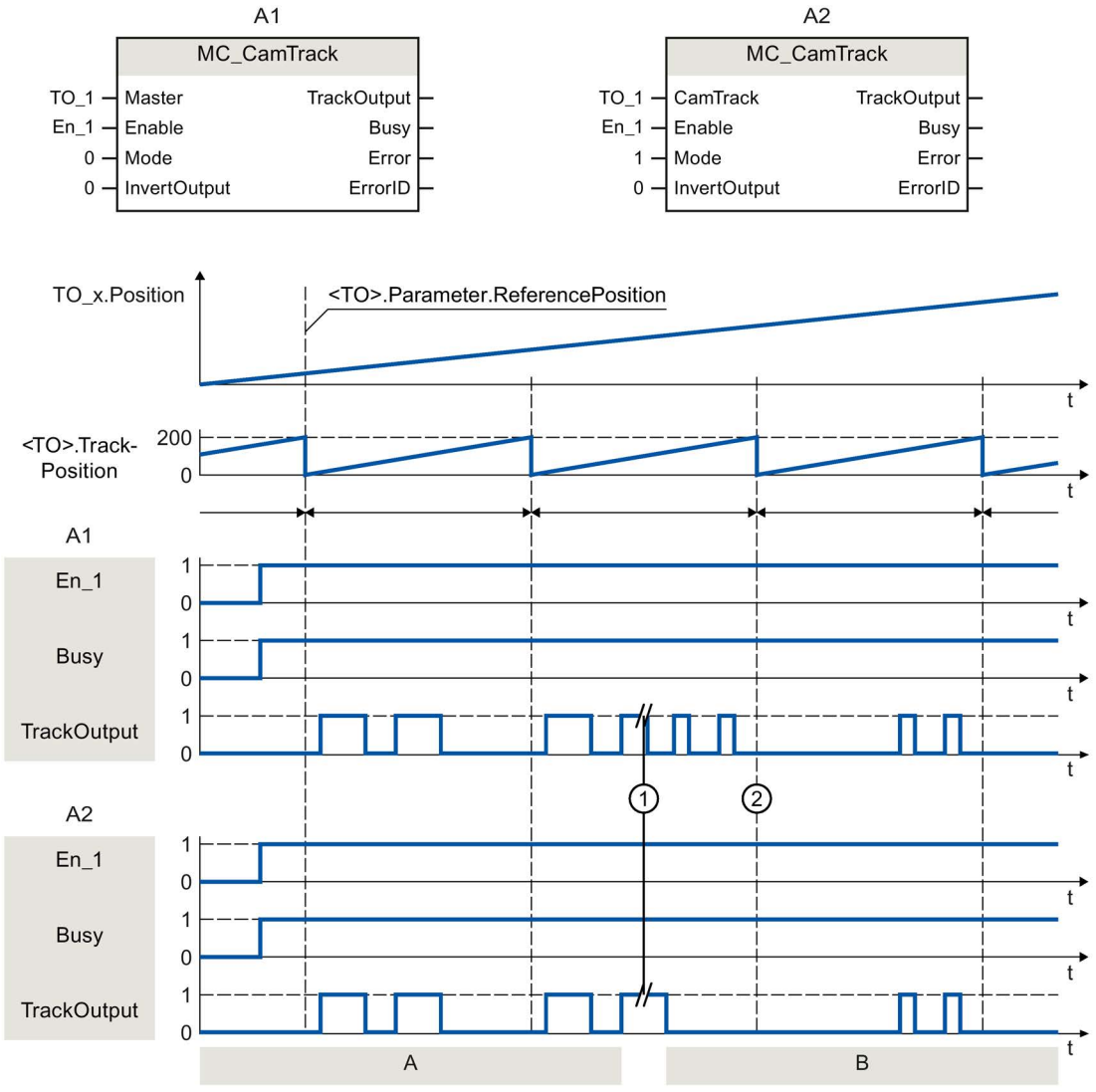
  – Positive effective direction: Current reference position (<TO>.MatchPosition) + cam track length (<TO>.Parameter.CamTrackLength)

  – Negative effective direction: Current reference position (<TO>.MatchPosition) - cam track length (<TO>.Parameter.CamTrackLength)

- Output the changes of the cam track when calling the Motion Control instruction "MC_CamTrack" and "Mode" = 1.

Example

The following figure shows an example of the differences in the activation behavior.



A1	A	The cam track is activated the first time with "MC_CamTrack.Enable" = TRUE and the output cams are output immediately with set "MC_CamTrack.Mode" = 0.
	B	After cam track data were changed (①), the cam track is activated by calling Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and the modified data takes effect immediately (①) with set "MC_CamTrack.Mode" = 0.
A2	A	The cam track is activated the first time with "MC_CamTrack.Enable" = TRUE and the output cams are output immediately with set "MC_CamTrack.Mode" = 1.
	B	After cam track data were changed (①), the cam track is activated by calling Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and the modified data takes effect at the end of the current track cycle (②) with set "MC_CamTrack.Mode" = 1.

3.9.5 Hysteresis

The hysteresis is set in the cam track technology object. The behavior and effect of the hysteresis setting corresponds to the hysteresis (Page 140) for the cam technology object.

3.9.6 Time offset of cam switching points

Switching times of the output and the connected actuator (e.g. valve) can be compensated for using the activation time or deactivation time of the cam track technology object.

The time offset of cam switching points corresponds to the activation time or deactivation time (Page 142) for the cam technology object.

3.9.7 Tags

Status display	
<TO>.Status	0: Inactive 1: Active 2: Active and waiting for next track
<TO>.TrackOutput	A cam of cam track is switched.
<TO>.SingleCamState	Switched on output cam (bit-masked)
<TO>.TrackPosition	Display of the current position within the cam track The distance to the current reference position of the current cam track (<TO>.MatchPosition) is displayed.
<TO>.MatchPosition	Reference position of the current cam track During cyclic processing of the cam track, the continued reference position of the current cam track is displayed. The unique detection and output of the position is only possible when the assigned technology object is in motion.
Parameters	
<TO>.Parameter.CamTrackType	Output cam type 0: Distance output cam 1: Time-based output cam
<TO>.Parameter.PositionType	Position reference 0: Position setpoint 1: Actual position
<TO>.Parameter.ReferencePosition	Reference position
<TO>.Parameter.CamTrackLength	Track length
<TO>.Parameter.CamMasking	Bit masking of individual output cams
<TO>.Parameter.OnCompensation	Activation time (lead time for the switch-on edge)
<TO>.Parameter.OffCompensation	Deactivation time (lead time for the switch-off edge)
<TO>.Parameter.Hysteresis	Hysteresis value
<TO>.Parameter.Cam[1 … 32].OnPosition	Start position (distance and time-based output cams)
<TO>.Parameter.Cam[1 … 32].OffPosition	End position (distance output cam)
<TO>.Parameter.Cam[1 … 32].Duration	Switch-on duration (time-based output cam)
<TO>.Parameter.Cam[1 … 32].Existent	Validity of an output cam FALSE: Output cam not used TRUE: Output cam is used
Interface	
<TO>.Interface.EnableOutput	Output cam output at the bit specified under "Address" FALSE: No output TRUE: Output
<TO>.Interface.Address	I/O address for digital cam output
Units	
<TO>.Units.LengthUnit	Unit of the length data
<TO>.Units.TimeUnit	Unit of the time data

StatusWord	
<TO>.StatusWord.X0 (Control)	The technology object is in operation.
<TO>.StatusWord.X1 (Error)	An error occurred at the technology object.
<TO>.StatusWord.X2 (RestartActive)	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart.
<TO>.StatusWord.X3 (OnlineStartValuesChanged)	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object.
<TO>.StatusWord.X4 (OutputInverted)	The output cam output is inverted.
<TO>.StatusWord.X5 (CommunicationOk)	The cam track is synchronized with the output module and available for use.
<TO>.StatusWord.X6 (CamDataChanged)	The data of individual output cams has been changed but not yet taken effect with Motion Control instruction "MC_CamTrack".
ErrorWord	
<TO>.ErrorWord.X0 (SystemFault)	A system-internal error has occurred.
<TO>.ErrorWord.X1 (ConfigFault)	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program.
<TO>.ErrorWord.X2 (UserFault)	Error in user program at a Motion Control instruction or its use.
<TO>.ErrorWord.X3 (CommandNotAccepted)	Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
<TO>.ErrorWord.X13 (PeripheralError)	Error accessing a logical address.
ErrorDetail	
<TO>.ErrorDetail.Number	Alarm number
<TO>.ErrorDetail.Reaction	Effective alarm reaction 0: No reaction 5: Cam track processing Is complete.

Guidelines

4

4.1 Guidelines on use of motion control

The guidelines described here present the basic procedure for using Motion Control with the CPU S7-1500. These guidelines serve as recommendations.

Requirements

- A project with a CPU S7-1500 has been created.

Procedure

Proceed as follows to use Motion Control with the CPU S7-1500:

1. Add technology object (Page 176)
2. Working with the configuration editor (Page 177)
3. Programming (Page 294)
4. Downloading to CPU (Page 325)
5. Functional test in the Commissioning window (Page 326)
6. Diagnostics (Page 341)

Using versions

5

5.1 Overview of versions

For S7-1500 Motion Control, a distinction is made between the version of the technology, the technology objects and the Motion Control instructions. The overview shown below includes S7-1500 and S7-1500T. Only one technology version can be operated on a CPU.

When changing to a CPU ≥ V1.6, you must change the technology version accordingly. Card replacement from a CPU < V1.6 to a ≥ CPU V1.6 is supported. In the TIA Portal, you can use a CPU ≥ 1.6 only to work on projects with a correspondingly higher technology version.

There are two ways of changing the technology version:

- Changing the version of the Motion Control instructions

  You change the version of the Motion Control instructions in the "Instructions" task card in the folder "Technology > Motion Control > S7-1500 Motion Control".

  If the Motion Control instruction version used does not correspond to the compatibility list, the relevant Motion Control instructions are highlighted in red in the program editor.

- Adding a technology object with an alternative version

  If a technology object with an alternative version is added in the "Add new object" dialog, the technology version is changed to the alternative version.

The technology objects and Motion Control instructions are only converted to the selected version of the technology during compilation.

The version of a technology object or a Motion Control instruction is indicated in the properties of the technology object, "General > Information" tab, "Version" field.

Compatibility list

The table below shows the compatibility of the technology version with the CPU version:

CPU	Technology	Technology object	Motion Control instruction
V1.0, V1.1, V1.5[1]	V1.0	Speed axis V1.0 Positioning axis V1.0 External encoder V1.0	MC_Power V1.0 MC_Reset V1.0 MC_Home V1.0 MC_Halt V1.0 MC_MoveAbsolute V1.0 MC_MoveRelative V1.0 MC_MoveVelocity V1.0 MC_MoveJog V1.0
V1.6	V2.0 Innovations: • Synchronous axis technology object • Gearing with MC_GearIn • Superimposed positioning with MC_MoveSuperimposed • Standardization of the "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control • Simulation mode • Support of safety functions of the drive	Speed axis V2.0 Positioning axis V2.0 External encoder V2.0 Synchronous axis V2.0	MC_Power V2.0 MC_Reset V2.0 MC_Home V2.0 MC_Halt V2.0 MC_MoveAbsolute V2.0 MC_MoveRelative V2.0 MC_MoveVelocity V2.0 MC_MoveJog V2.0 MC_MoveSuperimposed V2.0 MC_GearIn V2.0

CPU	Technology	Technology object	Motion Control instruction
V2.0	V3.0 Innovations: • Technology object measuring input • Technology object output cam • Cam track technology object • Force/torque limiting • Fixed stop detection • "Virtual axis" operating mode for simulation mode • Technology CPU S7-1500T Additional innovations for S7-1500T: • Cam technology object (S7-1500T) • Gearing with MC_GearInPos (S7-1500T) • Camming with MC_CamIn (S7-1500T) • Using multiple encoders (S7-1500T)	Speed axis V3.0 Positioning axis V3.0 External encoder V3.0 Synchronous axis V3.0 Measuring input V3.0 Output cam V3.0 Cam track V3.0 Cam V3.0 (S7-1500T)	MC_Power V3.0 MC_Reset V3.0 MC_Home V3.0 MC_Stop V3.0 MC_MoveAbsolute V3.0 MC_MoveRelative V3.0 MC_MoveVelocity V3.0 MC_MoveJog V3.0 MC_MoveSuperimposed V3.0 MC_SetSensor V3.0 (S7-1500T) MC_TorqueLimit V3.0 MC_MeasuringInput V3.0 MC_MeasuringInputCyclic V3.0 MC_AbortMeasuringInput V3.0 MC_OutputCam V3.0 MC_CamTrack V3.0 MC_GearIn V3.0 MC_GearInPos V3.0 (S7-1500T) MC_PhasingAbsolute V3.0 (S7-1500T) MC_PhasingRelative V3.0 (S7-1500T) MC_CamIn V3.0 (S7-1500T) MC_SynchronizedMotionSimulation (S7-1500T) MC_InterpolateCam V3.0 (S7-1500T) MC_GetCamFollowingValue V3.0 (S7-1500T) MC_GetCamLeadingValue V3.0 (S7-1500T)

1) Card replacement from a CPU < V1.6 to a CPU ≥ V1.6 is supported.

Parameter "Mode" of the Motion Control instruction "MC_Home"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.

The table below shows a comparison of the "MC_Home.Mode" parameter for technology V1.0 and ≥ V2.0:

MC_Home.HomingMode V1.0	Parameter value	MC_Home.Mode ≥ V2.0
Direct homing (absolute)	0	Direct homing (absolute)
Direct homing (relative)	1	Direct homing (relative)
Passive homing	2	Passive homing (without reset)
Passive homing (with configured home position)	3	Active homing
Active homing	4	Reserved
Active homing (with configured home position)	5	Active homing (with configured home position)
Absolute encoder adjustment (relative)	6	Absolute encoder adjustment (relative)
Absolute encoder adjustment (absolute)	7	Absolute encoder adjustment (absolute)
Passive homing (without reset)	8	Passive homing
Abort passive homing	9	Abort passive homing
-	10	Passive homing (with configured home position)

You can find additional information about the "MC_Home.Mode" parameter in the description of the Motion Control instruction "MC_Home" (Page 379).

Tags of the technology object

Starting from technology version V3.0, all input and output addresses are specified using data type VREF. This results in the following changes to the tags of the technical object:

Tag of technology object	Changes starting from V3.0
<TO>.Actor.Interface.AddressIn	Data type: VREF
<TO>.Actor.Interface.AddressOut	Data type: VREF
<TO>.Sensor[n].Interface.AddressIn	Data type: VREF
<TO>.Sensor[n].Interface.AddressOut	Data type: VREF
<TO>.Actor.Interface.EnableDriveOutputAddress	Data type: VREF
<TO>.Actor.Interface.EnableDriveOutputBitNumber	Tag eliminated
<TO>.Actor.Interface.DriveReadyInputAddress	Data type: VREF
<TO>.Actor.Interface.DriveReadyInputBitNumber	Tag eliminated
<TO>.Sensor[n].ActiveHoming.DigitalInputAddress	Data type: VREF
<TO>.Sensor[n].ActiveHoming.DigitalInputBitNumber	Tag eliminated
<TO>.Sensor[n].PassiveHoming.DigitalInputAddress	Data type: VREF
<TO>.Sensor[n].PassiveHoming.DigitalInputBitNumber	Tag eliminated
<TO>.PositionLimits_HW.MinInputAddress	Data type: VREF
<TO>.PositionLimits_HW.MinInputBitNumber	Tag eliminated
<TO>.PositionLimits_HW.MaxInputAddress	Data type: VREF
<TO>.PositionLimits_HW.MaxInputBitNumber	Tag eliminated

5.2 Changing a technology version

Before you can access all the benefits of a new technology version, you need to change the technology version for existing projects.

Changing a technology version

To change the technology version, follow these steps:

1. Replace the CPU in the project with a CPU with an appropriate higher version.
2. Open the program editor (e.g. by opening the OB1).

   The technology objects and Motion Control instructions are highlighted in red after the CPU is replaced.
3. In the "Instructions" task card, select the appropriate higher technology version in the "Technology > Motion Control" folder.
4. Save and compile the project.

   The version of the technology objects and Motion Control instructions is changed to the appropriate higher technology version during compilation of the project.

   Pay attention to any error information that is displayed during compilation. Deal with the causes of the errors indicated.
5. Check the configuration of the technology objects.

Resetting the "Mode" parameter of the Motion Control instruction "MC_Home"

When the technology version is changed from V1.0 to ≥ V2.0, the "MC_Home.HomingMode" parameter (V1.0) is renamed to "MC_Home.Mode" (≥ V2.0).
The assignment of the parameter values is changed as well.

To reset the "MC_Home.Mode" parameter (V2.0), follow these steps:

1. To change the technology version, follow the instructions given above.

   When compiling the project, the "MC_Home.HomingMode"parameter (V1.0) is renamed to "MC_Home.Mode" (≥ V2.0):

   – The assignment of the parameter values is changed. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and ≥ V2.0 is available in section Version overview (Page 161).

     You can find additional information about the "MC_Home.Mode" parameter in the description of the Motion Control instruction "MC_Home" (Page 379).

   – The value configured at the "MC_Home.HomingMode" parameter (V1.0) is lost. As a note on renaming, the following text is entered as the parameter value in the "MC_Home.Mode" parameter (≥ V2.0).

     "The interface has changed. You can find additional information in the description of the Motion Control instruction "MC_Home".

   – There is a message in the "Info > Compile" tab in the Inspector window stating that the operand has the wrong data type.

2. Change the value of the "MC_Home.Mode" parameter (≥ V2.0) in your user program according to the new assignment.
3. Save and compile the project.

5.3 Replacing devices

You can replace an S7-1500 with an S7-1500T and vice versa. The behavior with respect to functions and the existing configuration is different depending on what is being replaced.

- S7-1500 ⇒ S7-1500T

  The functions of the S7-1500 are expanded to include additional parameters for the extended functions of the S7-1500T. The additional parameters are preassigned with default values and must be configured appropriately.

- S7-1500T ⇒ S7-1500
  - Extended functions are only supported by an S7-1500T and are no longer available after a replacement with S7-1500.
  - Unsupported function blocks are marked.
  - Unsupported technology objects are displayed in an error message after compilation and must be deleted.

5.4 Copying technology objects

You can copy technology objects from an S7-1500 to an S7-1500T and vice versa. In order to copy technology objects, they must be supported by both CPUs. Extended functions are only supported by an S7-1500T.

- Copying a technology object from an S7-1500 to an S7-1500T

  Additional parameters for the extended functions are preassigned with default values and must be configured appropriately.

- Copying a technology object from an S7-1500T to an S7-1500

  Additional parameters and those not supported by S7-1500 are reset to their default values.

Configuring 6

6.1 Adding and configuring drives in the device configuration

6.1.1 Add and configure PROFINET IO drives

Adding and configuring a PROFINET IO drive is described below with the example of a **SINAMICS S120 drive**. Adding and configuring other PROFINET IO drives may differ from the description in certain respects.

You need the Hardware Support Package (HSP) V90 to add and configure a SINAMICS V90 PN drive in the TIA Portal. Information on configuring a SINAMICS V90 PN drive with SIMATIC S7-1500 in the TIA Portal is available in the documentation for the Hardware Support Package.

Requirements

- The SIMATIC S7-1500 device is created in the project.
- The desired drive can be selected in the hardware catalog.

If the drive is not available in the hardware catalog, it must be installed in the "Options" menu as a device description file (GSD).

Adding a drive and telegram in the device configuration

1. Open the device configuration and change to the network view.
2. In the hardware catalog, open the folder "Additional Field Devices > PROFINET IO > Drives > Siemens AG > SINAMICS".
3. Select the desired drive with the desired version, then drag it to the network view.
4. Assign the drive to the PROFINET interface of the PLC.
5. Open the drive in the device view.
6. Drag a Drive Object (DO) and a standard telegram from the hardware catalog to a slot of the device overview of the drive.
7. Make sure that the order of the telegrams in the device configuration and in the drive parameter assignment are identical.

Depending on the version of the SINAMICS S120 drive, select "DO with standard telegram X", or "DO Servo" and a "Standard telegram X" for the telegram.

For more information on suitable telegrams, refer to the section PROFIdrive telegrams (Page 33).

Repeat step 6, if you want to add another drive and another standard telegram.

Activating isochronous mode of the drive in the device configuration

PROFINET drives can always be operated in isochronous mode or non-isochronous mode. Isochronous mode, however, increases the quality of the position control of the drive.

If you want to control the drive in isochronous mode, follow these steps:

1. Open the device view of the drive.
2. In the properties dialog, select the tab "PROFINET Interface [X1] > Advanced options > Isochronous mode".
3. Select the "Isochronous mode" check box in this tab.

The entry for the telegram also has to be selected for isochronous mode in the detailed view.

Interconnecting the port of the PLC with the port of the drive

1. Open the topology view in the device configuration.
2. Interconnect the port of the PLC with the port of the drive.

Configuring the PLC as the sync master and setting isochronous mode

1. Select the device view of the PLC.
2. In the properties dialog, select the tab "PROFINET Interface [X1] > Advanced options > Real-time settings > Synchronization".
3. Select "Sync master" from the "Synchronization role" drop-down list.
4. Click the "Domain settings" button.
5. Open the "Domain Management > Sync Domains" tab and set the desired "Send clock" (isochronous clock).

Select drive in the configuration of the technology object

1. Add a new technology object axis, or open the configuration of an existing axis.
2. Open the configuration "Hardware interface > Drive".
3. Select "PROFIdrive" from the "Drive type" drop-down list.
4. Select the Drive Object of the PROFINET drive from the "Drive" list.

For information on how to add a technology object, refer to the section Add technology object (Page 176).

Result

The technology object is connected to the drive and the "MC Servo" organization block can be checked / configured.

The telegram of the configured drive is assigned to the "PIP OB Servo" process image.

Checking/configuring the properties of the MC Servo

1. Open the "Program blocks" folder in the project navigator.
2. Select the "MC Servo" organization block.
3. Select the "Properties" command in the shortcut menu.
4. Select the "Cycle time" entry in the area navigation.
5. The option "Synchronous to the bus" must be selected in the dialog box.
6. A "PROFINET IO_System" must be selected in the "Distributed I/O" drop-down list.
7. The application cycle of "MC-Servo" must correspond to the send clock of the bus or be reduced by an integral factor relative to the send clock of the bus.

Result

The PROFINET IO drive is now configured so that it can be controlled in the PROFINET IO network in isochronous mode.

The properties of the SINAMICS drive must be configured according to the configuration of the axis with a separate STARTER program.

Checking isochronous mode on the drive

If the configuration sequence described above is not adhered to during configuration of the axis, and drive-specific error occurs when the project is compiled, the setting for isochronous mode on the drive must be checked.

1. Open the device view of the drive.
2. Select standard telegram in the device overview.
3. Select the properties dialog "General > I/O Addresses".
4. The following settings apply for the input and output addresses:
   - "Isochronous mode" is enabled.
   - "MC Servo" must be select the "Organization block".
   - "PIP OB Servo" must be select the "Process image".

See also

PROFIdrive telegrams (Page 33)

Add technology object (Page 176)

6.1.2 Add and configure PROFIBUS DP drives

Adding and configuring a PROFIBUS IO drive is described below using a **SINAMICS S120**. Adding and configuring other PROFIBUS drives may differ from the description in certain respects.

Requirements

- The SIMATIC S7-1500 device is created in the project.
- The desired drive can be selected in the hardware catalog.

If the drive is not available in the hardware catalog, it must be installed in the "Options" menu as a device description file (GSD).

Adding a drive and telegram in the device configuration

1. Open the device configuration and change to the network view.
2. In the hardware catalog, open the folder "Additional Field Devices > PROFIBUS DP > Drives > Siemens AG > SINAMICS".
3. Select the folder of the desired drive with the desired version, then drag the drive object to the network view.
4. Assign the drive to the PROFIBUS interface of the PLC.
5. Open the drive in the device view.
6. Drag a standard telegram from the hardware catalog to the slot of the device overview of the drive.

For more information on suitable telegrams, refer to the section PROFIdrive telegrams (Page 33).

Use the "Axis disconnector" in the hardware catalog if you want to add another drive and another standard telegram in the device overview.

Activating isochronous mode of the drive in the device configuration

PROFIBUS drives can be operated in cyclic mode or isochronous mode. Isochronous mode, however, increases the quality of the position control of the drive.

If you want to control the drive in isochronous mode, follow these steps:

1. Open the device view of the drive.
2. In the properties dialog, select the tab "General > Isochronous Mode".
3. Select the "Synchronize DP slave to constant DP bus cycle time" check box .

Setting isochronous mode

1. Select the network view.
2. Select the DP master system.
3. In the properties dialog, select the tab "General > Constant bus cycle time".
4. Select the desired "Constant DP bus cycle times".

Select drive in the configuration of the technology object

1. Add a new technology object axis, or open the configuration of an existing axis.
2. Open the configuration "Hardware interface > Drive".
3. Select "PROFIdrive" from the "Drive type" drop-down list.
4. Select the standard telegram of the PROFIBUS drive from the "Drive" list.

For information on how to add a technology object, refer to the section
Add technology object (Page 176).

Result

The technology object is connected to the drive and the "MC Servo" organization block can be checked / configured.

The telegram of the configured drive is assigned to the "PIP OB Servo" process image.

Checking/configuring the properties of the MC Servo

1. Open the "Program blocks" folder in the project navigator.
2. Select the "MC Servo" organization block.
3. Select the "Properties" command in the shortcut menu.
4. Select the "Cycle time" entry in the area navigation.
5. The option "Synchronous to the bus" must be selected in the dialog box.
6. A "PROFINET DP system" must be selected in the "Distributed I/O" drop-down list.
7. The application cycle of "MC-Servo" must correspond to the send clock of the bus or be reduced by an integral factor relative to the send clock of the bus.

You can select a drive connected to the CPU via a communications processor/communications module (CP/CM) in the configuration of the technology object. You cannot select the DP master system of the CP/CM as the source clock for MC-Servo [OB91].

Result

The PROFIBUS DP drive is configured in such a way that it can be controlled in the PROFIBUS network in isochronous mode.

The properties of the SINAMICS drive must be configured according to the configuration of the axis with a separate STARTER program.

Checking isochronous mode on the drive

If the configuration sequence described above is not adhered to during configuration of the axis, and drive-specific error occurs when the project is compiled, isochronous mode can be checked on the drive.

1. Open the device view of the drive.
2. Select standard telegram in the device overview.
3. Select the properties dialog "General > I/O Addresses".
4. The following settings apply for the input and output addresses:
   - "MC Servo" must be select the "Organization block".
   - "PIP OB Servo" must be select the "Process image".

See also

PROFIdrive telegrams (Page 33)

Add technology object (Page 176)

6.1.3 Adding and configuring drives with analog connections

A description is provided below of how to add and configure a drive with an analog drive connection and an encoder. The connection is made for example as a positioning axis with an incremental encoder and using a technology module in the rack of the PLC.

Requirements

The SIMATIC S7-1500 device is created in the project.

Adding and configuring an analog output module in the device configuration

1. Open the device configuration of the PLC.
2. Select an analog output module from the hardware catalog and drag the module to the rack of the PLC.
3. Select the analog output module in the device view.
4. Open the "General" tab in the properties dialog and select there "Name of the Analog Output Module > I/O Addresses".
5. Enter the desired start address.
6. In the properties dialog, select the tab "General > IO Tags".
7. Enter the tag name for the desired analog output.

Adding and configuring a technology module

1. Switch to the device view of the PLC.
2. In the hardware catalog, open the folder "TM > Count > TM Count 2X24V".
3. Drag the counter module to a free slot in the rack.
   (When inserted in the rack of the PLC, the technology module cannot be operated in isochronous mode.)
4. Select the technology module in the device view.
5. In the properties dialog, open the "General" tab and select there "Count 2x24V > Basic Parameters > Channel X > Operating Mode" of the channel to be used.
6. Select "Position input for Motion Control" option for "Selection of the operating mode for the channel".
7. Under "Module parameters", adapt the parameters of the incremental encoder (steps per revolution = increments per revolution).
8. Under "Reaction to CPU STOP", select the item "Continue working".

Selecting the drive and encoder in the configuration of the technology object

1. Add a new positioning axis/synchronous axis technology object, or open the configuration of an existing positioning axis/synchronous axis.
2. Open the configuration "Hardware interface > Drive".
3. Select "Analog drive connection" from the "Drive type" drop-down list.
4. Select the previously defined tag name of the analog output from the "Output" list.
5. Open the configuration "Hardware interface > Encoder".
6. Under "Select encoder connection" select "Encoder on technology module (TM)".
7. Select the channel of the incremental encoder from the "Technology module" list under "local modules".
8. Open the configuration "Hardware interface > Data exchange with encoder > Fine resolution" and enter the "0" value for "bits in the incr. actual value".

For information on how to add a technology object, refer to the section
Add technology object (Page 176)

Result

The analog drive connection and the encoder connection are configured.

The analog addresses and the addresses of the TM module are assigned to the process image "PIP OB Servo".

Checking the encoder connection / drive connection

The encoder data are applied to the position control cycle clock. If in doubt, check the following settings:

1. Switch to the device view of the PLC.
2. Select the module technology.
3. Open the properties dialog "Basic Parameters > I/O Addresses".
4. The following settings apply for the input and output addresses:
   - "MC Servo" must be select the "Organization block".
   - "PIP OB Servo" must be select the "Process image".
5. Select the analog module.
6. Open the properties dialog "Name of the Analog Module > I/O Addresses".
7. The settings from Step 4 apply for the input and output addresses

See also

Add technology object (Page 176)

6.2 Add technology object

To add a technology object in the project navigator, proceed as follows:

Requirements

A project with a CPU S7-1500 has been created.

Procedure

1. Open the CPU's folder in the project navigator.
2. Open the "Technology Objects" folder.
3. Double-click "Add new object".

   The "Add new object" dialog opens.
4. Select the "Motion Control" technology.
5. Open the folder "Motion Control" > "SIMATIC S7-1500".
6. Select the desired technology object. You can infer the function of the technology object from the displayed description.
7. In the "Name" field, adapt the name of the axis to your requirements.
8. Select the "Manual" option if you want to change the suggested data block number.
9. Click on "Further Information" if you want to add your own information to the technology object.
10. Click on the "Cancel" button if you want to discard the entries.

    Activate the "Add new and open" check box if you want to open the configuration after adding the technology object.

    Click on the "OK" button if you want to add the technology object.

Result

The new technology object was created and saved in the project navigator in the folder "Technology objects".

If the organization blocks "MC-Servo" and "MC-Interpolator" had not yet been added, they have now been added.

6.3 Working with the configuration editor

You configure the properties of a technology object in the configuration window. To open the configuration window of the technology object in the project view, follow these steps:

1. Open the device "Technology objects" group in the project navigator.
2. Select the technology object and double-click on "Configuration".

The configuration is divided into categories which depend on the object type, for example: Basic parameters, hardware interface, extended parameters.

Configuration editor icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values you can use the technology object without additional changes.
	The configuration contains user-defined or automatically adapted values and is complete. All input fields of the configuration contain valid values and at least one preset value has changed.
	The configuration is incomplete or incorrect. At least one input field or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the field shows you the roll-out error message that indicates the cause of error.

6.4 Compare values

If there is an online connection to the CPU, the "Compare values" function appears in the configuration of the technology object.

The "Compare values" function provides the following options:

- Comparison of configured start values of the project with the start values in the CPU and the actual values
- Direct editing of actual values and the start values of the project
- Immediate detection and display of input errors with suggested corrections
- Backup of actual values in the project
- Transfer of start values of the project to the CPU as actual values

Icons and operator controls

If there is an online connection to the CPU, the actual values are displayed at the parameters.

In addition to the actual values of the parameters, the following symbols appear:

Symbol	Description
	Start value in CPU matches the configured Start value in project
	Start value in CPU does not match the configured Start value in project
	The comparison of the Start value in CPU with the configured Start value in project cannot be performed
	The value is not comparable with any significance since it is not relevant in one of configurations.
	Use the button to show the start value of the CPU and the start value of the project for the respective parameter.

You can change the start value of the CPU directly and then download it to the CPU. For directly editable parameters, the actual value can also be changed and the change will be transferred directly to the CPU.

6.5 Configuring the Speed-Control Axis technology object

6.5.1 Configuration - Basic Parameters

Configure the basic properties of the technology object in the "Basic Parameters" configuration window.

Name

Define the name of the speed axis in this field. The technology object is listed under this name in the project tree. The tags of the speed axis can be used in the user program under this name.

Axis type

Select the "Virtual axis" check box if you want to move the axis in simulation mode without hardware configuration. (See also the description of "Simulation" below.)

Speed measuring unit

Select the desired measuring unit for speed in the drop-down list.

Simulation

Select the "Activate simulation" check box if you want to move the axis in simulation mode with hardware configuration.

In simulation mode, speed, positioning and synchronous axes can be simulated in the CPU without connected drives and encoders. Simulation mode is possible starting from technology version 3.0 even without configured drives (virtual axis).

For simulation mode without hardware connected to the CPU, the startup time of the CPU can be influenced using the "Parameter assignment time for centralized and distributed I/O" parameter. You can find the parameter in the CPU properties in the "Startup" area navigation.

See also

Measuring units (Page 30)

Virtual axis/simulation (Page 48)

6.5.2 Hardware interface

6.5.2.1 Configuration - Drive

In the "Drive" configuration window, configure which drive type and which drive you want to use.

Drive type

In the drop-down list, select whether you want to deploy a PROFIdrive drive or a drive with an analog drive connection.

PROFIdrive drives are connected to the controller by means of a digital communication system (PROFINET or PROFIBUS). The communication occurs via PROFIdrive telegrams.

Drives with an analog drive connection receive the speed setpoint via an analog output signal (e.g. from -10 V to +10 V) from the PLC.

Drive type: PROFIdrive

Data connection

In the drop-down list, select whether the data connection is to be made directly with the drive device or via an editable data block in the user program.

Drive / data block

In the "Drive" field, select an already configured PROFIdrive drive / slot. If a PROFIdrive drive was selected, then it can be configured using the "Device configuration" button.

Switch to the device configuration, and add a PROFIdrive drive in the network view, in the event that no PROFIdrive drive can be selected.

If "Data block" was selected for the data connection, a previously created data block ("Optimized block access" disabled) containing a tag structure of data type "PD_TELxyz" must be selected here ("xyz" stands for the telegram number used).

Drive type: Analog drive connection

Analog output

In the "Output" field, select the PLC tag of the analog output over which the drive is to be controlled.

In order to be able to select an output, an analog output module must have been added in the device configuration, and the PLC tag name for the analog output must be defined.

Activating enable output

In the "Enable output" field, select the PLC tag of the digital output to enable the drive. With the enable output, the speed controller in the drive is enabled, or disabled.

In order to be able to select an enable output, a digital output module must have been added in the device configuration, and the PLC tag name for the digital output must be defined.

Note

If you do not use an enable output, the drive cannot be immediately disabled on the part of the system due to error reactions or monitoring functions. A controlled stop of the drive is not guaranteed.

Enable ready input

In the "Ready input" field, select the PLC tag of the digital input with which the drive is to report its operational readiness to the technology object. The power unit is switched on and the analog speed setpoint input is active.

In order to be able to select a ready input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

Note

The enable output and the ready input can be separately enabled.

The following boundary conditions apply to the activated ready input:

- The axis is only enabled (MC_PowerStatus = TRUE) when a signal is present at the ready input.
- If the signal at the ready input goes away for an enabled axis, the axis is disabled with an error.
- If the axis is disabled with the instruction MC_Power (Enable = FALSE), the axis is disabled even when a signal is present at the ready input.

See also

Configuration - Data exchange with the drive (Page 182)

Drive and encoder connection (Page 32)

6.5.2.2 Configuration - Data exchange with the drive

You configure the data transmission to the drive in this configuration window.

Selected drive type: PROFIdrive

Drive telegram

In the drop-down list, select the telegram for the drive. The specification must match the setting in the device configuration.

Automatic transfer of drive parameter values

Select the check box if you want the drive parameters "Reference speed", "Reference torque" and "Maximum speed" to be transferred as values from the drive configuration to the CPU. The drive parameters are transferred from the bus after the (re-)initialization of the technology object and (re)start of the drives and the CPU.

Alternatively, you must synchronize the following parameters manually:

- **Reference speed**

  Configure the reference speed of the drive in accordance with the manufacturer's specifications in this field. The specification of the drive speed is a percentage of the reference speed in the range -200% to +200%.

- **Maximum speed**

  Configure the maximum speed of the drive in this field.

- **Reference torque**

  Configure the reference torque of the drive corresponding to its configuration in this field.

  The reference torque is needed for force/torque reduction, which is supported with telegram 10x.

Note

Automatic transfer of drive parameters is only possible with SINAMICS drives as of V4.x. For this, "Drive" must be selected for the data connection in configuration window "Hardware interface > Drive".

Selected drive type: Analog drive connection

Reference speed

The reference speed of the drive is the speed at which the drive rotates when there is an output of 100% at the analog output. The reference speed must be configured for the drive and transferred in the configuration of the technology object.

The analog value that is output at 100% depends on the type of the analog output.
For example, for an analog output with +/- 10 V, the value 10 V is output at 100%.

Analog outputs can be overdriven by about 17%. This means that an analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.

See also

Automatic transfer of drive and encoder parameters in the device (Page 40)

Drive and encoder connection (Page 32)

6.5.3 Extended Parameters

6.5.3.1 Configuration - Mechanics

Configure the connection of the load to the drive in the "Mechanics" configuration window.

Invert drive direction

Select the check box if the direction of rotation of the drive is to be inverted.

Load gear

Number of motor revolutions / number of load revolutions

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions. Specify here an integral number of motor revolutions and the resulting number of load revolutions.

See also

Mechanics (Page 53)

6.5.3.2 Configuration - Dynamic Defaults

In the "Dynamic default values" configuration window, configure the default values for speed, acceleration, deceleration jerk of the axis.

The default values have an effect, when values < 0 are specified in Motion Control instructions for the "Velocity", "Acceleration", "Deceleration" or "Jerk" parameters. The default values can be applied separately for each of the parameters just listed.

Speed

In this field, define the default value for the speed of the axis.

Acceleration / Deceleration - Ramp-up time / Ramp-down time

Set the desired default value for acceleration in the "Ramp-up time" or "Acceleration" fields. The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The following equations show the relationship between the ramp-up time and acceleration and the ramp-down time and deceleration:

$$\text{Ramp-up time} = \frac{\text{Speed}}{\text{Acceleration}}$$

$$\text{Ramp-down time} = \frac{\text{Speed}}{\text{Deceleration}}$$

Note

A change in the velocity influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

Smoothing time / jerk

You can enter the jerk limit parameters in the "Smoothing time" box, or alternatively in the "Jerk" box:

- Set the desired jerk for the acceleration and deceleration ramp in the "Jerk" field.
  The value 0 means that jerk limiting is deactivated.
- Set the desired smoothing time for the acceleration ramp in the "Smoothing time" field.

Note

The jerk value is identical for the acceleration and deceleration ramp. The smoothing time in effect for the deceleration ramp results from the following relationships:

- **Acceleration > Deceleration**
  A shorter smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration < Deceleration**
  A longer smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration = Deceleration**
  The smoothing times of the acceleration and deceleration ramp are equal.

If an error occurs, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Smoothing time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Jerk}}$$

$$\text{Smoothing time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Jerk}}$$

Motion jobs started in the user program are performed with the selected jerk.

See also

Velocity profile (Page 60)

6.5.3.3 Configuration - Emergency stop

In the "Emergency stop" configuration window, you can configure the emergency stop deceleration of the axis. In the event of an error, and when disabling the axis, the axis is brought to a standstill with this deceleration using the Motion Control instruction "MC_Power" (input parameter StopMode = 0).

Emergency stop deceleration / Emergency stop ramp-down time

Configure the deceleration value for emergency stop in the "Emergency stop deceleration" field or the "Emergency stop ramp-down time" field.

The relationship between emergency stop ramp-down time and emergency stop deceleration can be seen in the following equation:

$$\textit{Emergency stop ramp-down time} = \frac{\textit{Maximum speed}}{\textit{Emergency stop deceleration}}$$

The configuration of the emergency stop deceleration is related to the configured maximum speed of the axis. If the maximum speed of the axis changes, then the value of the emergency stop deceleration also changes (the emergency stop ramp-down time remains unchanged).

See also

Emergency stop deceleration (Page 61)

6.5.3.4 Limits

Configuration - Dynamic limits

In the "Dynamic limits" configuration window, configure the maximum values for speed, acceleration, deceleration and jerk of the axis.

Maximum speed

In this field, define the maximum permitted speed of the axis.

Maximum acceleration / maximum deceleration - ramp-up time / ramp-down time

Set the desired acceleration in the "Ramp-up time" or "Acceleration" fields.
The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The following equations show the relationship between the ramp-up time and acceleration and the ramp-down time and deceleration:

$$\text{Ramp-up time} = \frac{\text{Maximum velocity}}{\text{Acceleration}}$$

$$\text{Ramp-down time} = \frac{\text{Maximum speed}}{\text{Deceleration}}$$

Note

A change in the maximum speed influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

Smoothing time / jerk

You can enter the jerk limit parameters in the "Smoothing time" box, or alternatively in the "Jerk" box:

- Set the desired jerk for the acceleration ramp and the deceleration ramp in the "Maximum jerk" box. The value 0 means that the jerk is not limited.
- Set the desired smoothing time for the acceleration ramp in the "Smoothing time" field.

Note

The configured smoothing time displayed in the configuration, applies only to the acceleration ramp.

If the values of the acceleration and deceleration differ, the smoothing time of the deceleration ramp is calculated and used according to the jerk of the acceleration ramp.

The smoothing time of the deceleration is adapted as follows:

- **Acceleration > Deceleration**

  A shorter smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration < Deceleration**

  A longer smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration = Deceleration**

  The smoothing times of the acceleration and deceleration ramp are equal.

If an error occurs, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Smoothing time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Jerk}}$$

$$\text{Smoothing time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Jerk}}$$

Motion jobs started in the user program are performed with the selected jerk.

See also

Velocity profile (Page 60)

Configuration - Torque limits

Configure the torque limiting of the drive in the "Torque limits" configuration window.

The configuration is now available if a drive that supports force/torque limiting is selected and a telegram 10x is used.

Effective

In the drop-down list, select whether the limit value is to be in effect "on load side" or "on motor side".

Torque limiting

Enter a default value for the torque limit in the specified measuring unit in this field.

The default value is in effect when the torque limiting is specified using Motion Control instruction "MC_TorqueLimiting", input parameter "Limit" < 0.

If the gear efficiency is critical, this can be set in the <TO>.Actor.Efficiency tag.

See also

Force/torque limiting (Page 63)

6.6 Configuring the positioning axis/synchronous axis technology object

6.6.1 Configuration - Basic Parameters

Name

Define the name of the positioning axis/synchronous axis in this field. The technology object is listed under this name in the project tree. The variables of the technology object can be used in the user program under this name.

Axis type

Select the "Virtual axis" check box if you want to move the axis in simulation mode without hardware configuration. (See also the description of "Simulation" below.)

In this selection, configure whether the axis should perform linear or rotary motions.

Measuring units

In the drop-down list, select the desired measuring units for the position, velocity, torque and force of the axis.

Modulo

Select the "Enable modulo" check box if you want to use a recurring system of units for the axis (e.g. 0 to 360° for an axis of the "rotary" axis type).

- **Modulo start value**

  In this field, define the position at which the modulo range should begin (e.g. 0° for an axis of the "rotary" axis type).

- **Modulo length**

  In this field, define the length of the modulo range (e.g. 360° for an axis of the "rotary" axis type).

Simulation

Select the "Activate simulation" check box if you want to move the axis in simulation mode with hardware configuration.

In simulation mode, speed, positioning and synchronous axes can be simulated in the CPU without connected drives and encoders. Simulation mode is possible starting from technology version 3.0 even without configured drives (virtual axis).

For simulation mode without hardware connected to the CPU, the startup time of the CPU can be influenced using the "Parameter assignment time for centralized and distributed I/O" parameter. You can find the parameter in the CPU properties in the "Startup" area navigation.

See also

Virtual axis/simulation (Page 48)

Measuring units (Page 30)

Modulo setting (Page 31)

Mechanics (Page 53)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

6.6.2 Hardware interface

6.6.2.1 Configuration - Drive

In the "Drive" configuration window, configure which drive type and which drive you want to use.

Drive type

In the drop-down list, select whether you want to deploy a PROFIdrive drive or a drive with an analog drive connection.

PROFIdrive drives are connected to the controller by means of a digital communication system (PROFINET or PROFIBUS). The communication occurs via PROFIdrive telegrams.

Drives with an analog drive connection receive the speed setpoint via an analog output signal (e.g. from -10 V to +10 V) from the PLC.

Drive type: PROFIdrive

Data connection

In the drop-down list, select whether the data connection is to be made directly with the drive device or via an editable data block in the user program.

Drive / data block

In the "Drive" field, select an already configured PROFIdrive drive / slot. If a PROFIdrive drive was selected, then it can be configured using the "Device configuration" button.

Switch to the device configuration, and add a PROFIdrive drive in the network view, in the event that no PROFIdrive drive can be selected.

If "Data block" was selected for the data connection, a previously created data block ("Optimized block access" disabled) containing a tag structure of data type "PD_TELx" must be selected here ("x" stands for the telegram number used).

Drive type: Analog drive connection

Analog output

In the "Analog output" field, select the PLC tag of the analog output via which the drive is to be controlled.

In order to be able to select an output, an analog output module must have been added in the device configuration, and the PLC tag name for the analog output must be defined.

Activating enable output

Select the "Activate enable output" check box if the drive supports an enable.

Select the PLC tag of the digital output for the drive enable in the corresponding field. With the enable output, the speed controller in the drive is enabled, or disabled.

In order to be able to select an enable output, a digital output module must have been added in the device configuration, and the PLC tag name for the digital output must be defined.

Note

If you do not use an enable output, the drive cannot be immediately disabled on the part of the system due to error reactions or monitoring functions. A controlled stop of the drive is not guaranteed.

Enable ready input

Select the "Enable ready input" check box if the drive can signal its readiness.

Select the PLC tag of the digital input via which the drive is to signal its operational readiness to the technology object in the corresponding field. The power unit is switched on and the analog speed setpoint input is active.

In order to be able to select a ready input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

Note

The enable output and the ready input can be separately enabled.

The following boundary conditions apply to the activated ready input:

- The axis is only enabled (MC_Power Status = TRUE) when a signal is present at the ready input.
- If the signal at the ready input goes away for an enabled axis, the axis is disabled with an error.
- If the axis is disabled with the instruction MC_Power (Enable = FALSE), the axis is disabled even when a signal is present at the ready input.

See also

Data connection of drive/encoder via data block (Page 49)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

6.6.2.2 Configuration - Encoder

For closed loop position control, positioning axes/synchronous axes require an actual position value in the form of an encoder position. The encoder position is transmitted to the controller by means of a PROFIdrive telegram.

Configure the encoder and encoder type in the "Encoder" configuration window.

Data connection

In the drop-down list, select whether the data connection should be established directly with the encoder or via a data block that can be edited in the user program.

The selection is only possible for encoders that are connected via PROFIdrive and support parameter P979.

Encoder / Data block

Select a previously configured encoder in this configuration field.

The following encoders can be selected:

- **Connection to the drive (not with analog drive connection)**

  The encoder is configured using the configuration of the PROFIdrive drive.
  The drive evaluates the encoder signals and sends them to the controller in the PROFIdrive telegram.

- **Encoder on technology module (TM)**

  Select a previously configured technology module and the channel to be used.
  Only technology modules set to the "Position input for Motion Control" mode are displayed for selection.

  If no technology module is available for selection, change to the device configuration and add a technology module. If you have selected a technology module, you can access the configuration of the technology module using the "Device configuration" button.

  You can operate the technology module centrally on an S7-1500 CPU or decentrally on a distributed I/O. Isochronous mode is not possible with central operation in the CPU.

  You can identify the technology modules suitable for position detection for Motion Control in the documentation for the technology module and the catalog data.

- **PROFIdrive encoder on PROFINET/PROFIBUS (PROFIdrive)**

  In the "PROFIdrive encoder" field, select a previously configured encoder on PROFINET/PROFIBUS. If an encoder was selected, it can be configured using the "Device configuration" button.

  Switch to the device configuration in the network view, and add an encoder, in the event that no encoder can be selected.

If "Data block" was selected for the data connection, a previously created data block ("Optimized block access" disabled) containing a tag structure of data type "PD_TELx" must be selected here ("x" stands for the telegram number used).

Encoder type

Select the encoder type of the encoder in the drop-down list. The following encoder types are available:

- Incremental
- Absolute
- Cyclic absolute

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Data connection of drive/encoder via data block (Page 49)

6.6.2.3 Configuration - Data exchange with the drive

Configure the data exchange with the drive in the "Data exchange with the drive" configuration window.

The configuration differs according to the selected drive type:

Drive type: PROFIdrive

Drive telegram

In the drop-down list, select the telegram for the drive.

The specification must match the setting in the device configuration.

Automatic transfer of drive parameter values

Select the check box if you want the drive parameters "Reference speed", "Maximum speed" and "Reference torque" to be transferred as values from the drive configuration to the CPU. The drive parameters are transferred from the bus after the (re-)initialization of the technology object and (re)start of the drives and the CPU.

Alternatively, you must synchronize the following parameters manually:

- **Reference speed**

  Configure the reference speed of the drive in accordance with the manufacturer's specifications in this field. The specification of the drive speed is a percentage of the reference speed in the range -200% to +200%.

- **Maximum speed**

  Configure the maximum speed of the drive in this field.

- **Reference torque**

  Configure the reference torque of the drive corresponding to its configuration in this field.

  The reference torque is needed for force/torque reduction, which is supported with telegram 10x.

Note

Automatic transfer of drive parameters is only possible with SINAMICS drives as of V4.x. For this, "Drive" must be selected for the data connection in configuration window "Hardware interface > Drive".

Drive type: Analog drive connection

Reference speed

The reference speed of the drive is the speed at which the drive rotates when there is an output of 100% at the analog output. The reference speed must be configured for the drive and transferred in the configuration of the technology object.

The analog value that is output at 100% depends on the type of the analog output.
For example, for an analog output with +/- 10 V, the value 10 V is output at 100%.

Analog outputs can be overdriven by about 17%. This means that an analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.

Maximum speed

Specify the maximum speed of the drive in this field.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Automatic transfer of drive and encoder parameters in the device (Page 40)

6.6.2.4 Configuration - Data exchange with encoder

Configure detailed encoder parameters and the data exchange with the encoder in the "Data exchange with encoder" configuration window.

The display and selection of the configuration parameters described here is dependent on the following parameters:

- Configuration window "Basic parameters": Drive type (linear/rotary)
- Configuration window "Hardware interface > Encoder": Encoder type (incremental/absolute/cyclic absolute)
- Configuration window - "Extended parameters > Mechanics": Encoder mounting type

Encoder telegram

In the drop-down list, select the telegram via which the encoder is to be connected.

The telegram must match the device configuration.

Automatic transfer of encoder parameter values

Select the check box if you want to transfer the encoder parameters from the encoder configuration to the CPU. The encoder parameters are transferred from the bus after the (re-)initialization of the technology object and (re)start of the encoder and the CPU.

Note

Automatic transfer of encoder parameters is only possible with PROFIdrive encoders as of product version A16. For this, "Hardware interface > Encoder" must be selected as the "Encoder" data connection in the configuration window.

Alternatively, you must synchronize the following parameters manually:

Measuring system

In the drop-down list, select whether a linear or rotary measuring system is to be used.

You can obtain the basic system from the representation in the "Extended parameters > Mechanics" configuration window.

Increments per revolution

In this configuration field, configure the number of increments that the encoder resolves per revolution.

Number per revolution:

In this configuration field, configure the number of revolutions that the absolute encoder can detect.

Distance between two increments

In this configuration field, configure the distance between two increments of the encoder.

Fine resolution

Bits in the incremental actual value (Gx_XIST1)

Configure the number of reserved bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.

Bits in the absolute actual value (Gx_XIST2)

Configure the number of reserved bits for fine resolution within the absolute value (Gx_XIST2) in this field.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Automatic transfer of drive and encoder parameters in the device (Page 40)

6.6.3 Configuration - leading value interconnections (synchronous axis only)

You can interconnect a synchronous axis with multiple leading value-capable technology objects. Leading value-capable technology objects are:

- Positioning axes
- Synchronous axes
- External encoders (only with S7-1500T CPU)

You can select only one leading value during runtime of your user program.

All interconnection required during operation must be set up during configuration of the technology object.

Possible leading values

In the "Possible leading values" column of the "Leading value interconnections" list, add all leading value-capable technology objects that you need during operation as a leading value for the synchronous axis.

You can interconnect the axes added in the list with the synchronous axis as a leading value with the corresponding Motion Control instruction.

All configured leading value interconnections for the technology object are displayed in the cross-reference list of the technology object.

Coupling type

In the "Type of coupling" column, configure whether the leading value is to be coupled via setpoint or actual value.

"Actual value" is available only for the S7-1500T CPU.

See also

Leading value coupling (Page 109)

Synchronous axis technology object (Page 107)

6.6.4 Extended Parameters

6.6.4.1 Configuration - Mechanics

Configuration - Mechanics

In the "Mechanics" configuration window, configure the mounting type of the encoder, and the adaptation of the actual encoder value to the mechanical conditions.

Settings for

In the drop-down list, select the encoder for which the following configurations are to apply.

Encoder mounting type

In the drop-down list, select how the encoder is mounted to the mechanics.

The configuration differs depending on the axis type and the encoder mounting type selected in the "Basic parameters" configuration window.

Axis type: Linear

- Linear - On motor shaft (Page 202)
- Linear - On load side (Page 203)
- Linear - External Measuring System (Page 204)

Axis type: Rotary

- Rotary - On motor shaft (Page 205)
- Rotary - On load side (Page 206)
- Rotary - External Measuring System (Page 207)

Invert encoder direction

Select this check box if you must invert the direction of rotation of the encoder.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Axis type: Linear

Linear - On motor shaft

The encoder is connected to the motor shaft in a mechanically fixed manner.
Motor and encoder form a unit.

Invert drive direction

Select the check box if the direction of rotation of the drive is to be inverted.

Load gear

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions.

Number of motor revolutions

In this configuration field, configure the integer number of motor revolutions.

Number of load revolutions

In this configuration field, configure the integer number of load revolutions.

Position parameters

Leadscrew pitch

In this configuration field, configure the distance by which the load is moved when the leadscrew makes one revolution.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Linear - On load side

The encoder is mechanically connected to the load side of the gear.

Invert drive direction

Select the check box if the direction of rotation of the drive is to be inverted.

Load gear

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions.

Number of motor revolutions

In this configuration field, configure the integer number of motor revolutions.

Number of load revolutions

In this configuration field, configure the integer number of load revolutions.

Position parameters

Leadscrew pitch

In this configuration field, configure the distance by which the load is moved when the leadscrew makes one revolution.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Linear - External Measuring System

An external measuring system provides the position values of the linear load motion.

Distance per encoder revolution

In this configuration field, configure the linear load travel per encoder revolution.

Invert drive direction

Select the check box if the direction of rotation of the drive is to be inverted.

Load gear

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions.

Number of motor revolutions

In this configuration field, configure the integer number of motor revolutions.

Number of load revolutions

In this configuration field, configure the integer number of load revolutions.

Position parameters

Leadscrew pitch

In this configuration field, configure the distance by which the load is moved when the leadscrew makes one revolution.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Axis type: Rotary

Rotary - On motor shaft

The encoder is connected to the motor shaft in a mechanically fixed manner.
Motor and encoder form a unit.

Invert drive direction

Select the check box if the direction of rotation of the drive is to be inverted.

Load gear

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions.

Number of motor revolutions

In this configuration field, configure the integer number of motor revolutions.

Number of load revolutions

In this configuration field, configure the integer number of load revolutions.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Rotary - On load side

The encoder is mechanically connected to the load side of the gear.

Invert drive direction

Select the check box if the direction of rotation of the drive is to be inverted.

Load gear

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions.

Number of motor revolutions

In this configuration field, configure the integer number of motor revolutions.

Number of load revolutions

In this configuration field, configure the integer number of load revolutions.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Rotary - External Measuring System

An external measuring system provides the position values of the rotary load motion.

Distance per encoder revolution

In this configuration field, configure the linear load travel per encoder revolution.

Invert drive direction

Select the check box if the direction of rotation of the drive is to be inverted.

Load gear

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions.

Number of motor revolutions

In this configuration field, configure the integer number of motor revolutions.

Number of load revolutions

In this configuration field, configure the integer number of load revolutions.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

6.6.4.2 Configuration - Dynamic Defaults

In the "Dynamic default values" configuration window, configure the default values for velocity, acceleration, deceleration and jerk of the axis.

The default values take effect, when values < 0 are specified in Motion Control instructions for the "Velocity", "Acceleration", "Deceleration" or "Jerk" parameters. The default values can be applied separately for each of the parameters just listed.

The default values for acceleration and deceleration also act on the traversing motions of active homing.

Velocity

In this field, define the default value for the velocity of the axis.

Acceleration / Deceleration - Ramp-up time / Ramp-down time

Configure the desired default value for acceleration in the "Ramp-up time" or "Acceleration" fields. The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The following equations show the relationship between the ramp-up time and acceleration and the ramp-down time and deceleration:

$$\text{Ramp-up time} = \frac{\text{Velocity}}{\text{Acceleration}}$$

$$\text{Ramp-down time} = \frac{\text{Velocity}}{\text{Deceleration}}$$

Note

A change in the velocity influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

Smoothing time / jerk

You can enter the jerk limit parameters in the "Smoothing time" box, or alternatively in the "Jerk" box:

- Set the desired jerk for the acceleration and deceleration ramp in the "Jerk" field. The value 0 means that jerk limiting is deactivated.
- Set the desired smoothing time for the acceleration ramp in the "Smoothing time" field.

Note

The jerk value is identical for the acceleration and deceleration ramp. The smoothing time in effect for the deceleration ramp results from the following relationships:

- **Acceleration > Deceleration**

  A shorter smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration < Deceleration**

  A longer smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration = Deceleration**

  The smoothing times of the acceleration and deceleration ramp are equal.

If an error occurs, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Smoothing time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Jerk}}$$

$$\text{Smoothing time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Jerk}}$$

Motion jobs started in the user program are performed with the selected jerk.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Velocity profile (Page 60)

6.6.4.3 Configuration - Emergency stop

In the "Emergency stop" configuration window, you can configure the emergency stop deceleration of the axis. In the event of an error, and when disabling the axis, the axis is brought to a standstill with this deceleration using the Motion Control instruction "MC_Power" (input parameter StopMode = 0).

Emergency stop deceleration / Emergency stop ramp-down time

Configure the deceleration value for emergency stop in the "Emergency stop deceleration" field or the "Emergency stop ramp-down time" field.

The relationship between emergency stop ramp-down time and emergency stop deceleration can be seen in the following equation:

$$\textit{Emergency stop ramp-down time} = \frac{\textit{Maximum velocity}}{\textit{Emergency stop deceleration}}$$

The configuration of the emergency stop deceleration is related to the configured maximum velocity of the axis. If the maximum velocity of the axis changes, then the value of the emergency stop deceleration also changes (the emergency stop ramp-down time remains unchanged).

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Emergency stop deceleration (Page 61)

6.6.4.4 Limits

Configuration - Position limits

Configure the hardware and software limit switches of the axis in the "Position limits" configuration window.

Enable HW limit switches

The check box activates the function of the negative and positive hardware limit switches. The negative hardware limit switch is located on the side in the negative direction of travel, and the positive hardware limit switch on the side in the positive direction of travel.

If a hardware limit switch is reached, technology alarm 531 is output, and the technology object is disabled (alarm response: remove enable).

Exception: If a hardware limit switch is crossed during an active home position approach with activated direction reversal at the hardware limit switch, the axis stops with the configured maximum deceleration and continues the home position approach in the opposite direction.

Note

Only use hardware limit switches that remain permanently switched after the approach. This switching state may only be canceled after the return into the permitted traversing range.

The digital inputs of the hardware limit switches are evaluated by default in cyclic data exchange. In the settings for the input module under "I/O addresses", select the entry "MC-Servo" for "Organization block" and the entry "TPA OB Servo" for "Process image" if the hardware limit switches are to be evaluated in the position control cycle clock of the drive.

Negative / positive HW limit switch input

In these fields, select the PLC tag of the digital input for the negative and positive HW limit switches.

In order to be able to select an input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

CAUTION

During installation of hardware limit switches, attention must be paid to the filter times of the digital inputs.

Based on the time for one position control cycle clock and the filter time of the digital inputs, the resulting delay times must be taken into account.

The filter time is configurable in individual digital input modules in the device configuration.

The digital inputs are set to a filter time of 6.4 ms by default. If these are used as hardware limit switches, undesired decelerations may occur. If this occurs, reduce the filter time for the relevant digital inputs.

The filter time can be set under "Input filter" in the device configuration of the digital inputs.

Negative / positive HW limit switch level selection

In the drop-down list, select the triggering signal level ("Low level" / "High level") of the hardware limit switch. With "Low level", the input signal is FALSE after the axis has reached or crossed the hardware limit switch. With "High level", the input signal is TRUE after the axis has reached or crossed the hardware limit switch.

Enable software limit switch

This check box activates the high and low software limit switches. When software switches are activated, an active motion comes to a stop at the position of the software limit switch. The technological object signals an error. After acknowledgment of the error, the axis can again be moved in the direction of its operating range.

Note

Activated software limit switches act only on a homed axis.

Position of negative / positive SW limit switch

Configure the operating range of the axis with the positions of the negative and positive software limit switches.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Configuration - Dynamic limits

In the "Dynamic limits" configuration window, configure the maximum values for velocity, acceleration, deceleration and jerk of the axis.

Maximum velocity

In this field, define the maximum permitted velocity of the axis.

Maximum acceleration / maximum deceleration - ramp-up time / ramp-down time

Set the desired acceleration in the "Ramp-up time" or "Acceleration" fields.
The desired deceleration can be set in the "Ramp-down time" or "Deceleration" fields.

The following equations show the relationship between the ramp-up time and acceleration and the ramp-down time and deceleration:

$$\textit{Ramp-up time} = \frac{\textit{Maximum velocity}}{\textit{Acceleration}}$$

$$\textit{Ramp-down time} = \frac{\textit{Maximum velocity}}{\textit{Deceleration}}$$

Note

A change in the maximum velocity influences the acceleration and deceleration values of the axis. The ramp-up and ramp-down times are retained.

The "maximum deceleration" for active homing with change of direction at the hardware limit switch must be set sufficiently large, to brake the axis before reaching the mechanical endstop.

Smoothing time / jerk

You can enter the jerk limit parameters in the "Smoothing time" box, or alternatively in the "Jerk" box:

- Set the desired jerk for the acceleration and deceleration ramp in the "Jerk" field. The value 0 means that the jerk is not limited.
- Set the desired smoothing time for the acceleration ramp in the "Smoothing time" field.

Note

The configured smoothing time displayed in the configuration, applies only to the acceleration ramp.

If the values of the acceleration and deceleration differ, the smoothing time of the deceleration ramp is calculated and used according to the jerk of the acceleration ramp.

The smoothing time of the deceleration is adapted as follows:

- **Acceleration > Deceleration**

  A shorter smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration < Deceleration**

  A longer smoothing time is used for the deceleration ramp compared with the acceleration ramp.
- **Acceleration = Deceleration**

  The smoothing times of the acceleration and deceleration ramp are equal.

If an error occurs, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

The following equations show the relationship between the smoothing times and the jerk:

$$\text{Smoothing time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Jerk}}$$

$$\text{Smoothing time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Jerk}}$$

Motion jobs started in the user program are performed with the selected jerk.

See also

Velocity profile (Page 60)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Configuration - Torque limiting

Configure the force/torque limiting of the drive in the "Torque limiting" configuration window.

The configuration is now available if a drive that supports force/torque limiting is selected and a telegram 10x is used. Telegram 101 cannot be used.

Effective

In the drop-down list, select whether the limit value is to be in effect "on load side" or "on motor side".

Torque limiting

Enter a default value for the force/torque limit in the specified measuring unit in this field.

The default value is in effect when the torque limiting is specified using Motion Control instruction "MC_TorqueLimiting", input parameter "Limit" < 0.

Torque limiting applies to the following axis configurations:

- Axis type is "Rotary" and limit value is in effect "On load side" or "On motor side"
- Axis type is "Linear" and limit value is in effect "On motor side"

Force limit

Enter a default value for the force limit in the specified measuring unit in this field.

The default value is in effect when the force limit is specified using Motion Control instruction "MC_TorqueLimiting", input parameter "Limit" < 0.

The force limit applies to the following axis configuration: Axis type is "Linear" and limit value is in effect "On load side"

If the gear and leadscrew efficiency is crucial, this can be set in the <TO>.Actor.Efficiency tag.

Deactivating/activating position-related monitoring

As a result of the force/torque limiting on the drive, a larger following error may occur or the axis standstill may not be detected reliably in positioning monitoring.

Deactivate "Position-related monitoring" in order to deactivate monitoring of the following error and the positioning monitoring during force/torque limiting.

See also

Force/torque limiting (Page 63)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Configuration - Fixed stop detection

Configure the fixed stop detection in the configuration window.

A "Travel to fixed stop" can be realized by activating fixed stop detection using the Motion Control instruction "MC_TorqueLimiting" and a position-controlled motion job. The operation is also referred to as clamping.

Positioning tolerance

In this configuration field, configure the positioning tolerance that is regarded as a breaking away or turning back of the fixed stop when exceeded. To detect the breaking away or turning back of the fixed stop, the position setpoint must be located outside the positioning tolerance. The configured position tolerance must be less than the configured following error.

Following error

If the drive is stopped by a mechanical fixed stop during a motion job, the following error is increased. The accumulating following error serves as a criterion for fixed stop detection. In the "Following error" configuration field, configure the value of the following error starting from which the fixed stop detection is to take effect. The configured following error must be greater than the configured position tolerance.

Note

If the following error monitoring was activated in the position monitoring configuration, the "Maximum following error" configured there must be greater than the "Following error" of the fixed stop detection.

See also

Fixed stop detection (Page 65)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

6.6.4.5 Homing

Homing means matching the position value of a technology object to the real, physical location of the drive. Absolute target positions of the axis can only be approached with a homed axis.

In S7-1500 Motion Control, the axis is homed with the Motion Control instruction, "MC_Home". A distinction is made between the following operating modes of the Motion Control instruction:

Operating modes of the Motion Control instruction "MC_Home"

- **Active homing**

  With active homing, the Motion Control instruction "MC_Home" performs the configured home position approach. Active traversing motions are aborted. When the homing mark is detected, the position of the axis is set according to the configuration.

- **Passive homing**

  With passive homing, the Motion Control instruction "MC_Home" instruction does not carry out any homing motion. The traversing motion required for this must be implemented by the user with other Motion Control instructions. Active traversing motions are not aborted upon start of passive homing. When the homing mark is detected, the axis is set according to the configuration.

- **Direct homing absolute**

  The axis position is set without taking into consideration the home position switch. Active traversing motions are not aborted. The value of input parameter "Position" of Motion Control instruction "MC_Home" is set immediately as the actual position of the axis.

- **Direct homing relative**

  The axis position is set without taking into consideration the home position switch. Active traversing motions are not aborted. The following statement applies to the axis position after homing:

  New axis position = Current axis position + Value of parameter "Position" of instruction "MC_Home".

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Homing (Page 69)

Active homing

Configuration - Active homing

In the "Active Homing" configuration window, configure the parameters for active homing. "Active homing" is performed using the Motion Control instruction "MC_Home " Mode = 3 and 5.

Note

Parameter "MC_Home.Mode" (S7-1500 CPU)

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.
A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

Settings for

In the drop-down list, select the encoder for which the homing settings are to apply (only for S7-1500T).

Select the homing mode

Select from among the following homing modes:

- Zero mark via PROFIdrive telegram and reference cam (Page 219)
- Zero mark via PROFIdrive frame (Page 221)
- Homing mark via digital input (Page 222)

See also

Homing (Page 69)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Zero mark via PROFIdrive telegram and reference cam

Enable direction reversal at the hardware limit switch

Select this check box to use the hardware limit switch as a reversing cam for the home position approach. After the axis has reached the hardware limit switch during active homing, it is ramped down at the configured maximum deceleration rate and the direction is then reversed. The reference cam is then searched for in the reverse direction. If this function is not enabled and the axis reaches the hardware limit switch during active homing, then the drive is disabled and braked with the ramp configured in the drive.

Approach direction

Select the approach direction for the reference cam search.

"Positive" is the approach direction in the direction of positive position values; "negative" in the direction of negative position values.

Homing direction

Select the direction in which the zero mark should be approached for homing.

Approach velocity

In this field, specify the velocity at which the reference cam is searched for during the homing procedure. Any configured home position offset is traversed at the same velocity.

Homing velocity

In this field, specify the velocity at which the axis approaches the zero mark for homing. For zero mark detection, the reference cam must be exited.

Home position offset

In the case of a differing zero mark position and home position, enter the corresponding home position offset in this field. The axis approaches the home position at approach velocity.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 5.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Homing (Page 69)

Zero mark via PROFIdrive frame

Enable direction reversal at the hardware limit switch

Select this check box to use the hardware limit switch as a reversing cam for the home position approach. After the axis has reached the hardware limit switch during active homing, it is ramped down at the configured maximum deceleration rate and the direction is then reversed. The zero mark is then sought in the reverse direction. If this function is not enabled and the axis reaches the hardware limit switch during active homing, then the drive is disabled and braked with the ramp configured in the drive.

Homing direction

Select the direction in which the next zero mark should be approached for homing.

"Positive" is the homing direction in the direction of positive position values; "negative" in the direction of negative position values.

Approach velocity

In the "Zero mark via PROFIdrive frame" homing mode, the approach velocity for traversing the home position offset is used.

Homing velocity

In this field, specify the velocity at which the axis approaches the zero mark for homing.

Home position offset

In the case of a differing zero mark position and home position, enter the corresponding home position offset in this field. The axis approaches the home position at approach velocity.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 5.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Homing (Page 69)

Homing mark via digital input

If a digital input is used as a homing mark, the accuracy of the homing process is not as high as with hardware-supported homing using zero marks.

You can improve the accuracy by using a low homing velocity.

Pay attention to the setting of short filter times for the digital input as well.

Digital input homing mark/cam

In this configuration field, select the PLC tag of the digital input that is to act as a homing mark (reference cam). Also select the level at which the homing mark is to be detected.

In order to be able to select an input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

Enable direction reversal at the hardware limit switch

Select this check box to use the hardware limit switch as a reversing cam for the home position approach. After the axis has reached the hardware limit switch during active homing, it is ramped down at the configured maximum deceleration rate and then reversed. The homing mark is then sensed in reverse direction. If this function is not enabled and the axis reaches the hardware limit switch during active homing, then the drive is disabled and braked with the ramp configured in the drive.

Approach direction

Select the approach direction for the homing mark search.

"Positive" is the approach direction in the direction of positive position values; "negative" in the direction of negative position values.

Homing direction

Select the direction in which the homing mark for homing is to be approached.

Homing mark

Select the switch position of the "digital input" that is to be used as the homing mark.

When a "digital input" is crossed, two switching edges that are spatially separated from one another are generated. The selection of the positive or negative side ensures that the homing mark is always evaluated at the same mechanical position.

The positive side is the switch position with a greater position value; the negative side is the switch position with the lesser position value.

The selection of the side is independent of the approach direction, and independent of whether it causes a rising or falling edge.

Approach velocity

In this field, specify the velocity at which the axis searches for the "digital input" during the home position approach. Any configured home position offset is traversed at the same velocity.

Homing velocity

In this field, specify the velocity at which the axis approaches the home position for homing.

Home position offset

If the homing mark position is different from the home position, enter the corresponding home position offset in this field. The axis approaches the home position at approach velocity.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect, when the Motion Control instruction "MC_Home" is executed with Mode = 5.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Homing (Page 69)

Passive homing

Configuration - Passive homing

Configure the parameters for passive homing in the "Passive Homing" (homing on the fly) configuration window. Passive homing is performed using the Motion Control instruction "MC_Home" Mode = 2, 8 and 10.

Note

Parameter "MC_Home.Mode" (S7-1500 CPU)

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.
A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

Settings for

In the drop-down list, select the encoder for which the homing settings are to apply (only for S7-1500T).

Select the homing mode

Select from among the following homing modes:

- Zero mark via PROFIdrive telegram and reference cam (Page 225)
- Zero mark via PROFIdrive frame (Page 226)
- Homing mark via digital input (Page 227)

See also

Homing (Page 69)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Zero mark via PROFIdrive telegram and reference cam

Homing direction

Select the direction in which the zero mark should be approached for homing. The next zero mark after leaving the reference cam is used.

The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with Mode = 10.

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.
A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Homing (Page 69)

Zero mark via PROFIdrive frame

Homing direction

Select the direction in which the next zero mark should be approached for homing.
The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with Mode = 10.

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.
A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

See also

Synchronous axis technology object (Page 107)

Positioning axis technology object (Page 106)

Homing (Page 69)

Homing mark via digital input

Digital input homing mark/cam

In this dialog field, select a digital input that is to act as a homing mark (reference cam). Also select the level at which the homing mark is to be detected.

Homing direction

Select the direction in which the homing mark for homing is to be approached.

The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Homing mark

Select which switch position of the "digital input" is to be used as the homing mark.

When a "digital input" is crossed, two switching edges that are spatially separated from one another are generated. The selection of the positive or negative side ensures that the homing mark is always evaluated at the same mechanical position.

The positive side is the switch position with a greater position value; the negative side is the switch position with the lesser position value.

The selection of the side is independent of the approach direction, and independent of whether it causes a rising or falling edge.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with Mode = 10.

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Homing (Page 69)

6.6.4.6 Position monitoring functions

Configuration - Positioning monitoring

In the "Positioning monitoring" configuration window, configure the criteria for monitoring the target position.

Positioning window:

Configure the size of the positioning window in this field. If the axis is located within this window, the position is considered to be "reached".

Positioning tolerance time:

Configure the positioning tolerance time within which the position value must reach the positioning window in this field.

Minimum dwell time in positioning window:

Configure the minimum dwell time in this field. The current position value must be located in the positioning window for at least the "minimum dwell time".

If one of the criteria is violated, then the axis is stopped and a positioning alarm is displayed.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Position monitoring functions (Page 89)

Configuration - Following error

In the "Following Error" configuration window, configure the permissible deviation of the actual position of the axis from the set position. The following error can be dynamically adapted to the current velocity of the axis.

Enable following error monitoring

Select this check box, if you want to enable following error monitoring. When following error monitoring is enabled, the axis will be stopped in the error range (orange); in the warning range an alarm will be displayed.

When following error monitoring is disabled, the configured limits have no effect.

Maximum following error:

Configure the following error that is permissible at maximum velocity in this field.

Warning level:

Configure a percentage of the current following error limit, above which a following error warning should be output in this field.

Example: The current maximum following error is 100 mm; the warning level is configured at 90%. If the current following error exceeds a value of 90 mm, then a following error warning will be output.

Following error:

In this field, configure the permissible following error for low velocities (without dynamic adjustment of the following error).

Start of dynamic adjustment:

Configure the velocity starting from which the following error is to be dynamically adjusted in this field. Starting from this velocity, the following error up to the maximum velocity will be adjusted to the maximum following error.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Position monitoring functions (Page 89)

Configuration - Standstill signal

In the "Standstill signal" configuration window, configure the criteria for standstill detection.

Standstill window:

Configure the size of the standstill window in this field. For standstill to be indicated, the velocity of the axis must be within this window.

Minimum dwell time in standstill window:

Configure the minimum dwell time in the standstill window in this field. The velocity of the axis must also be in the standstill window for the specified duration.

If both criteria are met, then the standstill of the axis is indicated.

See also

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

Position monitoring functions (Page 89)

6.6.4.7 Configuration - Control loop

In the "Control loop" configuration window, configure the precontrol and the gain Kv of the position control loop.

The Kv factor affects the following parameters:

- Positioning accuracy and stop control
- Uniformity of motion
- Positioning time

The better the mechanical conditions of the axis are (high stiffness), the higher the Kv factor can be configured. This reduces the following error, and a higher dynamic response is achieved.

For basic information, refer to the section Closed-loop control (Page 94).

Precontrol

Configure the velocity precontrol as a percentage in this field.

Speed control loop equivalent time

Configure the speed control loop substitute time in this field.

When velocity precontrol is activated, the position setpoint is delayed by the speed control loop substitute time before generating the control deviation. This prevents an overshoot or a leading of the actual value compared with the position setpoint. The speed control loop substitute time is a simplified substitute model of the dynamic behavior of the speed control loop. The speed control loop substitute time is figured into the balancing filter.

Gain (Kv factor)

In the input field, enter the gain Kv of the position control loop.

Dynamic Servo Control (DSC):

For position-controlled axes (positioning axes/synchronous axes), the closed loop position control can occur either in the CPU or in the drive, provided the drive supports Dynamic Servo Control (DSC). Select your preferred control process:

- **Position control in the drive (DSC enabled)**
  With the Dynamic Servo Control (DSC) function, the position controller is executed in the drive in the cycle clock of the speed control loop. This enables you to set a much larger position controller gain factor Kv. This increases the dynamics for setpoint sequence and disturbance variable correction for highly dynamic drives.
- **Position control in the PLC**

Note

Dynamic Servo Control (DSC) is only possible with one of the following PROFIdrive telegrams:

- Standard telegram 5 or 6
- SIEMENS telegram 105 or 106

See also

Closed-loop control (Page 94)

Control structure (Page 95)

Function and structure of the optimization (Page 334)

Positioning axis technology object (Page 106)

Synchronous axis technology object (Page 107)

6.7 Configuring the technology object external encoder

6.7.1 Configuration - Basic Parameters

Configure the basic properties of the technology object in the "Basic Parameters" configuration window.

Name

Define the name of the external encoder in this field. The technology object is listed under this name in the project tree. The tags of the external encoder can be used in the user program under this name.

External encoder type

In this selection, configure whether the external encoder records linear or rotary motions.

Measuring units

In the drop-down list, select the desired measuring units for the position and velocity of the external encoder.

Modulo

Select the check box "Enable modulo", if you want to use a recurring measuring system for the external encoder (e.g. 0-360° for an external encoder of the "rotary" type).

- **Modulo start value**

  In this field, define the position at which the modulo range should begin (e.g. 0° for an external encoder of the "rotary" type).

- **Modulo length**

  In this field, define the length of the modulo range (e.g. 360° for an external encoder of the "rotary" type).

See also

Measuring units (Page 30)

Modulo setting (Page 31)

Technology object external encoder (Page 113)

6.7.2 Hardware interface

6.7.2.1 Configuration - Encoder

The external encoder records the position of an externally controlled drive. The encoder required for this purpose communicates the encoder position to the controller by means of a PROFIdrive telegram. Configure the encoder and encoder type in the "Encoder" configuration window.

Data connection

In the drop-down list, select whether the data connection should be established directly with the encoder or via a data block that can be edited in the user program.

The selection is only possible for encoders that are connected via PROFIdrive and support parameter P979.

Encoder / Data block

Select the encoder you have configured in the device configuration in this area.

The following encoders can be used:

- **Encoder on technology module (TM)**

  In the "Encoder" configuration field, select a previously configured technology module and the channel to be used. Only technology modules set to the "Position input for Motion Control" mode are displayed for selection.

  You can operate the technology module centrally on an S7-1500 PLC or decentrally on a distributed I/O. Isochronous mode is not possible with central operation in the CPU.

  You can identify the technology modules suitable for position detection for Motion Control in the documentation for the technology module and the catalog data.

- **Connection via PROFINET/PROFIBUS (PROFIdrive)**

  In the "Encoder" configuration field, select a previously configured encoder connected to PROFINET/PROFIBUS.

If "Data block" was selected for the data connection, a previously created data block ("Optimized block access" disabled) containing a tag structure of data type "PD_TELx" must be selected here ("x" stands for the telegram number used).

Encoder type

Select the encoder type in this configuration field. The following encoder types are available for selection:

- Incremental encoder
- Absolute encoder
- Absolute encoder cyclic absolute

See also

Technology object external encoder (Page 113)

Data connection of drive/encoder via data block (Page 49)

6.7.2.2 Configuration - Data exchange

Configuration - Data exchange

Configure detailed encoder parameters and the data exchange with the encoder in the "Data exchange with encoder" configuration window. The configuration varies according to the encoder connection:

- Encoder to technology module (Page 237)
- Encoder to PROFINET/PROFIBUS (Page 240)

See also

Technology object external encoder (Page 113)

Encoder to technology module

Data exchange with encoder

In this area, you can configure the encoder telegram and the criteria for how the encoder data are to be evaluated. The specifications must match those in the device configuration.

Encoder telegram

In the drop-down list for the technology module, select the telegram that you have configured in the technology module.

Automatic transfer of encoder parameter values

Select the check box if you want to transfer the encoder parameters from the encoder configuration to the CPU. The encoder parameters are transferred from the bus after the (re-)initialization of the technology object and (re)start of the encoder and the CPU.

Note

Automatic transfer of encoder parameters is only possible with PROFIdrive encoders as of product version A16. For this, "Hardware interface > Encoder" must be selected as the "Encoder" data connection in the configuration window.

As an alternative, you must synchronize the following parameters ("Data exchange with encoder" configuration window) manually.

Encoder type

Configure how the encoder data are to be evaluated in this area. The specifications must match those in the device configuration.

Encoder type	Rotary incremental
Increments per revolution:	Configure the number of increments that the encoder resolves per revolution in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.

Encoder type	Rotary absolute
Increments per revolution:	Configure the number of increments that the encoder resolves per revolution in this field.
Number of revolutions:	Configure the number of revolutions that the absolute encoder can detect in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.
Bits for fine resolution in the absolute actual value (Gx_XIST2)	Configure the number of bits for fine resolution within the absolute actual value (Gx_XIST2) in this field.

Encoder type	Rotary cyclic absolute
Increments per revolution:	Configure the number of increments that the encoder resolves per revolution in this field.
Number of revolutions:	Configure the number of revolutions that the absolute encoder can detect in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.
Bits for fine resolution in the absolute actual value (Gx_XIST2)	Configure the number of bits for fine resolution within the absolute actual value (Gx_XIST2) in this field.

Encoder type	Linear incremental
Distance between two increments:	Configure the distance between two increments of the encoder in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.

Encoder type	Linear absolute
Distance between two increments:	Configure the distance between two increments of the encoder in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.
Bits for fine resolution in the absolute actual value (Gx_XIST2)	Configure the number of bits for fine resolution within the absolute actual value (Gx_XIST2) in this field.

See also

Configuration - Data exchange (Page 237)

Encoder to PROFINET/PROFIBUS (Page 240)

Technology object external encoder (Page 113)

Encoder to PROFINET/PROFIBUS

Data exchange with encoder

In this area, you can configure the encoder telegram and the criteria for how the encoder data are to be evaluated. The specifications must match those in the device configuration.

Encoder telegram

In the drop-down list, select the telegram of the encoder. The specification must match the setting in the device configuration.

Automatic transfer of encoder parameter values

Select the check box if you want to transfer the encoder parameters from the encoder configuration to the CPU. The encoder parameters are transferred from the bus after the (re-)initialization of the technology object and (re)start of the encoder and the CPU.

Note

Automatic transfer of encoder parameters is only possible with PROFIdrive encoders as of product version A16. For this, "Hardware interface > Encoder" must be selected as the "Encoder" data connection in the configuration window.

As an alternative, you must synchronize the following parameters ("Data exchange with encoder" configuration window) manually.

Encoder type

Depending on the selected encoder type, configure the following parameters:

Encoder type	Rotary incremental
Steps per revolution:	Configure the number of increments that the encoder resolves per revolution in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.

Encoder type	Rotary absolute
Steps per revolution:	Configure the number of increments that the encoder resolves per revolution in this field.
Number of revolutions:	Configure the number of revolutions that the absolute encoder can detect in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.
Bits for fine resolution in the absolute actual value (Gx_XIST2)	Configure the number of bits for fine resolution within the absolute actual value (Gx_XIST2) in this field.

Encoder type	Rotary cyclic absolute
Steps per revolution:	Configure the number of increments that the encoder resolves per revolution in this field.
Number of revolutions:	Configure the number of revolutions that the absolute encoder can detect in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.
Bits for fine resolution in the absolute actual value (Gx_XIST2)	Configure the number of bits for fine resolution within the absolute actual value (Gx_XIST2) in this field.

Encoder type	Linear incremental
Distance between two increments:	Configure the distance between two increments of the encoder in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.

Encoder type	Linear absolute
Distance between two increments:	Configure the distance between two increments of the encoder in this field.
Bits for fine resolution in the incremental actual value (Gx_XIST1)	Configure the number of bits for fine resolution within the incremental actual value (Gx_XIST1) in this field.
Bits for fine resolution in the absolute actual value (Gx_XIST2)	Configure the number of bits for fine resolution within the absolute actual value (Gx_XIST2) in this field.

Invert encoder direction

Select this check box if you would like to invert the actual value of the encoder.

See also

Configuration - Data exchange (Page 237)

Encoder to technology module (Page 237)

Technology object external encoder (Page 113)

6.7.3 Extended Parameters

6.7.3.1 Configuration - Mechanics

Configuration - Mechanics

Configure the encoder parameters for the position of the externally controlled drive in the "Mechanics" configuration window.

The configuration varies according to the type of encoder:

- Linear (Page 244)
- Rotary (Page 245)

See also

Mechanics (Page 53)

Technology object external encoder (Page 113)

Linear

Invert encoder direction

Select this check box if you would like to invert the actual value of the encoder.

Load gear

Number of motor revolutions / number of load revolutions

The gear ratio of the measuring gearbox is specified as the ratio between motor revolutions and load revolutions. Specify here an integer number of motor revolutions and the resulting number of load revolutions.

Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

Position parameters

Leadscrew pitch

In this configuration field, configure the distance by which the load is moved when the leadscrew makes one revolution.

See also

Configuration - Mechanics (Page 243)

Rotary (Page 245)

Mechanics (Page 53)

Technology object external encoder (Page 113)

Rotary

Invert encoder direction

Select this check box if you would like to invert the actual value of the encoder.

Load gear

Number of motor revolutions / number of load revolutions

The gear ratio of the measuring gearbox is specified as the ratio between encoder revolutions and load revolutions. Specify here an integral number of load revolutions and the resulting number of encoder revolutions.

Select the same values for the number of motor revolutions and load revolutions, if no load gear is present.

See also

Configuration - Mechanics (Page 243)

Linear (Page 244)

Mechanics (Page 53)

Technology object external encoder (Page 113)

6.7.3.2 Homing

Configuration - Homing

Configure the parameters for homing the external encoder in the "Homing" configuration window. Homing is performed using the Motion Control instruction "MC_Home" Mode = 2, 8 and 10.

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

Select the homing mode

Select from among the following homing modes:

- Zero mark via PROFIdrive telegram and reference cam (Page 247)
- Zero mark via PROFIdrive frame (Page 248)
- Homing mark via digital input (Page 249)

See also

Technology object external encoder (Page 113)

Zero mark via PROFIdrive telegram and reference cam

Homing direction

Select the direction in which the zero mark should be approached for homing.
The next zero mark after leaving the reference cam is used.

The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with Mode = 10.

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.
A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

See also

Configuration - Homing (Page 246)

Zero mark via PROFIdrive frame (Page 248)

Homing mark via digital input (Page 249)

Technology object external encoder (Page 113)

Zero mark via PROFIdrive frame

Homing direction

Select the direction in which the next zero mark should be approached for homing.
The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Home position

In this field, configure the absolute coordinate of the home position.
The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with Mode = 10.

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.
A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

See also

Configuration - Homing (Page 246)

Zero mark via PROFIdrive telegram and reference cam (Page 247)

Homing mark via digital input (Page 249)

Technology object external encoder (Page 113)

Homing mark via digital input

Digital input homing mark

In this configuration field, select a digital input that is to act as a homing mark (reference cam). Also select the level at which the homing mark is to be detected.

Homing direction

Select the direction in which the homing mark for homing is to be approached.

The following options are available:

- **Positive**

  Axis moves in the direction of higher position values.

- **Negative**

  Axis moves in the direction of lower position values.

- **Current**

  The currently effective approach direction is used for homing.

Homing mark

Select which switch position of the "digital input" is to be used as the homing mark.

When a "digital input" is crossed, two switching edges that are spatially separated from one another are generated. The selection of the positive or negative side ensures that the homing mark is always evaluated at the same mechanical position.

The positive side is the switch position with a greater position value; the negative side is the switch position with the lesser position value.

The selection of the side is independent of the approach direction, and independent of whether it causes a rising or falling edge.

Home position

In this field, configure the absolute coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with Mode = 10.

Note

Parameter "MC_Home.Mode"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and V2.0 is available in the section Version overview (Page 161).

See also

Configuration - Homing (Page 246)

Zero mark via PROFIdrive frame (Page 248)

Zero mark via PROFIdrive telegram and reference cam (Page 247)

Technology object external encoder (Page 113)

6.8 Configuring the technology object measuring input

6.8.1 Configuration - Basic Parameters

Configure the basic properties of the technology object in the "Basic Parameters" configuration window.

Name

Define the name of the measuring input in this field. The technology object is listed under this name in the project tree. The tags of the measuring input can be used in the user program under this name.

Assigned axis or external encoder

The axis or external encoder assigned to the measuring input is displayed. You can use the link to directly access the configuration of the basic parameters of the higher-level technology object.

Measuring unit

The indicated measuring unit for the position of the measuring input corresponds to the measuring unit of the higher-level technology object.

See also

Measuring units (Page 30)

Technology object measuring input (Page 115)

6.8.2 Configuration - Hardware interface

Input of measuring input

Measuring input type

Select the measuring input type.

- **Measuring using TM Timer DIDQ**

  Select a measurement input for a measurement using a Timer DI.
  The selection box shows all channels that are configured correctly.

- **Measuring using SINAMICS measuring input**

  Select a measurement input for a measurement using an input of a SINAMICS measuring input. The selection box shows all compatible telegram types. All terminals that can potentially be used as measuring inputs are shown.

- **Measuring using PROFIdrive telegram (drive or external encoder)**

  Select the measuring input number in the telegram for a measurement using PROFIdrive telegram. The text field contains the default value "1".

  Two communication channels are available in the PROFIdrive telegram for measured value transfer. These are assigned to one measurement input/digital input each.
  For the connection, you first configure which of the two channels is to be used by the measuring input at the technology object measuring input with the parameter <TO>Parameter.PROFIdriveProbeNumber. To do this, you use the PROFIdrive parameters to configure the digital input on the drive that is to be used for the configured communication channel.

  – Measurement input for the first communication channel

    (<TO>Parameter.PROFIdriveProbeNumber = 1)

    Via P488[0] related to the first encoder in the telegram and via P488[1] related to the second encoder in the telegram.

  – Measurement input for the second communication channel

    (<TO>Parameter.PROFIdriveProbeNumber = 2)

    Via P489[0] related to the first encoder in the telegram and via P489[1] related to the second encoder in the telegram.

  – With P728.8 to P728.15, you configure all DI/DOs used as a measurement input on the control unit. Use P680 of the control unit to specify the terminals for the global measuring inputs.

    Note that the measuring inputs and the inputs of the measurement must be assigned in the telegram without gaps and in ascending order.

Then enter a correction time if possible delay times in the measured signal are to be compensated for.

See also

Technology object measuring input (Page 115)
Configuring technology modules for Motion Control (Page 262)
Automatic transfer of drive and encoder parameters in the device (Page 40)

6.8.3 Configuration - Extended parameters

Adjustment for activation time of the measuring range

To adjust the activation time defined on the system side, enter an additional activation time here.

The configuration window also displays the following times calculated on the system side:

- Time after the measuring job request until the measuring event can be recoreded
- Time after the measuring event until the measurement result is displayed (for measuring of one or two edges)

See also

Measuring with measuring range (Page 123)

Time-related boundary conditions (Page 125)

Technology object measuring input (Page 115)

6.9 Configuring the cam technology object

6.9.1 Configuration - Basic Parameters

Configure the basic properties of the technology object in the "Basic Parameters" configuration window.

Name

Define the name of the output cam in this field. The technology object is listed under this name in the project tree. The tags of the output cam can be used in the user program under this name.

Assigned axis or external encoder

The axis or external encoder assigned to the output cam is displayed. You can use the link to directly access the configuration of the basic parameters of the higher-level technology object.

Output cam type

Select based on the desired switching behavior of an output cam type:

- Distance output cam (position-dependent switch-on/switch-off)
- Time-based output cam (position-dependent switch-on and position-independent or time-dependent switch-off)

Output cam reference

Configure in this selection whether the switching points of the output cam are to reference the actual position or the position setpoint.

Measuring unit

The indicated measuring unit for the position of the output cam corresponds to the measuring unit of the higher-level technology object.

When a time-based output cam is selected as the output cam type, the measuring unit for the switch-on duration and other times is also indicated. For output cams, this is always ms.

See also

Measuring units (Page 30)

Technology object output cam (Page 129)

6.9.2 Configuration - Hardware interface

Output cam output

Select whether the generated switching signals are to be output at the digital output.

- **Output activated**

  Select one of the following two output options for the output cam output:

  – **Output by TM Timer DIDQ**

    For output by TM Timer DIDQ, select a previously configured technology module and the channel to be used in the "Output" field.

    If no technology module is available for selection, change to the device configuration and add a technology module.

  – **Output by digital output module**

    For output by a digital output module, select this in the "Cam output" field.
    Only the digital outputs with previously defined PLC tags are displayed for selection.

  Select the logical operation of the output cam signal at the output.
  The logic operation relates to the last signal to be output after the set inversion, if any.

  All output cams that use the selected output are shown graphically.

- **Output deactivated**

  When the output is deactivated, the output cam is evaluated only in the software.

See also

Technology object output cam (Page 129)

Configuring technology modules for Motion Control (Page 262)

6.9.3 Extended parameters

6.9.3.1 Configuration - Activation time

The specified output cam type is indicated in the upper area of the "Activation time" configuration window.

Activation time and deactivation time

For a time shift of the switch-on and switch-off times of an output cam, enter an activation time and a deactivation time.

See also

Compensation of actuator switching times (Page 142)

Technology object output cam (Page 129)

6.9.3.2 Configuration - Hysteresis

To prevent unwanted changes in the switching state of the output cam of a cam track, enter a hysteresis value.

When using an output cam with reference to actual position, always enter a hysteresis value (> 0.0).

See also

Hysteresis (Page 140)

Technology object output cam (Page 129)

6.10 Configuring the cam track technology object

6.10.1 Configuration - Basic Parameters

Configure the basic properties of the technology object in the "Basic Parameters" configuration window.

Name

Define the name of the cam track in this field. The technology object is listed under this name in the project tree. The tags of the cam track can be used in the user program under this name.

Assigned axis or external encoder

The axis or external encoder assigned to the cam track is displayed. You can use the link to directly access the configuration of the basic parameters of the higher-level technology object.

Output cam type

Select based on the desired switching behavior of an output cam type for the cam track:

- Distance output cam (position-dependent switch-on/switch-off)
- Time-based output cam (position-dependent switch-on and position-independent or time-dependent switch-off)

Output cam reference

In this selection, configure whether the switching points of the cam track are to reference the actual position or the position setpoint.

Measuring unit

The indicated measuring unit for the position of the cam track corresponds to the measuring unit of the higher-level technology object.

When a time-based output cam is selected as the output cam type, the measuring unit for the switch-on duration and other times is also indicated. For output cams, this is always ms.

See also

Measuring units (Page 30)

Cam track technology object (Page 145)

6.10.2 Configuration - Hardware interface

Output cam track

Select whether the generated switching signals are to be output at the digital output.

- **Output activated**

  Select one of the following two output options for the output track:

  – **Output by TM Timer DIDQ**

    For output by TM Timer DIDQ, select a previously configured technology module and the channel to be used in the "Output" field.

    If no technology module is available for selection, change to the device configuration and add a technology module.

  – **Output by digital output module**

    For output by a digital output module, select this in the "Cam output" field.
    Only the digital outputs with previously defined PLC tags are displayed for selection.

- **Output deactivated**

  When the output is deactivated, the cam track is evaluated only in the software.

See also

Cam track technology object (Page 145)

Configuring technology modules for Motion Control (Page 262)

6.10.3 Extended parameters

6.10.3.1 Track data

Configuration - Activation time

The specified output cam type is displayed.

Activation time and deactivation time

Enter the activation time and the deactivation time.

For a time shift of the switch-on and switch-off times of the output cam of a cam track, enter an activation time and a deactivation time.

See also

Time offset of cam switching points (Page 157)

Cam track technology object (Page 145)

Configuration - Hysteresis

To prevent unwanted changes in the switching state of the output cam of a cam track, enter a hysteresis value.

When using an output cam with reference to actual position, always enter a hysteresis value (> 0.0).

See also

Hysteresis (Page 157)

Cam track technology object (Page 145)

Configuration - Track dimensions

Track length

Enter the corresponding track length.

Also take into account the output cam data of the individual output cams when defining the track length. Output cams, the start position of which lies outside the cam track length are not included. They become active only if the cam track length is increased so that at least the respective start position of an output cam is within the new track length.

Axis reference position

Enter the position of an axis or external encoder starting from which the output of the cam track is to occur. The start of the cam track is placed at the entered position.

You can enter a negative or positive value for the reference position.

Modulo length of the axis

When an axis with modulo function is used, the modulo length of the axis is displayed.

See also

Cam track technology object (Page 145)

6.10.3.2 Configuration - Output cam data

The specified output cam type is displayed.

Enter the properties for the output cams of the cam track that are to be output. You can set up to 32 individual output cams on a cam track.

Also take into account any previously defined track length when defining the output cam data. Output cams, the start position of which lies outside the cam track length are not included. They become active only if the cam track length is increased so that at least the respective start position of an output cam is within the new track length.

The input options described below are displayed in the Output cam data configuration window according to the configured output cam type.

- **Valid**

  Only output cams set as "valid" are output and have a status display.

- **Start position**
  - The start position may not be greater than the end position for distance output cams.
  - If the start position is equal to the end position, the distance output cam does not switch.
  - The switching ranges of individual output cams are permitted to overlap.

- **End position**
  - The "End position" column is only displayed when distance output cam is set for the output cam type.
  - The end position must not be less than the start position.

- **Switch-on duration**

  The "Switch-on duration" column is only displayed when time-based output cam is set for the cam type.

See also

Cam track technology object (Page 145)

6.11 Configuring technology modules for Motion Control

6.11.1 Overview

Use of technology modules with Motion Control

You can use technology modules as well as compact CPUs with Motion Control. To use the technology functions for Motion Control, the parameters of the device configuration of the technology module or the compact CPU and the parameters of the configuration of the technology object must be configured accordingly. Which parameters are relevant for the function is described below. You can set additional parameters that are not listed here. The description of the parameters is found in the documentation of the respective technology module.

The following technology modules support Motion Control functionalities:

S7-1500/ET 200MP	ET 200 SP
TM Count 2x24V (Page 263)	TM Count 1x24V (Page 263)
TM PosInput 2 (Page 265)	TM PosInput 1 (Page 265)
TM Timer DIDQ 16x24V (Page 268) *	TM Timer DIDQ 10x24V (Page 268) *
–	TM Pulse 2x24V (Page 269)
TM PTO 4 (Page 270)	
CPU 1511C-1 PN / CPU 1512C-1 PN (Page 272)	–

* ET 200MP and ET 200SP: Isochronous mode is only possible with PROFINET interface modules.

Isochronous mode

Technology modules can be used centrally or distributed in the system. However, isochronous mode is supported only with decentralized use.

6.11.2 TM Count 1x24V / TM Count 2x24V

For use with Motion Control, the following parameters must be configured:

Configuration		
Technology module **TM Count 1x24V / TM Count 2x24V**	**Technology object**	
	Axis	**External encoder**
TM Count 1x24V / TM Count 2x24V > Channel 0/1 > Operating mode	–	–
Select "Position input for Motion Control" mode		
TM Count 1x24V / TM Count 2x24V > Channel 0/1 > Module parameters	**Hardware interface > Encoder**	**Hardware interface > Encoder**
–	Select "Encoder" data connection and the channel configured for Motion Control on the technology module as encoder	Select "Encoder" data connection and the channel configured for Motion Control on the technology module as encoder
Signal type • Incremental encoder	Select encoder type corresponding to configuration for technology module • Incremental	Select encoder type corresponding to configuration for technology module • Incremental
–	**Hardware interface > Data exchange with encoder**	**Hardware interface > Data exchange**
	Telegram "DP_TEL83_STANDARD" is automatically selected after the selection of the encoder.	Telegram "DP_TEL83_STANDARD" is automatically selected after the selection of the encoder.
	Disable "Automatic transfer of encoder parameter values"	Disable "Automatic transfer of encoder parameter values"
	Select rotary or linear measuring system type	Select rotary or linear measuring system type
Signal evaluation • Single • Double • Quadruple	Select fine resolution corresponding to configuration for technology module • 0 = Single • 1 = Double • 2 = Quadruple	Select fine resolution corresponding to configuration for technology module • 0 = Single • 1 = Double • 2 = Quadruple
• Rotary type: Enter increments per revolution • Linear type: Configuration not relevant	• Rotary type: Enter increments per revolution corresponding to configuration at technology module (1:1) • Linear type: Enter distance between increments	• Rotary type: Enter increments per revolution corresponding to configuration at technology module (1:1) • Linear type: Enter distance between increments

Configuration		
Technology module **TM Count 1x24V / TM Count 2x24V**	**Technology object**	
	Axis	**External encoder**
–	**Hardware interface > Data exchange with the drive**	–
• Rotary type: Enter reference speed corresponding to configuration for technology object (1:1) • Linear type: Configuration not relevant	Enter reference speed	
–	**Homing**	**Homing**
Select the homing signal for homing mark 0: • Signal N of the incremental encoder • DI0	Use the homing mode "Use zero mark via PROFIdrive telegram".	Use the homing mode "Use zero mark via PROFIdrive telegram".
TM Count 2x24V > I/O addresses	–	–
The organization block ("MC-Servo") and the process image ("TPA OB Servo") are selected automatically for the input and output addresses by selecting the channel in the encoder configuration at the technology object.		
Process image: PIP OB servo		

6.11.3 TM PosInput 1 / TM PosInput 2

For use with Motion Control, the following parameters must be configured:

Configuration		
Technology module **TM PosInput 1 / TM PosInput 2**	**Technology object**	
	Axis	**External encoder**
TM PosInput 1/2 > Channel 0/1 > Operating mode Select "Position input for Motion Control" mode	–	–
TM PosInput 1/2 > Channel 0/1 > Module parameters You set the parameters for the encoder signals of the channel under "Module parameters" in the "Position input for Motion Control" mode. The parameters must be set depending on the encoder used. The configuration of the encoder is required for use with an SSI absolute encoder. Information on the configuration is available in the documentation for the respective technology module.	**Hardware interface > Encoder**	**Hardware interface > Encoder**
–	Select "Encoder" data connection and the channel activated and configured as encoder on the technology module	Select "Encoder" data connection and the channel activated and configured as encoder on the technology module
Signal type • Incremental encoder • Absolute encoder	Select encoder type corresponding to configuration for technology module • Incremental • Absolute / cyclic absolute	Select encoder type corresponding to configuration for technology module • Incremental • Absolute / cyclic absolute

Configuration		
Technology module **TM PosInput 1 / TM PosInput 2**	**Technology object**	
	Axis	**External encoder**
–	**Hardware interface > Data exchange with encoder**	**Hardware interface > Data exchange**
	Telegram "DP_TEL83_STANDARD" is automatically selected after the selection of the encoder.	Telegram "DP_TEL83_STANDARD" is automatically selected after the selection of the encoder.
	Disable "Automatic transfer of encoder parameter values"	Disable "Automatic transfer of encoder parameter values"
	Select rotary or linear measuring system type	Select rotary or linear measuring system type
Signal evaluation • Single • Double • Quadruple	Select fine resolution corresponding to configuration for technology module • Incremental encoder: – 0 = Single – 1 = Double – 2 = Quadruple • Absolute encoder: – 0 = Single	Select fine resolution corresponding to configuration for technology module • Incremental encoder: – 0 = Single – 1 = Double – 2 = Quadruple • Absolute encoder: – 0 = Single
• Rotary type: Enter increments per revolution • Linear type: Configuration not relevant	• Rotary type: Enter increments per revolution corresponding to configuration at technology module (1:1) • Linear type: Enter distance between increments	• Rotary type: Enter increments per revolution corresponding to configuration at technology module (1:1) • Linear type: Enter distance between increments
–	**Hardware interface > Data exchange with the drive**	–
• Rotary type: Enter reference speed corresponding to configuration for technology object (1:1) • Linear type: Configuration not relevant	Enter reference speed	

Configuration		
Technology module **TM PosInput 1 / TM PosInput 2**	**Technology object**	
	Axis	**External encoder**
–	**Homing**	**Homing**
Select the homing signal for homing mark 0: • Signal N of the incremental encoder • DI0	Use the homing mode "Use zero mark via PROFIdrive telegram".	Use the homing mode "Use zero mark via PROFIdrive telegram".
TM PosInput 1/2 > I/O addresses	–	–
The organization block ("MC-Servo") and the process image ("TPA OB Servo") are selected automatically for the input and output addresses by selecting the channel in the encoder configuration at the technology object.		

"–" No configuration for technology module/technology object is required for these parameters

6.11.4 TM Timer DIDQ 10x24V / TM Timer DIDQ 16x24V

You can operate the TM Timer DIDQ technology module centrally on an S7-1500 CPU or decentrally on a distributed I/O. For use with a measuring input, output cam or cam track, the technology module must be used decentrally and with isochronous mode.

For use with Motion Control, the following parameters must be configured:

Use with output cam / cam track technology object

Configuration	
Technology module **TM Timer DIDQ 10x24V / TM Timer DIDQ 16x24V**	**Technology object** **Output cam / Cam track**
Basic parameters	–
Select desired number of outputs under channel configuration	
Channel parameters	**Hardware interface > Output cam output / Output cam track**
–	Activate output
	Select output by TM Timer DIDQ
Select "Timer DQ" mode for the respective output	Select output cam output
I/O addresses	–
Select "Isochronous mode"	
The organization block ("MC-Servo") and the process image ("TPA OB Servo") are updated automatically for the input and output addresses by selecting the channel in the encoder configuration at the technology object.	

"–" No configuration for technology module/technology object is required for these parameters

Use with technology object measuring input

Configuration	
Technology module **TM Timer DIDQ 10x24V / TM Timer DIDQ 16x24V**	**Technology object** **Measuring input**
Basic parameters	–
Select desired number of inputs under channel configuration	
Channel parameters	**Hardware interface > Measuring input**
Configuration of DI group: Use inputs individually	–
Select "Timer DI" mode for the respective input	Select measuring using TM Timer DIDQ
–	Select measuring input
Select application-dependent input delay	–
I/O addresses	
Select "Isochronous mode"	
The organization block ("MC-Servo") and the process image ("TPA OB Servo") are updated automatically for the input and output addresses by selecting the channel in the input configuration at the technology object.	

"–" No configuration for technology module/technology object is required for these parameters

6.11.5 TM Pulse 2x24V

For use with Motion Control, the parameters described below must each be configured:

Drive connection using PWM (pulse width modulation)

Configuration	
TM Pulse 2x24V	**Technology object** **Axis**
TM Pulse 2x24V > Channel configuration	–
Select if you want to use 1 or 2 channels.	
TM Pulse 2x24V > Channel > Operating mode	
Select "Pulse width modulation PWM" or "PWM with DC motor" operating mode	
TM Pulse 2x24V > Channel > Parameters	**Hardware interface > Drive**
Select "S7 analog output" output format	Select analog drive connection For the selection of the analog output, create a PLC tag of the "Int" type with corresponding address. The offset for the PLC tag to the start address is 2. To activate the output of the PWM signal, set the following two bits of the control interface of the PWM channel in the user program: • SW_ENABLE (= Bit 0 in Byte 9) • TM_CTRL_DQ (= Bit 1 in Byte 9) The offset for byte 9 to the start address of the PWM channel is 9.
TM Pulse 2x24V > Channel > I/O addresses	–
Select the organization block "MC-Servo" for the input and output addresses. The "TPA OB Servo" process image is selected automatically for the input and output addresses by selecting the organization block.	

"–" No configuration for technology object is required for these parameters

6.11.6 TM PTO 4

For use with Motion Control, the following parameters must be configured.

Configuration	
Technology module **TM PTO 4**	**Technology object** **Axis**
TM PTO 4 > Channel configuration	–
Configure the number of channels (1 to 4) you want to use.	
TM PTO 4 > Channel 0…3 > Operating mode	
Select signal type: • PTO (pulse (A) and direction (B)) • PTO (count up (A) and count down (B)) • PTO (A, B phase-shifted) • PTO (A, B phase-shifted - quadruple)	
Select signal evaluation: • Single • Quadruple	
Select signal interface: • 5V difference signal (RS 422) • 24V asymmetric	
Configure the input delay.	
–	**Hardware interface > Drive**
	Select drive type "PROFIdrive" and "Drive" data connection. Select the pulse output configured at the technology module as drive.
	Hardware interface > Encoder
	The encoder of the actuator telegram (simulated encoder) is automatically selected. Alternatively, an existing encoder interface can be selected.

Configuration	
Technology module **TM PTO 4**	**Technology object** **Axis**
TM PTO 4 > Channel 0…3 > Axis parameters	**Data exchange with the drive**
–	Telegram "DP_TEL3_STANDARD" is automatically selected after the selection of the drive.
	Deselect "Automatic transfer of drive parameter values"
Enter reference speed corresponding to configuration for technology object (1:1)	Enter reference speed of the drive
Enter maximum speed corresponding to configuration for technology object (1:1)	Enter maximum speed of the drive. If the maximum speed is exceeded, technology alarm 102 is triggered and displayed.
–	**Data exchange with encoder**
	Telegram "DP_TEL3_STANDARD" is automatically selected after the selection of the encoder.
	Disable "Automatic transfer of encoder parameter values"
	Select rotary measuring system type.
Enter increments per revolution	Enter increments per revolution corresponding to configuration at technology module (1:1)
Configure fine resolution • 0 = Single • 2 = Quadruple	Configure fine resolution corresponding to configuration for technology module. • 0 = Single • 2 = Quadruple
TM PTO 4 > Channel 0…3 > Hardware inputs/outputs	**Homing**
If you want to use a hardware output to enable the drive, activate this function. Next select one of the two hardware outputs DQ0 or DQ2.	–
Activate the hardware input (DI0) for the reference cam.	Use the homing mode "Use zero mark via PROFIdrive telegram".
Select the edge of the hardware input for triggering the reference cam function.	
When using a measuring input, activate the hardware input (DI1) for the measuring input.	–
Select the hardware input that is used to display whether the drive is ready.	
TM PTO 4 > I/O addresses	
The organization block ("MC-Servo") and the process image ("TPA OB Servo") are selected automatically for the input and output addresses by selecting the PTO channel for the technology object.	

"–" No configuration for technology module / technology object is required for these parameters

6.11.7 CPU 1511C-1 PN / CPU 1512C-1 PN

For use with Motion Control, the parameters described below must be configured.

Drive connection via PTO (Pulse Train Output)

Configuration	
CPU 1511C-1 PN / CPU 1512C-1 PN	**Technology object**
	Axis
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > General	–
To activate a channel for PTO mode, select one of the following operating modes: • PTO (pulse (A) and direction (B)) • PTO (count up (A), count down (B)) • PTO (A,B phase shifted) • PTO (A,B phase shifted, quadruple)	
–	**Hardware interface > Drive**
	Select drive type "PROFIdrive" and "Drive" data connection. Select the pulse generator of the CPU configured for PTO mode as drive.
	Hardware interface > Encoder
	The encoder of the actuator telegram (simulated encoder) is automatically selected. Alternatively, an existing encoder interface can be selected.
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > Axis parameters	**Hardware interface > Data exchange with the drive**
–	Telegram "DP_TEL3_STANDARD" is automatically selected after the selection of the drive.
	Deselect "Automatic transfer of drive parameter values"
Enter reference speed corresponding to configuration for technology object (1:1)	Enter reference speed of the drive
Enter reference speed corresponding to configuration for technology object (1:1)	Enter maximum speed of the drive. If the maximum speed is exceeded, technology alarm 102 is triggered and displayed.
–	**Hardware interface > Data exchange with encoder**
	Telegram "DP_TEL3_STANDARD" is automatically selected after the selection of the encoder.
	Disable "Automatic transfer of encoder parameter values"
	Select rotary measuring system type.
Enter increments per revolution	Enter increments per revolution corresponding to configuration for CPU (1:1)
The fine resolution has the fixed value "0 bit" (= single) and cannot be changed.	Enter the fine resolution corresponding to the configuration for CPU Bits in incr. actual value (G1_XIST1): 0 (= single)

Configuration	
CPU 1511C-1 PN / CPU 1512C-1 PN	Technology object Axis
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > Hardware inputs/outputs	**Homing**
Select the hardware input for the reference switch In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	Use the homing mode "Use zero mark via PROFIdrive telegram" for drive connection via PTO.
Select the edge of the hardware input for triggering the reference cam function.	
When using a measuring input, select the hardware input of the measuring input. The following table includes the configuration description.	–
Select the hardware input that is used to display whether the drive is ready. In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	
With selected "PTO (PTO (pulse (A) and direction (B))" mode, the hardware output for the PTO signal A ("Pulse output (A)") is automatically selected through the device configuration and cannot be changed. For PTO signal B ("Direction output (B)") select one of the hardware outputs offered in the selection box. The hardware outputs for the PTO signals are selected through the device configuration for the following operating modes and cannot be changed: • PTO (count up (A), count down (B)) • PTO (A,B phase shifted) • PTO (A,B phase shifted, quadruple)	
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > I/O addresses	
The organization block ("MC-Servo") and the process image ("TPA OB Servo") are selected automatically for the input and output addresses by selecting the PTO channel for the technology object.	

"–" No configuration for CPU/technology object is required for these parameters

Additional configuration for use with the technology object measuring input

Configuration	
Technology module CPU 1511C-1 PN / CPU 1512C-1 PN	Technology object Measuring input
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > Hardware inputs/outputs	**Hardware interface > Measuring input**
Select the hardware input of the measuring input. In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	Measuring using PROFIdrive telegram (drive or external encoder)
	In the "Number of the measuring input" selection box, select "1" (measuring input 1).

Drive connection using PWM (pulse width modulation)

Note that only travel in the positive direction is possible with a drive connection using the integrated PWM function of the compact CPU.

Configuration	
CPU 1511C-1 PN / CPU 1512C-1 PN	**Technology object**
	Speed axis
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > General	–
Select "Pulse width modulation PWM" mode	
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > Hardware inputs/outputs	
Select the hardware output to be used for pulse output.	
Select whether the set hardware output is to work as a fast push-pull switch or as P switch.	
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > Parameters	**Hardware interface > Drive**
Select "S7 analog output" output format	Select analog drive connection For the selection of the analog output, create a PLC tag of the "Int" type with corresponding address. The offset for the PLC tag of the control interface of the PWM channel is 2. To activate the output of the PWM signal, set the following two bits of the control interface of the PWM channel in the user program: • SW_ENABLE (= Bit 0 in Byte 9) • TM_CTRL_DQ (= Bit 1 in Byte 9) The offset for byte 9 to the start address of the PWM channel is 9.
Select minimum pulse width of 0 µs	–
Select required period duration (e.g. 100 µs)	
Pulse generators (PTO/PWM) > PTO1…4/PWM1…4 > I/O addresses	
Select the organization block "MC-Servo" for the input and output addresses. The "TPA OB Servo" process image is selected automatically for the input and output addresses by selecting the organization block.	

"–" No configuration for technology object is required for these parameters

Encoder connection via HSC (High-speed counter)

Configuration		
CPU 1511C-1 PN / CPU 1512C-1 PN	Technology object	
	Axis	External encoder
High-speed counter (HSC) > HSC 1…6 > General > Enable	–	–
Enable high-speed counter		
High-speed counter (HSC) > HSC 1…6 > Basic parameters > Operating mode		
Select "Position input for Motion Control" mode		
High-speed counter (HSC) > HSC 1…6 > Basic parameters > Module parameters	**Hardware interface > Encoder**	**Hardware interface > Encoder**
–	Select "Encoder" data connection and the high-speed counter activated and configured as encoder on the CPU	Select "Encoder" data connection and the high-speed counter activated and configured as encoder on the CPU
Signal type • Incremental encoder	Select encoder type according to the device configuration of the CPU • Incremental	Select encoder type according to the device configuration of the CPU • Incremental
–	**Hardware interface > Data exchange with encoder**	**Hardware interface > Data exchange**
	Telegram "DP_TEL83_STANDARD" is automatically selected after the selection of the encoder.	Telegram "DP_TEL83_STANDARD" is automatically selected after the selection of the encoder.
	Deselect "Automatic transfer of encoder parameter values"	Deselect "Automatic transfer of encoder parameter values"
	Select rotary measuring system type.	Select rotary measuring system type.
Signal evaluation • Single • Double • Quadruple	Set fine resolution according to the configured signal evaluation set for the high-speed counter (HSC) • 0 = Single • 1 = Double • 2 = Quadruple	Set fine resolution according to the configured signal evaluation set for the high-speed counter (HSC) • 0 = Single • 1 = Double • 2 = Quadruple
Enter increments per revolution	Enter increments per revolution corresponding to device configuration for CPU (1:1)	Enter increments per revolution corresponding to device configuration for CPU (1:1)
–	**Hardware interface > Data exchange with the drive**	–
Enter reference speed corresponding to configuration for technology object (1:1)	Enter reference speed	

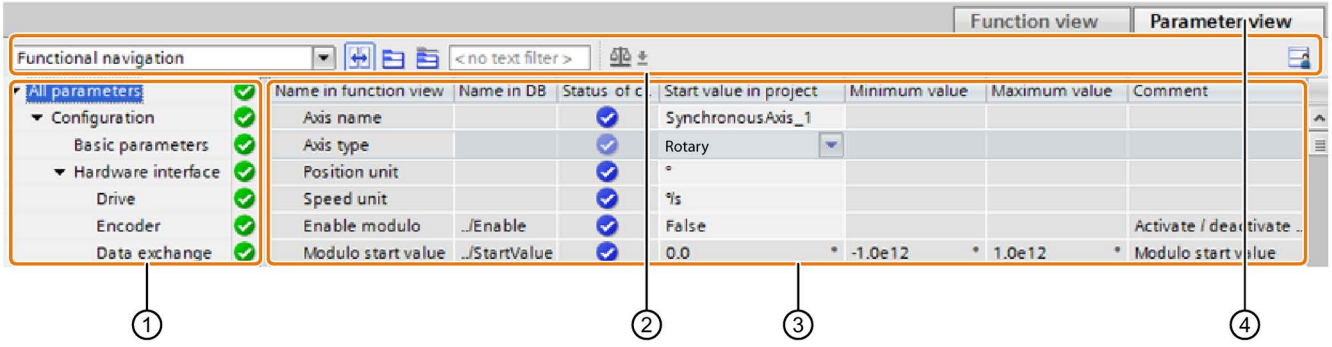
Configuration		
CPU 1511C-1 PN / CPU 1512C-1 PN	**Technology object**	
	Axis	**External encoder**
–	**Homing**	**Homing**
Select the homing signal for homing mark 0: • Signal N of the incremental encoder • DI0 (can be set with the hardware inputs/outputs) In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	Use the homing mode "Use zero mark via PROFIdrive telegram".	Use the homing mode "Use zero mark via PROFIdrive telegram".
High-speed counter (HSC) > HSC 1…6 > I/O addresses The organization block ("MC-Servo") and the process image ("TPA OB Servo") are selected automatically for the input and output addresses by selecting the HSC channel for the technology object.	–	–

"–" No configuration for CPU/technology object is required for these parameters

6.12 Parameter view

6.12.1 Introduction to the parameter view

The Parameter view provides you with a general overview of all relevant parameters of a technology object. You obtain an overview of the parameter settings and can easily change them in offline and online mode.



① Navigation (Page 281)
② Toolbar (Page 280)
③ Parameter table (Page 282)
④ "Parameter view" tab

Function scope

The following functions are available for analyzing the parameters of the technology objects and for enabling targeted monitoring and modification.

Display functions:

- Display of parameter values in offline and online mode
- Display of status information of the parameters
- Display of value deviations and option for direct correction
- Display of configuration errors
- Display of value changes as a result of parameter dependencies
- Display of all memory values of a parameter: Start value PLC, Start value in project, Monitor value
- Display of the parameter comparison of the memory values of a parameter

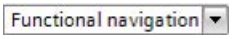
Operator control functions:

- Navigation for quickly changing between the parameters and parameter structures.
- Text filter for faster searches for particular parameters.
- Sorting function for customizing the order of parameters and parameter groups to requirements.
- Memory function for backing up structural settings of the Parameter view.
- Monitoring and modifying of parameter values online.
- Function for saving a snapshot of parameter values of the CPU in order to capture momentary situations and to respond to them.
- Function for applying a snapshot of parameter values as start values.
- Download of modified start values to the CPU.
- Comparison functions for comparing parameter values with one another.

6.12.2 Structure of the parameter view

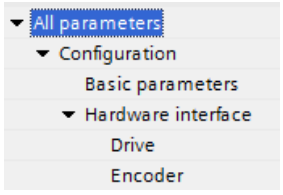
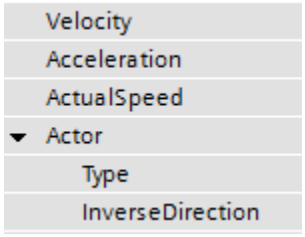
6.12.2.1 Toolbar

The following functions can be selected in the toolbar of the parameter view.

Symbol	Function	Explanation
	Select navigation structure	Toggle between function-based navigation and the view of the data structure of the technology data block.
	Couples the function view and parameter view for the objects selected in the navigation	Enables the targeted toggling between the parameter view and function-based view.
	Collapse/expand all nodes and objects	Collapses or expands all nodes and objects of the navigation or the data structure in the currently active view.
	Collapse/expand the nodes below the marked nodes	Collapses or expands the marked nodes and objects of the navigation or the data structure in the currently active view.
	Text filter...	After entry of a character string: Display of all parameters containing the entered string in one of the currently visible columns.
	Selection of compare values	Selection of parameter values that are to be compared with one another in online mode (Start value in project, Start value PLC) Only in online mode.
	Save window settings	Saves your display settings for the Parameter view (e.g. selected navigation structure, activated table columns, etc.)

6.12.2.2 Navigation

Within the "Parameter view" tab, the following alternative navigation structures can be selected.

Navigation		Explanation
Functional navigation		In the functional navigation, the structure of the parameters is based on the structure in the configuration window ("Function view" tab), commissioning window and diagnostics window.
Data structure		In the "Data structure" navigation, the structure of the parameters is based on the structure of the technology data block.

You can use the "Select navigation structure" drop-down list to toggle the navigation structure.

6.12.2.3 Parameter table

The table below shows the meaning of the individual columns of the parameter table. You can show or hide the columns as required.

- Column "Offline" = X: Column is visible in offline mode.
- Column "Online" = X: Column is visible in online mode (online connection to the CPU).

Column	Explanation	Offline	Online
Name in function view	Name of the parameter in the function view. The display field is empty for parameters that are not configured via the technology object.	X	X
Name in DB	Name of the parameter in the technology data block. If the parameter is part of a structure or UDT, the prefix "../" is added. The display field is empty for parameters that are not contained in the technology data block.	X	X
Full name in DB	Complete path of the parameter in the instance DB. The display field is empty for parameters that are not contained in the technology data block.	X	X
Status of configuration	Display of the completeness of the configuration using status symbols.	X	
Compare result	Result of the "Compare values" function. This column is displayed when there is an online connection.		X
Start value in project	Configured start value in project. Error indication if entered values have a syntax or process-related error.	X	X
Default value	Value that is pre-assigned to the parameter. The display field is empty for parameters that are not contained in the technology data block.	X	X
Start value PLC	Start value in the CPU. This column is displayed when there is an online connection.		X
Monitor value	Current value in the CPU. This column is displayed when there is an online connection.		X
Modify value	Value that is to be used to change the monitor value. This column is displayed when there is an online connection.		X
Minimum value	Minimum process-related value of the parameter. If the minimum value is dependent on other parameters, it is defined: • Offline: by the start value in the project. • Online: by the monitor values.	X	X
Maximum value	Maximum process-related value of the parameter. If the maximum value is dependent on other parameters, it is defined: • Offline: by the start value in the project. • Online: by the monitor values.	X	X
Setpoint	Designates the parameter as a setpoint. These parameters can be initialized online.	X	X

Column	Explanation	Offline	Online
Data type	Data type of the parameter. The display field is empty for parameters that are not contained in the technology data block.	X	X
Retain	Designates the value as a retentive value. The values of retentive parameters are retained even after the voltage supply is switched off.	X	X
Accessible from HMI	Indicates whether the HMI can access this parameter during runtime.	X	X
Visible in HMI	Indicates whether the parameter is visible in the selection list of the HMI by default.	X	X
Comment	Brief description of the parameter.	X	X

6.12.3 Opening the parameter view

Requirement

The technology object was added in the project navigator.

Procedure

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click the "Configuration" object.
4. Select the "Parameter view" tab in the top right corner.

Result

The Parameter view opens. Each displayed parameter is represented by one row in the parameter table.

The displayable parameter properties (table columns) vary depending on whether you are working with the Parameter view in offline or online mode.

In addition, you can selectively display and hide individual table columns.

6.12.4 Working with the parameter view

6.12.4.1 Overview

The following table provides an overview of the functions of the Parameter view in online and offline mode described in the following.

- Column "Offline" = X: This function is possible in offline mode.
- Column "Online" = X: This function is possible in online mode.

Function/action	Offline	Online
Filtering the parameter table (Page 285)	X	X
Sorting the parameter table (Page 286)	X	X
Transferring parameter data to other editors (Page 287)	X	X
Indicating errors (Page 287)	X	X
Editing start values in the project (Page 288)	X	X
Monitoring values online in the parameter view (Page 290)		X
Modifying values (Page 291)		X
Comparing values (Page 293)		X

6.12.4.2 Filtering the parameter table

You can filter the parameters in the parameter table in the following ways:

- With the text filter
- With the subgroups of the navigation

Both filter methods can be used simultaneously.

With the text filter

Texts that are visible in the parameter table can be filtered. This means only texts in displayed parameter rows and columns can be filtered.

1. Enter the desired character string for filtering in the “Text filter...” input box.

   The parameter table displays only the parameters containing the character string.

The text filtering is reset.

- When another parameter group is selected in the navigation.
- When navigation is changed from data navigation to functional navigation, or vice versa.

With the subgroups of the navigation

1. Click the desired parameter group in the navigation, e.g., "Static".

   The parameter table only shows the static parameters.
   You can select further subgroups for some groups of the navigation.

2. Click “All parameters” in the navigation if all parameters are to be shown again.

6.12.4.3 Sorting the parameter table

The values of the parameters are arranged in rows. The parameter table can be sorted by any displayed column.

- In columns containing numerical values, sorting is based on the magnitude of the numerical value.
- In text columns, sorting is alphabetical.

Sorting by column

1. Position the cursor in the header cell of the desired column.

   The background of this cell turns blue.

2. Click the column header.

Result

The entire parameter table is sorted by the selected column. A triangle with tip facing up appears in the column header.

Clicking the column header again changes the sorting as follows:

- Symbol "▲": Parameter table is sorted in ascending order.
- Symbol "▼": Parameter table is sorted in descending order.
- No symbol: The sorting is removed again. The parameter table assumes the default display.

The "../" prefix in the "Name in DB" column is ignored when sorting.

6.12.4.4 Transferring parameter data to other editors

You can paste parameters of the parameter view in the following editors:

- Program editor
- Watch table
- Signal table for Trace

The following options are available for pasting:

- Drag-and-drop
- <Ctrl+C>/<Ctrl+V>
- Copy/Paste via shortcut menu

6.12.4.5 Indicating errors

Error display

Parameter assignment errors that result in compilation errors (e.g. limit violation) are indicated in the Parameter view.

Every time a value is entered in the Parameter view, a check is made for process-related and syntax errors and displayed with the following indicators:

- Red error symbol in the "Status of configuration" (offline mode) or "Compare result" (online mode, depending on the selected comparison type) columns
- Table field with red background

  If you click the bad field, a roll-out error message appears with information of the permissible value range or the required syntax (format)

Compilation error

From the error message of the compiler, you can directly open the Parameter view (functional navigation) containing the parameter causing the error in situations where the parameter is not displayed in the configuration window.

6.12.4.6 Editing start values in the project

With the Parameter view, you can edit the start values in the project in offline mode and online mode.

- You make value changes in the "Start value in project" column of the parameter table.
- In the "Status of configuration" column of the parameter table, the progress of the configuration is indicated by the familiar status symbols from the configuration window of the technology object.

Boundary conditions

- If other parameters depend on the parameter whose start value was changed, the start value of the dependent parameters are also adapted.
- If a parameter of a technology object is not editable, it is also not editable in the parameter view. The ability to edit a parameter can also depend on the values of other parameters.

Defining new start values

To define start values for parameters in the Parameter view, follow these steps:

1. Open the Parameter view of the technology object.
2. Enter the desired start values in the "Start value in project" column. The value must match the data type of the parameter and must not exceed the value range of the parameter.
   The limits of the value range can be seen in the "Maximum value" and "Minimum value" columns.

The "Status of configuration" column indicates the progress of the configuration with colored symbols.

Following adaptation of the start values and downloading of the technology object to the CPU, the parameters take the defined value at startup if they are not declared as retentive ("Retain" column).

Error display

When a start value is input, a check is made for process-related and syntax errors and the result is indicated.

Bad start values are indicated by:

- Red error symbol in the "Status of configuration" (offline mode) or "Compare result" (online mode, depending on the selected comparison type) columns

and/or

- Red background in the "Start value in project" field
  If you click on the bad field, a roll-out error message appears with information of the permissible value range or the necessary syntax (format)

Correcting bad start values

1. Correct bad start values using information from the roll-out error message.

   Red error symbol, red field background, and roll-out error message are no longer displayed.

The project cannot be successfully compiled unless the start values are error-free.

6.12.4.7 Monitoring values online in the parameter view

You can monitor the values currently taken by the parameters of the technology object in the CPU (monitor values) directly in the Parameter view.

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The Parameter view of the technology object is open.

Procedure

As soon as the Parameter view is online, the following columns are additionally displayed:

- Compare result
- Start value PLC
- Monitor value
- Modify value
- Selection for transmission

The "Monitor value" column shows the current parameter values on the CPU.

Display

All columns that are only available online have an orange background:

- Values in light-orange cells can be changed.
- Values in cells with a dark orange background cannot be changed.

See also

Parameter table (Page 282)

6.12.4.8 Modifying values

With the Parameter view, you can modify values of the technology object in the CPU.

You can assign values to the parameter once (Modify value) and modify them immediately. The modify request is executed as quickly as possible without reference to any particular point in the user program.

⚠ DANGER

Danger when modifying:

Changing the parameter values while the plant is operating may result in severe damage to property and personal injury in the event of malfunctions or program errors.

Make sure that dangerous states cannot occur before you use the "Modify" function.

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The Parameter view of the technology object is open.
- The parameter can be modified (associated field in the "Modify value" column has a light-orange background).

Procedure

To modify parameters immediately, follow these steps:

- Enter the desired modify values in the “Modify values” column of the parameter table.

The selected parameters are modified once and immediately with the specified values and can be monitored in the "Monitor values" column. The check boxes for modifying in the "Selection for transmission" column are automatically cleared after the modify request is complete.

Error display

When a start value is input, a check is made immediately for process-related and syntax errors and the result is indicated.

Bad start values are indicated by:

- Red background in the “Modify value” field

and

- If you click the bad field, a roll-out error message appears with information of the permissible value range or the necessary syntax (format)

Bad modify values

- Modify values with process-related errors can be transmitted.
- Modify values with syntax errors **cannot** be transmitted.

6.12.4.9 Comparing values

You can use comparison functions to compare the following memory values of a parameter:

- Start value in project
- Start value PLC

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The Parameter view of the technology object is open.

Procedure

To compare the start values on the various target systems, follow these steps:

1. Click the "Selection of compare values" icon .

   A selection list containing the comparison options opens:

   – Start value in project - Start value PLC (default setting)

2. Select the desired comparison option.

   The selected comparison option is executed as follows:

   – A scales symbol appears in the header cells of the two columns selected for comparison.

   – Symbols are used in the "Compare result" column to indicate the result of the comparison of the selected columns.

Symbol in "Compare result" column

Symbol	Meaning
	The compare values are equal and error-free.
	The compare values are not equal and error-free.
	At least one of the two compare values has a process-related or syntax error.
	The comparison cannot be performed. At least one of the two compare values is not available (e.g., snapshot).

Symbol in the navigation

The symbols are shown in the same way in the navigation if the compare result applies to at least one of the parameters below the displayed navigation structure.

Programming 7

7.1 Introduction

The "Programming" section contains general information on supplying and evaluating the Motion Control instructions and on technology data blocks.

You can find an overview of the Motion Control instructions in the Functions (Page 26) section.

You can use Motion Control instructions in the user program to assign jobs to the technology object. You define the job using the input parameters of the Motion Control instructions. The current job status is indicated in the output parameters.

The technology data block is available to you as an additional interface to the technology object.

7.2 Technology data block

7.2.1 Introduction

The properties of real objects (e.g. drives) are configured by means of the technology objects and saved in a technology data block. The technology data block contains all configuration data, setpoint and actual values, and status information of the technology object. The TIA Portal automatically creates the technology data block when the technology object is created. You access the data of the technology data block (read/write access) with your user program.

A listing and description of the tags can be found in the Appendix (Page 442).

7.2.2 Evaluating the technology data block

Description

Access to data in the technology data block occurs in accordance with the access to standard data blocks.

Reading values from the technology data block

In your user program you can read actual values (e.g. current position) and status information, or detect error messages in the technology object. When you program a query in your user program (e.g. current velocity), the value is directly read from the technology object.

Reading values from the technology data block takes longer than for other data blocks.
If you use these tags several times in a single cycle of your user program, it is recommended to copy the tag values to local tags, and use the local tags in your program.

Writing values to the technology data block

The configuration of the technology object in the TIA Portal is used to write the corresponding data to the technology data block. After they have been loaded into the CPU, these data are stored in the CPU on the SIMATIC Memory Card (load memory).

In the following cases, it may be necessary for the user program to write values to the technology data block:

- Adaptation of the configuration of the technology object (e.g. dynamic limits, software limit switches)
- Use of overrides
- Adaptation of position control (e.g. "Kv" parameter)

Changes to values in the technology data block by the user program can take effect at various points in time. The relevant property of the individual tags can be found in their descriptions in the Appendix (Page 442):

Effectiveness of changes	Description	
Direct (DIR)	You write changes using direct assignments. The changes are applied only at the start of the next MC-Servo [OB91]. The changes are retained until the next POWER OFF of the CPU or restart of the technology object.	
	LREAL (e.g. <TO>.Override.Velocity)	The technology object performs a range check on the written value, and immediately starts using the new value. If range limits are violated when writing, the technology object automatically corrects the values. If the value is below the range, then the value is set to the low limit of the range; if the range is exceeded, then the value is set to the high limit of the range.
	DINT/BOOL (e.g. <TO>.PositionLimits_SW.Active)	Changes are only permitted in the defined value range. Value changes outside the value range are not applied. If you enter invalid values, the programming error OB (OB 121) is started.
When Motion Control instruction is called (CAL) (e.g. <TO>.Sensor[n].ActiveHoming.HomePositionOffset)	You write changes using direct assignments. The changes are applied at the start of the next MC-Servo [OB91] after the call of the corresponding Motion Control instruction in the user program. The changes are retained until the next POWER OFF of the CPU or restart of the technology object.	
Restart (RES) (e.g. <TO>.Homing.AutoReversal)	Since restart-relevant tags have dependencies on other tags, value changes cannot be applied at any arbitrary time. The changes are only used after reinitialization (restart) of the technology object. During a restart the technology object is reinitialized with the data in load memory. You therefore write changes to the start value in the load memory with the extended instruction "WRIT_DBL" (write to data block in load memory). You trigger the restart in your user program using the Motion Control instruction "MC_Reset" with parameter "Restart" = TRUE. Additional information regarding the restart can be found in the Restarting technology objects (Page 324) section.	
Read only (RON) (e.g. <TO>.Position)	The tag cannot and must not be changed during runtime of the user program.	

Note

Save changes with "WRIT_DBL"

Changes to tags immediately in effect are lost on POWER OFF of the CPU, or restart of the technology object.

If changes in the technology data block should also be retained after POWER OFF of the CPU, or restart of the technology object, you must write the changes to the start value in the load memory with the extended instruction "WRIT_DBL".

Note

Using the "READ_DBL" and "WRIT_DBL" data block functions

The "READ_DBL" and "WRIT_DBL" data block functions may only be used on individual tags in conjunction with the tags of the technology object. The "READ_DBL" and "WRIT_DBL" data block functions must not be applied to data structures of the technology object.

Isochronous evaluation of data

If you want to process data of the technology data block in isochronous mode from a Motion Control application cycle, there is the option of evaluating this data in the MC-PreServo [OB67]/MC-PostServo [OB95] as of technology version V3.0.

See also

Organization Blocks for Motion Control (Page 97)

7.2.3 Evaluate StatusWord, ErrorWord and WarningWord

To be able to symbolically use individual status and error information from the "StatusWord", "ErrorWord" and "WarningWord" data double words, you can evaluate them as described below. For consistent evaluation, you should avoid using bit addressing to access these data double words in the technology data block. Access to an individual bit in the technology data block only lasts as long as the access to the entire data word.

When required, copy the required data double word to a tag of a data structure and query the individual bits of the tag.

The allocation of the individual bits in the data double words can be found in the Appendix (Page 442) in the description of the tags of the corresponding technology object.

Requirements

The technology object has been created.

Procedure

To evaluate the individual bits in the data word "StatusWord", follow these steps:

1. Crate a global data structure. Name the data structure, e.g. as "Status".
2. Create a double word (DWORD) in the data structure "Status".
   Name the double word, e.g. as "Temp".
3. Create 32 Boolean tags in the "Status" data structure. You can obtain a clearer overview by giving the individual Boolean tags identical names as the bits in the technology DB (e.g. name the fifth Boolean tag "HomingDone").
4. Copy the tag <TO>.StatusWord as needed from the technology data block to the double word "Temp" in your data structure.
5. Copy the individual bits of double word "Temp" to the corresponding Boolean tags with bit accesses.
6. Use the Boolean tags to query the status bits.

Evaluate the data words "ErrorWord" and "WarningWord" as specified in steps 1 to 6.

Example

The following example shows how you can read out and save the fifth bit "HomingDone" of the data word "StatusWord":

```
SCL                                          Explanation
#Status.Temp := "TO".StatusWord;             //Copy status word
#Status.HomingDone := #Status.Temp.%X5;      //Copy individual bits per bit access
```

```
STL                                          Explanation
L "TO".StatusWord                            //Copy status word
T #Status.Temp
U #Status.Temp.%X5                           //Copy individual bits per bit access
= #Status.HomingDone
```

7.2.4 Change restart-relevant data

In order to change restart-relevant data in the technology data block, write to the starting values of the tags in load memory using the extended instruction "WRIT_DBL". In order for the changes to be applied, a restart of the technology object must be performed.

Whether changes to the value of a tag are relevant for the restart can be found in the description of the tags in the Appendix (Page 456).

Requirement

The technology object has been created.

Procedure

To change restart-relevant data, proceed as follows:

1. Create a data block and fill it with the restart-relevant values, that you want to change in the technology data block. In doing so, the data types must match the tags to be changed.
2. Write the values from your data block to the starting values of the tags of the technology data block in load memory, using the extended instruction "WRIT_DBL".

   If restart-relevant data were changed, this will be indicated in the <TO>.StatusWord.X3 (OnlineStartValuesChanged) tag of the technology object.
3. Perform a restart of the technology object using the Motion Control instruction "MC_Reset" with parameter "Restart" = TRUE.

After the restart of the technology object, the new value is transferred into the technology data block in work memory, and is effective.

7.3 Motion Control instructions

7.3.1 Motion Control instruction parameters

Description

The individual Motion Control instructions are described in detail in the section S7-1500 Motion Control V3 (Page 371).

When creating your user program, take the following explanations of the Motion Control instruction parameters into account.

Reference to the technology object

The technology object is specified for the Motion Control instruction as follows:

- **Parameter "Axis"**

  The "Axis" input parameter of a Motion Control instruction contains a reference to the technology object that is to execute the corresponding job.

  The corresponding technology object is also referenced in the following parameters:

  – Parameter "Master"

  – Parameter "Slave"

  – Parameter "Cam"

  – Parameter "MeasuringInput"

  – Parameter "OutputCam"

  – Parameter "CamTrack"

  As of technology version V3.0, the reference to the technology object can also be specified with the data type DB_ANY.

Job start and transfer of input parameters of a Motion Control instruction

For the start of jobs and the transfer of modified parameter values, a distinction is made between the following Motion Control instructions:

- **Motion Control instructions with "Execute" parameter**

  With a positive edge at the "Execute" parameter, the job is started and the existing values for the input parameters are transferred.

  Subsequently changed parameter values are not transferred until the next job start.

  Resetting the "Execute" parameter does not end the job, but it does affect the display duration of the job status. As long as "Execute" is set to TRUE, the output parameters will be updated. If "Execute" is reset before the completion of a job, the parameters "Done", "Error" and "CommandAborted" are correspondingly set for only one call cycle.

- **Motion Control instructions with "Enable" parameter**

  The job is started by setting the "Enable" parameter.

  As long as "Enable" = TRUE, the job remains active and changed parameter values will be transferred each time the instruction is called in the user program.

  The job is ended by resetting the "Enable" parameter.

  The input parameters "JogForward" and "JogBackward" of the Motion Control instruction "MC_MoveJog" correspond in their behavior to the "Enable" parameter.

Job status

The following output parameters indicate the status of the job execution:

- **Motion Control instructions with "Done" parameter**

  The normal completion of a job is indicated with parameter "Done" = TRUE.

- **Motion Control instructions without "Done" parameter**

  The achievement of the job objective is indicated by other parameters (e.g. "Status", "InVelocity"). For more information, refer to the section Tracking running jobs (Page 312).

- **Parameter "Busy"**

  As long as a job is being processed, the "Busy" parameter shows the value TRUE.
  If a job was ended or aborted, "Busy" shows the value FALSE.

- **Parameter "CommandAborted"**

  If a job was aborted by another job, the CommandAborted parameter shows the value "TRUE".

- **Parameter "Error"**

  If a Motion Control instruction error occurs, the "Error" parameter shows the value TRUE. The ErrorID parameter indicates the cause of the error.

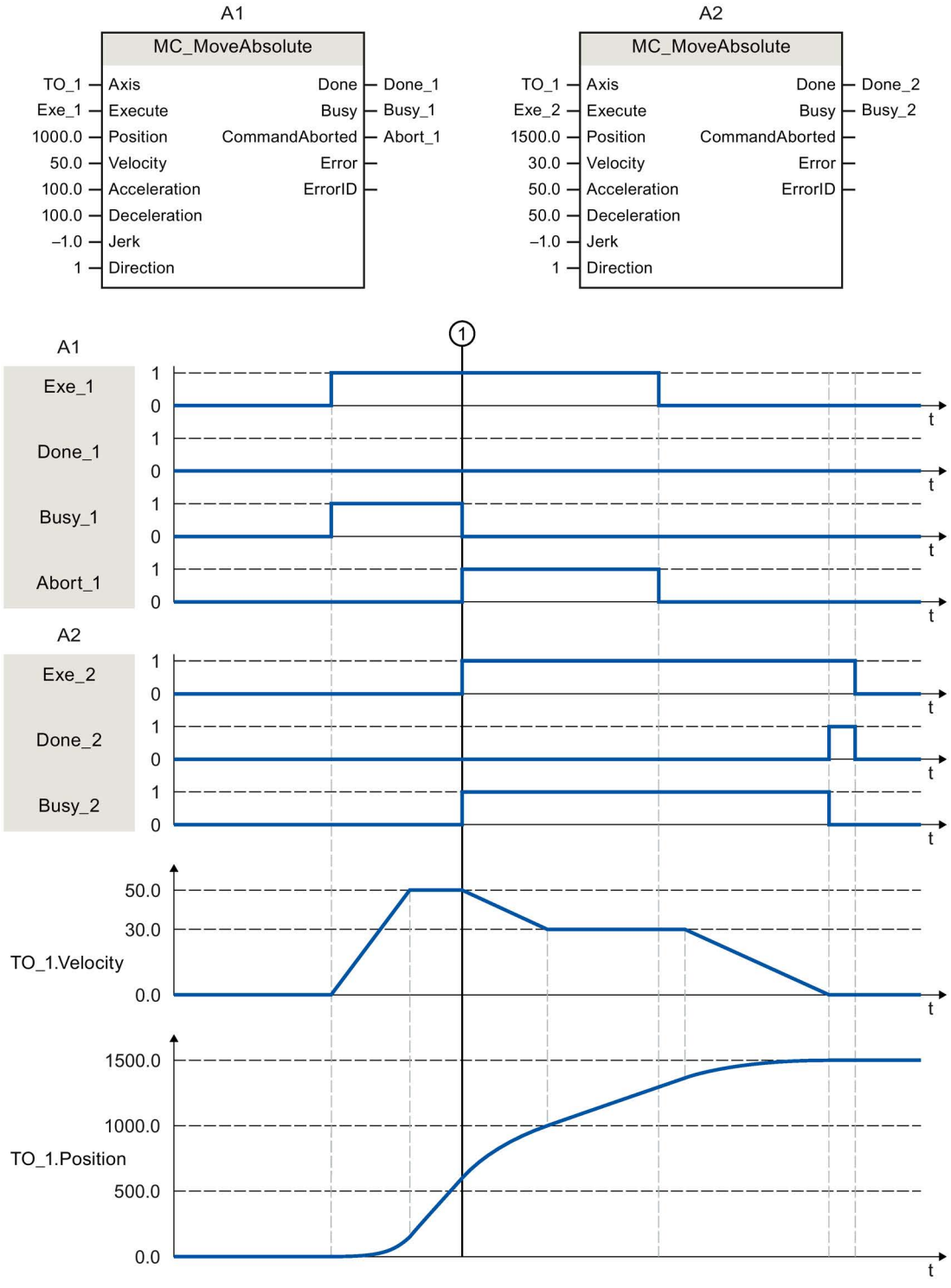
As long as the "Execute" or "Enable" parameter is set to TRUE, the output parameters will be updated. Otherwise the parameters "Done", "Error" and CommandAborted" are correspondingly set for only one cycle.

Abort of running jobs

An active Motion Control job is aborted by the start of a new Motion Control job. In the process, the current dynamic setpoints (acceleration, deceleration, jerk, velocity) are set to the values of the overriding job.

Example of parameter behavior

The behavior of the parameters of Motion Control instructions is shown in the following chart using the example of two "MC_MoveAbsolute" jobs.



Using "Exe_1", an "MC_MoveAbsolute" job (A1) with target position 1000.0 is initiated. "Busy_1" is set to TRUE. The axis is accelerated to the specified velocity and moved to the target position (see TO_1.Velocity and TO_1.Position). Before the target position is reached, the job is overridden at time ① by another "MC_MoveAbsolute" job (A2). The abort is signaled via "Abort_1", and "Busy_1" is set to FALSE. The axis is braked to the velocity specified in A2 and moved to the new target position 1500.0. When the axis reaches the target position, this is signaled via "Done_2".

Non position-controlled operation

The position control of the axis can be deactivated with the following parameters:

- MC_Power.StartMode = 0
- MC_MoveVelocity.PositionControlled = FALSE
- MC_MoveJog.PositionControlled = FALSE

For more information, refer to the section " Non position-controlled operation (Page 308).

7.3.2 Add Motion Control instructions

You add Motion Control instructions to a program block in the same way as other instructions. You control all available functions of the technology object using the Motion Control instructions.

Requirements

The technology object was created.

Procedure

To add Motion Control instructions in your user program, proceed as follows:

1. Double click your program block in the project tree (the program block must be called in the cyclical program).

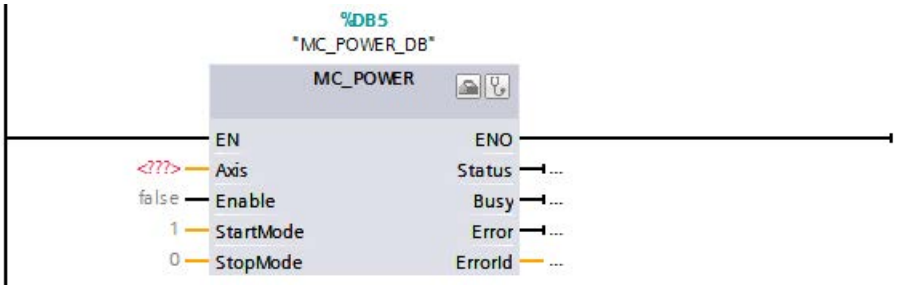
   The program block is opened in the programming editor, and the available instructions are displayed.

2. In the "Instructions" task card, open the "Technology > Motion Control" folder.
3. Using drag-and-drop, move the Motion Control instruction, e.g. "MC_Power", to the desired segment of the program block.

   The "Call options" dialog opens.

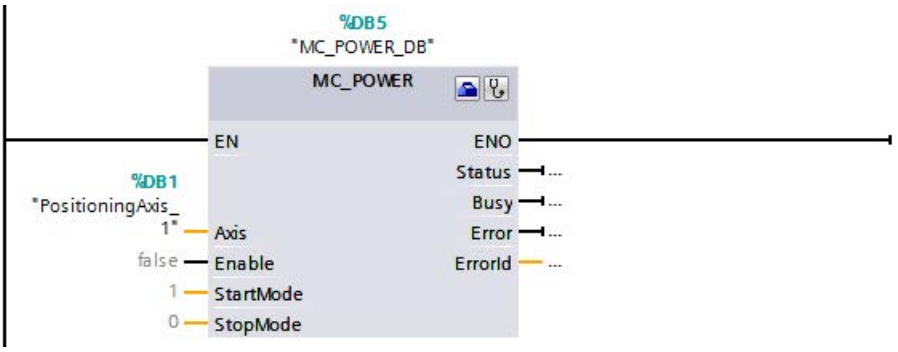
4. In the dialog, specify a name and a number for the instance data block of the Motion Control instruction.
5. Click "OK".

   The Motion Control instruction "MC_Power" is inserted into the network.



   The instance data block is automatically created under "Program Blocks > System Blocks > Program Resources".

6. Input parameters without a default value (e.g. "Axis"), must be assigned. Select the technology object in the project tree and move it onto <...> in the "Axis" parameter using drag-and-drop.



Once the technology object is specified in the "Axis" parameter, the following buttons are available to you:

	To open the configuration of the technology object, click on the toolbox icon.
	To open the diagnostics of the technology object, click on the stethoscope icon.

7. Add additional Motion Control instructions in accordance with steps 3 through 6.

See also

Tracking active jobs (Page 312)

Tags of the positioning axis/synchronous axis technology object (Page 456)

7.3.3 Parameter transfer for function blocks

If you want to reuse a function block with Motion Control instructions for different technology objects, create an input parameter of the data type of the respective technology object in the block interface of the calling function block. You assign the data type in the block interface with direct input. The parameter is then transferred as reference to the technology object to the "Axis" parameter of the Motion Control instructions. The data types of technology objects correspond to the structure of the associated technology data block.

By specifying the data type, you can address the tags of the technology object in the function block (<parameters of the block interface>.<tag of the technology object>).

If you do not need access to the tags of the technology object, you can use the data type DB_ANY.

The following table shows the data types for reference to the technology objects:

Technology object	Data type for reference to the technology object
Speed axis	TO_SpeedAxis
Positioning axis	TO_PositioningAxis
Synchronous axis	TO_SynchronousAxis
External encoder	TO_Encoder
Output cam	TO_OutputCam
Cam track	TO_CamTrack
Measuring input	TO_MeasuringInput
Cam (S7-1500T)	TO_Cam

Example

The following table shows the definition of the tags used:

Operand	Declaration	Data type	Description
Axis	Input	TO_PositioningAxis	Reference to the technology object
On	Input	BOOL	Signal to enable the axis
Act_Position	Output	LReal	Query of the actual position from the technology data block
MC_POWER_I	Static	MC_POWER	Multi-instance of the Motion Control instruction MC_Power

The following SCL program shows how to implement this task:

SCL	Explanation
`#MC_POWER_I(Axis := #Axis, Enable := #On);`	`//Call of the Motion Control instruction MC_Power with enable of the axis`
`#Act_Position := #Axis.ActualPosition;`	`//Query of the actual position from the technology data block`

7.3.4 Non position-controlled operation

The closed loop position control of an axis can be switched off/switched with the following Motion Control instructions:

- MC_Power
- MC_MoveVelocity
- MC_MoveJog

The non-position-controlled operation is displayed with <TO>.StatusWord.X28 (NonPositionControlled) = TRUE.

MC_Power

The axis is enabled without closed loop position control with "MC_Power" and the parameter "StartMode" = 0. The closed loop position control remain switched off until a different Motion Control instruction changes the status of the closed loop position control.

MC_MoveVelocity and MC_MoveJog

A "MC_MoveVelocity" or "MC_MoveJog" job with "PositionControlled" = FALSE forces non-position-controlled operation.

A "MC_MoveVelocity" or "MC_MoveJog" job with "PositionControlled" = TRUE forces position-controlled operation.

The selected mode remains in effect after the job is completed.

Influence of additional Motion Control instructions

Starting the following Motion Control instructions forces position-controlled operation of the axis:

- MC_Home with "Mode" = 3, 5
- MC_MoveAbsolute
- MC_MoveRelative
- MC_MoveSuperimposed
- MC_GearIn
- MC_GearInPos (S7-1500T)
- MC_CamIn (S7-1500T)

The closed loop position control remains active after completing the corresponding jobs.

The Motion Control instruction MC_Halt is executed in position-controlled and non-position-controlled operation. The status of the closed loop position control is not changed by "MC_Halt".

A torque limiting activated with "MC_TorqueLimiting" is in effect even with non-position-controlled operation.

Synchronous operation with setpoint coupling

A following axis is set into position-controlled operation with the start of a synchronous operation job. If the leading axis is in non-position-controlled operation at the start of the synchronous operation, the synchronous operation job remains waiting. Synchronization is not started until closed loop position control is activated and the start position of the synchronization has been reached.

Note

If the leading axis is set to non-position-controlled operation during active synchronous operation, the setpoint at the following axis is set to 0.0. This corresponds to a setpoint step change on the following axis. The following axis compensates for the step change according to the synchronous operation function and limited only to the maximum speed of the drive.

Synchronous operation with actual value coupling (S7-1500T)

A following axis is set into position-controlled operation with the start of a synchronous operation job. If the leading axis is in non-position-controlled operation at the start of the synchronous operation and the actual values are valid, synchronization is started.

If the leading axis is set to non-position-controlled operation during active synchronous operation, the synchronous operation remains active.

7.4 Starting Motion Control jobs

Description

Motion Control jobs are started by setting the "Execute" or "Enable" parameter of the Motion Control instruction. The call of the Motion Control instructions for a technology object should occur in an execution level.

When executing Motion Control jobs, you should also take note of the status of the technology object.

Starting Motion Control jobs should be performed in the following steps:

1. Query the status of the technology object.
2. Initiate new job for the technology object.
3. Check job status.

These steps are explained using the example of a job for absolute positioning.

1. Query the status of the technology object

Make sure that the technology object is in the appropriate status to perform the desired job:

- **Has the technology object been released?**

  To execute motion jobs, the technology object must be enabled.

  Enabling is performed using the Motion Control instruction "MC_Power".

  The "MC_Power.Status" parameter (<TO>.StatusWord.X0 (Enable)) must show the value TRUE.

- **Is a technology alarm pending?**

  To perform motion commands, no technology alarms or alarm responses may be pending. The tags of the technology objects <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction must show the value zero. After resolving the error, acknowledge any pending alarms using the Motion Control instruction "MC_Reset".

  A list of the technology alarms and alarm reactions can be found in the appendix, Technology alarms (Page 530).

- **Has the technology object been homed?**

  In order to perform a job for absolute positioning, the positioning axis/synchronous axis technology object must be homed. The referencing occurs via the Motion Control instruction "MC_Home". The "<TO>.StatusWord.X5 (HomingDone) " tag of the technology object must show the value TRUE .

2. Initiate new command for the technology object

In the "Position" parameter of the "MC_MoveAbsolute" instruction, specify the position to which the axis should be moved. Start the job with a positive edge at the "Execute" parameter.

3. Check command status

Parameter "Done" of the Motion Control instruction indicates successful completion of a job (target reached, in this case).

If an error is detected, the "Error" parameter of the Motion Control instruction is set to TRUE, and the job is rejected.

You can program an error handling routine for the Motion Control job. For this purpose, evaluate the error indicated in the "Error" parameter. The cause of the error is indicated in the ErrorID parameter. After resolving the cause of the error, restart the job.

Output of the "Error" = TRUE and "ErrorID" = 16#8001 status information during job processing indicates that a technology alarm was triggered.

You can find a list of the ErrorIDs in the Error detection (Page 559) appendix.

Additional information

An option for the evaluation of the individual status bits, error bits, and warning bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

7.5 Tracking active jobs

7.5.1 Introduction

The current status of the job processing is made available via the output parameters of the Motion Control instruction. These parameters are updated with each call of the Motion Control instruction.

When tracking jobs, a distinction is made between three groups:

- Motion Control instructions with "Done" parameter (Page 312)
- Motion Control instructions without "Done" parameter (Page 316)
- Motion Control instruction "MC_MoveJog" (Page 320)

7.5.2 Motion Control instructions with "Done" parameter

Description

Jobs of Motion Control instructions with the "Done" parameter are started with a positive edge at the "Execute" parameter. If the job was completed without errors or interruption by another job (e.g. "MC_MoveAbsolute": Target position reached), the "Done" parameter shows the value TRUE.

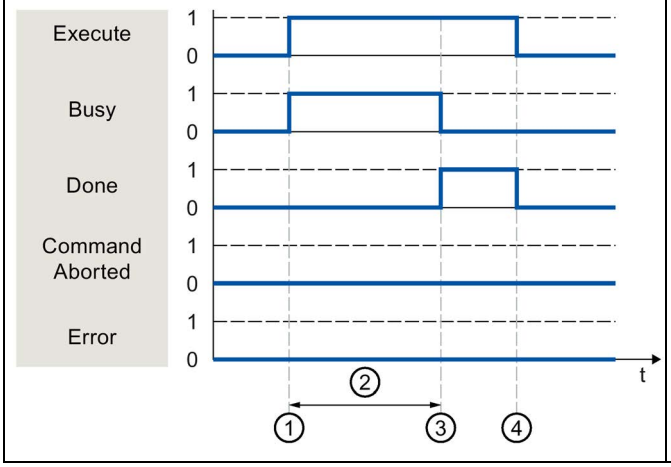
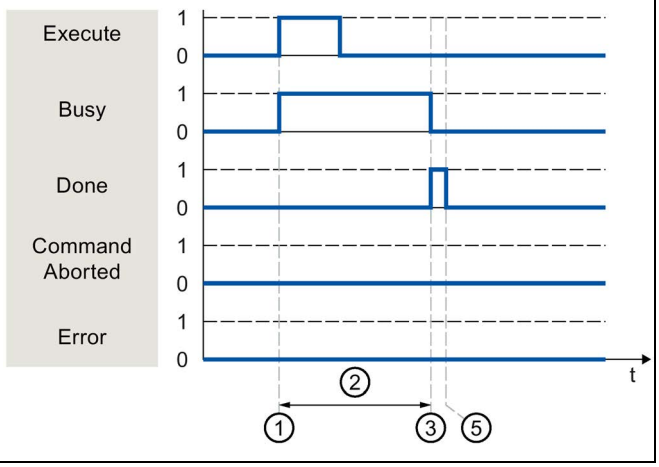
The following Motion Control instructions have a "Done" parameter:

- MC_Home
- MC_MoveRelative
- MC_MoveAbsolute
- MC_MoveSuperimposed
- MC_Halt
- MC_Reset
- MC_MeasuringInput
- MC_AbortMeasuringInput

The behavior of the parameters is shown below by way of example for various situations:

Complete execution of the job

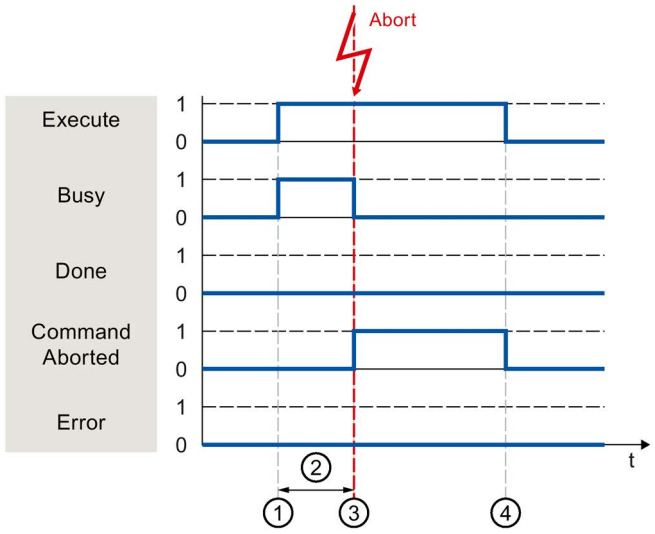
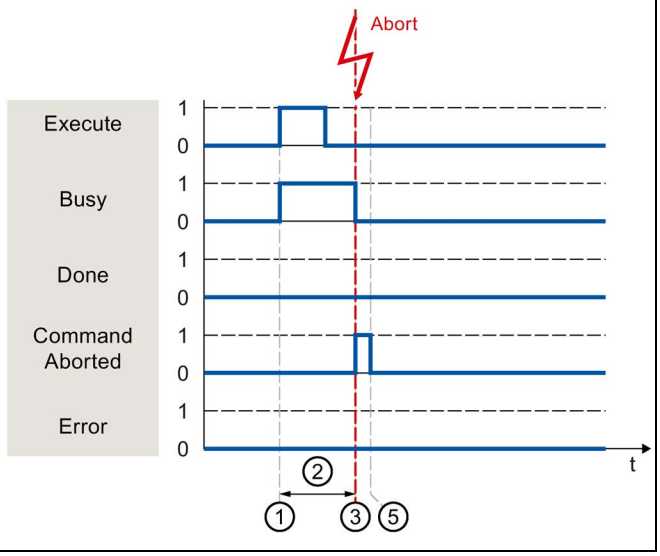
If the Motion Control job has been completely executed all the way to the end, this is indicated with parameter "Done" = TRUE. The signal state of the "Execute" parameter influences the display duration for the "Done" parameter:

You set "Execute" **after completion** of the job to FALSE.	You set "Execute" **during processing** of the job to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value FALSE during the job or the value TRUE can be retained until after completion of the job.
②	While the job is being executed, the "Busy" parameter shows the value TRUE.
③	At the completion of the job (for example, with Motion Control instruction "MC_MoveAbsolute": Target position reached), the "Busy" parameter changes to FALSE and the "Done" parameter to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "Done" parameter also retains the value TRUE.
⑤	If the "Execute" parameter was already set to FALSE before completion of the job, the "Done" parameter shows the value TRUE for only one execution cycle.

Job abort

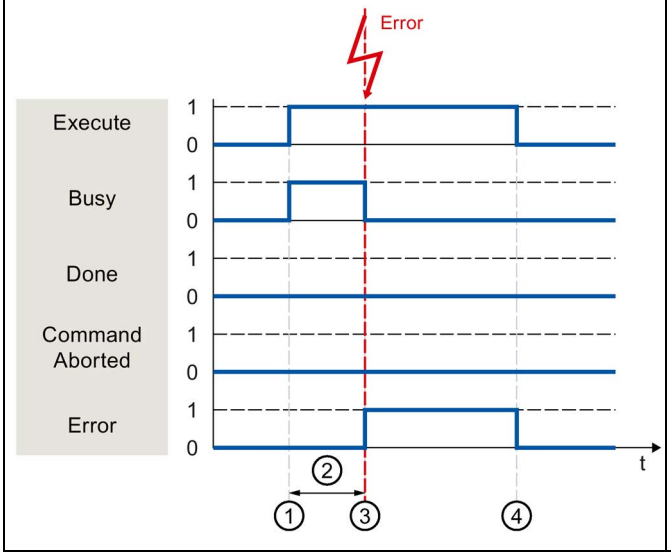
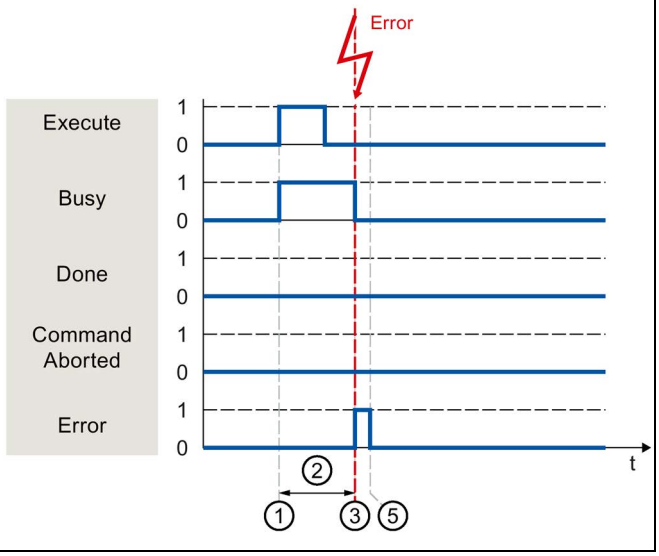
If the Motion Control job is aborted during processing by another job, this is indicated in the "CommandAborted" parameter with the value TRUE. The signal state of the "Execute" parameter influences the display duration for the "CommandAborted" parameter:

You set "Execute" **after** the job is aborted to FALSE.	You set "Execute" **before** the job is aborted to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value FALSE during the job or the value TRUE can be retained until after completion of the job.
②	While the job is being executed, the parameter "Busy" shows the value TRUE.
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE" and "CommandAborted" changes to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "CommandAborted" parameter also retains the value TRUE.
⑤	If the "Execute" parameter was already set to FALSE before the job is aborted, the "CommandAborted" parameter shows the value TRUE for only one execution cycle.

Error during job execution

If an error occurs during execution of the Motion Control job, this is indicated with parameter "Error" = TRUE. The signal state of the "Execute" parameter influences the display duration for the "Error" parameter:

You set "Execute" **after** the occurrence of the error to FALSE.	You set "Execute" **before** the occurrence of the error to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value FALSE during the job or the value TRUE can be retained until after completion of the job.
②	While the job is being executed, the "Busy" parameter shows the value TRUE.
③	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to FALSE and the "Error" parameter to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after the occurrence of the error, the "Error" parameter also retains the value TRUE.
⑤	If the "Execute" parameter was already set to FALSE before the occurrence of the error, the "Error" parameter shows the value TRUE for only one execution cycle.

7.5.3 Motion Control instructions without "Done" parameter

Description

Motion Control instructions without the "Done" parameter use a special parameter to indicate that the command objective (e.g. "InVelocity", "InGear") has been achieved. The target state or motion is stopped until the job is aborted or an error occurs.

The following Motion Control instructions have a special parameter for indicating the job status:

- MC_Power ("Status" parameter)
- MC_MoveVelocity ("InVeloctity" parameter)
- MC_GearIn ("InGear" parameter)
- MC_MoveJog ("InVelocity" parameter)

  The special behavior of "MC_MoveJog" is described in the section Motion Control instruction MC_MoveJog (Page 320).
- MC_TorqueLimiting ("InClamping" and "InLimitation") parameters

The following Motion Control instructions have no special parameter for indicating the job status: Feedback is provided via the following tags:

- MC_MeasuringInputCyclic

  The execution of a measuring job is indicated with parameter "Busy" = TRUE. Completed measuring events are indicated in the corresponding event counters <TO>.MeasuredValues.MeasuredValue1Counter and <TO>.MeasuredValues.MeasuredValue2Counter of the technology data block.
- MC_OutputCam

  The execution of a job is indicated with parameter "Busy" = TRUE. The CamOutput tag in the associated technology data block indicates the switching state of the output cam.
- MC_CamTrack

  The execution of a job is indicated with parameter "Busy" = TRUE. The TrackOutput tag in the associated technology data block indicates the switching state of the output cam.

The behavior of the parameter is shown for various situations using the Motion Control instruction "MC_MoveVelocity" as an example:

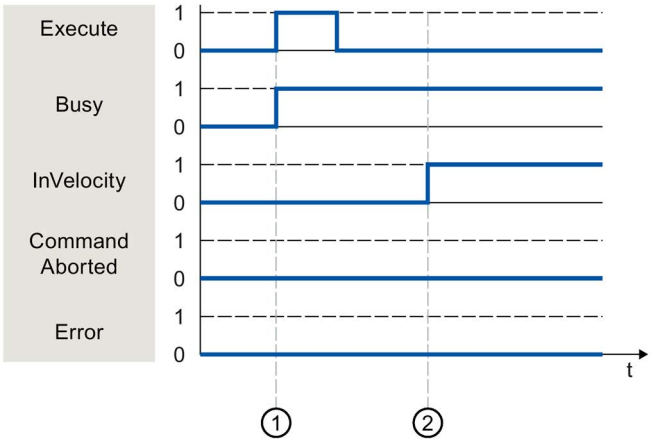
Example "MC_MoveVelocity"

An "MC_MoveVelocity" job is started with a positive edge at the "Execute" parameter. The job objective is fulfilled when the assigned velocity is reached and the axis travels at constant velocity. When the assigned velocity is reached and maintained, this is indicated in the "InVelocity" parameter with the value TRUE.

The motion of the axis can, for example, be stopped with an "MC_Halt" job.

The assigned velocity is reached and maintained

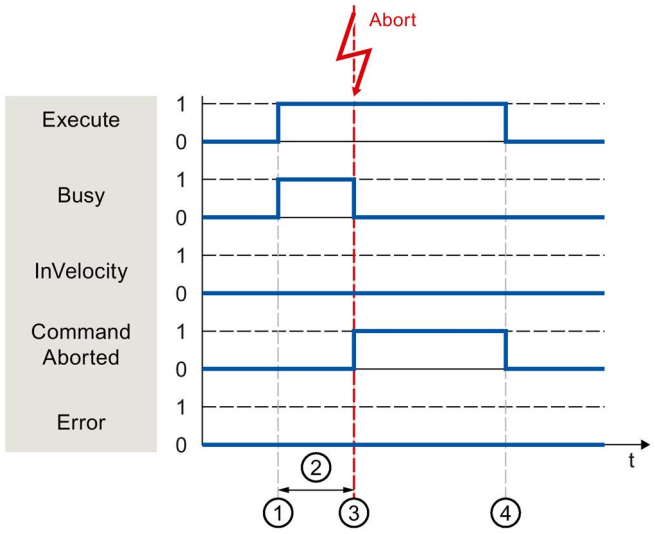
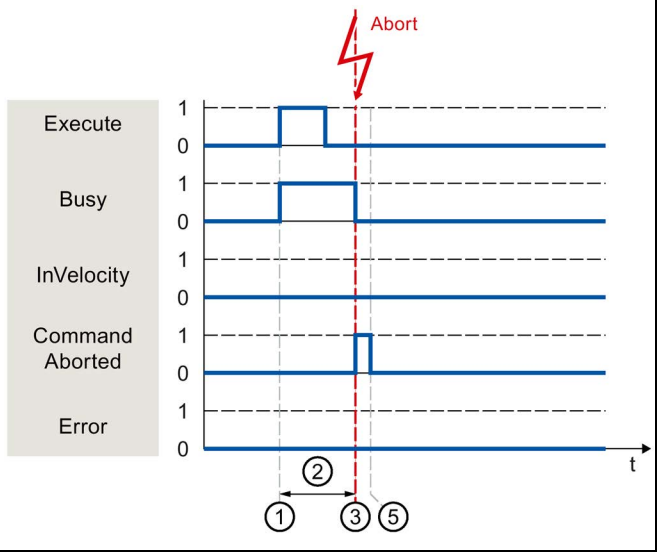
The achievement of the assigned velocity is indicated with parameter "InVelocity" = TRUE. The "Execute" parameter has no effect on the display duration for the "InVelocity" parameter.



①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value FALSE before or after the assigned velocity has been reached. While the job is being executed, the parameter "Busy" shows the value TRUE.
②	When the assigned velocity is reached, the "InVelocity" parameter changes to TRUE. The "Busy" and "InVelocity" parameters retain the value TRUE until another Motion Control job overrides the "MC_MoveVelocity" job.

The job is aborted before the assigned velocity is reached

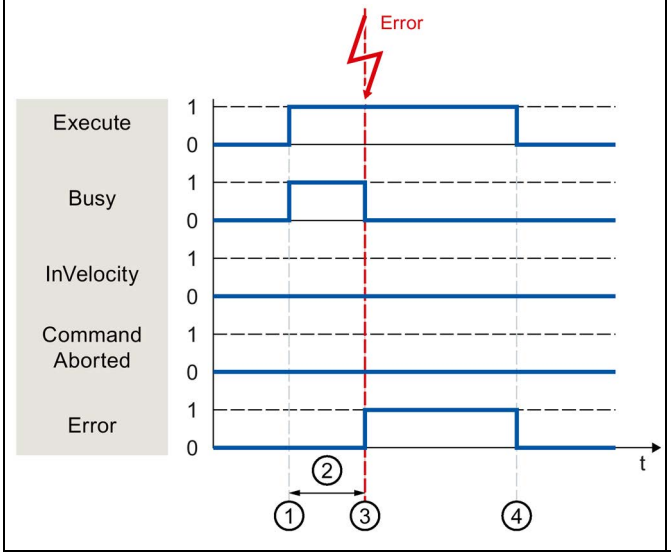
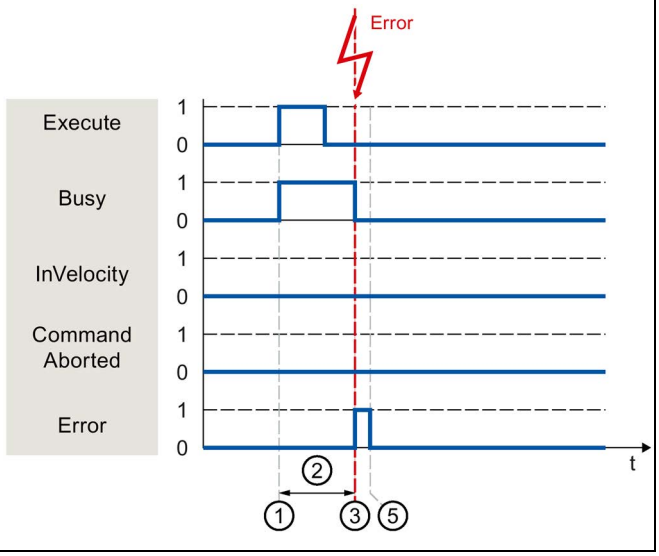
If the Motion Control job is aborted by another job before the assigned velocity is reached, this is indicated with parameter "CommandAborted" = TRUE. The signal state of the "Execute" parameter influences the display duration for the "CommandAborted" parameter.

You set "Execute" **after** the job is aborted to FALSE.	You set "Execute" **before** the job is aborted to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value FALSE during the job or the value TRUE can be retained until after the job is aborted.
②	While the job is being executed, the "Busy" parameter shows the value TRUE.
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE" and "CommandAborted" changes to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "CommandAborted" parameter also retains the value TRUE.
⑤	If the "Execute" parameter was already set to FALSE before the job is aborted, the "CommandAborted" parameter shows the value TRUE for only one execution cycle.

An error has occurred prior to reaching the assigned velocity

If an error occurs during execution of the Motion Control job before the assigned velocity has been reached, this is indicated with parameter "Error" = TRUE. The signal state of the "Execute" parameter influences the display duration for the "Error" parameter.

You set "Execute" **after** the occurrence of the error to FALSE.	You set "Execute" **before** the occurrence of the error to FALSE.
	

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value FALSE during the job or the value TRUE can be retained until after the error has occurred.
②	While the job is being executed, the "Busy" parameter shows the value TRUE.
③	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to FALSE, and the "Error" parameter to TRUE.
④	As long as the "Execute" parameter retains the value TRUE after completion of the job, the "Error" parameter also retains the value TRUE.
⑤	If the "Execute" parameter was already set to FALSE before the job is aborted, the "Error" parameter shows the value TRUE for only one execution cycle.

7.5.4 Motion Control instruction "MC_MoveJog"

Description

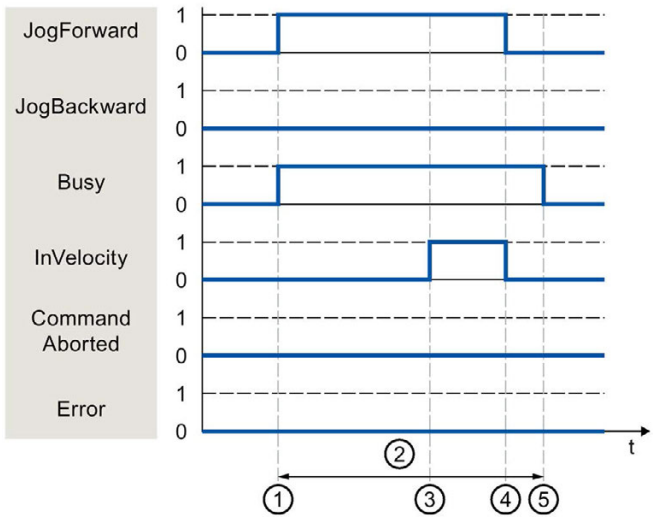
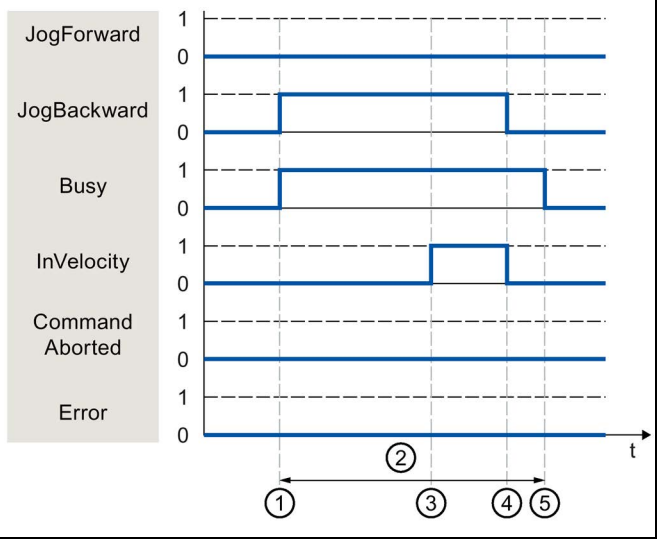
An "MC_MoveJog" job is started by setting the "JogForward" or "JogBackward" parameter. The job objective is fulfilled when the assigned velocity is reached and the axis travels at constant velocity. When the assigned velocity is reached and maintained, this is indicated in the "InVelocity" parameter with the value TRUE.

The job is complete when the "JogForward" or "JogBackward" parameter has been set to the value FALSE and the axis has come to a standstill.

The behavior of the parameters is presented below for various example situations:

The assigned velocity is reached and maintained

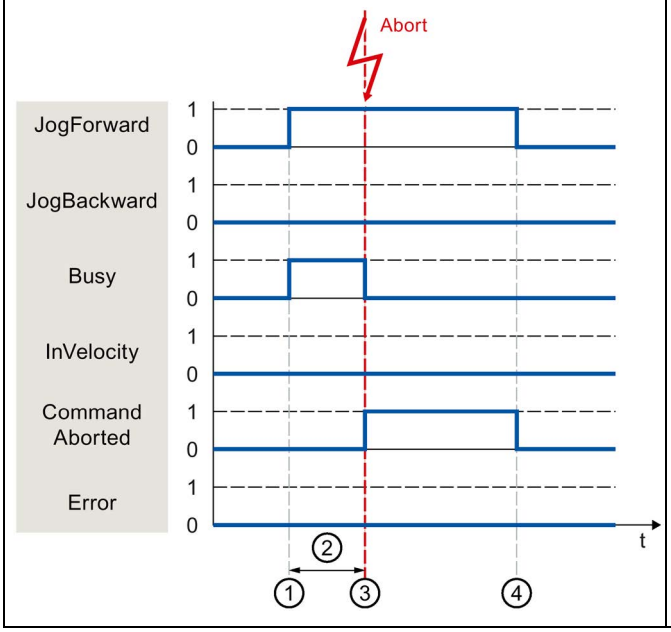
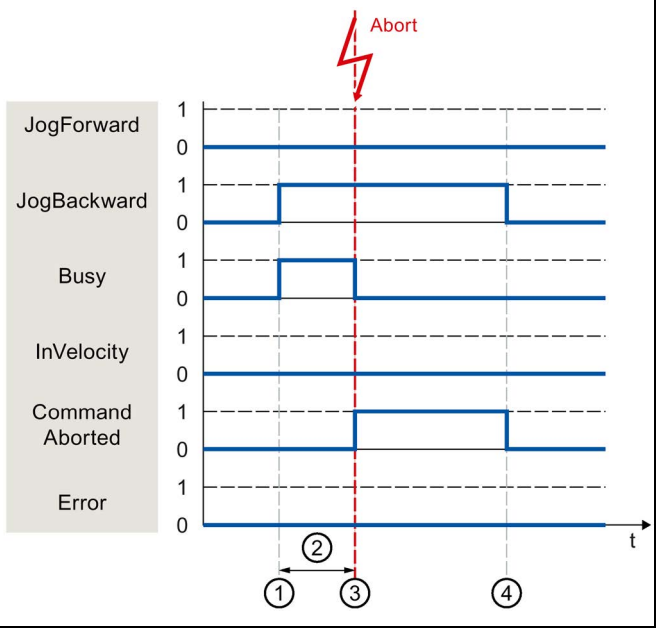
If the Motion Control job has been performed up to the point of reaching the assigned velocity, then this is indicated in the "InVelocity" parameter with the value TRUE.

Jog mode is controlled by the "JogForward" parameter.	Jog mode is controlled by the "JogBackward" parameter.
	

①	The job is started by setting the "JogForward" or "JogBackward" parameter.
②	While the job is being executed, the "Busy" parameter shows the value TRUE.
③	When the assigned velocity is reached, the "InVelocity" parameter changes to TRUE.
④	When the "JogForward" or "JogBackward" parameter is reset, the motion of the axis ends. The axis decelerates. The "InVelocity" parameter changes to FALSE.
⑤	If the axis has come to a standstill, then the Motion Control job is complete and the "Busy" parameter changes to FALSE.

The job is aborted during execution

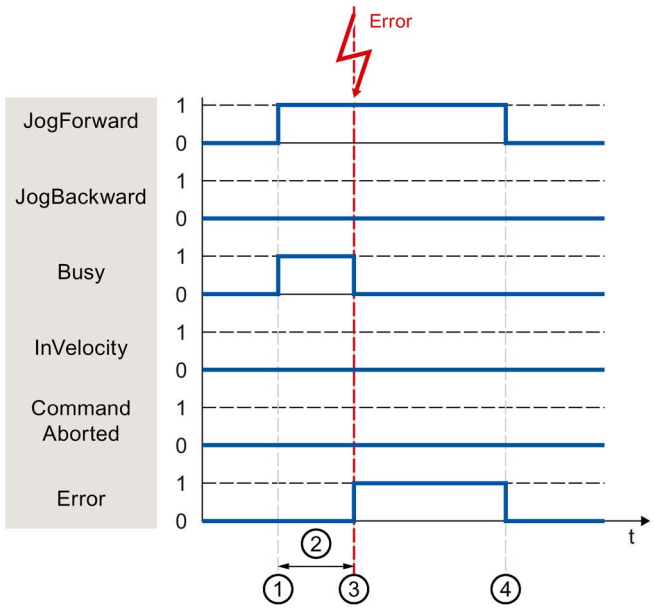
If the Motion Control job is aborted during processing by another job, this is indicated in the "CommandAborted" parameter with the value TRUE. The behavior of the "CommandAborted" parameter is independent of reaching the assigned velocity.

Jog mode is controlled by the "JogForward" parameter.	Jog mode is controlled by the "JogBackward" parameter.
	

①	The job is started by setting the "JogForward" or "JogBackward" parameter.
②	While the job is processing, the "Busy" parameter shows the value TRUE.
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE" and "CommandAborted" changes to TRUE.
④	When the "JogForward" or "JogBackward" parameter is reset, the "CommandAborted" parameter likewise changes to FALSE.

An error occurs during the execution of the job

If an error occurs during execution of the Motion Control job, this is indicated in the "Error" parameter with the value TRUE. The behavior of the "Error" parameter is independent of reaching the assigned velocity.

Jog mode is controlled by the "JogForward" parameter.	Jog mode is controlled by the "JogBackward" parameter.
	

①	The job is started by setting the "JogForward" or "JogBackward" parameter.
②	While the job is being executed, the "Busy" parameter shows the value TRUE.
③	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to "FALSE", and "Error" changes to TRUE.
④	When the "JogForward" or "JogBackward" is reset to the value FALSE, the "Error" parameter likewise changes to FALSE.

7.6 Ending Motion Control jobs

When a job is ended, a distinction is made between error-free completion of the job and a motion abort.

Completion of job

The completion of a Motion Control job is indicated as described in the Tracking running jobs (Page 312) section.

Motion abort

If a motion must be aborted, you can perform the following measures:

- Execute "MC_Halt (Page 385)"

  To abort a motion and stop the axis, you can use the "MC_Halt" instruction.

- Deactivate "MC_Power (Page 371)"

  In an emergency, you can stop the axis via an emergency stop ramp. To do so, set the "Enable" parameter of the "MC_Power" instruction to FALSE. The axis is decelerated according to the selected "StopMode" and all jobs for the technology object are aborted.

Measuring job abort

With the Motion Control instruction "MC_AbortMeasuringInput", an active one-time or cyclic measuring job is aborted.

Cancellation of an active output cam/cam track

- "MC_OutputCam (Page 426)"

  An active output cam is disabled when the "Enable" parameter of Motion Control instruction "MC_OutputCam" is set to FALSE.

- "MC_CamTrack (Page 430)"

  An active cam track is disabled when the "Enable" parameter of Motion Control instruction "MC_CamTrack" is set to FALSE.

7.7 Restart of technology objects

Description

After the CPU is switched on, or after technology objects are downloaded into the CPU, the system automatically initializes the technology objects with the start values from the technology data blocks. If restart-relevant changes are detected during a reload into the CPU, a restart of the technology object is automatically performed.

If restart-relevant data have been changed in RUN mode by the user program, then the technology object must be reinitialized by the user in order for the changes to be used. At a RUN → STOP transition, the CPU automatically performs a restart of technology objects with restart-relevant changes.

If changes in the technology data block should also be retained after the restart of the technology object, then you must write the changes to the start value in load memory using the extended instruction "WRIT_DBL".

Restart required

A necessary TO restart is indicated at "Technology object > Diagnostics > Status and error bits > Axis status or Encoder status > Online start value changed", as well as in the tag of technology object <TO>.StatusWord.X3 (OnlineStartValuesChanged).

Restarting a technology object

A restart of the technology object is triggered by the user by means of the "MC_Reset" Motion Control instruction, with parameter "Restart" = TRUE.

During a restart, all configuration data of the technology object are loaded from load memory into work memory. In the process, the actual values in the technology data block are overwritten.

Note the following during a restart of the technology object:

- A restart resets the "Referenced" status of a technology object with incremental actual values (<TO>.StatusWord.X5 (HomingDone).
- While a restart is being performed, the technology object cannot perform any jobs. An active restart will be indicated under "Technology object > Diagnostics > Status and error bits > Axis status or Encoder status > Restart active", and in the <TO>.StatusWord.X2 (RestartActive) tag of the technology object.
- Motion Control jobs are rejected during a restart with the "Error" = TRUE and "ErrorID" = 16#800D parameters (job not executable, because a restart is active).
- While a restart is being executed, you cannot access the technology data block.

See also

Change restart-relevant data (Page 299)

Downloading to CPU

8

Description

When downloading to the CPU S7-1500, it is always verified that the project files are consistent online and offline after the download.

The data of the technology objects are saved in technology data blocks. The conditions for downloading blocks thus apply when loading new or modified technology objects.

Load in RUN mode

When loading in the CPU's RUN mode, it is checked whether a load without restart of the technology objects is possible.

If restart-relevant configuration values were changed, then a restart of the technology object is automatically performed after the load into the CPU.

Loading a technology object is only possible if the technology object is disabled.

You **cannot** download the following changes to the CPU in RUN mode:

- Changes to the MC-Servo clock speeds
- Changes to the hardware interface of the technology object in "Technology object > Configuration > Hardware interface"

Commissioning 9

9.1 Introduction

The following guidelines describe the steps that you should note when commissioning the Motion Control-specific components of your equipment.

The commissioning of other components of your automation system depends on the particular equipment configuration. Commissioning (not Motion Control) is described in the Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

9.2 Commissioning guidelines

These guidelines serve as recommendations for commissioning equipment with Motion Control. The procedure is described using the example of a positioning axis technology object.

Requirement

- The configuration of the following components is complete:
  - CPU
  - BUS communication
  - Drives
  - Technology objects
- The user program has been created.
- The wiring of the CPU and of the associated I/O is complete.
- The commissioning and optimization of the drive is complete.

Procedure

Proceed as follows to commission the Motion Control-specific components of your equipment:

Step	Action to be performed	Supported by TIA Portal
Turn on CPU	Turn on the power supply and the CPU.	-
"Disable" position controller	Set the gain (Kv factor) of the position control loop to zero. (This setting avoids unwanted drive movements that may be caused by incorrect parameterization of the position control loop.)	"Technology object > Configuration > Extended parameters > Control loop"
Load project into the CPU	Bring the CPU to the STOP mode. Download your project to the CPU (load hardware and software).	• "Toolbar > Stop CPU" • "Toolbar > Download to device"
Create online connection to the CPU	Select the "Receive messages" check box under "Online & Diagnostics > Online Access". Configure the interface of the TIA Portal, and create an online connection with the CPU.	• Device configuration • "Online & Diagnostics > Online Access"
Disable Motion Control specific user program	In order to avoid conflicts with the axis control panel, lock the enabling of technology objects in your user program (MC_Power.Enable = FALSE).	• PLC programming • Motion Control instructions
Evaluating pending messages	Evaluate the message display in the inspector window. Resolve the causes of pending technology alarms. Acknowledge the technology alarms (Page 342).	"Inspector window > Diagnostics > Message display"
Check hardware limit switches	Click the hardware limit switches. Check for correct message display (technology alarm 531). Acknowledge the technology alarm.	"Inspector window > Diagnostics > Message display"
Check the connection and configuration of the drive (setpoint)	Bring the CPU into the RUN mode. Open the Axis control panel (Page 329) and take over control. Perform the following steps: • Enable the technology object. ⇒ The drive must turn itself on, and where applicable release the brake. The position is held. • Move the axis in jog mode at low velocity in the positive direction. ⇒ The drive must move. The actual position value must increase (positive direction). • Disable the technology object. ⇒ The drive must turn itself off, and where applicable apply the brake.	"Technology object > Commissioning > Axis control panel"
Check the connection and configuration of the encoder (actual value)	Check the scaling of the actual values (rotation direction, distance evaluation, and resolution of the encoder) ⇒ The change in the actual mechanical position must match the change in the actual values.	• "Technology object > Diagnostics > PROFIdrive frame" • "Technology object > Commissioning > Axis control panel"

Step	Action to be performed	Supported by TIA Portal
Checking the reference speed	Traverse the axis in jog mode at low velocity in the positive direction. ⇒ The displayed current velocity must match the velocity setpoint. If the displayed current velocity deviates significantly from the velocity setpoint, adjust the reference speed.	• "Technology object > Hardware interface > Data exchange" • "Technology object > Commissioning > Axis control panel"
Optimize position controller	Use the Optimization (Page 334) commissioning function to optimize the gain (Kv) of the position control loop. For this purpose, adapt following error limits as needed.	"Technology object > Commissioning > Optimization"
Transfer the gain Kv to the project.	Enter the gain Kv that you determined by means of the optimization function in your configuration data. Load your project into the CPU.	"Technology object > Configuration > Extended parameters > Control loop"
Enable Motion Control specific user program	Unlock the enabling technology objects lock in your user program (MC_Power.Enable = TRUE).	• PLC programming • Motion Control instructions
Check the functioning of the user program	Check the programmed functions of your user program.	• Watch and force tables • Online and diagnostic functions
End of commissioning for a positioning axis technology object	To commission additional technology objects, perform the corresponding steps again.	See above.

9.3 Axis control panel

9.3.1 Function and structure of the axis control panel

Description

You traverse individual axes with the axis control panel.

A user program is not necessary for the operation of the axis control panel. With the axis control panel, you take over master control for a technology object and control the movements of the axis.

⚠ WARNING

Uncontrolled axis motions

During operation with the axis control panel, the axis can execute uncontrolled motions (e.g. due to erroneous configuration of the drive, or of the technology object). Furthermore, any synchronized following axis is moved as well when moving a leading axis with the axis control panel.

Therefore, perform the following protective measures before operation with the axis control panel:

- Ensure that the EMERGENCY OFF switch is within the reach of the operator.
- Enable the hardware limit switches.
- Enable the software limit switches.
- Ensure that following error monitoring is enabled.
- Make sure that no following axis is coupled to the axis to be moved.

The axis control panel of the speed axis, positioning axis and synchronous axis can be found in the project tree under "Technology object > Commissioning".

The axis control panel is divided into the following areas:

- Master control
- Axis
- Operating mode
- Modify
- Axis status
- Current values

The following table lists the elements of the axis control panel:

Area	Element	Description
Master control		In the "Master control" area, you take over master control of the technology object, or return it to your user program.
	"Activate" button	With the "Activate" button, you set up an online connection to the CPU and take over master control for the selected technology object. • To take over master control, the technology object must be disabled in the user program. • Any synchronized following axis is moved as well when moving a leading axis with the axis control panel. • If the online connection to the CPU is lost during operation with the axis control panel, then after the sign of life monitoring has elapsed, the axis will be stopped with maximum deceleration. In this case, an error message is displayed ("ErrorID" = 16#8013) and the master control is passed back to the user program. • When you click the "Activate" button, a warning message is displayed. In the warning, you can adapt the sign-of-life monitoring (100 to 60000 ms). If the master control of the axis control panel is lost repeatedly without a direct error message, the online connection to the CPU may be impaired because the communication load is too high. In this case, the message "Error during commissioning" is entered in the message display log. Sign-of-life failure between controller and TIA Portal" is displayed. To eliminate this error, adapt the sign-of-life monitoring in the warning. • Until master control is returned, the user program has no influence on the functions of the technology object. Motion Control jobs from the user program to the technology object are rejected with error ("ErrorID" = 16#8012: axis control panel active). • When master control is taken over, the configuration of the technology object is adopted. Changes to the configuration of the technology object do not take effect until master control has been returned. For this reason, make any necessary changes before master control is taken over. • If master control has been taken over for the technology object, the axis control panel is blocked for access by another installation of the TIA Portal (Team Engineering as of CPU V1.5).
	"Deactivate" button	With the "Deactivate" button, you return master control to your user program.
Axis		In the "Axis" area, enable or disable the technology object.
	"Enable" button	With the "Enable" button, you enable the selected technology object
	"Disable" button	With the "Disable" button, you disable the selected technology object
Operating mode		Select the required mode in the "Operating mode" drop-down list.

Area	Element	Description
Modify		The "Control" area displays the parameters for traversing with the axis control panel according to the selected operating mode.
	Position	Position to which the axis is homed. (Homing and set home position modes only)
	Distance	Distance the axis is traversed. (Relative positioning mode only)
	Target position	Position to which the axis is traversed. (Absolute positioning mode only)
	Velocity/ Velocity setpoint	Velocity or speed at which the axis is traversed. Default: 10% of the default value (Velocity/speed setpoint, Jog and Positioning modes only)
	Acceleration	Acceleration with which the axis is traversed. Default: 10% of the default value
	Deceleration	Deceleration with which the axis is traversed. Default: 10% of the default value
	Jerk	Jerk with which the axis is traversed. Default: 100% of default value
	"Start" button	With the "Start" button, you start a job according to the selected operating mode.
	"Forward" button	With the "Forward" button, you start a motion in the positive direction according to the selected operating mode.
	"Backward" button	With the "Backward" button, you start a motion in the negative direction according to the selected operating mode.
	"Stop" button	With the "Stop" button, you cancel a job or stop the axis.
Axis status		The "Axis status" area displays the status of the axis and the status of the drive.
	Drive ready	Drive is ready to execute setpoints.
	Error	An error occurred at the technology object.
	Enabled	The technology object has been enabled. The axis can be moved with motion jobs.
	Homed	The technology object is homed.
	More	The "More" link takes you to the window "Technology object > Diagnostics > Status and error bits".
	Active errors	The error that occurred most recently is displayed in the "Active errors" text field.
	"Confirm" button	With the "Confirm" button, you acknowledge pending errors.
Current values		The "Current values" area shows the actual values of the axis.
	Position	Actual position of the axis
	Velocity	Actual velocity of the axis

Note

No transfer of the parameters

The configured parameter values are discarded when master control is returned. Transfer the values as needed into your configuration.

If you have changed configuration values with the axis control panel during operation, they have no effect on the operation of the axis control panel.

Operating mode

The following table shows the operating modes of the axis control panel:

Operating mode	Description
Homing	This function corresponds to active homing. The parameters for homing (Page 69) must be configured. Homing is not possible with an absolute encoder. The technology object is not referenced when this mode is used with an absolute encoder.
Set home position	This function corresponds to direct homing (absolute). With the "Start" button, you set the actual position to the value specified in "Position" and the "Homed" status is set.
Jog	Motion commands occur by means of jogging. With the "Forward" or "Backward" button you start motion in the positive or negative direction. The motion runs for as long as you hold down the left mouse button.
Velocity specification/speed setpoint	The axis is moved at the specified velocity or speed until you stop the movement. The motion commands are performed according to the setpoints assigned under "Controller".
Positioning relative	The positioning is executed as a controlled, relative traversing motion according to the defaults assigned under "Controller".
Positioning absolute	The positioning is executed as a controlled, absolute traversing motion according to the defaults assigned under "Controller". If you have enabled the "Modulo" setting of the technology object, the buttons "Forward" and "Backward" are shown in the "Controller" area. The axis is positioned within the modulo range. Position settings outside the modular range are recalculated to the modulo range. If you have not enabled the "Modulo" setting of the technology object, only the "Start" button is shown in the "Controller" area. You can directly approach the entered position.

9.3.2 Using the axis control panel

Requirement

- The CPU must be in RUN mode.
- The project has been created and downloaded to the CPU.
- The technology object is disabled by your user program (MC_Power.Enable = FALSE).
- The axis control panel for the technology object is not used by another installation of the TIA Portal (Team Engineering as of CPU V1.5).

Procedure

Proceed as follows to enable control the axis using the axis control panel:

1. Click "Activate" in the "Master control" area to assume master control over the technology object and to set up an online connection to the CPU.

   A warning message is displayed.
2. If necessary, adapt the sign-of-life monitoring and confirm with "OK".
3. In the "Axis" area, click the "Enable" button to enable the technology object.
4. In the drop-down list in the "Operation mode" area, select the desired function of the axis control panel.
5. In the "Control" area, specify the parameter values for your job.
6. Click the "Start", "Forward" or "Backward" button to start the job.
7. Click the "Stop" button to stop the job.
8. Repeat steps 3 through 6 for additional jobs.
9. In the "Axis" area, click the "Disable" button to disable the technology object.
10. In the "Master control" area, click the "Deactivate" button to return master control to your user program.

9.4 Optimization

9.4.1 Function and structure of the optimization

Description

The "Optimization" function supports you in determining the optimal precontrol and gain (Kv factor) for the closed loop position control of the axis. The axis velocity profile is recorded by means of the Trace function for this purpose for the duration of a configurable positioning movement. You can then evaluate the recording, and adjust the precontrol and gain accordingly.

The "Optimization" function for the positioning axis and synchronous axis technology objects can be found in the project tree under "Technology object > Commissioning".

The "Tuning" dialog is divided into the following areas:

- Master control
- Axis
- Measurement configuration
- Optimize position controller
- Run measurement
- Trace

The following table lists the elements of optimization:

Area	Element	Description
Master control		In the "Master control" area, you take over master control of the technology object, or return it to your user program.
	"Activate" button	With the "Activate" button, you set up an online connection to the CPU and take over master control for the selected technology object. • To take over master control, the technology object must be disabled in the user program. • Any synchronized following axis is moved as well when moving a leading axis with the axis control panel. • If the online connection to the CPU is lost during operation with the axis control panel, then after the sign of life monitoring has elapsed, the axis will be stopped with maximum deceleration. In this case, an error message is displayed ("ErrorID" = 16#8013) and the master control is passed back to the user program. • When you click the "Activate" button, a warning message is displayed. You can adapt the sign-of-life monitoring here (100 to 60000 ms). If the master control of the axis control panel is lost repeatedly without a direct error message, the online connection to the CPU may be impaired because the communication load is too high. In this case, the message "Error during commissioning" is entered in the message display log. Sign-of-life failure between controller and TIA Portal" is displayed. To eliminate this error, adapt the sign-of-life monitoring in the warning. • Until master control is returned, the user program has no influence on the functions of the technology object. Motion Control jobs from the user program to the technology object are rejected with error ("ErrorID" = 16#8012: axis control panel active). • When master control is taken over, the configuration of the technology object is adopted. Changes to the configuration of the technology object do not take effect until master control has been returned. For this reason, make any necessary changes before master control is taken over. • If master control has been taken over for the technology object, the axis control panel is blocked for access by another installation of the TIA Portal (Team Engineering as of CPU V1.5).
	"Deactivate" button	With the "Deactivate" button, you return master control to your user program.
Axis		In the "Axis" area, enable or disable the technology object.
	"Enable" button	With the "Enable" button, you enable the selected technology object
	"Disable" button	With the "Disable" button, you disable the selected technology object

Area	Element	Description
Measurement configuration		In the "Measurement configuration" area, you configure the settings for a test step.
	Distance	Travel distance for a test step
	Measurement duration	Time for a test step
	"Adapt dynamic values" check box	With the "Adapt dynamic values" check box, you enable adaptation of the acceleration and the maximum velocity.
	Acceleration	Presetting of the acceleration for a test step
	Maximum velocity	Presetting of the maximum velocity for a test step
Optimize position controller		In the "Optimize position controller" area, you make the settings for optimization of the controller characteristics. You open a list of values using the symbol next to the field. The list of values contains the following values of the respective parameter: • Online actual value • Online start value • Project start value Enter the new value in the text field for the actual value. The new value is applied by clicking the "Forward" or "Backward" button in the "Run measurement" area.
	Precontrol	Current percentage velocity precontrol of the position controller
	Speed control loop substitute time	Current speed control loop substitute time With velocity precontrol, a simplified speed control loop model can be generated using the speed control loop substitute time. This prevents overmodulation by the position controller of the manipulated variable for velocity during the acceleration and deceleration phases. To accomplish this, the position setpoint of the position controller is delayed by the amount of the speed control loop substitute time in relation to the velocity precontrol.
	Gain	Current gain of the position controller (Kv)
Run measurement		In the "Run measurement" area, you perform the test steps.
	"Forward" button	With the "Forward" button, you start a test step for optimization in the positive direction.
	"Backward" button	With the "Backward" button, you start a test step for optimization in the negative direction.
	"Stop" button	You stop a test step with the "Stop" button.
Trace		The Trace function is displayed in the lower area of the "Tuning" dialog. With each test step, a Trace recording of the required parameters is automatically started and displayed after completion of the test step. After master control has been returned, the Trace recording is deleted. You can find a full description of the trace function in the section on using the trace and logic analyzer function.

Note

No transfer of the parameters

The configured parameter values are discarded after master control is returned.

Transfer the values as needed into your configuration. You can apply the values for the gain, precontrol and speed control loop substitute time in your configuration using the "Project start value" value.

See also

Closed-loop control (Page 94)

9.4.2 Optimize position controller

Requirements

- The CPU must be in the RUN mode.
- The project has been created and downloaded to the CPU.
- The technology object is disabled by your user program (MC_Power.Enable = FALSE).
- The axis control panel for the technology object is not used by another installation of the TIA Portal (Team Engineering as of CPU V1.5).

Optimizing position control gain (Kv)

Proceed as follows to optimize the gain (Kv):

1. In the "Master control" area, click the "Activate" button to activate master control for the technology object, and to establish an online connection to the CPU.

   A warning message is displayed.
2. If necessary, adapt the sign-of-life monitoring and confirm with "OK".
3. In the "Axis" area, click the "Enable" button to enable the technology object.
4. If necessary, configure values for the distance, duration, and dynamics of a test step in the "Measurement configuration" area.
5. If necessary, configure values for the precontrol and speed control loop substitute time of a test step in the "Configure position controller" area.
6. Enter a start value for the gain. Start with a low value.
7. Click the "Forward" or "Start" button to start a test step for the optimization.
   For the specified duration, a setpoint is output according to the specified distance.
   The axis moves by the specified distance. A trace recording of the motion (setpoint and actual values) is created automatically.

   You can find a full description of the trace function in the section on using the trace and logic analyzer function.

   Note

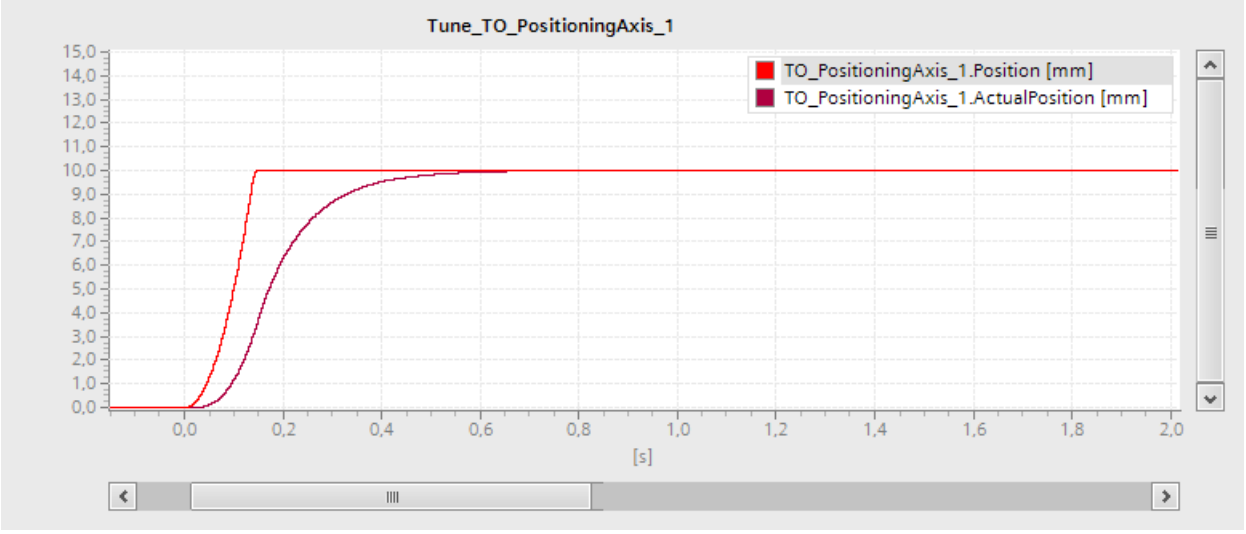
   Adapt following error limits

   If error messages from following error monitoring are repeatedly displayed during optimization, temporarily adapt the following error limits.
8. Evaluate the curve of the trace recording. Adapt the gain incrementally. Click the "Forward" or "Backward" button after each value you enter. This applies the value and start a new movement and trace recording each time.

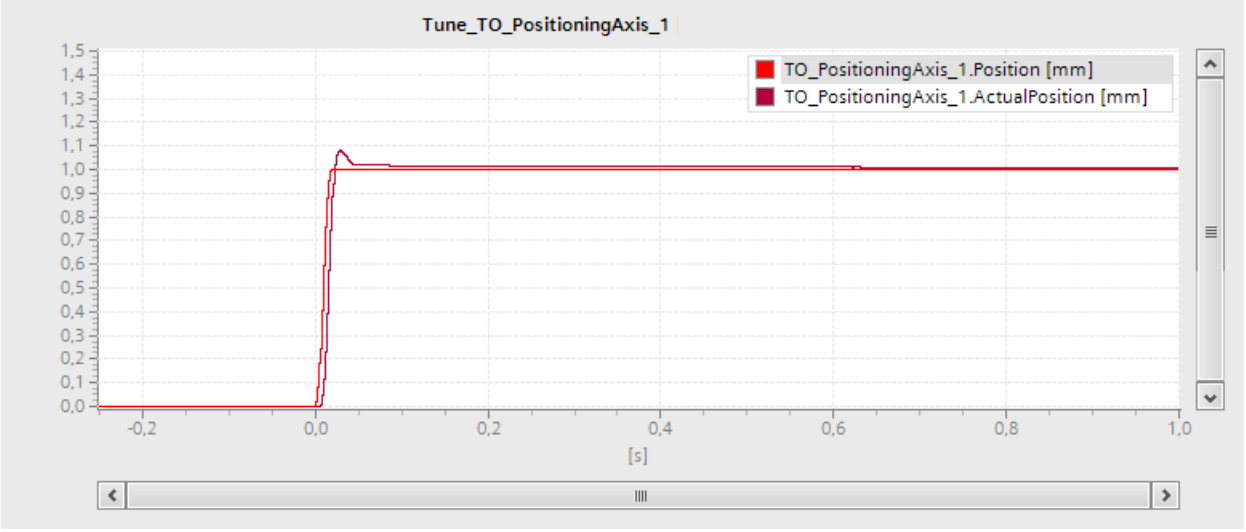
When adjusting the gain, pay attention to the following properties of the curve:

- The curve shows a brief compensation time.
- The curve does not show any motion reversal of the actual position.
- When approaching the position setpoint, no overshoot occurs.
- The curve shows a stable overall behavior (oscillation-free curve).

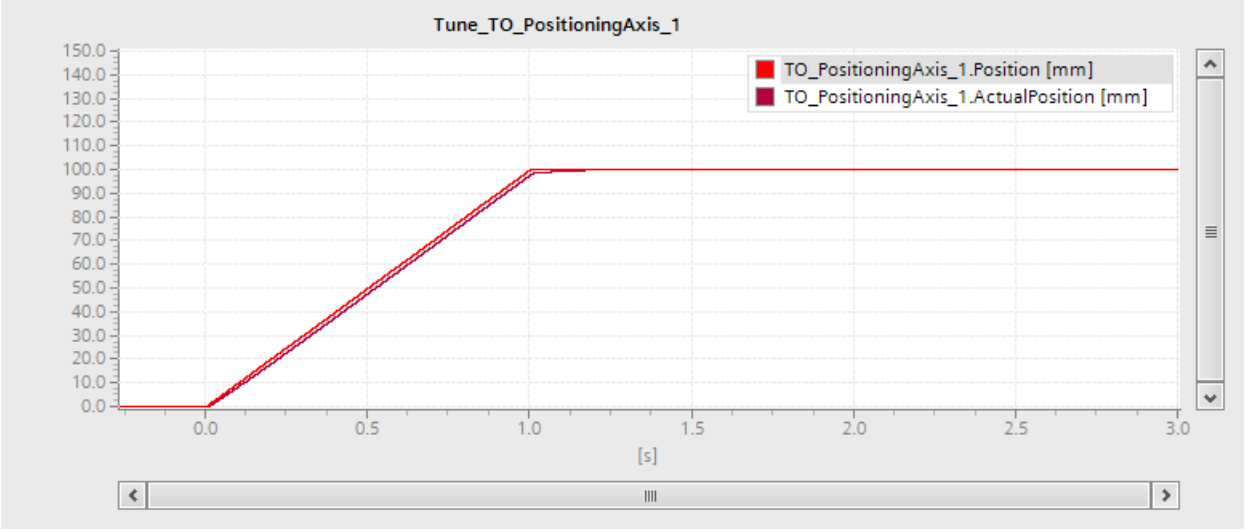
The following trace recording shows a curve with a long settling time:



The following trace recording shows a curve with overshoot when approaching the setpoint:



The following trace recording shows a curve in which the gain is optimal and the overall response is steady:



Transferring the parameter values of the position controller to the project

To transfer the determined parameter values of the position controller to your project, follow these steps:

1. Click the icon next to the field of the respective parameter.

   A list of values is displayed.
2. Enter the measured value in the "Project start value" field of the value list.
3. In the "Axis" area, click the "Disable" button to disable the technology object.
4. In the "Master control" area, click the "Deactivate" button to return master control to your user program.
5. Load your project into the CPU.

10 Diagnostics

10.1 Introduction

The Diagnostics chapter is limited to describing the diagnostic concept for Motion Control, and describing the Diagnostics view of the individual technology objects in the TIA Portal.

For more information about system diagnostics with the S7-1500 CPU, refer to the "Diagnostics" (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

10.2 Diagnostic concept

The diagnostic concept encompasses alarms and associated messages, as well as error messages in the Motion Control instructions. The TIA Portal also supports you with consistency checks during configuration of the technology objects, and during the creation of your user program.

All alarms in runtime (from the CPU, technology, hardware etc.) are displayed in the Inspector window of the TIA Portal. Diagnostic information that relates to technology objects (technology alarms, status information) are additionally displayed in the Diagnostics window of the respective technology object.

During motion control, if an error occurs at a technology object (e.g. approaching a hardware limit switch), then a technology alarm (Page 342) is triggered, and a corresponding message is displayed in the TIA Portal as well as on HMI devices.

In your user program, technology alarms are generally signaled via error bits in the technology data block. The number of the technology alarm with the highest priority is also displayed. In order to simplify error evaluation, the "Error" and "ErrorID" parameters of the Motion Control instructions also indicate that a technology alarm is pending.

Program errors (Page 346) can occur during parameter assignment or during the processing sequence of the Motion Control instructions (e.g. invalid parameter specification when calling the instruction, initiation of a job without enable via MC_Power). Motion Control instruction errors are indicated at the call of instructions using the "Error" and "ErrorID" parameters.

10.3 Technology alarms

Description

If an error occurs at a technology object (e.g. approaching a hardware limit switch), a technology alarm is triggered and indicated. The impact of a technology alarm on the technology object is specified by the alarm reaction.

Alarm classes

Technology alarms are divided into three classes:

- **Acknowledgeable warning**

  The processing of Motion Control job is continued. The current motion of the axis can be influenced, e.g. by limiting the current dynamic values to the configured limit values.

- **Alarm requiring acknowledgment**

  Motion jobs are aborted in accordance with the alarm reaction. You must acknowledge the alarms in order to continue execution of new jobs after eliminating the cause of the error.

- **Fatal error**

  Motion jobs are aborted in accordance with the alarm reaction.

  To be able to use the technology object again after eliminating the cause of the error, you must restart the technology object (Page 324).

Display of technology alarms

A technology alarm is displayed in the following locations:

- **TIA Portal**
  - **"Technology object > Diagnostics > Status and error bits"**

    Display of pending technology alarms for each technology object.
  - **"Technology object > Commissioning > Axis control panel"**

    Display of the last pending technology alarm for each technology object.
  - **"Inspector window > Diagnostics > Message display"**

    Select the "Receive messages" check box under "Online & Diagnostics > Online Access" in order to display technology alarms via the message display.

    With an online connection to the CPU, the pending technology alarms for all technology objects are displayed. Additionally, the archive view is available to you.

    The message display can also be activated and displayed on a connected HMI.
  - **"CPU > Online & diagnostics"**

    Display of the technology alarms that have been entered in the diagnostic buffer.
- **User program**
  - **Tags <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction**

    Indication of the number and the reaction of the technology alarm with the highest priority.
  - **Tag <TO>.StatusWord**

    A pending technology alarm is indicated with bit 1 ("Error").
  - **Tag <TO>.ErrorWord**

    Indication of alarms and fatal errors.
  - **Tag <TO>.WarningWord**

    Indication of warnings.
  - **Parameter "Error" and "ErrorID"**

    In a Motion Control instruction, the parameters "Error" = TRUE and "ErrorID" = 16#8001 indicate that a technology alarm is pending.
- **Display of the CPU**

  In order to show technology alarms on the CPU display, make the following setting when loading to the CPU:
  In the "Load preview" dialog, select the action "Consistent download" for the "Text libraries" entry.

Alarm reaction

A technology alarm always contains an alarm reaction, which describes the impact on the technology object. The alarm reaction is specified by the system.

The following table shows possible alarm reactions:

Alarm reaction	Description
Axes (speed axis, positioning axis, synchronous axis)	
No reaction (warnings only) <TO>.ErrorDetail.Reaction = 0	The processing of Motion Control job is continued. The current motion of the axis can be influenced, e.g. by limiting the current dynamic values to the configured limit values.
Stop with current dynamic values <TO>.ErrorDetail.Reaction = 1	Active motion commands are aborted. The axis is braked with the dynamic values that present in the Motion Control instruction and brought to a standstill.
Stop with maximum dynamic values <TO>.ErrorDetail.Reaction = 2	Active motion commands are aborted. The axis is braked with the dynamic values configured under "Technology object > Extended parameters > Dynamic limits", and brought to a standstill. The configured maximum jerk is hereby taken into account.
Stop with emergency stop ramp <TO>.ErrorDetail.Reaction = 3	Active motion commands are aborted. The axis is braked with the emergency stop deceleration configured under "Technology object > Extended parameters > Emergency stop ramp", without any jerk limit, and brought to a standstill.
Remove enable <TO>.ErrorDetail.Reaction = 4	Active motion commands are aborted. The setpoint zero is output and the enable is removed. The axis is braked to a standstill according to the configuration in the drive.
Track setpoints <TO>.ErrorDetail.Reaction = 5	Active motion commands are aborted. The setpoint zero is output and the enable is removed. The actual values supplied by the drive are automatically tracked as setpoints.
Other technology objects (output cam, cam track, measuring input, cam, external encoder)	
No reaction (warnings only) <TO>.ErrorDetail.Reaction = 0	The processing of Motion Control job is continued. The current motion of the axis can be influenced, e.g. by limiting the current dynamic values to the configured limit values.
Terminate processing of the technology object: • Output cam <TO>.ErrorDetail.Reaction = 6 • Cam track <TO>.ErrorDetail.Reaction = 7 • Measuring input <TO>.ErrorDetail.Reaction = 8 • Cam <TO>.ErrorDetail.Reaction = 9 • External encoder <TO>.ErrorDetail.Reaction = 10	Processing of the technology object is terminated. All running Motion Control jobs are aborted.

Acknowledging technology alarms

You can acknowledge technology alarms as follows:

- **TIA Portal**
  - **"Technology object > Commissioning > Axis control panel"**

    Click "Confirm" to acknowledge all alarms and warnings pending for the selected technology object.
  - **"Inspector window > Diagnostics > Message display"**

    You can acknowledge the alarms and warnings for all technology objects either individually, or all at once.
- **HMI**

  At an HMI with enabled message display, you can acknowledge the alarms and warnings for all technology objects either individually, or all at once.
- **User program**

  Acknowledge pending technology alarms for a technology object with the Motion Control instruction "MC_Reset".

Additional information

You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.

10.4 Errors in Motion Control instructions

Description

Errors in Motion Control instructions (e.g. invalid parameter value setting) are indicated by the "Error" and "ErrorID" output parameters.

Under the following conditions, "Error" = TRUE and "ErrorID" = 16#8xxx are indicated for the Motion Control instruction:

- Illegal status of the technology object, which prevents the execution of the job.
- Invalid parameter assignment of the Motion Control instruction, which prevents the execution of the job.
- As a result of the alarm reaction for a technology object error.

Error display

If there is a Motion Control instruction error, the "Error" parameter shows the value TRUE. The cause of the error is given in the "ErrorID" parameter.

Jobs to the technology object are rejected when "Error" = TRUE. Running jobs are not influenced by rejected jobs.

If "Error" = TRUE and "ErrorID" = 16#8001 is indicated during job execution, a technology alarm has occurred. In this case, evaluate the indication of the technology alarm.

If "Error" = TRUE is displayed during execution of a "MC_MoveJog" job, the axis is braked and brought to a standstill. In this case, the deceleration configured for the "MC_MoveJog" instruction takes effect.

Acknowledge error

Acknowledging errors in Motion Control instructions is not required.

Restart a job after resolving the error.

Additional information

You can find a list of the ErrorIDs in the Error detection (Page 559) appendix.

10.5 Speed-controlled axis technology object

10.5.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object.
The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables.
The associated technology object tag is given in parentheses.

Axis status

The following table shows the possible axis status values:

Status	Description
Simulation active	The axis is simulated in the CPU. Setpoints are not output to the drive.
Enabled	The technology object has been enabled. The axis can be moved with motion jobs. (<TO>.StatusWord.X0 (Enable))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Axis control panel active	The axis control panel is active. The axis control panel has master control over the technology object. The axis cannot be controlled from the user program. (<TO>.StatusWord.X4 (ControlPanelActive))
Drive ready	Drive is ready to execute setpoints. (<TO>.StatusDrive.InOperation)
Restart required	Data relevant for the restart has been changed. The changes will not be applied until the technology object is restarted. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no job running)	No motion job is running for the technology object. (<TO>.StatusWord.X6 (Done))
Jog	The axis is being moved with a job for jog mode of Motion Control instruction "MC_MoveJog" or from the axis control panel. (<TO>.StatusWord.X9 (JogCommand))
Speed setpoint	The axis is traversed with a job with speed setpoint of the Motion Control instruction "MC_MoveVelocity" or using the axis control panel. (<TO>.StatusWord.X10 (VelocityCommand))
Constant speed	The axis is moved with constant speed or is stationary. (<TO>.StatusWord.X12 (ConstantVelocity))
Accelerating	Axis is being accelerated. (<TO>.StatusWord.X13 (Accelerating))
Decelerating	The axis is being decelerated. (<TO>.StatusWord.X14 (Decelerating))
Torque limit active	The configured threshold for the force/torque affects the axis. (<TO>.StatusWord.X27 (InLimitation))

Warnings

The following table shows the possible warnings:

Warning	Description
Configuration	One or several configuration parameters are adjusted internally at a certain time. (<TO>.WarningWord.X1 (ConfigWarning))
Job rejected	Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met. (<TO>.WarningWord.X3 (CommandNotAccepted))
Dynamic limitation	Dynamic values are restricted to the dynamic limits. (<TO>.WarningWord.X6 (DynamicError))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	Error in user program at a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Drive	Error in the drive. (<TO>.ErrorWord.X4 (DriveFault))
Data exchange	Communication with a connected device is faulty. (<TO>.ErrorWord.X7 (CommunicationFault))
I/O	Error accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))
Job rejected	Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met (e.g. technology object not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
Dynamic limitation	Dynamic values are restricted to the dynamic limits. (<TO>.ErrorWord.X6 (DynamicError))

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

StatusWord tag (speed axis) (Page 450)

ErrorWord tag (speed axis) (Page 452)

WarningWord tag (speed axis) (Page 454)

10.5.2 Motion status

Description

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the motion status of the axis. The Diagnostics function is available in online operation.

"Current values" area

The following table shows the meaning of the status data:

Status	Description
Speed setpoint	Speed setpoint of the axis (<TO>.Velocity)
Speed override	Speed setpoint correction as percentage The speed setpoint specified in motion control instructions or set by the axis control panel are superimposed with an override signal and corrected as a percentage. Valid speed correction values range from 0.0 % to 200.0 %. (<TO>.Override.Velocity)

"Dynamic limits" area

This area displays the limit values for the dynamic parameters.

The following table shows the meaning of the status data:

Status	Description
Speed	Configured maximum speed (<TO>.DynamicLimits.MaxVelocity)
Acceleration	Configured maximum acceleration (<TO>.DynamicLimits.MaxAcceleration)
Deceleration	Configured maximum deceleration (<TO>.DynamicLimits.MaxDeceleration)

10.5.3 PROFIdrive telegram

Description

The "Technology object > Diagnostics > PROFIdrive telegram" diagnostics function is used in the TIA Portal to monitor the PROFIdrive telegram that the drive returns to the controller. The Diagnostics function is available in online operation.

"Drive" area

This area displays the following parameters contained in the PROFIdrive telegram from the drive to the controller:

- Status words "ZSW1" and "ZSW2"
- The speed setpoint (NSET) that was output to the drive
- The actual speed that was signaled from the drive (NACT)

10.6 Positioning axis/synchronous axis technology object

10.6.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object.
The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables.
The associated technology object tag is given in parentheses.

Axis status

The following table shows the possible axis status values:

Status	Description
Simulation active	The axis is simulated in the CPU. Setpoints are not output to the drive. (<TO>.StatusWord.X25 (AxisSimulation))
Enabled	The technology object has been enabled. The axis can be moved with motion jobs. (<TO>.StatusWord.X0 (Enable))
Position-controlled mode	The axis is in position-controlled mode. (Inversion of <TO>.StatusWord.X28 (NonPositionControlled))
Homed	The technology object is homed. The relationship between the position in the technology object and the mechanical position was successfully created. (<TO>.StatusWord.X5 (HomingDone))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Axis control panel active	The axis control panel is active. The axis control panel has master control over the technology object. The axis cannot be controlled from the user program. (<TO>.StatusWord.X4 (ControlPanelActive))
Drive ready	Drive is ready to execute setpoints. (<TO>.StatusDrive.InOperation)
Encoder values valid	The actual encoder values are valid. (<TO>.StatusSensor[n].State)
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Status limit switch

The following table shows the possibilities for enabling the software and hardware limit switches:

Status	Description
Negative SW limit switch approached.	The negative software limit switch was reached. (<TO>.StatusWord.X15 (SWLimitMinActive))
Positive SW limit switch approached.	The positive software limit switch was reached. (<TO>.StatusWord.X16 (SWLimitMaxActive))
Negative HW limit switch approached.	The negative hardware limit switch has been approached or overtraveled. (<TO>.StatusWord.X17 (HWLimitMinActive))
Positive HW limit switch approached.	The positive hardware limit switch has been approached or overtraveled. (<TO>.StatusWord.X18 (HWLimitMaxActive))

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no job running)	No job active at technology object. (<TO>.StatusWord.X6 (Done))
Homing job	The technology object executes a homing job of the Motion Control instruction "MC_Home" or from the axis control panel. (<TO>.StatusWord.X11 (HomingCommand))
Jog	The axis is being moved with a command for jog mode of Motion Control instruction "MC_MoveJog". (<TO>.StatusWord.X9 (JogCommand))
Velocity specification	The axis is traversed with a job with velocity specification of the Motion Control instruction "MC_MoveVelocity" or from the axis control panel. (<TO>.StatusWord.X10 (VelocityCommand))
Positioning job	The axis is traversed with a positioning job of Motion Control instruction "MC_MoveAbsolute" or "MC_MoveRelative" or from the axis control panel. (<TO>.StatusWord.X8 (PositioningCommand))
Constant velocity	The axis is moved with constant velocity or is stationary. (<TO>.StatusWord.X12 (ConstantVelocity))
Standstill	The axis is in standstill. (<TO>.StatusWord.X7 (StandStill))
Accelerating	Axis is being accelerated. (<TO>.StatusWord.X13 (Accelerating))
Decelerating	The axis is being decelerated. (<TO>.StatusWord.X14 (Decelerating))
Torque limit active	The configured threshold for the force/torque affects the axis. (<TO>.StatusWord.X27 (InLimitation))
Synchronization	Synchronous axis only The axis is synchronized to the leading value of a leading axis. (<TO>.StatusWord.X21 (Synchronizing))
Synchronous operation	Synchronous axis only The axis is synchronized and moves synchronously to the leading axis. (<TO>.StatusWord.X22 (Synchronous))

Warnings

The following table shows the possible warnings:

Warning	Description
Configuration	One or several configuration parameters are adjusted internally at a certain time. (<TO>.WarningWord.X1 (ConfigWarning))
Job rejected	Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met. (<TO>.WarningWord.X3 (CommandNotAccepted))
Dynamic limitation	Dynamic values are restricted to the dynamic limits. (<TO>.WarningWord.X6 (DynamicError))
Synchronization	Synchronous axis only Error during synchronous operation. The leading axis specified for the corresponding Motion Control instruction was not configured as a possible leading axis. (<TO>.WarningWord.X14 (SynchronousError))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	Error in user program at a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Drive	Error in the drive. (<TO>.ErrorWord.X4 (DriveFault))
Encoder	Error in encoder system. (<TO>.ErrorWord.X5 (SensorFault))
Data exchange	Communication with a connected device is faulty. (<TO>.ErrorWord.X7 (CommunicationFault))
I/O	Error accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))
Job rejected	Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met (e.g. technology object not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
Homing	Error during homing process. (<TO>.ErrorWord.X10 HomingFault))
Positioning	The positioning axis was not positioned correctly at the end of a positioning motion. (<TO>.ErrorWord.X12 (PositioningFault))
Dynamic limitation	Dynamic values are restricted to the dynamic limits. (<TO>.ErrorWord.X6 (DynamicError))
Following error	The maximum permitted following error has been exceeded. (<TO>.ErrorWord.X11 (FollowingErrorFault))
SW limit switch	A software limit switch has been reached. (<TO>.ErrorWord.X8 (SwLimit))
HW limit switch	A hardware limit switch has been reached or overtraveled. (<TO>.ErrorWord.X9 (HWLimit))
Synchronization	Synchronous axis only Error during synchronous operation. The leading axis specified for the corresponding Motion Control instruction was not configured as a possible leading axis. (<TO>.ErrorWord.X14 (SynchronousError))

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

StatusWord tag (positioning axis/synchronous axis) (Page 485)

ErrorWord tag (positioning axis/synchronous axis) (Page 488)

WarningWord tag (positioning axis/synchronous axis) (Page 491)

Additional displays for the technology CPU (Page 360)

10.6.2 Motion status

Description

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the motion status of the axis. The Diagnostics function is available in online operation.

"Current values" area

The following table shows the meaning of the status data:

Status	Description
Operative encoder	Operative encoder of the axis
Target position	Current target position of an active positioning job The target position value is only valid during execution of a positioning job. (<TO>.StatusPositioning.TargetPosition)
Actual position	Actual position of the axis If the technology object is not homed, then the value is displayed relative to the position that existed when the technology object was enabled. (<TO>.ActualPosition)
Actual velocity	Actual velocity of the axis (<TO>.ActualVelocity)
Velocity override	Percentage correction of the velocity specification The velocity setpoint specified in Motion Control instructions or set by the axis control panel is superimposed with an override signal and corrected as a percentage. Valid velocity correction values range from 0.0 % to 200.0 %. (<TO>.Override.Velocity)

"Dynamic limits" area

This area displays the limit values for the dynamic parameters.

The following table shows the meaning of the status data:

Status	Description
Velocity	Configured maximum velocity (<TO>.DynamicLimits.MaxVelocity)
Acceleration	Configured maximum acceleration (<TO>.DynamicLimits.MaxAcceleration)
Deceleration	Configured maximum deceleration (<TO>.DynamicLimits.MaxDeceleration)

See also

Additional displays for the technology CPU (Page 360)

10.6.3 PROFIdrive telegram

Description

The "Technology object > Diagnostics > PROFIdrive telegram" diagnostics function is used in the TIA Portal to monitor the PROFIdrive telegrams returned by the drive and encoder. The display of the Diagnostics function is available in online operation.

"Drive" area

This area displays the following parameters contained in the PROFIdrive telegram from the drive to the controller:

- Status words "ZSW1" and "ZSW2"
- The speed setpoint (NSET) that was output to the drive
- The actual speed that was signaled from the drive (NACT)

"Encoder" area

This area displays the following parameters contained in the PROFIdrive telegram from the encoder to the controller:

- Status word "Gx_ZSW"
- The actual position value "Gx_XIST1" (cyclic actual encoder value)
- The actual position value "Gx_XIST2" (absolute encoder value)

See also

Additional displays for the technology CPU (Page 360)

10.6.4 Additional displays for the technology CPU

The diagnostic functions contain expanded/additional displays for the S7-1500T technology CPU.

Status and error bits

The following table shows the expanded/additional displays of the status and error bits (Page 352):

Axis status	
Encoder values valid	The actual encoder values (encoder 1, encoder 2, encoder 3 or encoder 4) are valid. (<TO>.StatusSensor[n].State)
Active encoder	The encoder in effect operationally is encoder 1, encoder 2, encoder 3 or encoder 4. (<TO>.OperativeSensor)

Motion status

The following table shows the expanded/additional displays for the status of the motion (Page 358):

Current values	Description
Operative encoder	Operative encoder of the axis

PROFIdrive telegram

The "Encoder 1" to "Encoder 4" areas display the following parameters from the PROFIdrive telegram (Page 359) of the corresponding encoder to the controller:

- Status word "Gx_ZSW"
- The actual position value "Gx_XIST1" (cyclic actual encoder value)
- The actual position value "Gx_XIST2" (absolute encoder value)

See also

Status and error bits (Page 352)

Motion status (Page 358)

PROFIdrive telegram (Page 359)

10.7 Technology object external encoder

10.7.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object.
The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables.
The associated technology object tag is given in parentheses.

Encoder status

The following table shows the possible external encoder status values:

Status	Description
Enabled	The technology object has been enabled. (<TO>.StatusWord.X0 (Enable))
Homed	The technology object is homed. The relationship between the position in the technology object and the mechanical position was successfully created. (<TO>.StatusWord.X5 (HomingDone))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Encoder values valid	The actual encoder values are valid. (<TO>.StatusSensor[n].State)
Online start value changed	Data relevant for the restart has been changed. The changes will not be applied until the technology object is restarted. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Motion status

The following table shows the possible states of the job execution:

Status	Description
Done (no job running)	No Motion Control job is running for the technology object. (Enable by "MC_Power" job excepted) (<TO>.StatusWord.X6 (Done))
Homing job	The technology object executes a homing job of the Motion Control instruction "MC_Home". (<TO>.StatusWord.X11 (HomingCommand))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	Error in user program at a Motion Control instruction or its use. (<TO>.ErrorWord.X2 UserFault))
Encoder	Error in encoder system. (<TO>.ErrorWord.X5 (SensorFault))
Data exchange	Missing or faulty communication. (<TO>.ErrorWord.X7 (CommunicationFault))

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

StatusWord tag (external encoder) (Page 502)

ErrorWord tag (external encoder) (Page 503)

WarningWord tag (external encoder) (Page 505)

10.7.2 Motion status

Description

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the actual encoder values. The Diagnostics function is available in online operation.

"Current values" area

The following table shows the meaning of the status data:

Status	Description
Actual position	Actual position of the axis If the technology object is not homed, then the value is displayed relative to the position that existed when the technology object was enabled. (<TO>.ActualPosition)
Actual velocity	Actual velocity of the axis (<TO>.ActualVelocity)

10.7.3 PROFIdrive frame

Description

The "Technology object > Diagnostics > PROFIdrive interface" diagnostic function is used in the TIA Portal to monitor the PROFIdrive frame of the encoder. The display of the diagnostics function is available in the online mode TO.

"Encoder" area

This area displays the following parameters contained in the PROFIdrive frame that the encoder returns to the controller:

- Status word "G1_ZSW"
- The actual position value "G1_XIST1" (cyclic actual encoder value)
- The actual position value "G1_XIST2" (absolute value of the encoder)

10.8 Technology object measuring input

10.8.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object.
The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables.
The associated technology object tag is given in parentheses.

Measuring input status

The following table shows the possible states of the measuring input:

Status	Description
Active	The technology object is in operation. (<TO>.StatusWord.X0 (Control))
Waiting for measuring event	The measuring input is waiting for a measuring event. The technology data block tag "<TO>.Status" has the value "1" ("WAITING_FOR_TRIGGER").
Measured value present	The measuring input has acquired one or more measured values. The technology data block tag "<TO>.Status" has the value "2" ("TRIGGER_OCCURRED").
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart. (<TO>.StatusWord.X2 (RestartActive))
Measuring input ready	The measuring input is synchronized with the measuring module and can be used. (<TO>.StatusWord.X5 (CommunicationOK))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	Error in user program at a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	Command cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions are not met (e.g. axis assigned to the measuring input is not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
I/O	Error accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

StatusWord tag (measuring input) (Page 511)

ErrorWord tag (measuring input) (Page 512)

WarningWord tag (measuring input) (Page 514)

10.9 Technology object output cam

10.9.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object.
The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables.
The associated technology object tag is given in parentheses.

Output cam status

The following table shows the possible states of the output cam:

Status	Description
Active	The technology object is in operation. (<TO>.StatusWord.X0 (Control))
Switched	The output cam is switched. (<TO>.CamOutput)
Inverted output cam output	The output cam output is inverted. (<TO>.StatusWord.X4 (OutputInverted))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart. (<TO>.StatusWord.X2 (RestartActive))
Output cam output ready	The cam is synchronized with the output module and available for use. (<TO>.StatusWord.X5 (CommunicationOk))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	Error in user program at a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	Command cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions are not met (e.g. axis assigned to the output cam is not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
I/O	Error accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

StatusWord tag (output cam) (Page 518)

ErrorWord tag (output cam) (Page 519)

WarningWord tag (output cam) (Page 521)

10.10 Cam track technology object

10.10.1 Status and error bits

Description

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object.
The Diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables.
The associated technology object tag is given in parentheses.

Cam track status

The following table shows the possible states of the cam track:

Status	Description
Effective	The technology object is in operation. (<TO>.StatusWord.X0 (Control))
Switched	A cam of cam track is switched. (<TO>.TrackOutput)
Inverted output cam output	The output cam output is inverted. (<TO>.StatusWord.X4 (OutputInverted))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area, and in the <TO>.ErrorDetail.Number and <TO>.ErrorDetail.Reaction tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart. (<TO>.StatusWord.X2 (RestartActive))
Cam track output ready	The cam track is synchronized with the output module and available for use. (<TO>.StatusWord.X5 (CommunicationOk))
Online start value changed	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))
Cam data changed	The data of individual output cams has been changed but not yet taken effect with Motion Control instruction "MC_CamTrack". (<TO>.StatusWord.X6 (CamDataChanged))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data were incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	Error in user program at a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	Command cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions are not met (e.g. axis assigned to the cam track is not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
I/O	Error accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

StatusWord tag (cam track) (Page 526)

ErrorWord tag (cam track) (Page 527)

WarningWord tag (cam track) (Page 529)

10.10.2 Cam track status

Description

You use the "Technology object > Diagnostics > Cam track status" diagnostics function in the TIA Portal to monitor the status of the cam track. The Diagnostics function is available in online operation.

"Validity and masking of the output cams" area

The individual cams of a cam track are shown in this area along with the status for the following properties:

Status	Description
Valid	Validity of the individual cams of the cam track (<TO>.Parameter.Cam[1 … 32].Existent)
Masked	Bit masking of the individual cams of the cam track (<TO>.Parameter.CamMasking)
Effective	Switched on output cam (bit-masked) (<TO>.SingleCamState)

"Positions" area

The following status values are displayed in this area:

Status	Description
Current position within cam track	Position during cam track processing within a cam track cycle The distance to the current reference position of the current cam track (<TO>.MatchPosition) is displayed. (<TO>.TrackPosition)
Current cam track start	Reference position of the current cam track During cyclic processing of the cam track, the continued reference position of the current cam track is displayed. The unique detection and output of the position is only possible when the assigned technology object is in motion. (<TO>.MatchPosition)

Instructions 11

11.1 S7-1500 Motion Control V3

11.1.1 MC_Power V3

11.1.1.1 MC_Power: Enable, disable technology object V3

Description

With the Motion Control instruction "MC_Power", a technology object is enabled or disabled.

Applies to

- Synchronous axis
- Positioning axis
- Speed axis
- External encoder

Requirements

- The technology object has been configured correctly.

Override response

- An "MC_Power" job cannot be aborted by any other Motion Control job.
- An "MC_Power" job with parameter "Enable" = TRUE enables a technology object but does not thereby abort any other Motion Control instructions.
- Disabling the technology object (parameter "Enable" = FALSE) aborts all Motion Control jobs on the corresponding technology object in accordance with the selected "StopMode". This process cannot be canceled by the user.

Parameters

The following table shows the parameters of the "MC_Power" Motion Control instruction:

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_Axis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The technology object is enabled.
				FALSE	The technology object is disabled. All current jobs at the technology object are aborted in accordance with the configured "StopMode".
StartMode	INPUT	DINT	1	0	Enable positioning axis/synchronous axis not position-controlled
				1	Enable positioning axis/synchronous axis position-controlled
				The parameter acts initially when the positioning axis is enabled (Enable changes from FALSE to TRUE) and when the axis is enabled after successful acknowledgment of an alarm that caused the axis to be disabled. This parameter is ignored when a speed axis or external encoder is used.	
StopMode	INPUT	INT	0	Not applicable to the technology object external encoder If you disable a technology object with a negative edge at parameter "Enable", the axis decelerates in accordance with the selected "StopMode".	
				0	Emergency stop When the technology object is disabled, the axis brakes to a standstill without jerk limit, using the emergency stop deceleration configured in "Technology object > Configuration > Extended parameters > Emergency stop ramp". The enable is then canceled. (<TO>.DynamicDefaults. EmergencyDeceleration)
				1	Immediate stop When a technology object is disabled, the setpoint zero is output, and the enable is canceled. The axis is braked to a standstill according to the configuration in the drive.
				2	Stop with maximum dynamic values When the technology object is disabled, the axis is braked to a standstill using the maximum deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic limits". The configured maximum jerk is hereby taken into account. The enable is then canceled. (<TO>.DynamicLimits.MaxDeceleration; <TO>.DynamicLimits.MaxJerk)

Parameters	Declaration	Data type	Default value	Description	
Status	OUTPUT	BOOL	FALSE	Technology object enable status	
				FALSE	Disabled - A positioning axis, synchronous axis or speed axis does not accept any Motion Control jobs. - Speed control and position control are not active. - The actual values of the technology object are not checked for validity.
				TRUE	Enabled - An enabled positioning axis, synchronous axis or speed axis accepts Motion Control jobs. - Speed control and position control are active. - The actual values of the technology object are valid.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred in Motion Control instruction MC_Power. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Enabling technology objects

To enable a technology object, set the "Enable" parameter to TRUE.

When the Status parameter shows the value TRUE , the technology object is enabled.

If an axis is in motion when the technology object is enabled (actual velocity is present), the axis brakes to the setpoint zero, using the maximum deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic limits" (<TO>.DynamicLimits.MaxDeceleration). This braking ramp can be overridden by Motion Control jobs.

Note

Automatic enable after acknowledgment of a technology alarm

If the technology object is disabled due to a technology alarm, it will automatically be enabled again after the cause has been eliminated and the alarm has been acknowledged. This requires the "Enable" parameter to have retained the value TRUE during this process.

Disabling technology objects

To disable a technology object, set the "Enable" parameter to FALSE.

If an axis is in motion, it is braked to a standstill according to the selected "StopMode".

When the "Busy" and "Status" parameters show the value FALSE , the disabling of the technology object is complete.

Drive connection by means of PROFIdrive

When a drive is connected using PROFIdrive, the setpoint, enable and drive status are transmitted via the PROFIdrive telegram.

- **Enable technology object and activate drive**

  With parameter "Enable" = TRUE, the technology object is enabled. The drive is enabled according to the PROFIdrive standard.

  When the tag <TO>.StatusDrive.InOperation shows the value TRUE , the drive is ready to execute setpoints. The "Status" parameter is set to the value TRUE .

- **Disable technology object and deactivate drive**

  With parameter "Enable" = FALSE, the "Status" parameter is set to the value FALSE, and the axis is braked according to the selected "StopMode". The drive is disabled according to the PROFIdrive standard.

Analog drive connection

The setpoint is output via an analog output. Optionally, you can configure an enabling signal via digital output (<TO>.Actor.Interface.EnableDriveOutput), and a readiness signal via digital input (<TO>.Actor.Interface.DriveReadyInput).

- **Enable technology object and activate drive**

  With parameter "Enable" = TRUE, the enable output ("Enable drive output") is set.

  When the drive returns the readiness signal via the ready input ("Drive ready input"), the "Status" parameter and the technology object's <TO>.StatusDrive.InOperation tag are set to TRUE, and the setpoint is switched to the analog output.

- **Disable technology object and deactivate drive**

  With parameter "Enable" = FALSE, the "Status" parameter is set to the value FALSE, and the axis is braked according to the selected "StopMode". When the setpoint zero is reached, the enable output is set to FALSE.

Additional information

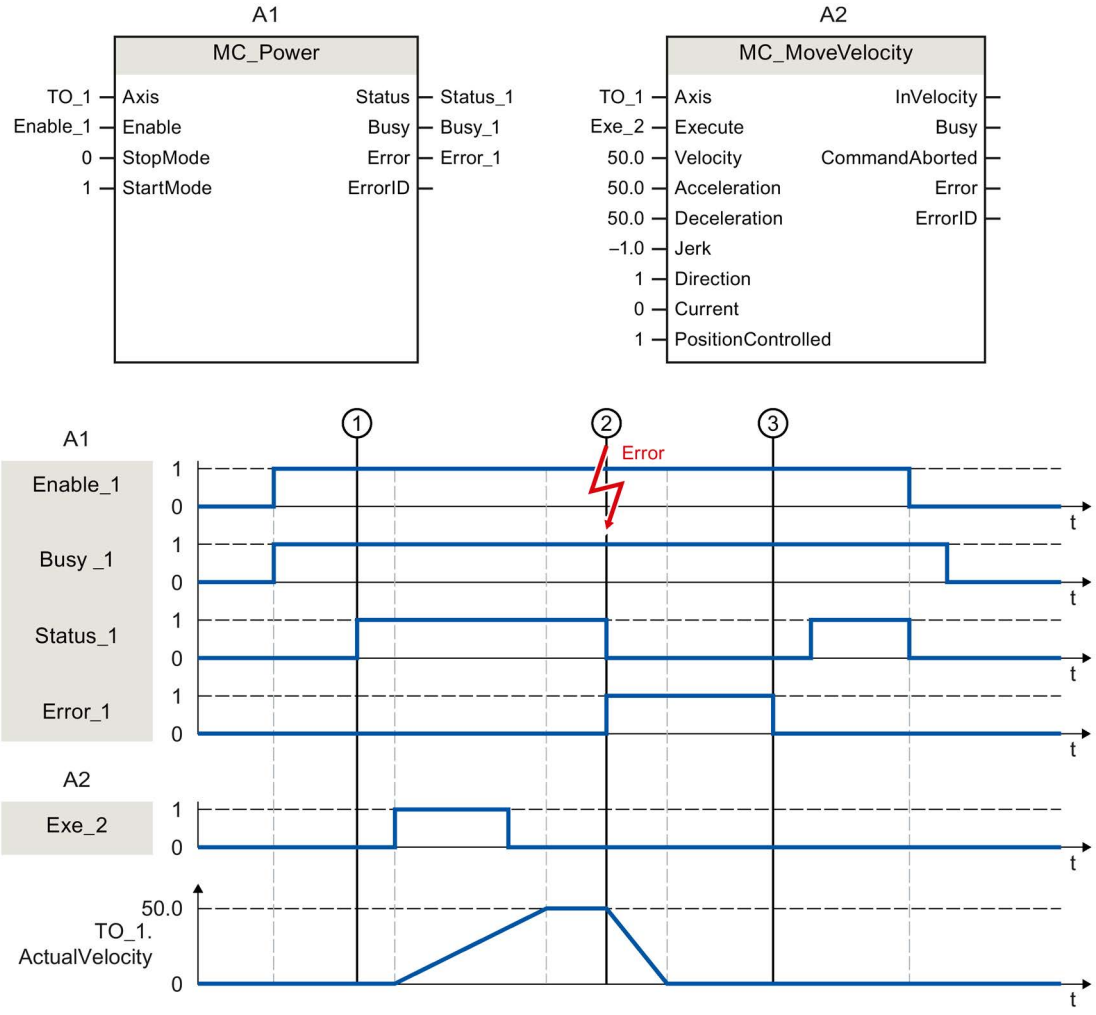
Additional information on enabling and disabling technology objects and drives can be found in the appendix, MC_Power Function Charts (Page 564).

See also

Error ID for Motion Control instructions (Page 559)

11.1.1.2 MC_Power: Function chart V3

Function chart: Enabling a technology object and example of alarm response



A technology object is enabled with "Enable_1= TRUE". The successful enable can be read from "Status_1" at time ①. The axis will then move with an "MC_MoveVelocity" job (A2). The velocity profile of the axis can be read from "Velocity Axis_1".

At time ② an error occurs in the technology object, which results in the disabling of the technology object (alarm response: remove enable). The axis is braked to a standstill according to the configuration in the drive. When the technology object is disabled, "Status_1" is reset. Since the axis was not disabled using "Enable_1" = FALSE, the selected "StopMode" does not apply. The cause of the error is corrected and the alarm is acknowledged at time ③.

Since "Enable_1" is still set, the technology object is enabled again. The successful enable can be read from "Status_1". Finally, the technology object is disabled with "Enable_1" = FALSE.

11.1.2 MC_Reset V3

11.1.2.1 MC_Reset: Acknowledge alarms, restart technology object V3

Description

With the Motion Control instruction "MC_Reset", you acknowledge all technology alarms that can be acknowledged in the user program. Acknowledgment also resets the "Error" and "Warning" bits in the technology data block.

With the Motion Control instruction "MC_Reset" with "Restart" = TRUE, you start reinitialization (restart) of technology objects. Upon restart of the technology object, the new configuration data are applied in the technology data block.

Applies to

- All technology objects

Requirements

- Positioning/synchronous axis, speed axis and external encoder technology objects:

  For a restart, the technology object must be disabled.

  ("MC_Power.Status" = FALSE and "MC_Power.Busy" = FALSE)

Override response

- Parameter "Restart" = FALSE:

  The MC_Reset job does not abort any running Motion Control jobs.

- Parameter "Restart" = TRUE:

  Processing of the "MC_Reset" instruction with parameter "Restart" = TRUE cannot be aborted by any other Motion Control job.

Parameters

The following table shows the parameters of the "MC_Reset" Motion Control instruction:

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_Object	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start job with a positive edge	
Restart	INPUT	BOOL	FALSE	TRUE	"Restart" Reinitialization of the technology object and acknowledgment of pending technology alarms. The technology object is reinitialized with the configured start values.
				FALSE	Acknowledgment of queued technology alarms.
Done	OUTPUT	BOOL	FALSE	TRUE	Error has been acknowledged. Restart has been executed.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
Command-Aborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Acknowledging technology alarms

To acknowledge technology alarms, follow these steps:

1. Check the requirements indicated above.
2. Set parameter "Restart" = FALSE.
3. Start the acknowledgment of the error with a positive edge at parameter "Execute".

When the Done parameter shows the value TRUE, the error has been acknowledged.

Note

Acknowledging with "Restart" = FALSE

If only the technology alarms are to be acknowledged, set "Restart" = FALSE.
The technology object cannot be used during a restart.

Restarting a technology object

To restart a technology object, follow these steps:

1. Check the requirements indicated above.
2. Set parameter "Restart" = TRUE.
3. Perform the restart with a positive edge at parameter "Execute".

When the "Done" parameter shows the value TRUE, the restart of the technology object is complete.

Additional information regarding the restart can be found in the Restarting technology objects (Page 324) section.

See also

Error ID for Motion Control instructions (Page 559)

11.1.3 MC_Home V3

11.1.3.1 MC_Home: Home technology object, set home position V3

Description

With the Motion Control instruction "MC_Home", you create the relationship between the position in the technology object and the mechanical position. The actual position value in the technology object is assigned to a homing mark at the same time. This homing mark represents a known mechanical position.

Homing is performed according to the mode selected with the "Mode" parameter and the configuration under "Technology object > Configuration > Extended parameters > Homing".

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter. A comparison of the "MC_Home.Mode" parameter for technology versions V1.0 and ≥ V2.0 is available in section Version overview (Page 161).

The preset values under "Technology object > Configuration > Extended parameters > Dynamic default values" are used for the dynamic values Acceleration, Deceleration and Jerk.

Applies to

- Synchronous axis
- Positioning axis
- External encoder

The following table shows which modes are possible with each of the technology objects:

Operating mode	Positioning axis/synchronous axis with incremental encoder	Positioning axis/synchronous axis with absolute encoder	External incremental encoder	External absolute encoder
Active homing ("Mode" = 3, 5)	X	-	-	-
Passive homing ("Mode" = 2, 8, 10)	X	-	X	-
Set actual position ("Mode" = 0)	X	X	X	X
Relative shift of the actual position ("Mode" = 1)	X	X	X	X
Absolute encoder adjustment ("Mode" = 6, 7)	-	X	-	X

Requirements

- The technology object has been configured correctly.
- "Mode" = 2, 3, 5, 8, 10
  The technology object must be enabled.
- "Mode" = 0, 1, 6, 7, 8
  The actual encoder values must be valid. (<TO>.StatusSensor[n].State = 2)

Override response

The override characteristics for "MC_Home" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of the "MC_Home" Motion Control instruction:

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_Axis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start job with a positive edge	
Position	INPUT	LREAL	0.0	The specified value is used according to the selected "Mode".	
Mode	INPUT	INT	0	Operating mode	
				0	Direct homing (absolute) The current position of the technology object is set to the value of parameter "Position".
				1	Direct homing (relative) The current position of the technology object is shifted by the value of parameter "Position".
				2	Passive homing (without reset) Functions like "Mode" 8, with the difference that the "homed" status is **not** reset when the function is enabled.
				3	Active homing The TO positioning axis/synchronous axis performs a homing movement according to the configuration. After the completion of the movement, the axis is positioned at the value of the "Position" parameter.
				4	Reserved
				5	Active homing ("Position" parameter has no effect) The TO positioning axis/synchronous axis performs a homing movement according to the configuration. After completion of the movement, the axis is positioned at the home position configured under "Technology object > Configuration > Extended parameters > Homing > Active homing". (<TO>.Homing.HomePosition)
				6	Absolute encoder adjustment (relative) The current position is shifted by the value of parameter "Position". The calculated absolute value offset is stored retentively in the CPU. (<TO>.StatusSensor[n]. AbsEncoderOffset)

Parameters	Declaration	Data type	Default value	Description	
				7	Absolute encoder adjustment (absolute) The current position is set to the value of parameter "Position". The calculated absolute value offset is stored retentively in the CPU. (<TO>.StatusSensor[n].AbsEncoderOffset)
				8	Passive homing When the homing mark is detected, the actual value is set to the value of the "Position" parameter.
				9	Abort passive homing An active job for passive homing is aborted.
				10	Passive homing ("Position" parameter has no effect) When the homing mark is detected, the actual value is set to the home position configured under "Technology object > Configuration > Extended parameters > Homing > Passive homing". (<TO>.Homing.HomePosition)
ReferenceMark-Position	OUTPUT	LREAL	0.0	Display of the position at which the technology object was homed (valid when "Done" = TRUE)	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Resetting the "Homed" status

The "Homed" status of a technology object is reset under the following conditions (<TO>.StatusWord.X5 (HomingDone)):

- **Technology objects with incremental actual values:**
  - Starting an "MC_Home" job with "Mode" = 3, 5, 8, 10

    (After successful completion of the homing operation, the "Homed" status is reset.)
  - Error in the encoder system, or encoder failure
  - Restart of the technology object
  - After POWER OFF -> POWER ON of the CPU
  - Memory reset
  - Modification of the encoder configuration
- **Technology objects with absolute actual values:**
  - Error in sensor system/encoder failure
  - Replacement of the CPU
  - Modification of the encoder configuration
  - Restoration of the CPU factory settings
  - Transfer of a different project into the controller

Homing a technology object with "Mode" = 1..8, 10

To home a technology object, follow these steps:

1. Check the requirements indicated above.
2. Specify the desired homing function in the "Mode" parameter.
3. Initialize the necessary parameters with values, and start the homing operation with a positive edge at the "Execute" parameter.

When the "Done" parameter shows the value TRUE, the "MC_Home" job has been completed according to the selected "Mode". The "Homed" status of the technology object is indicated under "Technology object > Diagnostics > Status and error bits > Motion status > Homed" (<TO>.StatusWord.X5 (HomingDone)).

Abort of a passive homing process with "Mode" = 9

With "Mode" = 9, the technology object is not homed. When an active "MC_Home" job for passive homing ("Mode" = 2, 8, 10) is overridden by another "MC_Home" job with "Mode" = 9, the running job is aborted with parameter "CommandAborted" = TRUE. The overriding job with "Mode" = 9 signals successful execution with parameter "Done" = TRUE.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

Homing (Page 69)

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

11.1.4 MC_Halt V3

11.1.4.1 MC_Halt: Stop axis V3

Description

With the Motion Control instruction "MC_Halt", you brake an axis until it comes to a standstill.

You define the dynamic behavior of the braking operation with parameters "Jerk" and "Deceleration".

Applies to

- Synchronous axis
- Positioning axis
- Speed axis

Requirements

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override characteristics for "MC_Halt" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of the "MC_Halt" Motion Control instruction:

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start job with a positive edge	
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
AbortAcceleration	INPUT	BOOL	FALSE	FALSE	The current acceleration at the start of the job is reduced using the configured jerk. Afterwards, the deceleration builds up
				TRUE	The acceleration is set to 0.0 at the start of the job, and the deceleration immediately builds up.
Done	OUTPUT	BOOL	FALSE	TRUE	Zero velocity reached
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Braking an axis with "MC_Halt"

Proceed as follows to decelerate an axis to a standstill:

1. Check the requirements indicated above.
2. Supply the parameters "Deceleration", "Jerk" and "AbortAcceleration" with the desired values.
3. Start the "MC_Halt" job with a positive edge at parameter "Execute".

The current motion state is indicated in "Busy", "Done" and "Error". The standstill of the axis is indicated under "Technology object > Diagnostics > Status and error bits > Motion status > Standstill" (<TO>.StatusWord.X7 (Standstill)).

Braking an axis with active force/torque limit

With active force/torque limiting the permitted torque may not be sufficient to move the calculated braking ramp. The "MC_Halt" command does not signal "Done" = TRUE.

To brake an axis with active force/torque limiting, use the Motion Control instruction "MC_MoveVelocity" with "MC_MoveVelocity.Velocity" = 0.0 and "MC_MoveVelocity.PositionControlled" = FALSE.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

See also

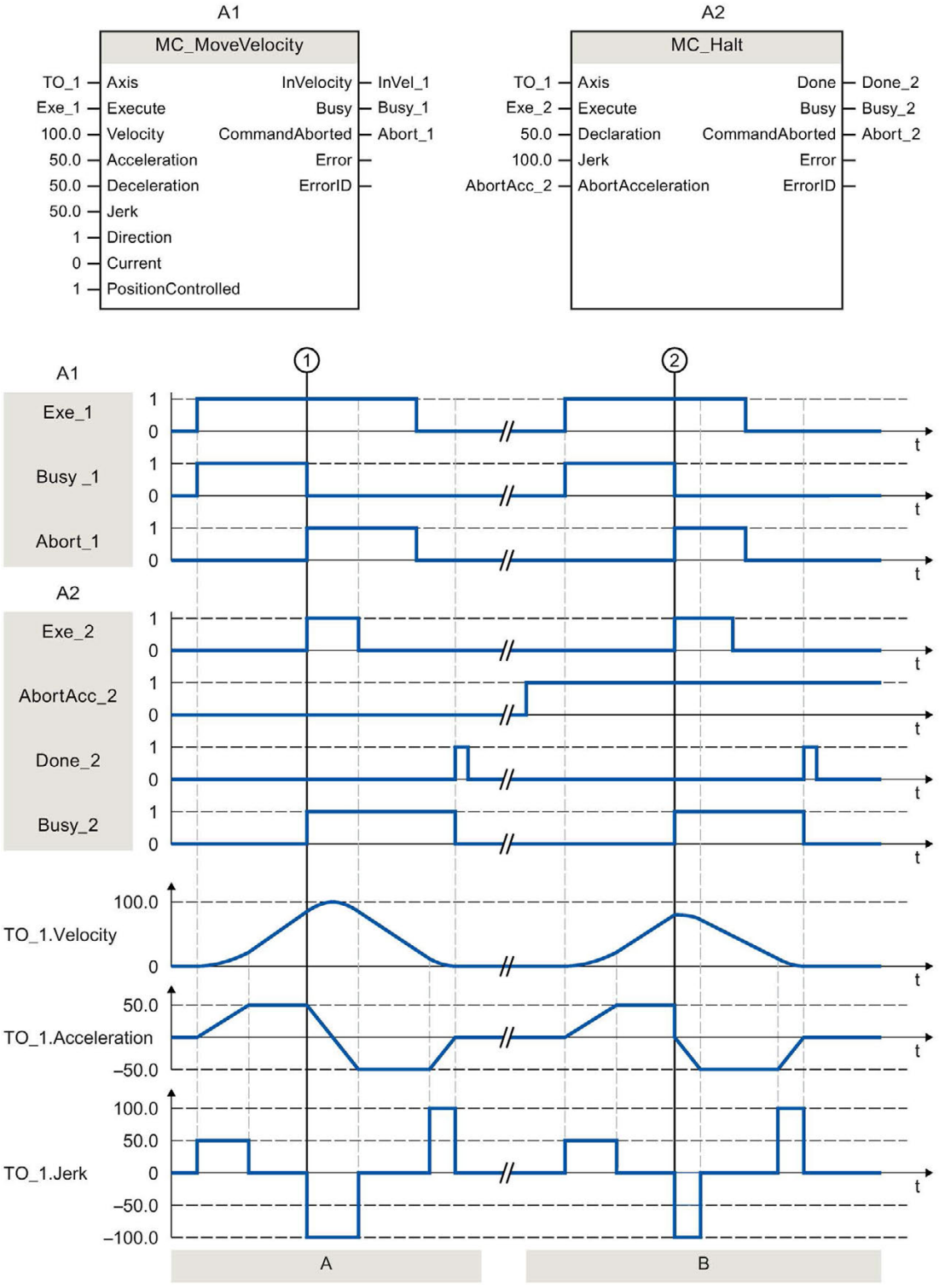
Override response of Motion Control commands V3 (Page 439)

MC_MoveVelocity: Move axis at velocity/speed setpoint V3 (Page 397)

Error ID for Motion Control instructions (Page 559)

11.1.4.2 MC_Halt: Function chart V3

Function chart: Stopping an axis and the overriding job characteristics



Section A	An axis is moved with an "MC_MoveVelocity" job (A1). At time ①, the "MC_MoveVelocity" job is overridden by an "MC_Halt" job (A2). The job abort is signaled via "Abort_1". With "AbortAcc_2" = FALSE, the current acceleration is reduced with the specified jerk. Afterward, the deceleration builds up and the axis is braked to a standstill. Successful completion of the "MC_Halt" job is signaled via "Done_2".
Section B	The axis is moved with an "MC_MoveVelocity" job (A1). At time ②, the "MC_MoveVelocity" job is overridden by an "MC_Halt" job (A2). The job abort is signaled via "Abort_1". With "AbortAcc_2" = TRUE, the current acceleration is set to zero immediately and the deceleration builds up. The axis is braked to a standstill. Successful completion of the "MC_Halt" job is signaled via "Done_2".

11.1.5 MC_MoveAbsolute V3

11.1.5.1 MC_MoveAbsolute: Absolute positioning of axis V3

Description

With the Motion Control instruction "MC_MoveAbsolute", you can move an axis to an absolute position.

You define the dynamic behavior of the motion with parameters "Velocity", "Jerk", "Acceleration" and "Deceleration".

Applies to

- Synchronous axis
- Positioning axis

Requirements

- The technology object has been configured correctly.
- The technology object has been enabled.
- The technology object is homed.

Override response

The override characteristics for "MC_MoveAbsolute" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of the "MC_MoveAbsolute" Motion Control instruction:

Parameters	Declaration	Data type	Default value	Description
Axis	INPUT	TO_Positioning-Axis	-	Technology object
Execute	INPUT	BOOL	FALSE	Start job with a positive edge
Position	INPUT	REAL	0.0	Absolute target position
Velocity	INPUT	LREAL	-1.0	Velocity setpoint for the positioning Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
Direction	INPUT	INT	1	Motion direction of the axis Is only evaluated with "modulo" enabled. "Technology object > Configuration > Basic parameters > Enable modulo
				1 Positive direction
				2 Negative direction
				3 Shortest path

Parameters	Declaration	Data type	Default value	Description	
Done	OUTPUT	BOOL	FALSE	TRUE	Target position reached.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Moving an axis to an absolute position

Proceed as follows to move an axis to an absolute position:

1. Check the requirements indicated above.
2. Specify the desired target position in the "Position" parameter.
3. Start the "MC_MoveAbsolute" job with a positive edge at parameter "Execute".

The current motion state is indicated in "Busy", "Done" and "Error".

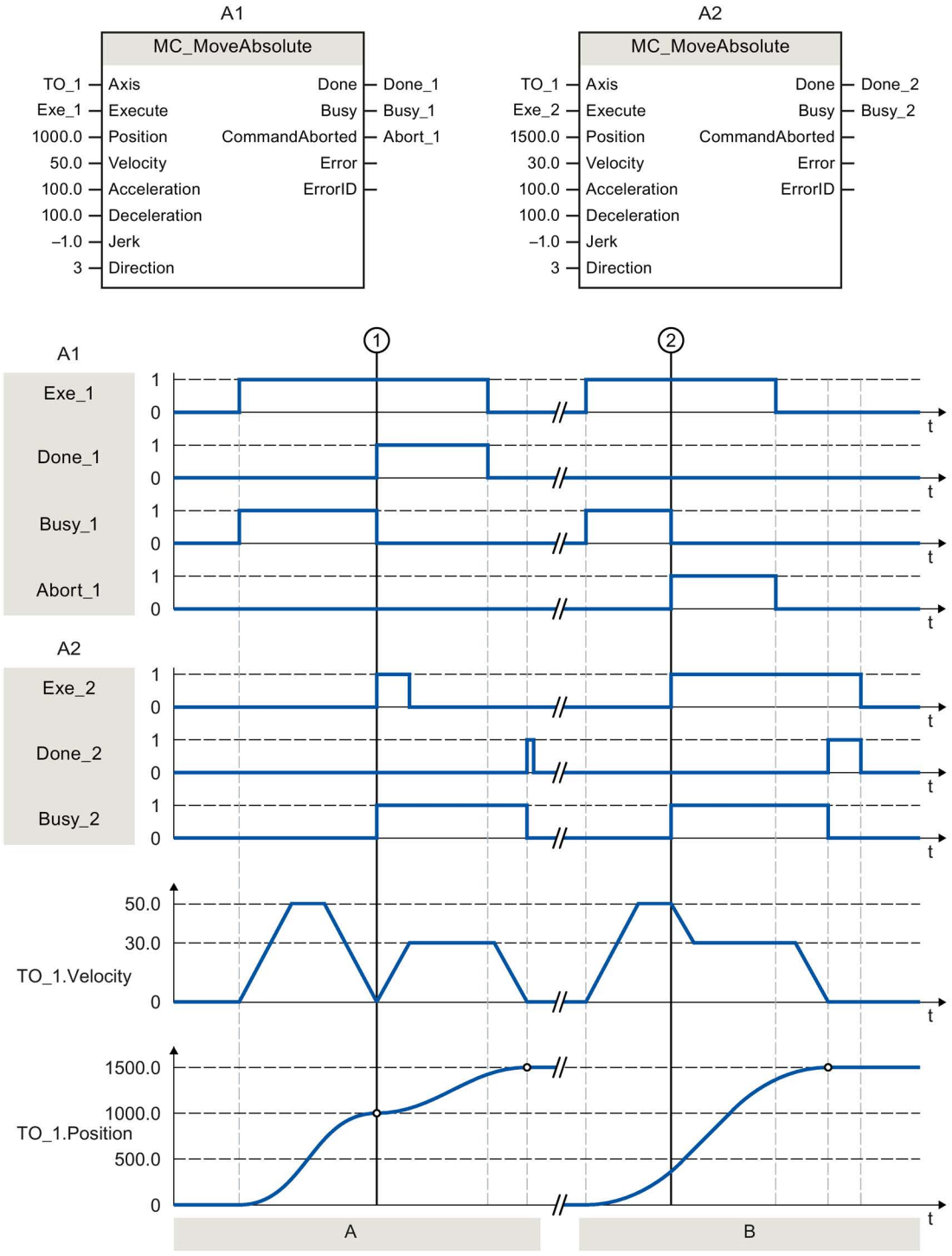
See also

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

11.1.5.2 MC_MoveAbsolute: Function chart V3

Function chart: Absolute positioning of an axis, and the response to an overriding job



Section A	An axis is moved to absolute position 1000.0 with an "MC_MoveAbsolute" job (A1). When the axis reaches the target position, this is signaled at time ① via "Done_1". At this time ①, another "MC_MoveAbsolute" job (A2) with target position 1500.0 is started. When the axis reaches the target position 1500.0, this is signaled via "Done_2". Since "Exe_2" was previously reset, "Done_2" is applied only to one cycle.
Section B	An active "MC_MoveAbsolute" job (A1) is overridden at time ② by another "MC_MoveAbsolute" job (A2). The abort is signaled via "Abort_1". The axis is braked to the changed velocity and moved to the new target position 1500.0. When the new target position is reached, this is signaled via "Done_2".

11.1.6 MC_MoveRelative V3

11.1.6.1 MC_MoveRelative: Relative positioning of axis V3

Description

With the Motion Control instruction "MC_MoveRelative", you move an axis relative to its position when execution of the job began.

You define the dynamic behavior of the motion with parameters "Velocity", "Jerk", "Acceleration" and "Deceleration".

Applies to

- Synchronous axis
- Positioning axis

Requirements

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override characteristics for "MC_MoveRelative" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of the "MC_MoveRelative" Motion Control instruction:

Parameters	Declaration	Data type	Default value	Description
Axis	INPUT	TO_PositioningAxis	-	Technology object
Execute	INPUT	BOOL	FALSE	Start job with a positive edge
Distance	INPUT	LREAL	0.0	Distance for the positioning process (negative or positive)
Velocity	INPUT	LREAL	-1.0	Velocity setpoint for the positioning Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)

Parameters	Declaration	Data type	Default value	Description	
Done	OUTPUT	BOOL	FALSE	TRUE	Target position reached
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Moving an axis relative to the starting position

Proceed as follows to move an axis relative to the starting position:

1. Check the requirements indicated above.
2. Specify distance to be moved in the "Distance" parameter.
3. Start the "MC_MoveRelative" job with a positive edge at parameter "Execute".

The current motion state is indicated in "Busy", "Done" and "Error".

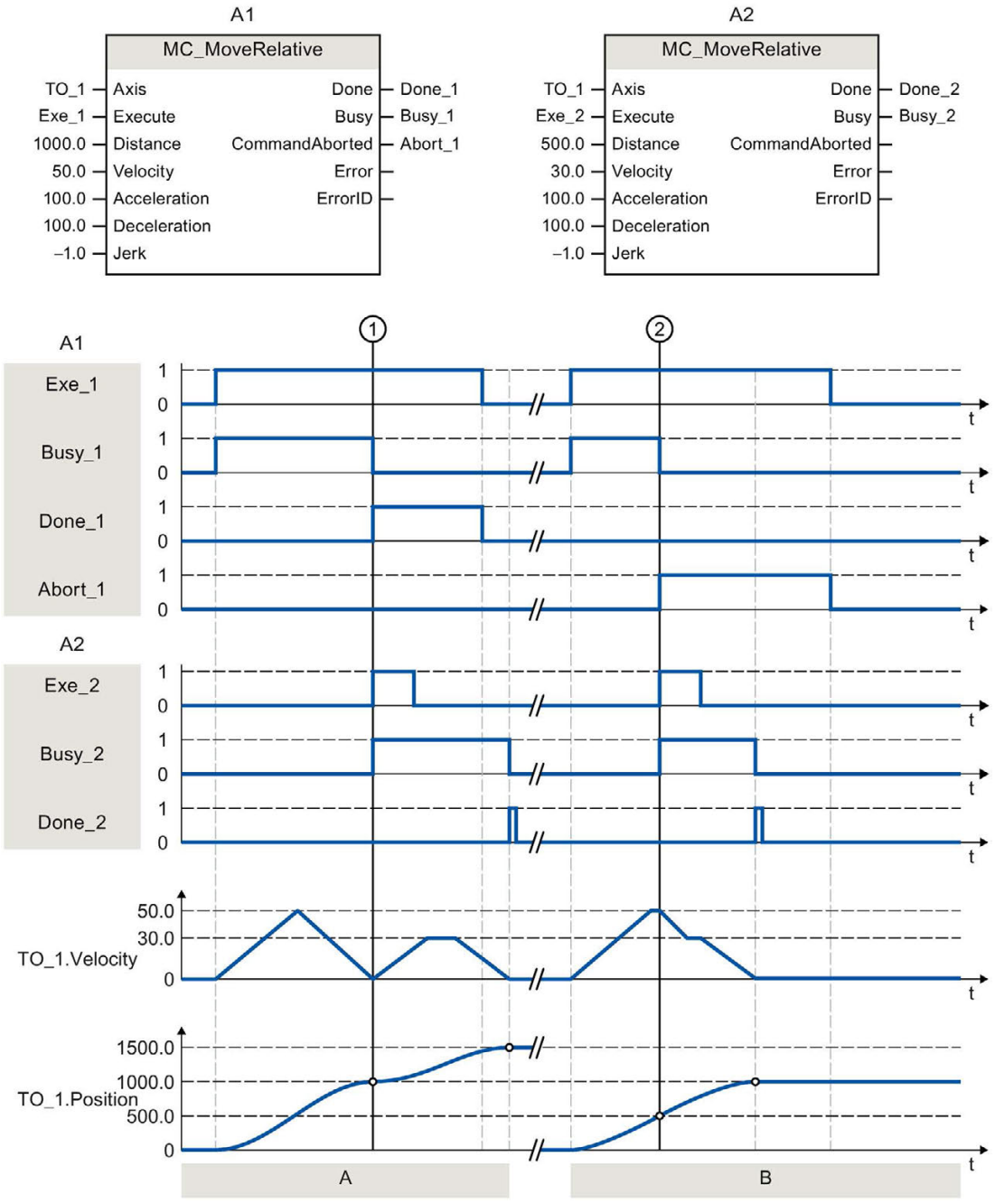
See also

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

11.1.6.2 MC_MoveRelative: Function chart V3

Function chart: Relative positioning of an axis, and the overriding job characteristics



Section A	The axis is moved by an "MC_MoveRelative" job (A1) by the distance ("Distance") 1000.0 (the starting position here is 0.0). When the axis reaches the target position, this is signaled at time ① via "Done_1". At this time ①, another "MC_MoveRelative" job (A2) with distance 500.0 is started. When the axis reaches the new target position, this is signaled via "Done_2". Since "Exe_2" was previously reset, "Done_2" is applied only to one cycle.
Section B	An active "MC_MoveRelative" job (A1) is overridden by another "MC_MoveRelative" job (A2). The abort is signaled at time ② via "Abort_1". The axis is then moved at the new velocity by the distance ("Distance") 500.0. When the new target position is reached, this is signaled via "Done_2".

11.1.7 MC_MoveVelocity V3

11.1.7.1 MC_MoveVelocity: Move axis at velocity/speed setpoint V3

Description

With the Motion Control instruction "MC_MoveVelocity", you move an axis at constant velocity/speed.

You define the dynamic behavior of the motion with parameters"Velocity", "Jerk", "Acceleration" and "Deceleration".

- Positioning axis/synchronous axis:

  A velocity is specified in the "Velocity" parameter.

- Speed axis:

  A speed is specified in the "Velocity" parameter.

Applies to

- Synchronous axis
- Positioning axis
- Speed axis

Requirements

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override characteristics for "MC_MoveVelocity" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of the "MC_MoveVelocity" Motion Control instruction:

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start job with a positive edge	
Velocity	INPUT	LREAL	100.0	Velocity/speed setpoint for the motion process ("Velocity" = 0.0 is permitted)	
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)	
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used. Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
Direction	INPUT	INT	0	Direction of rotation of the axis	
				0	The sign of the velocity specified at the "Velocity" parameter defines the direction of rotation.
				1	Positive direction of rotation Value of "Velocity" is used.
				2	Negative direction of rotation Value of "Velocity" is used.

Parameters	Declaration	Data type	Default value	Description	
Current	INPUT	BOOL	FALSE	Maintain current velocity	
				FALSE	Deactivated The values of parameters "Velocity" and "Direction" are taken into account.
				TRUE	activated The values at the parameters "Velocity" and "Direction" are **not** taken into account. The current velocity and direction at function start are retained. When the axis resumes motion at the velocity that was current at function start, the "InVelocity" parameter returns the value TRUE.
PositionControlled	INPUT	BOOL	TRUE	FALSE	Non position-controlled operation
				TRUE	Position-controlled mode
				The parameter applies as long as the MC_MoveVelocity command is executed. After this, the setting of MC_Power applies again. This parameter is ignored when a speed axis is used.	
InVelocity	OUTPUT	BOOL	FALSE	TRUE	The velocity setpoint / speed setpoint was reached and will be maintained.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Behavior with velocity setpoint / speed setpoint zero ("Velocity" = 0.0)

An "MC_MoveVelocity" job with "Velocity" = 0.0 stops the axis with the configured deceleration. When the velocity setpoint / speed setpoint zero is reached, the parameter "InVelocity" will indicate the value TRUE.

Under "Technology object > Diagnostics > Status and error bits > Motion status", "constant velocity" and "standstill" will be displayed (<TO>.StatusWord.X12 (ConstantVelocity); <TO>.StatusWord.X7 (Standstill)).

The parameters "InVelocity" and "Busy" show the value TRUE until the "MC_MoveVelocity" job is overridden by another Motion Control job.

Moving an axis with constant velocity / speed

Proceed as follows to move an axis with constant velocity / speed:

1. Check the requirements indicated above.
2. At the parameter "Velocity", specify the velocity / speed, with which the axis should be moved.
3. Start the "MC_MoveVelocity" job with a positive edge at parameter "Execute".

The current motion state is indicated in "Busy", "InVelocity" and "Error".

If the "InVelocity" parameter shows the value TRUE, then the velocity setpoint / speed setpoint was reached. The axis continues moving at this constant velocity. The parameters "InVelocity" and "Busy" show the value TRUE until the "MC_MoveVelocity" job is overridden by another Motion Control job.

Note

Response to a change in the override

If the velocity / speed is influenced during constant motion by a change in the override (<TO>.Override.Velocity), the "InVelocity" parameter is reset during the acceleration or deceleration. When the newly calculated velocity / speed is reached ("Velocity" × "Override" %), then "InVelocity" is reset.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

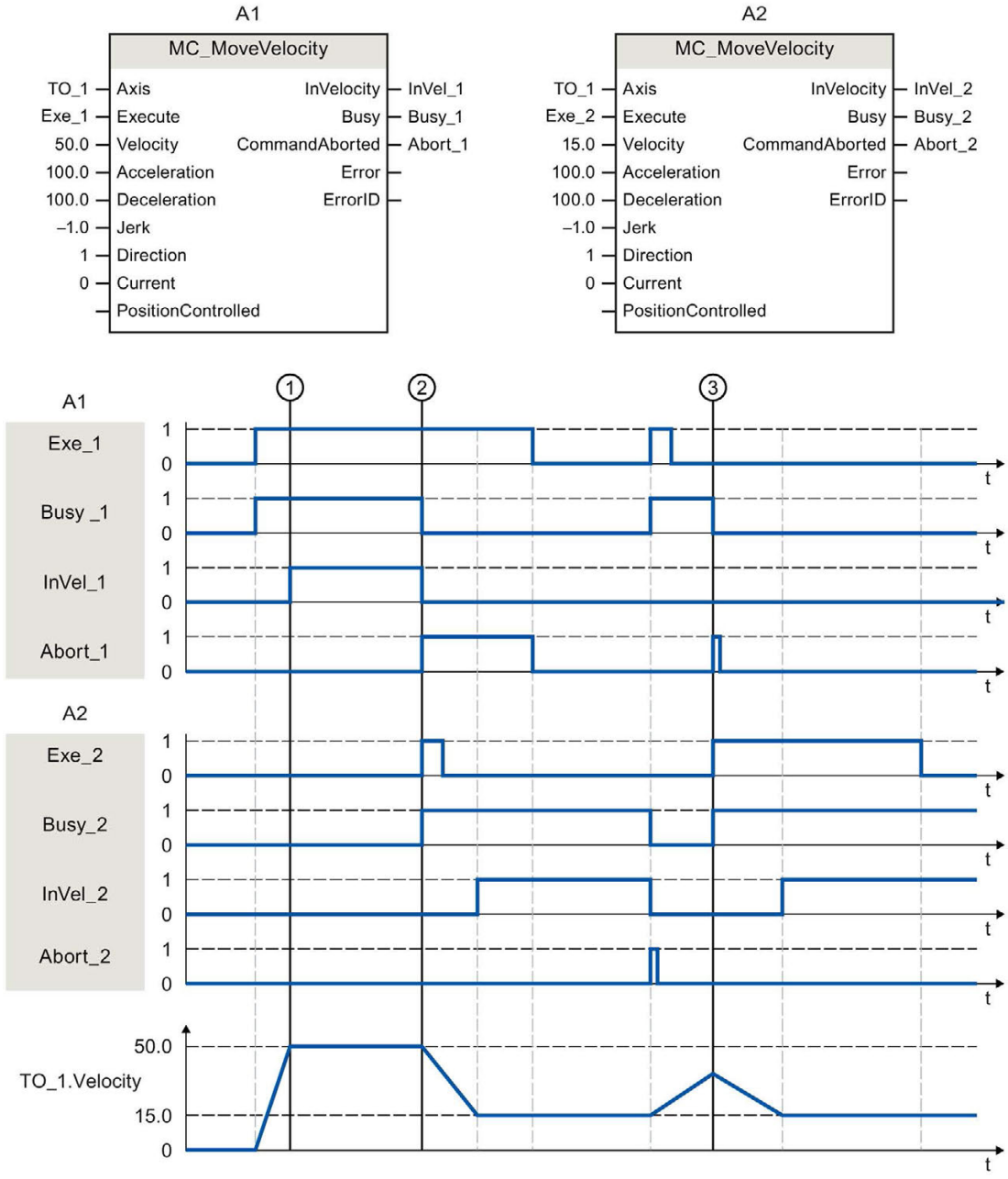
See also

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

11.1.7.2 MC_MoveVelocity: Function chart V3

Function chart: Moving an axis with velocity specification, and the response to an overriding job



An "MC_MoveVelocity" job (A1) initiated via "Exe_1" accelerates the axis and signals at time ① via "InVel_1" that the velocity setpoint 50.0 has been reached.

At time ②, the job is overridden by another "MC_MoveVelocity" job (A2). The abort is signaled via "Abort_1". When the new velocity setpoint 15.0 is reached, this is signaled via "InVel_2". The axis then continues moving at the constant velocity 15.0.

The running "MC_MoveVelocity" job (A2) is overridden by another "MC_MoveVelocity" job (A1). The abort is signaled via "Abort_2". The axis is accelerated to the new velocity setpoint 50.0. Before the velocity setpoint is reached, the current "MC_MoveVelocity" job A1) is overridden at time ③ by another "MC_MoveVelocity" job A2). The abort is signaled via "Abort_1". When the new velocity setpoint 15.0 is reached, this is signaled via "InVel_2". The axis then continues moving at the constant velocity 15.0.

11.1.8 MC_MoveJog V3

11.1.8.1 MC_MoveJog: Move axis in jog mode V3

Description

With the Motion Control instruction "MC_MoveJog", you move an axis in jog mode.

You define the dynamic behavior of the motion with parameters "Velocity", "Jerk", "Acceleration" and "Deceleration".

- Positioning axis/synchronous axis:

  A velocity is specified in the "Velocity" parameter.
- Speed axis:

  A speed is specified in the "Velocity" parameter.

Applies to

- Synchronous axis
- Positioning axis
- Speed axis

Requirements

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override characteristics for "MC_MoveJog" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveJog":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis	-	Technology object	
JogForward	INPUT	BOOL	FALSE	As long as the parameter is TRUE, the axis moves in the positive direction at the velocity specified in parameter "Velocity".	
JogBackward	INPUT	BOOL	FALSE	As long as the parameter is TRUE, the axis moves in the negative direction at the velocity specified in parameter "Velocity".	
Velocity	INPUT	LREAL	100.0	Velocity setpoint / speed setpoint for the motion Value > 0.0: The specified value is used. Value < 0.0: The absolute value of the specified value is used. ("Velocity" = 0.0 is permitted)	
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)	
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used. Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
PositionControlled	INPUT	BOOL	TRUE	FALSE	Non position-controlled operation
				TRUE	Position-controlled mode
				The parameter applies as long as the MC_MoveJog command is executed. After this, the setting of MC_Power applies again. This parameter is ignored when a speed axis is used.	
InVelocity	OUTPUT	BOOL	FALSE	TRUE	The velocity setpoint / speed setpoint was reached and will be maintained.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.

Parameters	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during execution of the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Behavior with velocity setpoint / speed setpoint zero ("Velocity" = 0.0)

An "MC_MoveJog" job with "Velocity" = 0.0 stops the axis with the configured deceleration. When the velocity setpoint / speed setpoint zero is reached, the parameter "InVelocity" will indicate the value TRUE.

Under "Technology object > Diagnostics > Status and error bits > Motion status", " constant velocity" and "standstill" will be displayed (<TO>.StatusWord.X12 (ConstantVelocity); <TO>.StatusWord.X7 (Standstill)).

Moving an axis in jog mode

Proceed as follows to move an axis in jog mode:

1. Check the requirements indicated above.
2. Move the axis in the positive direction with "JogForward", or in the negative direction with "JogBackward".

The current motion state is indicated in "Busy", "InVelocity" and "Error".

Note

Response to a change in the override

If the velocity / speed is influenced during constant motion by a change in the override (<TO>.Override.Velocity), the "InVelocity" parameter is reset during the acceleration or deceleration. When the newly calculated velocity is reached ("Velocity" × "Override" %), then "InVelocity" is set again.

Additional information

An option for the evaluation of the individual status bits can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

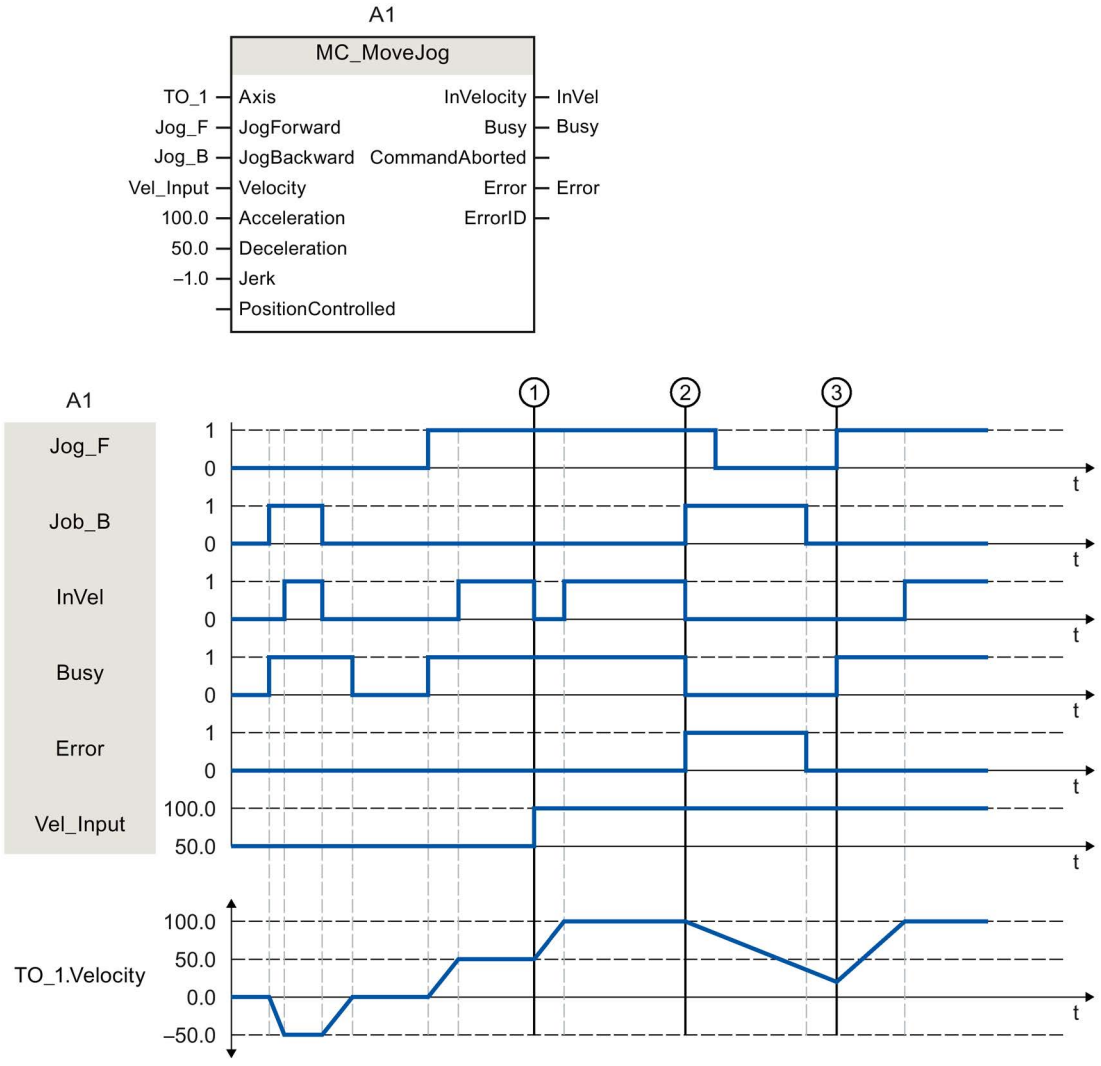
See also

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

11.1.8.2 MC_MoveJog: Function chart V3

Function chart: Moving an axis in jog mode



The axis is moved in the negative direction in jog mode via "Jog_B". When the velocity setpoint -50.0 is reached, this is signaled via "InVel" = TRUE. After "Jog_B" is reset, the axis is braked and brought to a standstill. Then the axis is moved in the positive direction via "Jog_F". When the velocity setpoint 50.0 is reached, this is signaled via "InVel" = TRUE.

At time ①, if "Jog_F" is set, the velocity setpoint is changed to 100.0 by means of "Vel_Input". Alternatively, you can also change the velocity setpoint using the velocity override. "InVel" is reset. Axis is being accelerated. When the new velocity setpoint 100.0 is reached, this is signaled via "InVel" = TRUE.

If "Jog_F" is set, "Jog_B" is likewise set at time ②. If both "Jog_F" and "Jog_B" are set, then the axis is braked with the last applicable deceleration. An error is indicated via "Error", and the "ErrorID" of the error 16#8007 (incorrect direction specification) is output.

This error is resolved by resetting the two inputs "Jog_F" and "Jog_B".

During the braking ramp, "Jog_F" is set at time ③. The axis is accelerated to the last configured velocity. When the velocity setpoint 100.0 is reached, this is signaled via "InVel" = TRUE.

11.1.9 MC_MoveSuperimposed V3

11.1.9.1 MC_MoveSuperimposed: Superimposed positioning of axis V3

Description

With the Motion Control instruction "MC_MoveSuperimposed", you start a relative positioning motion that is superimposed on a active basic motion.

You define the dynamic behavior of the motion with parameters "VelocityDiff", "Jerk", "Acceleration" and "Deceleration" . The dynamic values are added to the values of the basic motion. The duration of the basic motion is not extended by a superimposed motion.

The dynamics of the total axis motion is the sum of the dynamic values of the basic motion and the superimposed motion.

The behavior of the total motion depends on the type of basic motion:

- The basic motion is a single-axis motion:
  - The maximum dynamics of the superimposed motion is the difference between the current dynamic values of the basic motion and the dynamic limits.
  - The entire motion is limited to the configured dynamic limits.
- The basic motion is a synchronous motion:
  - The maximum dynamics of the superimposed motion is the difference between the current dynamic values of the basic motion and the dynamic limits.
  - The synchronous motion of the following axis is not limited to the dynamic limits of the following axis.
  - An "MC_MoveSuperimposed" job on a leading axis in synchronous operation affects the leading axis and the following axis.
  - An "MC_MoveSuperimposed" job on a following axis in synchronous operation only affects the following axis.

It is always the dynamics of the total motion that is displayed in the technology data block and in the TIA Portal.

Applies to

- Synchronous axis
- Positioning axis

Requirements

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override characteristics for "MC_MoveSuperimposed" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of Motion Control instruction "MC_MoveSuperimposed":

Parameters	Declaration	Data type	Default value	Description
Axis	INPUT	TO_PositioningAxis	-	Axis technology object
Execute	INPUT	BOOL	FALSE	Start job with a positive edge
Distance	INPUT	LREAL	0.0	Additional travel distance for the superimposing positioning operation (negative or positive)
VelocityDiff	INPUT	LREAL	-1.0	Maximum velocity deviation compared to the active motion Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)

Parameters	Declaration	Data type	Default value	Description	
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
Done	OUTPUT	BOOL	FALSE	TRUE	Superimposed positioning complete
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID (Page 559) for parameter "ErrorID"	

Starting superimposed positioning motion

To start a superimposed positioning motion with Motion Control instruction "MC_MoveSuperimposed", follow these steps:

1. Check the requirements indicated above.
2. Specify the additional distance to be moved in the "Distance" parameter.
3. Start the "MC_MoveSuperimposed" job with a positive edge at parameter "Execute".

The current motion state is indicated in "Busy", "Done" and "Error".

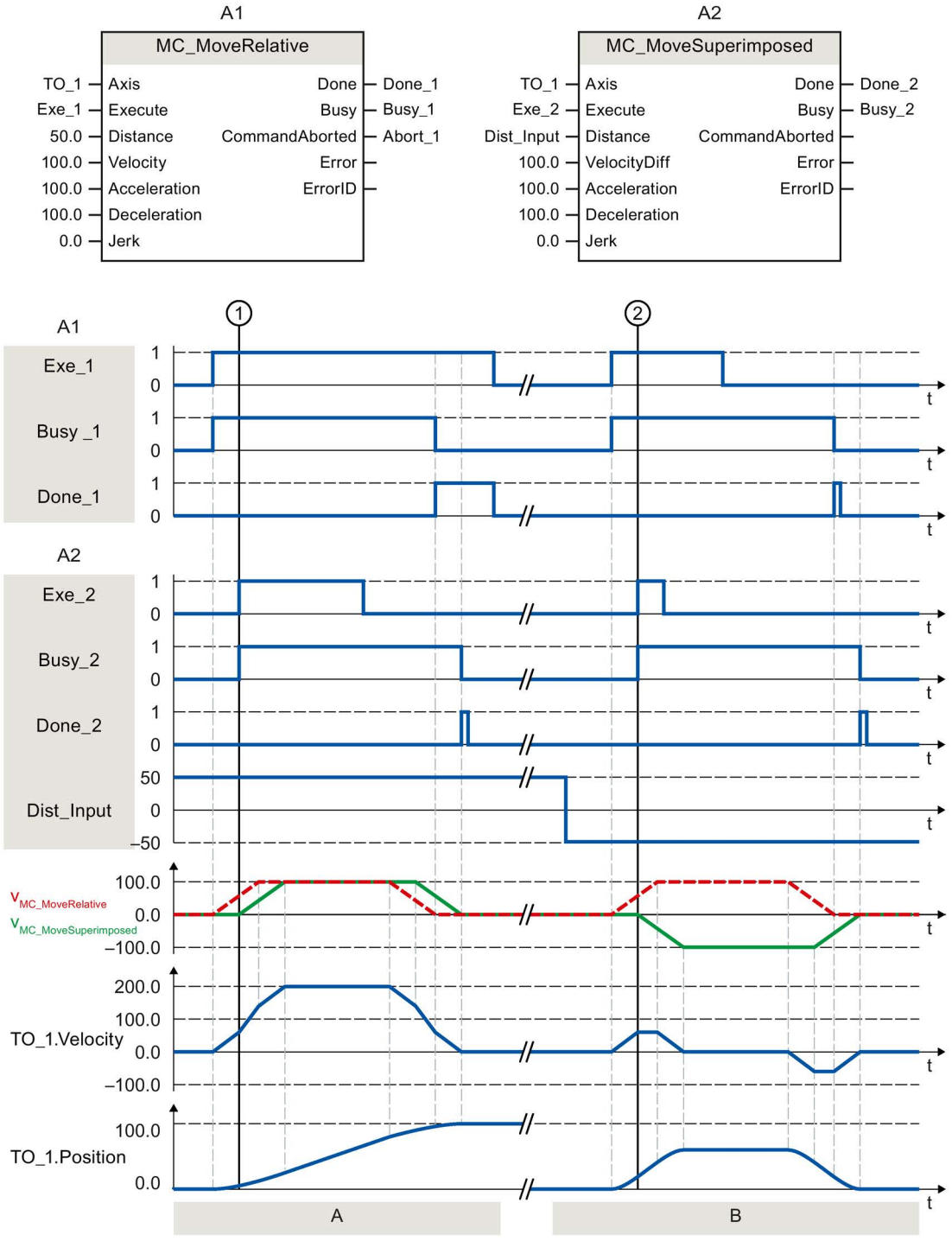
See also

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

11.1.9.2 MC_MoveSuperimposed: Function chart V3

Function chart: Positioning axes overlapping



Section A	Using "Exe_1", an "MC_MoveRelative" job with a distance of 50.0 is initiated. At time ①, using "Exe_2", an MC_MoveSuperimposed job with a distance of 50.0 is initiated. The axis is moved with the added dynamic values of both jobs by the distance 50 + 50 = 100.0. When the axis reaches the target position, this is signaled via "Done_2".
Section B	Using "Exe_1", an "MC_MoveRelative" job with a distance of 50.0 is initiated. At time ②, using "Exe_2", a MC_MoveSuperimposed job with a distance of -50.0 is initiated. The axis reverses and is moved with the added dynamic values of both jobs by the distance 50.0 - 50.0 = 0.0. When the axis reaches the target position, this is signaled via "Done_2".

11.1.10 MC_TorqueLimiting V3

11.1.10.1 MC_TorqueLimiting: Activate and deactivate force/torque limit / fixed stop detection

Description

With the Motion Control instruction "MC_TorqueLimiting", you activate and assign parameters for force/torque limiting and fixed stop detection.

Together with a position-controlled motion job, a "Travel to fixed stop" can be realized with the fixed stop detection.

In the axis configuration, you can configure whether the force/torque limiting is to relate to the drive side or the load side.

The functions of the Motion Control instruction "MC-TorqueLimiting" can be activated and deactivated before and during a motion job.

Force/torque limiting applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirements for force/torque limiting

- The technology object and the reference torque of the drive have been configured correctly.
- The drive must support force/torque reduction. Only PROFIdrive drives with SIEMENS telegram 10x support force/torque limiting.
- No enable-preventing errors are pending for the technology object (the technology object does not have to be enabled).

Fixed stop detection applies to

- Positioning axis
- Synchronous axis

Requirement for fixed stop detection

- The fixed stop detection can only be applied to position-controlled axes. For fixed stop detection, the axis must be enabled as position-controlled axis; motion commands must be executed as position-controlled motion commands.
- The technology object has been configured correctly.
- When a drive and telegram that support force/torque limiting is used, the reference torque of the drive must be correctly configured for the technology object.
- No enable-preventing errors are pending for the technology object (the technology object does not have to be enabled).

Override response

- An MC_TorqueLimiting job cannot be aborted by another Motion Control job.
- A new MC_TorqueLimiting job does not abort active Motion Control jobs.

Parameters

The following table shows the parameters of Motion Control instruction "MC_TorqueLimiting":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	Activate function corresponding to input parameter Mode
Limit	INPUT	LREAL	-1.0	Value of force/torque limiting (in the configured unit of measurement) If drive and telegram do not support force/torque limiting, the specified value is irrelevant.	
				≥ 0	Use the value specified in the parameter ("0" value is permissible)
				< 0	Use the value configured in the "Torque limiting" configuration window". Tag Torque Limit: <TO>.TorqueLimiting.LimitDefaults.Torque Tag Force Limit: <TO>.TorqueLimiting.LimitDefaults.Force
Mode	INPUT	DINT	0	0	Force/torque limiting
				1	Fixed stop detection If drive and telegram support force/torque limiting, this is applied.
InClamping	OUTPUT	BOOL	FALSE	TRUE	Mode = 1: The drive is kept at the fixed stop (clamping), the axis position is within the positioning tolerance.
InLimitation	OUTPUT	BOOL	FALSE	TRUE	Mode = 0 and 1: Drive is operating at the force/torque limit.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

Changes to input parameters "Limit" and "Mode" are also transferred at the cyclic call of the Motion Control instruction when "Enable = TRUE".

See also

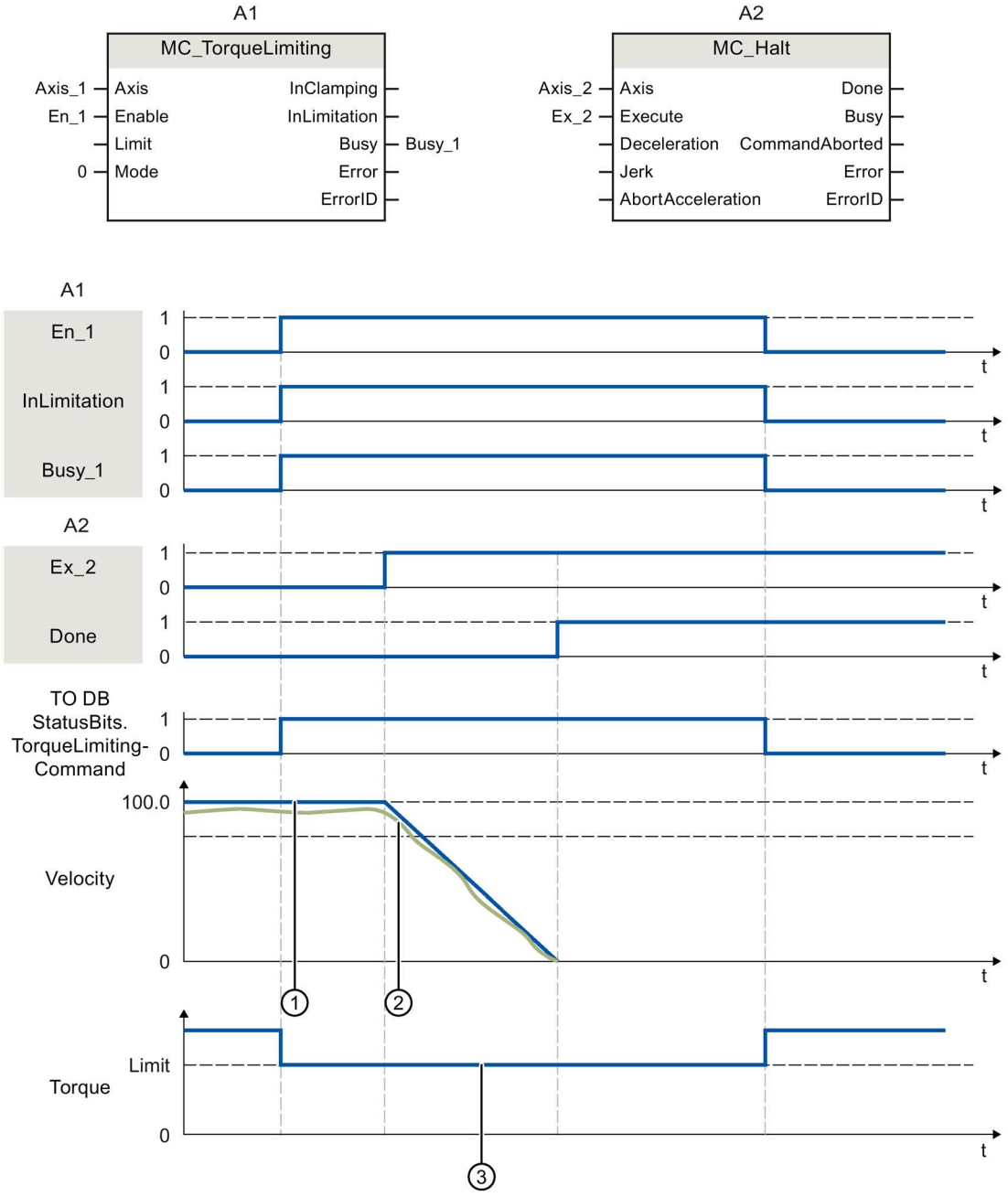
Force/torque limiting (Page 63)

Fixed stop detection (Page 65)

Error ID for Motion Control instructions (Page 559)

11.1.10.2 MC_TorqueLimiting: Function chart V3

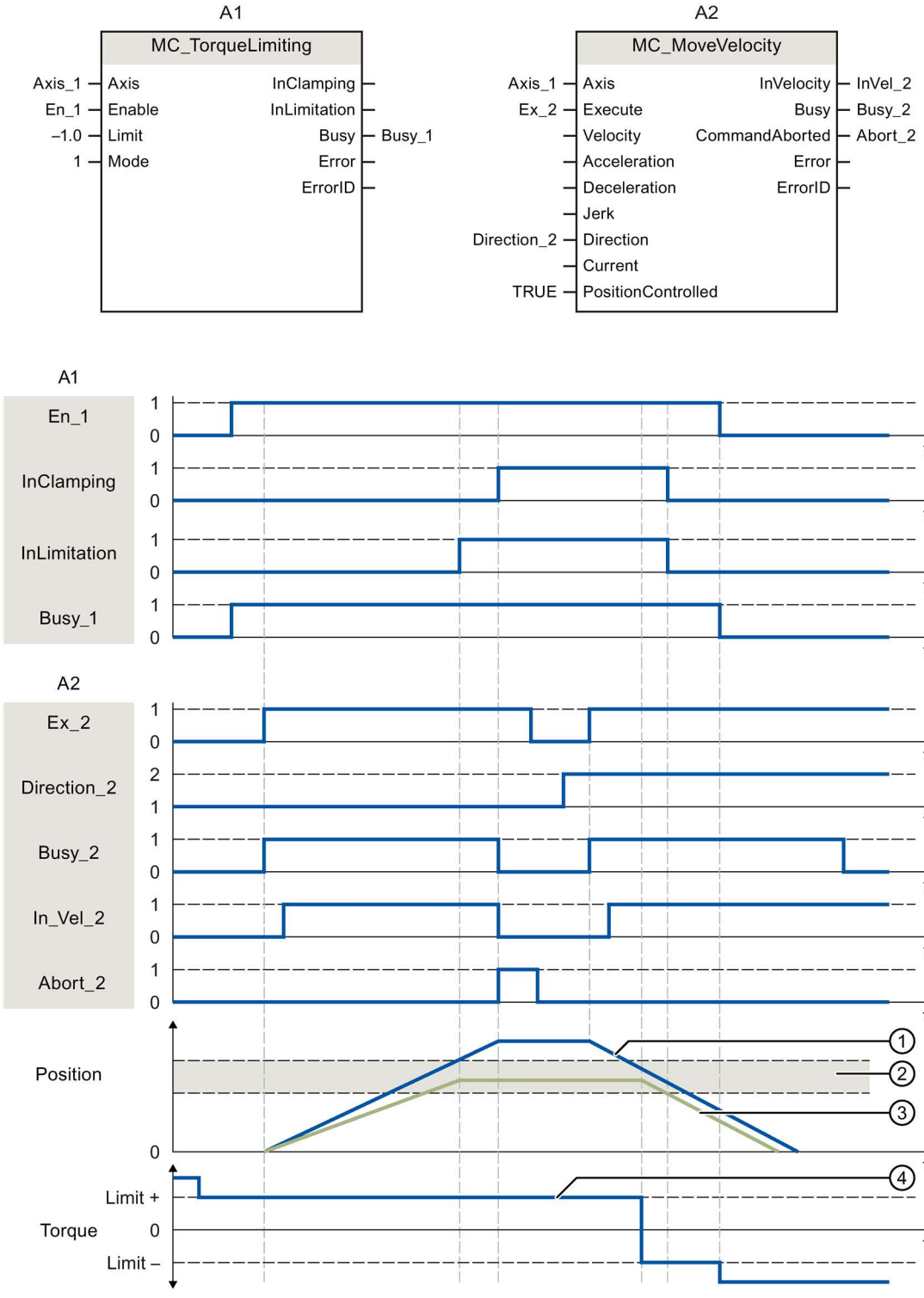
Function chart: Stopping an axis when the torque limit is reached



① Velocity setpoint
② Actual velocity
③ Torque

A "MC_Halt" Motion Control instruction is executed for an axis with active torque limiting "MC_TorqueLimiting". Torque limiting still "MC_TorqueLimiting.Enable" remains TRUE (active) and any accumulated following error is retained and will be reduced. When the actual velocity is "0.0" and the minimum dwell time in the standstill window has expired, "MC_Halt.Done" = TRUE". When position monitoring is activated, reaching of the target position is also monitored.

Function chart: Torque limiting with fixed stop detection (mode = 1)



① Actual position remains
② Target position reached (position setpoint)

③ Positioning tolerance
④ Torque

A "MC_MoveVelocity" Motion Control instruction is executed for an axis with active torque limiting "MC_TorqueLimiting". The torque limiting "MC_TorqueLimiting.Enable" is still TRUE (active) and the configured following error is reduced. When reaching the following error limit, the Motion Control instruction "MC_MoveVelocity" is canceled with "Abort" = TRUE. The drive is kept at the fixed stop (clamping), the axis position is within the positioning tolerance. The Motion Control instruction "MC_MoveVelocity" is called again with "Execute" = TRUE, and the axis is moved with constant velocity.

11.1.11 Measuring input, output cam, cam track

11.1.11.1 MC_MeasuringInput V3

MC_MeasuringInput: Start measuring once V3

With the Motion Control instruction "MC_MeasuringInput", a one-time measuring is started.

With the one-time measuring, one or two edges can be detected with one measuring job. The position of the respective technology object axis or external encoder is assigned to the measuring event. The measurement result is indicated in the function block and in the technology data block and can be further processed in the user program. This completes the measuring job.

Another measuring job must be started again using "MC_MeasuringInput.Execute" = TRUE.

Applies to

- Measuring input

Requirements

- The technology object has been configured correctly.
- The encoder of the axis must have "valid" status (StatusSensor[1..4].State = valid). Otherwise, the measuring job is rejected in the function block with an error indication.
- Measuring using PROFIdrive is not possible during active or passive homing.

Override response

The override characteristics for "MC_MeasuringInput" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of Motion Control instruction "MC_MeasuringInput":

Parameters	Declaration	Data type	Default value	Description	
MeasuringInput	INPUT	TO_Measuring-Input	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start job with a positive edge	
Mode	INPUT	DINT	0	Type of measurement	
				0	Measurement of next positive edge
				1	Measurement of next negative edge
				2	Measurement of next two edges
				3	Measurement of two edges, beginning with the positive edge • Positive edge = "MeasuredValue1" (measured value 1) • Negative edge = "MeasuredValue2" (measured value 2)
				4	Measurement of two edges, beginning with the negative edge • Negative edge = "MeasuredValue1" • Positive edge = "MeasuredValue2"
MeasuringRange	INPUT	BOOL	FALSE	Acquisition of measured values Observe the time-related boundary conditions (Page 125).	
				FALSE	Always acquire measured values
				TRUE	Acquire measured values only within the measuring range
StartPosition	INPUT	LREAL	0.0	Start position of the measuring range For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
EndPosition	INPUT	LREAL	0.0	End position of the measuring range For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
Done	OUTPUT	BOOL	FALSE	TRUE	The block has been completely processed. Measured values are valid.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The measuring job has been aborted.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.

Parameters	Declaration	Data type	Default value	Description
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"
MeasuredValue1	OUTPUT	LREAL	0.0	First measured value
MeasuredValue2	OUTPUT	LREAL	0.0	Second measured value (for measurement of two edges)

See also

Time-related boundary conditions (Page 125)

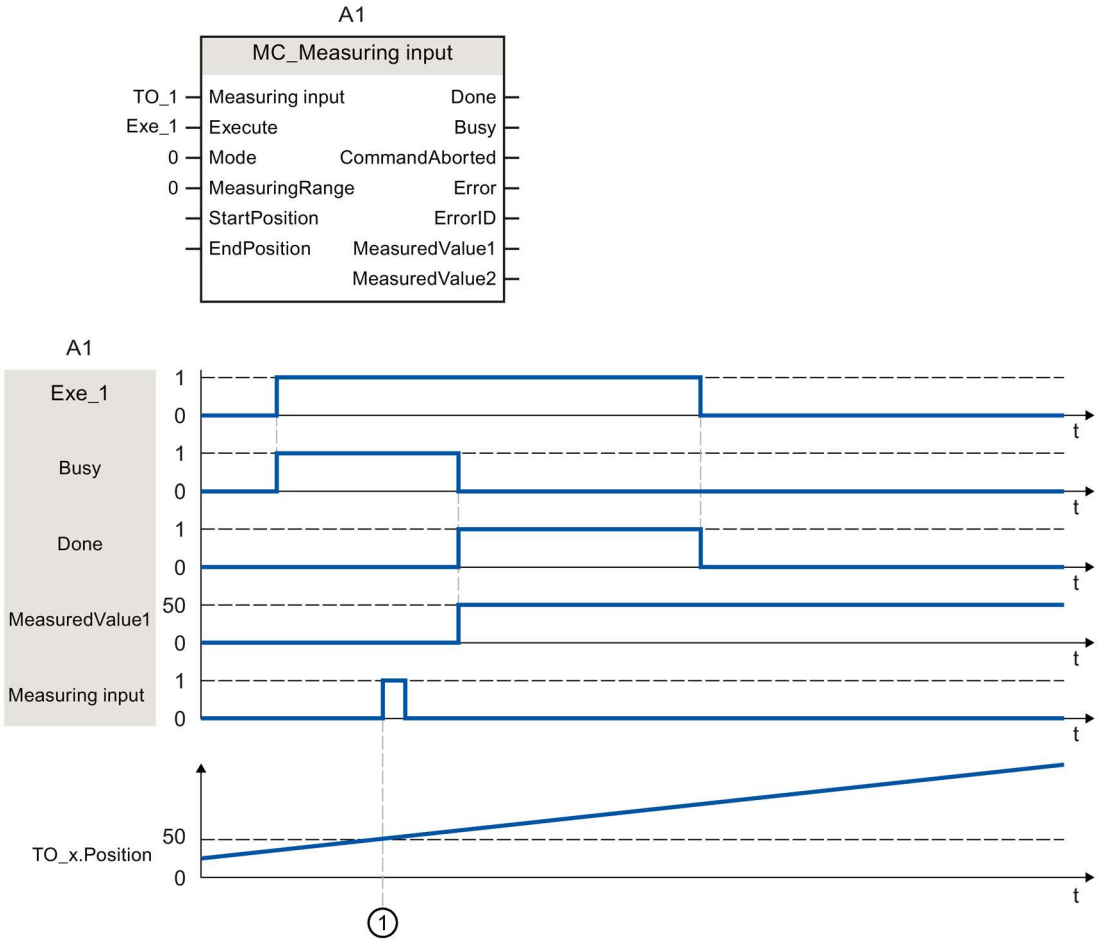
One-time measurement (Page 118)

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

MC_MeasuringInput: Function chart V3

Function chart: Start measuring job once



A "MC_MeasuringInput" job with "Mode" = 0 initiated using "Execute" performs a measurement of the next positive edge. A successfully completed measurement is signaled with "Done" = TRUE. The determined measured value ① (in example: 50) is output using "MeasuredValue1".

11.1.11.2 MC_MeasuringInputCyclic V3

MC_MeasuringInputCyclic: Start cyclic measuring V3

With the Motion Control instruction "MC_MeasuringInputCyclic", a cyclic measuring is started.

With cyclic measuring, up to two measuring events are detected by the system and the associated measuring positions displayed. The measurements are continued cyclically until they are ended per command.

Applies to

- Measuring input

Requirements

- The technology object has been configured correctly.
- Cyclic measuring is only possible when measuring using TM Timer DIDQ.
- The operationally active encoder of the axis must have "valid" status (StatusSensor[1..4].State = valid). Otherwise, the measuring job is rejected in the function block with an error indication.

Override response

The override characteristics for "MC_MeasuringInputCyclic" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of Motion Control instruction "MC_MeasuringInputCyclic":

Parameters	Declaration	Data type	Default value	Description	
MeasuringInput	INPUT	TO_Measuring-Input	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start job with a positive edge	
Mode	INPUT	DINT	0	Type of measurement	
				0	Measurement of positive edges
				1	Measurement of negative edges
				2	Measurement of both edges
MeasuringRange	INPUT	BOOL	FALSE	Acquisition of measured values Observe the time-related boundary conditions (Page 125).	
				FALSE	Always acquire measured values

Parameters	Declaration	Data type	Default value	Description	
				TRUE	Acquire measured values only within the measuring range
StartPosition	INPUT	LREAL	0.0	Start position of the measuring range For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
EndPosition	INPUT	LREAL	0.0	End position of the measuring range For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The measuring job has been aborted.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	
MeasuredValue1	OUTPUT	LREAL		First measured value	
MeasuredValue2	OUTPUT	LREAL		Second measured value (when measuring multiple edges in one position control cycle)	
Meas-uredValue1Counter	OUTPUT	UDINT	0	Count value for the first measured value	
Meas-uredValue2Counter	OUTPUT	UDINT	0	Count value for the second measured value	
LostEdgeCounter1	OUTPUT	UDINT	0	Count value for the lost edges in the cycle clock of the first measured value acquisition	
LostEdgeCounter2	OUTPUT	UDINT	0	Count value for the lost edges in the cycle clock of the second measured value acquisition	

See also

Time-related boundary conditions (Page 125)

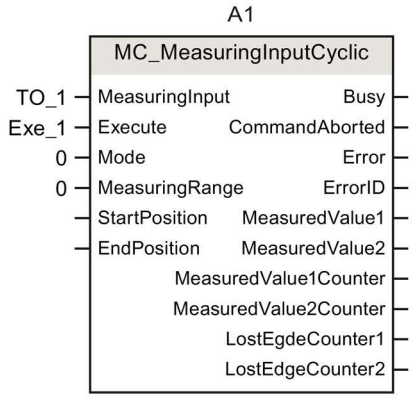
Cyclic measuring (Page 119)

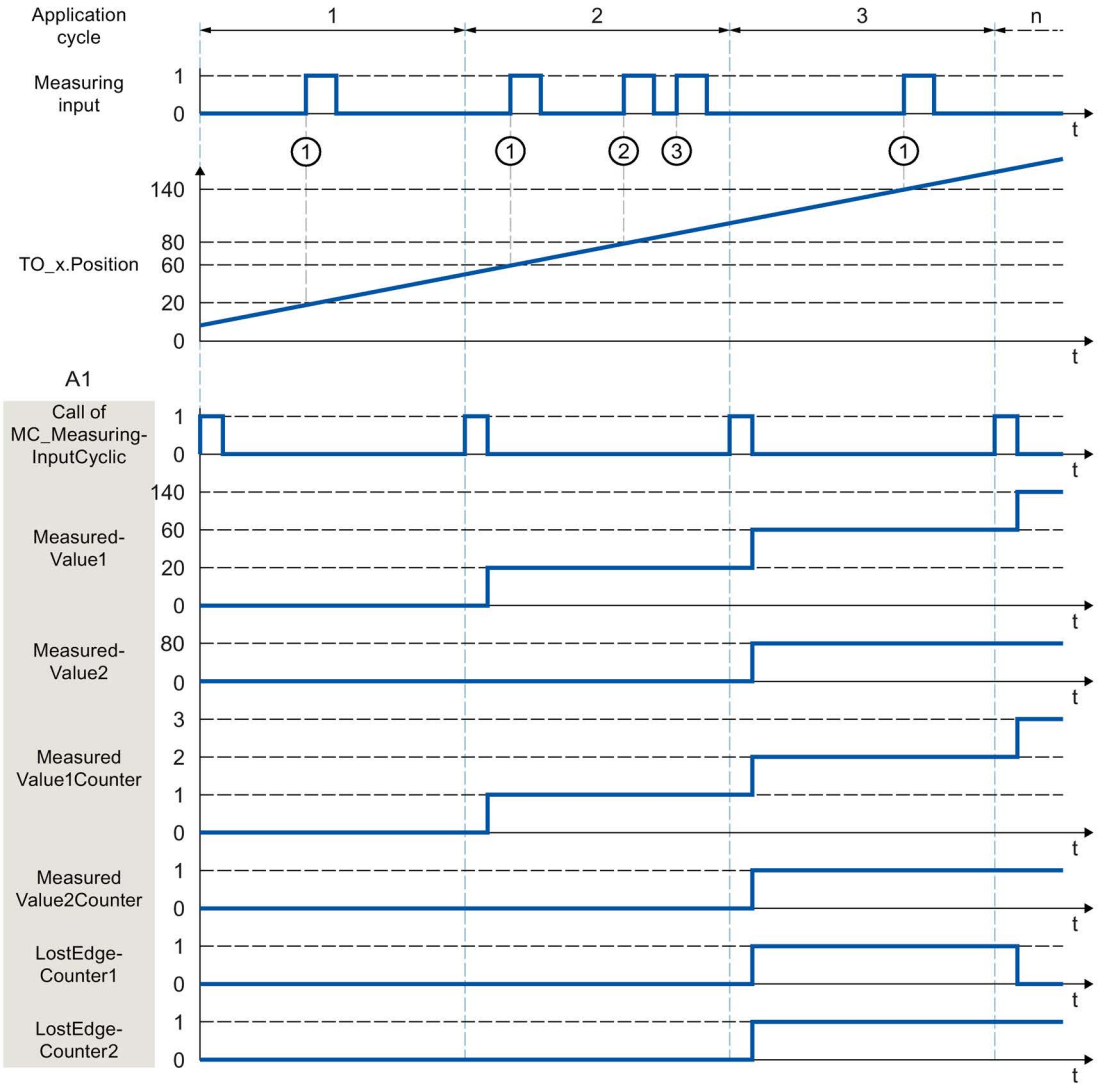
Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

MC_MeasuringInputCyclic: Function chart V3

Function chart: Start cyclic measuring job





A "MC_MeasuringInputCyclic" command initiated using "Execute" (signal and start point not shown) (e.g. call in MC-PreServo [OB67]) with "Mode" = 0 and without specified measuring range "MeasuringRange" = FALSE performs a measurement of the positive edges. By

calling the Motion Control instruction "MC_MeasuringInputCyclic" in MC-PreServo [OB67] or MC-PreServo [OB67], the measuring command as well as the measurement itself is called in the same application cycle.

The actual position determined at the time of the first positive edge ① in the position control cycle is output using "MeasuredValue1", and count tag "MeasuredValue1Counter" is incremented by "1".

The actual position determined at the time of the second positive edge ② in the position control cycle is output using "MeasuredValue2", and count tag "MeasuredValue2Counter" is incremented by "1".

If additional positive edges occur in the same position control cycle ③, these are recorded in LostEdgeCounter1 and LostEdgeCounter2.

11.1.11.3 MC_AbortMeasuringInput V3

MC_AbortMeasuringInput: Abort active measuring V3

With the Motion Control instruction "MC_AbortMeasuringInput", an active one-time or cyclic measuring job is aborted.

Applies to

- Measuring input

Requirements

- The technology object has been configured correctly.

Override response

The override characteristics for "MC_AbortMeasuringInput" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Parameters

The following table shows the parameters of Motion Control instruction "MC_AbortMeasuringInput":

Parameters	Declaration	Data type	Default value	Description	
MeasuringInput	INPUT	TO_Measuring-Input	-	Technology object	
Execute	INPUT	BOOL	FALSE	Start job with a positive edge	
Done	OUTPUT	BOOL	0	The function block has been processed. The measuring job has been deactivated.	
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job has been aborted.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

See also

Technology object measuring input (Page 115)

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

11.1.11.4 MC_OutputCam V3

MC_OutputCam: Activate/deactivate cam V3

Description

You use Motion Control instruction "MC_OutputCam" to activate the specified cam.

Depending on the cam type, the following input parameters are in effect:

- Distance output cam
  - "OnPosition"
  - "OffPosition"
- Time-based output cam
  - "OnPosition"
  - "Duration"

You define the operating mode and the effective direction of the cam with parameters "Mode" and "Direction".

When "MC_OutputCam.Enable" = TRUE, the input parameters are always read and take effect at the next position control cycle.

When a technological alarm occurs, the cam is processed again after error acknowledgment.

Applies to

- Output cam

Requirements

- The technology object has been configured correctly.
- The higher-level technology object must have a valid position.
- Setpoint output cams are not output for an axis in non-position-controlled operation.
- A setpoint output cam with the setting "MC_OutputCam.OnPosition" = 0 switches at position setpoint = 0.

Override response

The "MC_OutputCam" is canceled by:

- Disabling of the cam with "MC_OutputCam.Enable" = FALSE
- Only one instance of the "MC_OutputCam" function block can be active on an output cam in the user program. A second instance of the "MC_OutputCam" function block on a currently active output cam is rejected with an error.

Parameters

The following table shows the parameters of Motion Control instruction "MC_OutputCam":

Parameters	Declaration	Data type	Default value	Description	
OutputCam	INPUT	TO_OutputCam	-	Technology object	
Enable	INPUT	BOOL	FALSE	FALSE	Cam is disabled
				TRUE	Cam is being processed
OnPosition	INPUT	LREAL	0.0	Start position of the cam [unit of measurement of the interconnected technology object] For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
OffPosition	INPUT	LREAL	0.0	End position of the distance output cam [unit of measurement of the interconnected technology object] For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
Duration	INPUT	LREAL	0.0	Switch-on duration of the time-based output cam [unit of measurement: ms] The value for the switch-on duration of a time-based output cam must be greater than 0.0.	
Mode	INPUT	DINT	1	Operating mode	
				1	Standard Cam functionality (output not inverted)
				2	Cam functionality with inverted output
				3	Cam always ON (while "Enable" = TRUE)
Direction	INPUT	DINT	1	Activation direction of the cam	
				1	Positive direction
				2	Negative direction
				3	Both directions
CamOutput	OUTPUT	BOOL	-	Status display based on last call of Motion Control instruction "MC_OutputCam"	
Busy	OUTPUT	BOOL	FALSE	TRUE	Processing of the cam is active.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"	

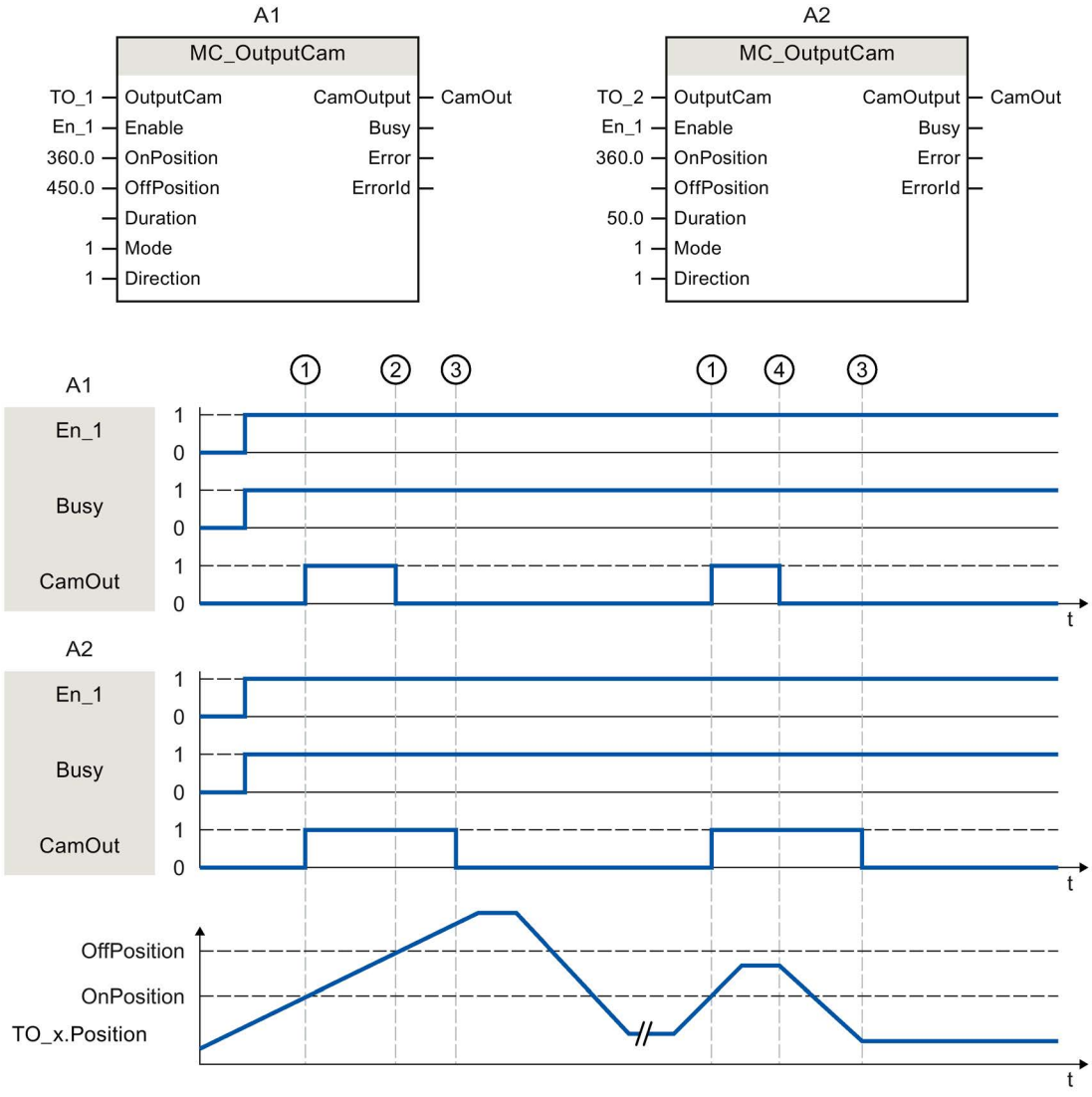
See also

Technology object output cam (Page 129)

Error ID for Motion Control instructions (Page 559)

MC_OutputCam: Function chart V3

Function chart: Activate the specified cam type



A1 Distance output cam

A2 Time-based output cam

A cam is activated with "Enable" = TRUE. The cam is output corresponding to the parameters.

The processing of the cam is indicated with "Busy" = TRUE.

When activation direction "Direction" = 1 (positive) is set, the cam behaves as follows, regardless of the cam type setting:

- The distance output cam switches on at "OnPosition" ① and switches off again at "OffPosition" ②. At a direction reversal the cam is switched off ④.
- The time-based output cam switches on at "OnPosition" ① and switches off again after expiration of the specified time "Duration" ③. A switched on time-based output cam remains active for the specified switch-on duration "Duration", even if overtravel of the start position occurs again in the reverse direction.

The switching state of the cam is output using "CamOutput".

With "Enable" = FALSE, the specified cam type is deactivated. "Busy" = FALSE shows that the cam is not being processed.

11.1.11.5 MC_CamTrack V3

MC_CamTrack: Activate/deactivate cam track V3

Description

With the Motion Control instruction "MC_CamTrack", the processing of a cam track is enabled.

Applies to

- Cam track

Requirements

- The technology object has been configured correctly.
- The higher-level technology object must have a valid position.
- Setpoint output cams are not output for an axis in non-position-controlled operation.

Override response

- The "MC_CamTrack" is aborted by the disabling of the cam track with "MC_CamTrack.Enable" = FALSE.
- Only one instance of the "MC_CamTrack" function block can be active on a cam track in the user program. A second instance of the "MC_CamTrack" function block on a currently active cam track is rejected with an error.
- The cam track is recalculated at a change of the parameters of the Motion Control instruction "MC_CamTrack" or in the technology data block. The cam track is processed in accordance with all parameter settings.

Parameters

The following table shows the parameters of Motion Control instruction "MC_OutputCam":

Parameters	Declaration	Data type	Default value	Description		
CamTrack	INPUT	TO_CamTrack	-	Technology object		
Enable	INPUT	BOOL	FALSE	FALSE	Cam track is disabled	
				TRUE	Cam track is processed	
Mode	INPUT	INT	1	0	"Enable" = TRUE	Cam track processing is activated immediately Cam track data takes effect immediately Previously activated distance output cams are aborted if their track signal is not still set due to the changed cam track data. Previously activated time-based output cams are always aborted.
					"Enable" = FALSE	Cam track processing is stopped immediately, distance output/time-based output cams are aborted immediately.
				1	"Enable" = TRUE	Cam track processing is activated immediate-ly/with the next track cycle: • When a cam track is activated for the first time, the cam track processing begins immediately. • If the cam track processing is already active, the current cam track is output up to the end of the track cycle. The new cam track data then takes effect.
					"Enable" = FALSE	Cam track processing is ended at the end of the cam track

Parameters	Declaration	Data type	Default value	Description		
				2	"Enable" = TRUE	Cam track output is switched on immediately and remains switched on
					"Enable" = FALSE	Cam track output is switched off immediately
InvertOutput	INPUT	BOOL	FALSE	Inverted output		
				TRUE	Track output is output inverted	
				FALSE	Track output is output not inverted	
TrackOutput	OUTPUT	BOOL	-	Indicates the switching state of the cam track.		
Busy	OUTPUT	BOOL	FALSE	TRUE	Processing of the cam track is active.	
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.	
ErrorID	OUTPUT	WORD	16#0000	Error ID (Page 559) for parameter "ErrorID"		

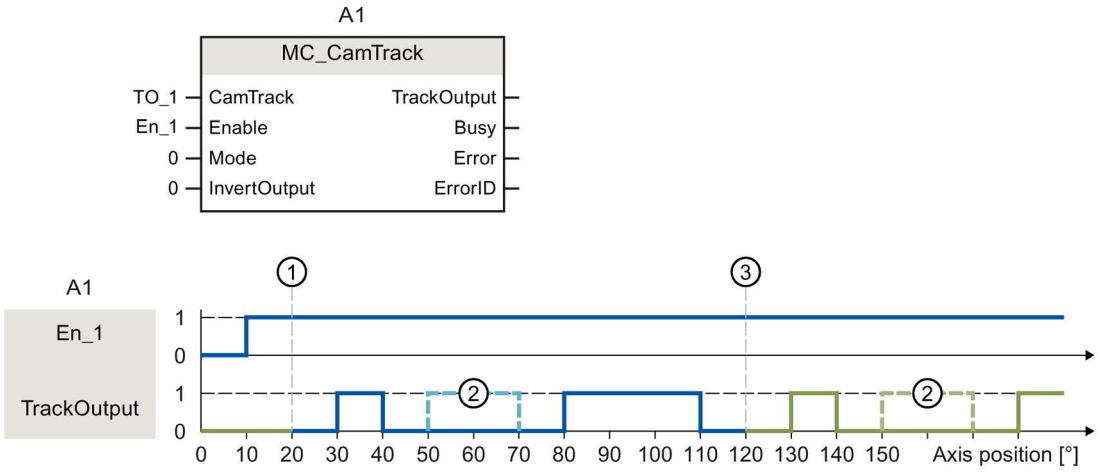
See also

Cam track technology object (Page 145)

Error ID for Motion Control instructions (Page 559)

MC_CamTrack: Function chart V3

Function chart: Activate cam track



① Axis reference position
② Cam configured as invalid
③ Start of cyclically continued cam track

A cam track is activated with "Enable" = TRUE. The cam track is output in accordance with the parameters set in the technology data block.

Tag		Value	Description
<TO>Parameter.			
	CamTrackType	0	Specified cam type for the cam track is distance output cam
	ReferencePosition	20.0	Specified axis reference position for the cam track
	CamTrackLength	100.0	Specified length of the cam track
	CamTrack[1].Existent	TRUE	The first distance output cam of the cam track is specified as valid
	CamTrack[1].OnPosition	10.0	Start position for the first cam of the cam track
	CamTrack[1].OffPosition	20.0	End position for the first cam of the cam track
	CamTrack[2].Existent	FALSE	The second distance output cam of the cam track is specified as invalid
	CamTrack[2].OnPosition	30.0	Start position for the second cam of the cam track
	CamTrack[2].OffPosition	50.0	End position for the second cam of the cam track
	CamTrack[3].Existent	TRUE	The third distance output cam of the cam track is specified as valid
	CamTrack[3].OnPosition	60.0	Start position for the third cam of the cam track
	CamTrack[3].OffPosition	90.0	End position for the third cam of the cam track

11.1.12 Synchronous motion

11.1.12.1 MC_GearIn V3

MC_GearIn: Start gear synchronization V3

Description

With the Motion Control instruction "MC_GearIn, you start a gearing (Page 110) operation between a leading axis and a following axis.

You define the dynamic behavior of the following axis for synchronization with parameters "Jerk", "Acceleration" and "Deceleration".

The synchronization duration and distance are dependent on the following parameters:

- Start time of the "MC_GearIn" job
- Dynamics of the following axis at the start time
- Dynamic settings for synchronization
- Dynamics of the leading axis

You specify the gear ratio as the relationship between two integers (numerator/denominator) with the parameters "RatioNumerator" and "RatioDenominator".

The numerator of the gear ratio is specified as positive or negative. This yields the following behavior:

- **Positive gear ratio:**

  The leading and following axes move in the same direction.

- **Negative gear ratio**:

  The following axis moves in the opposite direction of the leading axis.

You can start synchronous operation when the leading axis is at a standstill or when it is in motion.

Applies to

- Synchronous axis

Requirements

- The technology objects of the leading axis and the following axis have been configured correctly.
- The leading axis is a positioning axis, synchronous axis, or external encoder.
- The following axis is a synchronous axis.
- The leading axis is specified as possible leading axis in the configuration of the following axis in "Technology object > Configuration > Leading value interconnections".
- The following axis is enabled.

Override response

The override characteristics for "MC_GearIn" jobs are described in section Override response of Motion Control commands V3 (Page 439).

Disabling the leading axis with "MC_Power.Enable" = FALSE does not abort synchronous operation. The following axis follows the leading axis even during the braking ramp and after the leading axis is enabled again.

Parameters

The following table shows the parameters of Motion Control instruction "MC_GearIn":

Parameters	Declaration	Data type	Default value	Description
Master	INPUT	TO_Axis	-	Leading axis technology object
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object
Execute	INPUT	BOOL	FALSE	Start job with a positive edge
RatioNumerator	INPUT	DINT	1	Gear ratio numerator Permitted integer values: -2147483648 to 2147483648 (value 0 not permitted)
RatioDenominator	INPUT	DINT	1	Gear ratio denominator Permitted integer values: 1 to 2147483648
Acceleration	INPUT	LREAL	-1.0	Acceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration Value > 0.0: The specified value is used. Value = 0.0: Not permitted Value < 0.0: The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk Value > 0.0: Constant-acceleration velocity profile; the specified jerk is used Value = 0.0: Trapezoid velocity profile Value < 0.0: The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)

Parameters	Declaration	Data type	Default value	Description	
InGear	OUTPUT	BOOL	FALSE	TRUE	Synchronous operation reached The following axis is synchronized and moves synchronously to the leading axis.
Busy	OUTPUT	BOOL	FALSE	TRUE	Job is running.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID (Page 559) for parameter "ErrorID"	

Starting synchronous operation

To start synchronous operation with the Motion Control instruction "MC_GearIn", follow these steps:

1. Check the requirements indicated above.
2. Specify the leading axis, the following axis and the gear ratio at the corresponding parameters.
3. Start the "MC_GearIn" job with a positive edge at parameter "Execute".

The following axis is synchronized to the leading value of the leading axis. If the "InGear" parameter shows the value TRUE, the following axis is synchronized and moves synchronously to the leading axis. The parameters "InGear" and "Busy" show the value TRUE until the "MC_GearIn" job is overridden by another Motion Control job.

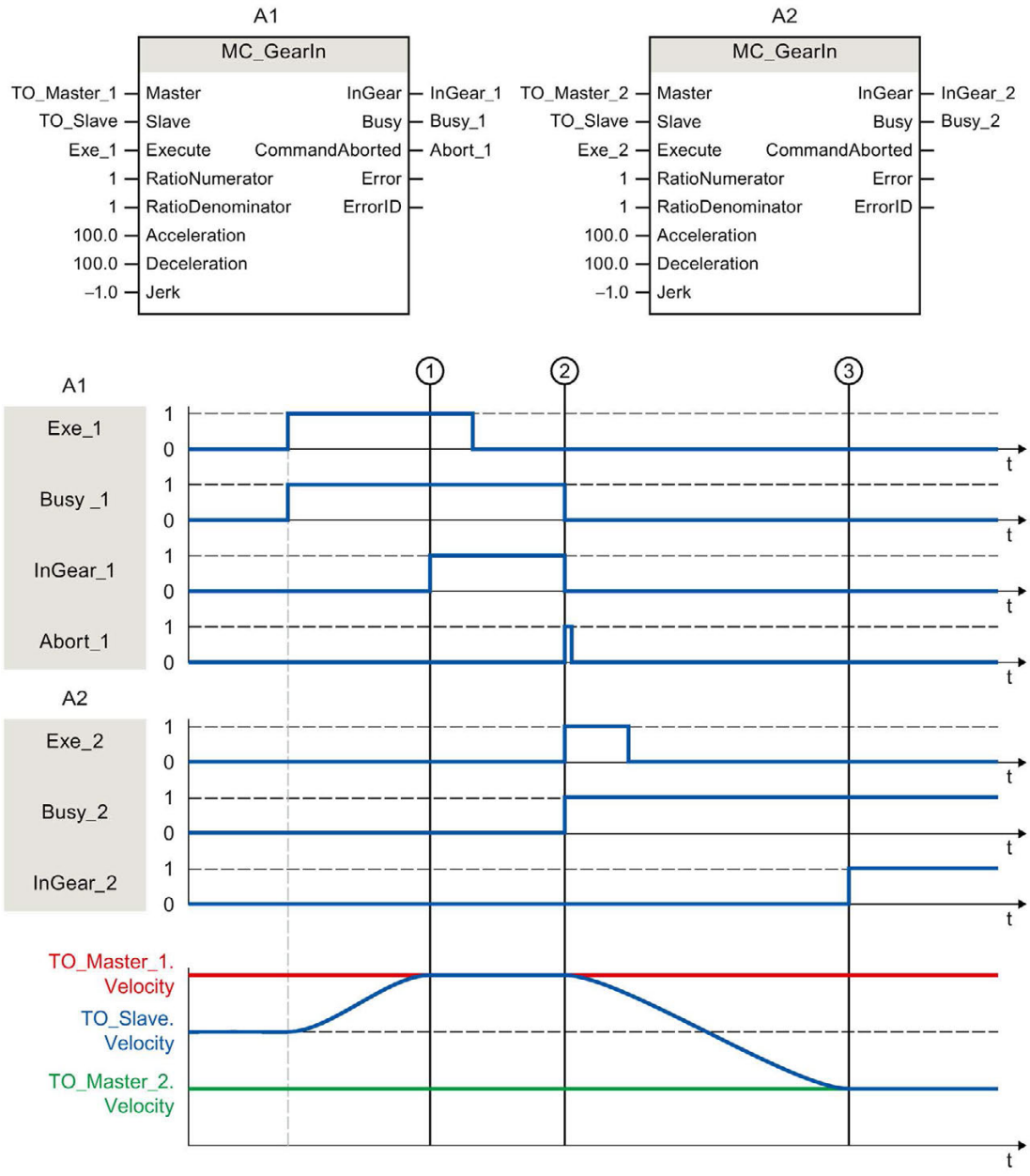
See also

Override response of Motion Control commands V3 (Page 439)

Error ID for Motion Control instructions (Page 559)

MC_GearIn: Function chart V3

Function chart: Synchronizing and switching the leading value



Using "Exe_1", an "MC_GearIn" job (A1) is initiated. The following axis (TO_Slave) is synchronized to the leading axis (TO_Master_1). "InGear_1" signals at time ① that the following axis is synchronized and moves synchronously to the leading axis.

At time ②, synchronous operation is overridden by another "MC_GearIn" job (A2). The abort is signaled via "Abort_1". The following axis is synchronized to the new leading axis (TO_Master_2). "InGear_2" signals at time ③ that the following axis is synchronized and moves synchronously to the leading axis.

11.1.13 Override response of Motion Control commands V3

Homing and motion jobs

The following table shows how a new Motion Control job affects active homing and motion jobs:

⇒ Active job ⇓ New job	MC_Home Mode = 2, 8, 10	MC_Home Mode = 3, 5	MC_Halt	MC_Move Absolute	MC_Move Relative	MC_Move Velocity	MC_Move Jog	MC_Move Super imposed
MC_Home Mode = 3, 5	A	A	A	A	A	A	A	A
MC_Home Mode = 9	A	-	-	-	-	-	-	-
MC_Halt	-	A	A	A	A	A	A	A
MC_Move Absolute	-	A	A	A	A	A	A	A
MC_Move Relative	-	A	A	A	A	A	A	A
MC_Move Velocity	-	A	A	A	A	A	A	A
MC_MoveJog	-	A	A	A	A	A	A	A
MC_Move Superimposed	-	-	-	-	-	-	-	A
MC_GearIn	-	A	A	A	A	A	A	A
MC_GearInPos pending (Busy = TRUE, StartSync = FALSE, InSync = FALSE)	-	-	-	-	-	-	-	-
MC_GearInPos active (Busy = TRUE, StartSync or InSync = TRUE)	-	A	A	A	A	A	A	A
MC_CamIn pending (Busy = TRUE, StartSync = FALSE, InSync = FALSE)	-	-	-	-	-	-	-	-
MC_CamIn active (Busy = TRUE, StartSync or InSync = TRUE)	-	A	A	A	A	A	A	A

A The running job is aborted with "JobAborted" = TRUE. The current dynamics is smoothly transitioned to the dynamic values of the new job.

- No effect, running job continues to be executed

Synchronous operation jobs

The following table shows how a new Motion Control job affects the motion of the axis on active synchronous operation jobs:

⇒ Active job ⇓ New job	MC_ GearIn	MC_GearIn-Pos pending (Busy = TRUE, InSync = FALSE, StartSync = FALSE)	MC_GearIn Pos active (Busy = TRUE, StartSync or InSync = TRUE)	MC_ Phasing Absolute	MC_ Phasing Relative	MC_CamIn pending (Busy = TRUE, InSync = FALSE, StartSync = FALSE)	MC_CamIn active (Busy = TRUE, StartSync or InSync = TRUE)
MC_Home Mode = 3, 5	A	-	A	A	A	-	A
MC_Halt	A	-	A	A	A	-	A
MC_MoveAbsolute	A	-	A	A	A	-	A
MC_MoveRelative	A	-	A	A	A	-	A
MC_MoveVelocity	A	-	A	A	A	-	A
MC_MoveJog	A	-	A	A	A	-	A
MC_MoveSuperimposed	-	-	-	-	-	-	-
MC_GearIn	A	A	A	A	A	A	A
MC_GearInPos pending (Busy = TRUE, StartSync = FALSE, InSync = FALSE)	-	A	-	-	-	A	-
MC_GearInPos active (Busy = TRUE, StartSync or InSync = TRUE)	A	A	A	A	A	A	A
MC_PhasingAbsolute	-	-	-	A	A	-	-
MC_PhasingRelative	-	-	-	A	A	-	-
MC_CamIn pending (Busy = TRUE, StartSync = FALSE, InSync = FALSE)	-	A	-	-	-	A	-
MC_CamIn active (Busy = TRUE, StartSync or InSync = TRUE)	A	A	A	A	A	A	A

A The running job is aborted with "JobAborted" = TRUE. The current dynamics is smoothly transitioned to the dynamic values of the new job.

- No effect, running job continues to be executed

A pending synchronous operation (Busy = TRUE, StartSync = FALSE, InSync = FALSE) does not cancel active commands. Only a pending synchronous operation command is permitted. A second pending synchronous operation command cancels the first pending synchronous operation command.

When one synchronous operation command is active and one synchronous operation command is pending, a new motion command cancels the active as well as the pending synchronous operation command.

Measuring input

The following table shows which new Motion Control jobs will override active measuring input jobs:

⇒ Active job ⇓ New job	MC_MeasuringInput	MC_MeasuringInputCyclic
MC_Home Mode = 2, 3, 5, 8, 9, 10	A	A
MC_Home Mode = 0, 1, 6, 7	-	-
MC_MeasuringInput	A	A
MC_MeasuringInputCyclic	A	A
MC_AbortMeasuringInput	A	A

A The running job is aborted with "JobAborted" = TRUE. The new job will be executed.

- No effect, running job continues to be executed

Appendix A

A.1 Tags of the speed axis technology object

A.1.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed directly and take effect at the start of the next MC-Servo [OB91].
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC-Servo [OB91] after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

A.1.2 Actual values and setpoints (speed axis)

The following tags indicate the setpoint and actual values of the technology object.

Tags

Legend (Page 442)

Tag	Data type	Values	W	Description
Velocity	LREAL	-	RON	Setpoint velocity / setpoint speed
ActualSpeed	LREAL	-	RON	Actual speed of the motor (with analog setpoint = 0.0)
Acceleration	LREAL	-	RON	Setpoint acceleration

A.1.3 Variable simulation (speed axis)

The tag structure <TO>.Simulation.<tag name> contains the configuration of the simulation mode. In simulation mode, you can simulate axes without a real drive in the CPU.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
Simulation.		STRUCT			
	Mode	UDINT	-	RES[1)]	Simulation mode 0: No simulation, normal operation 1: Simulation mode

1) Technology version V2.0: RON

A.1.4 VirtualAxis tag (speed axis)

The tag structure <TO>.VirtualAxis.<tag name> contains the configuration of the simulation mode. In simulation mode, you can simulate axes without a real drive in the CPU.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
VirtualAxis.		STRUCT			
	Mode	UDINT	-	RON	Virtual axis 0: No virtual axis 1: Axis is always and exclusively operated in simulation

A.1.5 Actor tags (speed axis)

The tag structure <TO>.Actor.<tag name> contains the controller-side configuration of the drive.

Tags

Legend (Page 442)

Tag	Data type	Values	W	Description
Actor.	STRUCT			
Type	DINT	-	RON	Drive connection 0: Analog output 1: PROFIdrive telegram
InverseDirection	BOOL	-	RES	Inversion of the setpoint FALSE: no TRUE: Yes
DataAdaption	DINT	-	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque in the device 0: No automatic transfer, manual configuration of values 1: Automatic transfer of values configured in the drive to the configuration of the technology object
Efficiency	LREAL	0.0 to 1.0	RES	Efficiency of gear
Interface.	STRUCT			
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram
AdressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram or the analog setpoint
EnableDriveOutput	BOOL	-	RES	"Enable output" for analog drives FALSE: disabled TRUE: Activated
EnableDriveOutput-Address	VREF	0 to 65535	RON	Address for the "Enable output" for analog setpoint
DriveReadyInput	BOOL	-	RES	"Ready input" for analog drives The analog drive signals its readiness to receive speed setpoints. FALSE: disabled TRUE: Activated
DriveReadyIn-putAddress	VREF	0 to 65535	RON	Address for the "Enable input" for analog setpoint

Tag			Data type	Values	W	Description
	DriveParameter.					
		ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the speed setpoint (N-set) of the drive The speed setpoint is transferred in the PROFIdrive telegram as a normalized value from -200% to 200% of the "ReferenceSpeed". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, provided the drive permits this.
		MaxSpeed	LREAL	0.0 to 1.0E12	RES	Maximum value for the speed setpoint of the drive (N-set) (PROFIdrive: MaxSpeed ≤ 2 × ReferenceSpeed Analog setpoint: MaxSpeed ≤ 1.17 × ReferenceSpeed)
		ReferenceTorque	LREAL	0.0 to 1.0E12	RES	Reference torque of drive (p2003). Valid for standard motor setting.

A.1.6 Torque Limiting tag (speed axis)

The tag structure <TO>.TorqueLimiting.<tag name> contains the configuration of the torque limiting.

Tags

Legend (Page 442)

Tag			Data type	Values	W	Description
TorqueLimiting.			STRUCT			
	LimitBase		DINT	-	RES	Torque limiting 0: Motor side 1: Load side
	PositionBased-Monitorings		DINT	-	RES	Positioning and following error monitoring 0: Monitoring deactivated 1: Monitoring activated
	LimitDefaults.		STRUCT			
		Torque	LREAL	0.0 to 1.0E12	CAL	Limiting torque
		Force	LREAL	0.0 to 1.0E12	CAL	Limiting force

A.1.7 LoadGear tags (speed axis)

The tag structure <TO>.LoadGear.<tag name> contains the configuration of the load gear.

Tags

Legend (Page 442)

Tag		Data type	Value range	W	Description
LoadGear.		STRUCT			
	Numerator	UDINT	1 to 4294967295	RES	Load gear numerator
	Denominator	UDINT	1 to 4294967295	RES	Load gear denominator

A.1.8 Units tags (speed axis)

The tag structure <TO>.Units.<tag name> shows the set technological units.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description	
Units.		STRUCT				
	VelocityUnit	UDINT	-	RON	Unit for velocity	
					1082	1/s
					1083	1/min
					1528	1/h
	TimeUnit	UDINT	-	RON	Unit for time	
					1054	s
	TorqueUnit	UDINT	-	RON	Unit for torque	
					1126	Nm
					1128	kNm
					1529	lbf in (pound-force-inch)
					1530	lbf ft
					1531	ozf in (ounce-force-inch)
					1532	ozf ft
					1533	pdl in (poundal-inch)
					1534	pdl ft
	ForceUnit	UDINT	-	RON	Unit for force	
					1120	N
					1122	kN
					1094	lbf (pound-force)
					1093	ozf (ounce-force)
					1535	pdl (poundals)

A.1.9 DynamicLimits tags (speed axis)

The tag structure <TO>.DynamicLimits.<tag name> contains the configuration of the dynamic limits. During Motion Control, no dynamic values greater than the dynamic limits are permitted. If you have specified greater values in a Motion Control instruction, then motion is performed using the dynamic limits, and a warning is indicated (alarm 501 to 503 - Dynamic values were limited).

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
DynamicLimits.		STRUCT			
	MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum permissible velocity of the axis
	MaxAcceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible acceleration of the axis
	MaxDeceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible deceleration of the axis
	MaxJerk	LREAL	0.0 to 1.0E12	DIR	Maximum permissible jerk on the axis

A.1.10 DynamicDefaults tags (speed axis)

The tag structure <TO>.DynamicDefaults.<tag name> contains the configuration of the dynamic defaults. These settings will be used when you specify a dynamic value less than 0.0 in a Motion Control instruction (exceptions: MC_MoveJog.Velocity, MC_MoveVelocity.Velocity). Changes to the default dynamic values will be applied at the next positive edge at the "Execute" parameter of a Motion Control instruction.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
DynamicDefaults.		STRUCT			
	Velocity	LREAL	0.0 to 1.0E12	CAL	Default velocity
	Acceleration	LREAL	0.0 to 1.0E12	CAL	Default acceleration
	Deceleration	LREAL	0.0 to 1.0E12	CAL	Default deceleration
	Jerk	LREAL	0.0 to 1.0E12	CAL	Default jerk
	EmergencyDeceleration	LREAL	0.0 to 1.0E12	DIR	Emergency stop deceleration

A.1.11 Override tags (speed axis)

The tag structure <TO>.Override.<tag name> contains the configuration for the override parameters. The override parameters are used to apply a correction percentage to default values. An override change takes effect immediately, and is performed with the dynamic settings in effect in the Motion Control instruction.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
Override.		STRUCT			
	Velocity	LREAL	0.0 to 200.0%	DIR	Velocity or speed override Percentage correction of the velocity/speed

A.1.12 StatusDrive tags (speed axis)

The tag structure <TO>.StatusDrive.<tag name> indicates the status of the drive.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
StatusDrive.		STRUCT			
	InOperation	BOOL	-	RON	Operational status of the drive FALSE: Drive not ready. Setpoints will not be executed. TRUE: Drive ready. Setpoints can be executed.
	CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and drive FALSE: Not established TRUE: Established
	Error	BOOL	-	RON	FALSE: No drive error TRUE: Drive error
	AdaptionState	DINT	-	RON	Status of automatic data transfer of drive parameters 0: "NOT_ADAPTED" (Data not transferred) 1: "IN_ADAPTION" (Data transfer in progress) 2: "ADAPTED" (Data transfer complete) 3: "NOT_APPLICABLE" (Data transfer not selected, not possible) 4: "ADAPTION_ERROR" (Error during data transfer)

A.1.13 StatusWord tag (speed axis)

The <TO>.StatusWord tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 0 "Enable") can be found in the section Evaluating StatusWord, ErrorWord and WarningWord (Page 298).

Tag

Legend (Page 442)

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status data of the technology object
Bit 0	-	-	-	"Enable" Enable status 0: Technology object disabled 1: Technology object enabled
Bit 1	-	-	-	"Error" 0: No error present 1: Error present
Bit 2	-	-	-	"RestartActive" 0: No "Restart" active 1: "Restart" active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" 0: "Restart" tags unchanged 1: Change to "Restart" tags. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"ControlPanelActive" Axis control panel 0: Deactivated 1: Activated
Bit 5	-	-	-	Reserved
Bit 6	-	-	-	"Done" 0: Motion job is running, or axis control panel active 1: No motion job is running and axis control panel deactivated
Bit 7	-	-	-	Reserved
Bit 8	-	-	-	Reserved
Bit 9	-	-	-	"JogCommand" 0: No "MC_MoveJog" job running 1: "MC_MoveJog" job running
Bit 10	-	-	-	"VelocityCommand" 0: No "MC_MoveVelocity" job running 1: "MC_MoveVelocity" job running
Bit 11	-	-	-	Reserved
Bit 12	-	-	-	"ConstantVelocity" 0: Axis is accelerating or decelerating. 1: Velocity setpoint reached. The axis is traversing at this constant velocity or is at a standstill.

Tag	Data type	Values	W	Description
Bit 13	-	-	-	"Accelerating" 0: No acceleration process active 1: Acceleration process active
Bit 14	-	-	-	"Decelerating" 0: No deceleration process active 1: Deceleration process active
Bit 15... Bit 24	-	-	-	Reserved
Bit 25	-	-	-	"AxisSimulation" 0: No simulation 1: Simulation is active
Bit 26	-	-	-	"TorqueLimitingCommand" 0: No "MC_TorqueLimiting" job is running 1: "MC_TorqueLimiting" job is running
Bit 27	-	-	-	"InLimitation" 0: Drive is not operating at the torque limit 1: Drive is operating at the torque limit
Bit 28... Bit 31	-	-	-	Reserved

A.1.14 ErrorWord tag (speed axis)

The <TO>.ErrorWord tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 442)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" System error
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4	-	-	-	"DriveFault" Error in drive
Bit 5	-	-	-	Reserved
Bit 6	-	-	-	"DynamicError" Specified dynamic values are limited to permissible values.
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8	-	-	-	Reserved
Bit 9	-	-	-	Reserved
Bit 10	-	-	-	Reserved
Bit 11	-	-	-	Reserved
Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14	-	-	-	Reserved
Bit 15	-	-	-	"AdaptionError" Error during data transfer
Bit 16... Bit 31	-	-	-	Reserved

A.1.15 ErrorDetail tags (speed axis)

The tag structure <TO>.ErrorDetail.<tag name> contains the alarm number and the effective local alarm reaction for the technology alarm that is currently pending for the technology object.

You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
ErrorDetail.		STRUCT			
	Number	UDINT	-	RON	Alarm number
	Reaction	DINT	0 to 5	RON	Effective alarm reaction 0: No reaction 1: Stop with current dynamic values 2: Stop with maximum dynamic values 3: Stop with emergency stop ramp 4: Remove enable 5: Track setpoints

A.1.16 WarningWord tag (speed axis)

The <TO>.WarningWord tag indicates pending warnings for the technology object.

Information on the evaluation of the individual bits (e.g. bit 13 "PeripheralWarning") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 442)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4	-	-	-	"DriveWarning" Error in drive
Bit 5	-	-	-	Reserved
Bit 6	-	-	-	"DynamicWarning" Specified dynamic values are limited to permissible values.
Bit 7				"CommunicationWarning" Communication error Missing or faulty communication.
Bit 8... Bit 12				Reserved
Bit 13				"PeripheralWarning" Error accessing a logical address
Bit 14				Reserved
Bit 15				"AdaptionWarning" Error in automatic data transfer
Bit 16... Bit 31	-	-	-	Reserved

A.1.17 ControlPanel tags (speed axis)

The tag structure <TO>.ControlPanel.<tag name> contains no user-relevant data. This tag structure is internally used.

Tags

Legend (Page 442)

Tag	Data type	Values	W	Description
ControlPanel.	STRUCT			
Input.	STRUCT			
TimeOut	LREAL	100 to 60000	DIR	
EsLifeSign	UDINT	-	DIR	
Command.	ARRAY [1..2] OF STRUCT			
ReqCounter	UDINT	-	DIR	-
Type	UDINT	-	DIR	-
Position	LREAL	-	DIR	-
Velocity	LREAL	-	DIR	-
Acceleration	LREAL	-	DIR	-
Deceleration	LREAL	-	DIR	-
Jerk	LREAL	-	DIR	-
Param	LREAL	-	DIR	-
Output.	STRUCT			
RTLifeSign	UDINT	-	RON	
Command.	ARRAY [1..2] OF STRUCT			
AckCounter	UDINT	-	RON	-
Error	BOOL	-	RON	-
ErrorID	UDINT	-	RON	-
Done	BOOL	-	RON	-
Aborted	BOOL	-	RON	-

A.1.18 InternalToTrace tags (speed axis)

The tag structure <TO>.InternalToTrace.<tag name> contains no user-relevant data. This tag structure is internally used.

Tags

Legend (Page 442)

Tag		Data type	Values	W	Description
InternalToTrace.		ARRAY [1..4] OF STRUCT			
	Id	DINT	-	DIR	-
	Value	LREAL	-	DIR	-

A.2 Tags of the positioning axis/synchronous axis technology object

A.2.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value (L - linear specification R - rotary specification) If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed directly and take effect at the start of the next MC-Servo [OB91].
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC-Servo [OB91] after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

A.2.2 Actual values and setpoints (positioning axis/synchronous axis)

The following tags indicate the setpoint and actual values of the technology object.

Tags

Legend (Page 456)

Tag	Data type	Values	W	Description
Position	LREAL	-	RON	Position setpoint
Velocity	LREAL	-	RON	Velocity setpoint / speed setpoint
ActualPosition	LREAL	-	RON	Actual position
ActualVelocity	LREAL	-	RON	Actual velocity
ActualSpeed	LREAL	-	RON	Actual speed of the motor (with analog setpoint = 0.0)
Acceleration	LREAL	-	RON	Setpoint acceleration
ActualAcceleration	LREAL	-	RON	Actual acceleration
OperativeSensor	UDINT	1 to 4	RON	Operative encoder

A.2.3 Simulation tag (positioning axis / synchronous axis)

The tag structure <TO>.Simulation.<tag name> contains the configuration of the simulation mode. In simulation mode, you can simulate axes without a real drive in the CPU.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
Simulation.		STRUCT			
	Mode	UDINT	-	RES[1])	Simulation mode 0: No simulation, normal operation 1: Simulation mode

1) Technology version V2.0: RON

A.2.4 VirtualAxis tag (positioning axis/synchronous axis)

The tag structure <TO>.VirtualAxis.<tag name> contains the configuration of the simulation mode. In simulation mode, you can simulate axes without a real drive in the CPU.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
VirtualAxis.		STRUCT			
	Mode	UDINT	-	RON	Virtual axis 0: No virtual axis 1: Axis is always and exclusively operated in simulation

A.2.5 Actor tags (positioning axis/synchronous axis)

The tag structure <TO>.Actor.<tag name> contains the controller-side configuration of the drive.

Tags

Legend (Page 456)

Tag	Data type	Values	W	Description
Actor.	STRUCT			
Type	DINT	-	RON	Drive connection 0: Analog output 1: PROFIdrive telegram
InverseDirection	BOOL	-	RES	Inversion of the setpoint FALSE: no TRUE: Yes
DataAdaption	DINT	-	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque 0: No automatic transfer, manual configuration of values 1: Automatic transfer of values configured in the drive to the configuration of the technology object
Efficiency	LREAL	0.0 to 1.0	RES	Efficiency of mechanics (gear and leadscrew)
Interface.	STRUCT			
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram
AdressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram or the analog setpoint
EnableDriveOutput	BOOL	-	RES	"Enable output" for analog drives FALSE: disabled TRUE: Activated
EnableDriveOutput-Address	VREF	0 to 65535	RON	Address for the "Enable output" for analog setpoint
DriveReadyInput	BOOL	-	RES	"Ready input" for analog drives The analog drive signals its readiness to receive speed setpoints. FALSE: disabled TRUE: Activated
DriveReadyIn-putAddress	VREF	0 to 65535	RON	Address for the "Enable input" for analog setpoint

Tag			Data type	Values	W	Description
	DriveParameter.					
		ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the speed setpoint (N-set) of the drive The speed setpoint is transferred in the PROFIdrive telegram as a normalized value from -200% to 200% of the "ReferenceSpeed". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, provided the drive permits this.
		MaxSpeed	LREAL	0.0 to 1.0E12	RES	Maximum value for the speed setpoint of the drive (N-set) (PROFIdrive: MaxSpeed ≤ 2 × ReferenceSpeed Analog setpoint: MaxSpeed ≤ 1.17 × ReferenceSpeed)
		ReferenceTorque	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the drive torque

See also

Evaluating the technology data block (Page 295)

A.2.6 TorqueLimiting tag (positioning axis/synchronous axis)

The tag structure <TO>.TorqueLimiting.<tag name> contains the configuration of the torque limiting.

Tags

Legend (Page 456)

Tag			Data type	Values	W	Description
TorqueLimiting.			STRUCT			
	LimitBase		DINT	-	RES	Torque limiting 0: Motor side 1: Load side
	PositionBasedMonitorings		DINT	-	RES	Positioning and following error monitoring 0: Monitoring deactivated 1: Monitoring activated
	LimitDefaults.		STRUCT			
		Torque	LREAL	0.0 to 1.0E12	CAL	Limiting torque
		Force	LREAL	0.0 to 1.0E12	CAL	Limiting force

A.2.7 Clamping tag (positioning axis/synchronous axis)

The tag structure <TO>.Clamping.<tag name> contains the configuration of the fixed stop detection.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
Clamping.		STRUCT			
	FollowingErrorDeviation	LREAL	0.001 to 1.0E12	DIR	Value of the following error starting from which the fixed stop is detected.
	PositionTolerance	LREAL	0.001 to 1.0E12	DIR	Position tolerance for clamping monitoring

A.2.8 Sensor[n] tags (positioning axis/synchronous axis)

The tag structure <TO>.Sensor[n].<tag name> contains the controller-end configuration for the encoder, and the configuration for active and passive homing.

Tags

Legend (Page 456)

Tag			Data type	Values	W	Description
Sensor[n].			ARRAY [1..4] OF STRUCT			
	Existent		BOOL	-	RON	Displaying created encoders
	Type		DINT	-	RON	Encoder type 0: "INCREMENTAL" (incremental) 1: "ABSOLUTE" (absolute) 2: "CYCLIC_ABSOLUTE" (cyclic absolute)
	InverseDirection		BOOL	-	RES	Inversion of the actual value FALSE: no TRUE: Yes
	System		DINT	-	RES	Encoder system 0: "LINEAR" (linear encoder) 1: "ROTATORY" (rotary encoder)
	MountingMode		DINT	-	RES	Mounting type of encoder 0: On motor shaft 1: On load side 2: External measuring system
	DataAdaption		DINT	-	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque in the device 0: No automatic transfer, manual configuration of values 1: Automatic transfer of values configured in the drive to the configuration of the technology object
	Interface.					
		AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram
		AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram
		Number	UDINT	1 to 2	RON	Number of the encoder in the telegram

Tag			Data type	Values	W	Description
	Parameter.					
		Resolution	LREAL	1.0E-12 to 1.0E12	RES	Resolution of a linear encoder (offset between two encoder pulses)
		StepsPer-Revolution	UDINT	1 to 8388608	RES	Increments per rotary encoder revolution
		FineResolution-Xist1	UDINT	0 to 31	RES	Number of bits for fine resolution Gx_XIST1 (cyclic actual encoder value)
		FineResolution-Xist2	UDINT	0 to 31	RES	Number of bits for fine resolution Gx_XIST2 (absolute value of encoder)
		Determinable-Revolutions	UDINT	0 to 8388608	RES	Number of differentiable encoder revolutions for a multi-turn absolute encoder (For a single-turn absolute encoder = 1; for an incremental encoder = 0)
		DistancePer-Revolution	LREAL	0.0 to 1.0E12	RES	Load distance per revolution of an externally mounted encoder
	ActiveHoming.		STRUCT			
		Mode	DINT	-	RES	Homing mode 0: Use zero mark via PROFIdrive telegram 1: Use zero mark via PROFIdrive telegram and reference cam 2: Use homing mark via digital input
		SideInput	BOOL	-	CAL	Side of the digital input for active homing: FALSE: Negative side TRUE: Positive side
		Direction	DINT	-	CAL	Homing direction / homing mark approach direction 0: Positive homing direction 1: Negative homing direction
		DigitalInput-Address	VREF	0 to 65535	RON	Address of digital input
		HomePosition-Offset	LREAL	-1.0E12 to 1.0E12	CAL	Home position offset
		SwitchLevel	BOOL	-	RES	Signal level that is present at the digital input when homing mark is approached FALSE: Low level TRUE: High level

Tag			Data type	Values	W	Description
	PassiveHoming.		STRUCT			
		Mode	DINT	-	RES	Homing mode 0: Use zero mark via PROFIdrive telegram 1: Use zero mark via PROFIdrive telegram and reference cam 2: Use homing mark via digital input
		SideInput	BOOL	-	CAL	Side of digital input during passive homing: FALSE: Negative side TRUE: Positive side
		Direction	DINT	-	CAL	Homing direction / homing mark approach direction 0: Positive homing direction 1: Negative homing direction 2: Current homing direction
		DigitalInput-Address	VREF	0 to 65535	RON	Address of digital input
		SwitchLevel	BOOL	-	RES	Signal level that is present at the digital input when homing mark is approached FALSE: Low level TRUE: High level

See also

Evaluating the technology data block (Page 295)

A.2.9 Extrapolation tag (positioning axis/synchronous axis)

The tag structure <TO>.Extrapolation.<tag name> contains the configuration of the actual value extrapolation.

Tags

Legend (Page 456)

Tag	Data type	Values	W	Description
Extrapolation.	STRUCT			
LeadingAxis-DependentTime	LREAL	-	RON	Extrapolation time component (caused by leading axis) Results from the following times: • Time of actual value acquisition for the leading axis • Ipo cycle • Time of actual position filter of leading axis (T1 + T2)
FollowingAxis-DependentTime	LREAL	0.0 to 1.0E12	DIR	Extrapolation time component (caused by following axis) Results from the following times: • For a following axis with set velocity precontrol: – Communication cycle – Ipo cycle – Speed control loop substitute time for the following axis – Output time of the setpoint for the following axis • For a following axis without velocity precontrol: – Communication cycle – Ipo cycle – Position control loop equivalent time (1/Kv from <TO>.PositionControl.Kv) – Output time of the setpoint for the following axis
PositionFilter.	STRUCT			
T1	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T1
T2	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T2
VelocityFilter.	STRUCT			
T1	LREAL	0.0 to 1.0E12	DIR	Velocity filter time constant T1
VelocityTolerance.	STRUCT			
Range	LREAL	0.0 to 1.0E12	DIR	Tolerance band width for velocity
Hysteresis.	STRUCT			
Value	LREAL	0.0 to 1.0E12	DIR	Hysteresis value

A.2.10 LoadGear tags (positioning axis/synchronous axis)

The tag structure <TO>.LoadGear.<tag name> contains the configuration for the load gear.

Tags

Legend (Page 456)

Tag		Data type	Value range	W	Description
LoadGear.		STRUCT			
	Numerator	UDINT	1 to 4294967295	RES	Load gear counter
	Denominator	UDINT	1 to 4294967295	RES	Load gear denominator

A.2.11 Properties tags (positioning axis/synchronous axis)

The tag structure <TO>.Properties.<tag name> contains the configuration of the type of axis or motion.

Tags

Legend (Page 456)

Tag		Data type	Value range	W	Description
Properties.		STRUCT			
	MotionType	DINT	-	RON	Indication of axis or motion type: 0: Linear axis or motion 1: Rotary axis or motion

A.2.12 Units tag (positioning axis/synchronous axis)

The tag structure <TO>.Units.<tag name> shows the set technological units.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description	
Units.		STRUCT				
	LengthUnit	UDINT	-	RON	Unit for position	
					1010	m
					1013	mm
					1011	km
					1014	µm
					1015	nm
					1019	in
					1018	ft
					1021	mi
					1004	rad
					1005	°
	VelocityUnit	UDINT	-	RON	Unit for velocity	
					1521	°/s
					1522	°/min
					1086	rad/s
					1523	rad/min
					1062	mm/s
					1061	m/s
					1524	mm/min
					1525	m/min
					1526	mm/h
					1063	m/h
					1527	km/min
					1064	km/h
					1066	in/s
					1069	in/min
					1067	ft/s
					1070	ft/min
					1075	mi/h
	TimeUnit	UDINT	-	RON	Unit for time	
					1054	S

Tag		Data type	Values	W	Description	
	TorqueUnit	UDINT	-	RON	Unit for torque	
					1126	Nm
					1128	kNm
					1529	lbf in (pound-force-inch)
					1530	lbf ft
					1531	ozf in (ounce-force-inch)
					1532	ozf ft
					1533	pdl in (poundal-inch)
					1534	pdl ft
	ForceUnit	UDINT	-	RON	Unit for force	
					1120	N
					1122	kN
					1094	lbf (pound-force)
					1093	ozf (ounce-force)
					1535	pdl (poundals)

A.2.13 Mechanics tags (positioning axis/synchronous axis)

The tag structure <TO>.Mechanics.<tag name> contains the configuration of the mechanics.

Tags

Legend (Page 456)

Tag		Data type	Value range	W	Description
Mechanics.		STRUCT			
	LeadScrew	LREAL	0.0 to 1.0E12	RES	Leadscrew pitch

A.2.14 Modulo tags (positioning axis/synchronous axis)

The tag structure <TO>.Modulo.<tag name> contains the configuration of the modulo function.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
Modulo.		STRUCT			
	Enable	BOOL	-	RES	FALSE: Modulo conversion disabled TRUE: Modulo conversion enabled When modulo conversion is enabled, a check is made for modulo length > 0.0
	Length	LREAL	0.001 to 1.0E12	RES	Modulo length
	StartValue	LREAL	-1.0E12 to 1.0E12	RES	Modulo start value

See also

Evaluating the technology data block (Page 295)

A.2.15 DynamicLimits tags (positioning axis/synchronous axis)

The tag structure <TO>.DynamicLimits.<tag name> contains the configuration of the dynamic limits. During Motion Control, no dynamic values greater than the dynamic limits are permitted. If you have specified greater values in a Motion Control instruction, then motion is performed using the dynamic limits, and a warning is indicated (alarm 501 to 503 - Dynamic values were limited).

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
DynamicLimits.		STRUCT			
	MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum permissible velocity of the axis
	MaxAcceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible acceleration of the axis
	MaxDeceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible deceleration of the axis
	MaxJerk	LREAL	0.0 to 1.0E12	DIR	Maximum permissible jerk on the axis

See also

Evaluating the technology data block (Page 295)

A.2.16 DynamicDefaults tags (positioning axis/synchronous axis)

The tag structure <TO>.DynamicDefaults.<tag name> contains the configuration of the dynamic defaults. These settings will be used when you specify a dynamic value less than 0.0 in a Motion Control instruction (exceptions: MC_MoveJog.Velocity, MC_MoveVelocity.Velocity). Changes to the default dynamic values will be applied at the next positive edge at the "Execute" parameter of a Motion Control instruction.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
DynamicDefaults.		STRUCT			
	Velocity	LREAL	0.0 to 1.0E12	CAL	Default velocity
	Acceleration	LREAL	0.0 to 1.0E12	CAL	Default acceleration
	Deceleration	LREAL	0.0 to 1.0E12	CAL	Default deceleration
	Jerk	LREAL	0.0 to 1.0E12	CAL	Default jerk
	EmergencyDeceleration	LREAL	0.0 to 1.0E12	DIR	Emergency stop deceleration

See also

Evaluating the technology data block (Page 295)

A.2.17 PositionLimits_SW tags (positioning axis/synchronous axis)

The tag structure <TO>.PositionLimits_SW.<tag name> contains the configuration for position monitoring with software limit switches. Software limit switches are used to limit the operating range of a positioning axis.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
PositionLimits_SW.		STRUCT			
	Active	BOOL	-	DIR	FALSE: Monitoring disabled TRUE: Monitoring enabled
	MinPosition	LREAL	-1.0E12 to 1.0E12	DIR	Position of negative software limit switches
	MaxPosition	LREAL	-1.0E12 to 1.0E12	DIR	Position of positive software limit switches ("MaxPosition" > "MinPosition")

See also

Evaluating the technology data block (Page 295)

A.2.18 PositionLimits_HW tags (positioning axis/synchronous axis)

The tag structure <TO>.PositionLimits_HW.<tag name> contains the configuration of position monitoring with hardware limit switches. Hardware limit switches are used to limit the traversing range of a positioning axis.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
PositionLimits_HW.		STRUCT			
	Active	BOOL	-	RES	FALSE: Monitoring disabled TRUE: Monitoring enabled With "Active", both (negative and positive) hardware limit switches are activated or deactivated.
	MinSwitchLevel	BOOL	-	RES	Level selection for activation of the negative hardware limit switch: FALSE: Low level (Low active) TRUE: High level (High active)
	MinSwitchAddress	VREF	0 to 65535	RON	Address for the negative hardware limit switch
	MaxSwitchLevel	BOOL	-	RES	Level selection for enabling of the positive hardware limit switch: FALSE: Low level (Low active) TRUE: High level (High active)
	MaxSwitchAddress	VREF	0 to 65535	RON	Address for the positive hardware limit switch

See also

Evaluating the technology data block (Page 295)

A.2.19 Homing tags (positioning axis/synchronous axis)

The tag structure <TO>.Homing.<tag name> contains the configuration for homing the TO.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
Homing.		STRUCT			
	AutoReversal	BOOL	-	RES	Reversal at the hardware limit switches FALSE: no TRUE: Yes
	ApproachDirection	BOOL	-	CAL	Direction of approach to the homing position switch FALSE: positive direction TRUE: Negative direction
	ApproachVelocity	LREAL	L: 0.0 to 10000.0 mm/s R: 0.0 to 360000.0°/s	CAL	Approach velocity Velocity during active homing at which the reference cam and home position are approached.
	ReferencingVelocity	LREAL	L: 0.0 to 1000.0 mm/s R: 0.0 to 36000.0°/s	CAL	Homing velocity Velocity during active homing at which the home position is approached.
	HomePosition	LREAL	-1.0E12 to 1.0E12	CAL	Home position

See also

Evaluating the technology data block (Page 295)

A.2.20 Override tags (positioning axis/synchronous axis)

The tag structure <TO>.Override.<tag name> contains the configuration for the override parameters. The override parameters are used to apply a correction percentage to default values. An override change takes effect immediately, and is performed with the dynamic settings in effect in the Motion Control instruction.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
Override.		STRUCT			
	Velocity	LREAL	0.0 to 200.0%	DIR	Velocity or speed override Percentage correction of the velocity/speed

See also

Evaluating the technology data block (Page 295)

A.2.21 PositionControl tags (positioning axis/synchronous axis)

The tag structure <TO>.PositionControl.<tag name> contains the settings of closed loop position control.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
PositionControl.		STRUCT			
	Kv	LREAL	0.0 to 2147480.0	DIR	Proportional gain of the closed loop position control("Kv" > 0.0)
	Kpc	LREAL	0.0 to 150.0%	DIR	Velocity precontrol of the closed loop position control Recommended setting: • Isochronous drive connection via PROFIdrive: 100.0% • Non-isochronous drive connection via PROFIdrive: 0.0 to 100.0% • Analog drive connection: 0.0 to 100.0%
	EnableDSC	BOOL	-	RES	Dynamic Servo Control (DSC) FALSE: DSC disabled TRUE: DSC enabled DSC is only possible with one of the following PROFIdrive telegrams: • Standard telegram 5 or 6 • SIEMENS telegram 105 or 106
	SmoothingTimeBy-ChangeDifference	LREAL	0.0 to 1.0E+12	DIR	Manipulated variable ramp at step change of control deviation due to encoder switchover.
	InitialOperativeSensor	UDINT	-	RES	Active encoder after initialization of the axis. (encoder number 1 to 4) This encoder is used after startup of the CPU and after a restart of the technology object (Page 324). At an operating mode transition from STOP → RUN of the CPU (without restart of the technology object), the encoder that was also active before the STOP is still being used.

Tag			Data type	Values	W	Description
	ControlDifference-Quantization.		STRUCT			
		Mode	DINT	-	RES	Type of quantification Configuration of a quantization when a drive with stepper motor interface is connected 0: No quantification 1: Quantization corresponding to encoder resolution 2: Quantization to a direct value (configuration is performed using the parameter view (data structure))
		Value	LREAL	0.001 to 1.0E+12	RES	Value of quantification Configuration of a value for quantization to a direct value (<TO>.PositionControl.-ControlDifferenceQuantization.Mode = 2) (configuration is performed using the parameter view (data structure))

See also

Evaluating the technology data block (Page 295)

A.2.22 DynamicAxisModel tags (positioning axis/synchronous axis)

The tag structure <TO>.DynamicAxisModel.<tag name> contains the settings of the balancing filter.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
DynamicAxisModel.		STRUCT			
	VelocityTimeConstant	LREAL	0.0 to 1.0E12	DIR	Speed control loop substitute time [s]

A.2.23 FollowingError tags (positioning axis/synchronous axis)

The tag structure <TO>.FollowingError.<tag name> contains the configuration for following error monitoring.

If the permissible following error is exceeded, then technology alarm 521 is output, and the technology object is disabled (alarm reaction: remove enable).

When the warning level is reached, a warning is output (technology alarm 522).

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
FollowingError.		STRUCT			
	EnableMonitoring	BOOL	-	RES	FALSE: Following error monitoring disabled TRUE: Following error monitoring enabled
	MinValue	LREAL	L: 0.0 to 1.0E12 R: 0.001 to 1.0E12	DIR	Permissible following error at velocities below the value of "MinVelocity".
	MaxValue	LREAL	L: 0.0 to 1.0E12 R: 0.002 to 1.0E12	DIR	Maximum permissible following error, which may be reached at the maximum velocity.
	MinVelocity	LREAL	0.0 to 1.0E12	DIR	"MinValue" is permissible below this velocity and is held constant.
	WarningLevel	LREAL	0.0 to 100.0	DIR	Warning level: Percentage value relative to the valid maximum following error.

See also

Evaluating the technology data block (Page 295)

A.2.24 PositionMonitoring tags (positioning axis/synchronous axis)

The tag structure <TO>.PositioningMonitoring.<tag name> contains the configuration for position monitoring at the end of a positioning motion.

If the actual position value at the end of a positioning motion is reached within the tolerance time and remains in the positioning window for the minimum dwell time, then <TO>.StatusWord.X5 (Done) is set in the technology data block. This completes a Motion Control job.

If the tolerance time is exceeded, then technology alarm 541 "Positioning monitoring" with supplemental value 1: "Target area not reached within the positioning tolerance time" will be indicated.

If the minimum dwell time is not met, then technology alarm 541 "Positioning monitoring" with supplemental value 2: "Target area exited within the minimum dwell time" will be indicated.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
PositioningMonitoring.		STRUCT			
	ToleranceTime	LREAL	0.0 to 1.0E12	DIR	Tolerance time Maximum permitted duration from reaching velocity setpoint zero, until entrance into the positioning window.
	MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time in the positioning window:
	Window	LREAL	0.0 to 1.0E12	DIR	Positioning window

See also

Evaluating the technology data block (Page 295)

A.2.25 StandstillSignal tags (positioning axis/synchronous axis)

The tag structure <TO>.StandstillSignal.<tag name> contains the configuration for the standstill signal.

If the actual velocity value is below the velocity threshold, and does not exceed it during the minimum dwell time, then the standstill signal <TO>.StatusWord.X7 (Standstill) is set.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
StandstillSignal.		STRUCT			Configuration for the standstill signal
	VelocityThreshold	LREAL	0.0 to 1.0E12	DIR	Velocity threshold If velocity is below this threshold, then the minimum dwell time begins.
	MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time

See also

Evaluating the technology data block (Page 295)

A.2.26 StatusPositioning tags (positioning axis/synchronous axis)

The tag structure <TO>.StatusPositioning.<tag name> indicates the status of a positioning motion.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
StatusPositioning.		STRUCT			
	Distance	LREAL	-1.0E12 to 1.0E12	RON	Distance to the target position
	TargetPosition	LREAL	-1.0E12 to 1.0E12	RON	Target position
	FollowingError	LREAL	-1.0E12 to 1.0E12	RON	Current following error
	SetpointExecutionTime	LREAL	-1.0E12 to 1.0E12	RON	Setpoint execution time of the axis (results from T_{lpo}, T_{vtc} or 1/kv, T_{dp} and T_O of the axis)

See also

Evaluating the technology data block (Page 295)

A.2.27 StatusDrive tags (positioning axis/synchronous axis)

The tag structure <TO>.StatusDrive.<tag name> indicates the status of the drive.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
StatusDrive.		STRUCT			
	InOperation	BOOL	-	RON	Operational status of the drive FALSE: Drive not ready. Setpoints will not be executed. TRUE: Drive ready. Setpoints can be executed.
	CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and drive FALSE: Not established TRUE: Established
	Error	BOOL	-	RON	FALSE: No drive error TRUE: Drive error
	AdaptionState	DINT	-	RON	Status of automatic data transfer of drive parameters 0: "NOT_ADAPTED" (Data not transferred) 1: "IN_ADAPTION" (Data transfer in progress) 2: "ADAPTED" (Data transfer complete) 3: "NOT_APPLICABLE" (Data transfer not selected, not possible) 4: "ADAPTION_ERROR" (Error during data transfer)

See also

Evaluating the technology data block (Page 295)

A.2.28 StatusServo tags (positioning axis/synchronous axis)

The tag structure <TO>.StatusServo.<tag name> indicates the status for the balancing filter.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
StatusServo.		STRUCT			
	BalancedPosition	LREAL	-	RON	Position after the balancing filter.
	ControlDifference	LREAL	-	RON	Control error

A.2.29 StatusSensor[n] tags (positioning axis/synchronous axis)

The tag structure <TO>.StatusSensor[n].<tag name> indicates the status of the measuring system.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
StatusSensor[n].		ARRAY [1..4] OF STRUCT			
	State	DINT	-	RON	Status of actual encoder value 0: "NOT_VALID" (not valid) 1: "WAITING_FOR_VALID" (waiting for valid status) 2: "VALID" (valid)
	CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and encoder FALSE: Not established TRUE: Established
	Error	BOOL	-	RON	FALSE: No error in the measuring system TRUE: Error in the measuring system.
	AbsEncoderOffset	LREAL	-	RON	Home point offset to the value of an absolute value encoder. The value will be retentively stored in the CPU.
	Control	BOOL	-	RON	FALSE: Encoder is not active TRUE: Encoder is active
	Position	LREAL	-	RON	Encoder position
	Velocity	LREAL	-	RON	Encoder velocity
	AdaptionState	DINT	-	RON	Status of automatic data transfer of encoder parameters 0: "NOT_ADAPTED" (Data not transferred) 1: "IN_ADAPTION" (Data transfer in progress) 2: "ADAPTED" (Data transfer complete) 3: "NOT_APPLICABLE" (Data transfer not selected, not possible) 4: "ADAPTION_ERROR" (Error during data transfer)

See also

Evaluating the technology data block (Page 295)

A.2.30 StatusExtrapolation tag (positioning axis/synchronous axis)

The tag structure <TO>.StatusExtrapolation.<tag name> indicates the status of the actual value extrapolation.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
Extrapolation.		STRUCT			
	FilteredPosition	LREAL	-1.0E12 to 1.0E12	RON	Position after position filter
	FilteredVelocity	LREAL	-1.0E12 to 1.0E12	RON	Velocity according to tolerance band
	ExtrapolatedPosition	LREAL	-1.0E12 to 1.0E12	RON	Extrapolated position
	ExtrapolatedVelocity	LREAL	-1.0E12 to 1.0E12	RON	Extrapolated velocity

A.2.31 StatusSynchronizedMotion tags (synchronous axis)

The tag structure <TO>.StatusSynchronizedMotion.<tag name> indicates the status of the synchronous operation.

Tags

Legend (Page 456)

Tag			Data type	Value range	W	Description
StatusSynchronizedMotion.			STRUCT			
	FunctionState		DINT	-	RON	Indication of which synchronous operation function is active 0: No synchronous operation active 1: Gearing (MC_GearIn) 2: Gearing with specified synchronous positions (MC_GearInPos) 3: Camming (MC_CamIn)
	PhaseShift		LREAL	-1.0E12 to 1.0E12	RON	Current absolute leading value shift
	ActualMaster		DB_ANY	0 to 65535	RON	At the start of a "MC_GearIn" job, the number of the technology data block of the currently used leading axis is displayed. "ActualMaster" = 0 when synchronous operation is inactive
	ActualCam		DB_ANY	0 to 65535	RON	Cam that is currently being used for camming
	MasterOffset		LREAL	-1.0E12 to 1.0E12	RON	Current shift of the leading value range of the cam
	MasterScaling		LREAL	-1.0E12 to 1.0E12	RON	Current scaling of the leading value range of the cam
	SlaveOffset		LREAL	-1.0E12 to 1.0E12	RON	Current shift of the following value range of the cam
	SlaveScaling		LREAL	-1.0E12 to 1.0E12	RON	Current scaling of the following value range of the cam
	StatusWord.		STRUCT			
	Bit 0	MaxVelocity-Exceeded	BOOL	-	RON	Configured maximum velocity is exceeded during synchronous operation.
	Bit 1	MaxAcceleration-Exceeded	BOOL	-	RON	Configured maximum acceleration is exceeded during synchronous operation.
	Bit 2	MaxDeceleration-Exceeded	BOOL	-	RON	Configured maximum deceleration is exceeded during synchronous operation.
	Bit 3	InSimulation	BOOL	-	RON	FALSE: Synchronous operation not simulated TRUE: Synchronous operation is being simulated
	Bit 4... Bit 31	-	BOOL	-	RON	Reserved

See also

Synchronous axis technology object (Page 107)

A.2.32 StatusWord tag (positioning axis/synchronous axis)

The <TO>.StatusWord tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 5 "HomingDone") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 456)

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status data of the technology object
Bit 0	-	-	-	"Enable" Enable status 0: Technology object disabled 1: Technology object enabled
Bit 1	-	-	-	"Error" 0: No error present 1: Error present
Bit 2	-	-	-	"RestartActive" 0: No "Restart" active 1: "Restart" active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" 0: "Restart" tags unchanged 1: Change to "Restart" tags. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"ControlPanelActive" Axis control panel 0: Deactivated 1: Activated
Bit 5	-	-	-	"HomingDone" Homing status 0: Technology object not homed 1: Technology object homed
Bit 6	-	-	-	"Done" 0: Motion job is running, or axis control panel active 1: No motion job is running and axis control panel deactivated
Bit 7	-	-	-	"Standstill" Standstill signal 0: Axis in motion 1: Axis at a standstill
Bit 8	-	-	-	"PositioningCommand" 0: No positioning job running 1: Positioning command running ("MC_MoveRelative", "MC_MoveAbsolute")
Bit 9	-	-	-	"JogCommand" 0: No "MC_MoveJog" job running 1: "MC_MoveJog" job running

Tag	Data type	Values	W	Description
Bit 10	-	-	-	"VelocityCommand" 0: No "MC_MoveVelocity" job running 1: "MC_MoveVelocity" job running
Bit 11	-	-	-	"HomingCommand" 0: No "MC_Home" job is running 1: "MC_Home" job is running
Bit 12	-	-	-	"ConstantVelocity" 0: Axis is accelerating or decelerating. 1: Velocity setpoint reached. The axis is traversing at this constant velocity or is at a standstill.
Bit 13	-	-	-	"Accelerating" 0: No acceleration process active 1: Acceleration process active
Bit 14	-	-	-	"Decelerating" 0: No deceleration process active 1: Deceleration process active
Bit 15	-	-	-	"SWLimitMinActive" 0: Negative software limit switch not reached 1: Negative software limit switch reached or overtraveled
Bit 16	-	-	-	"SWLimitMaxActive" 0: Positive software limit switch not reached 1: Positive software limit switch reached or overtraveled
Bit 17	-	-	-	"HWLimitMinActive" 0: Negative hardware limit switch not reached 1: Negative hardware limit switch reached or overtraveled
Bit 18	-	-	-	"HWLimitMaxActive" 0: Positive hardware limit switch not reached 1: Positive hardware limit switch reached or overtraveled
Bit 19	-	-	-	Reserved
Bit 20	-	-	-	Reserved
Bit 21	-	-	-	Positioning axis technology object: Reserved Synchronous axis technology object: "Synchronizing" 0: Axis is not being synchronized to a leading value. 1: Axis is being synchronized to a leading value.
Bit 22	-	-	-	Positioning axis technology object: Reserved Synchronous axis technology object: "Synchronous" 0: Axis is not moving synchronously to a leading value. 1: Axis is moving synchronously to a leading value.

Tag	Data type	Values	W	Description
Bit 23	-	-	-	"SuperimposedMotionCommand" 0: No superimposed motion active 1: Superimposed motion active
Bit 24	-	-	-	Positioning axis technology object: Reserved Synchronous axis technology object: "PhasingCommand" 0: No Motion Control instruction for leading value shift is active 1: Motion Control instruction for leading value shift is active
Bit 25	-	-	-	"AxisSimulation" 0: No simulation 1: Simulation is active
Bit 26	-	-	-	"TorqueLimitingCommand" 0: No "MC_TorqueLimiting" job is running 1: "MC_TorqueLimiting" job is running
Bit 27	-	-	-	"InLimitation" 0: Drive is not operating at the torque limit 1: Drive is operating at the torque limit
Bit 28	-	-	-	"NonPositionControlled" 0: Axis is in position-controlled mode 1: Axis is in non-position-controlled mode
Bit 29	-	-	-	Reserved
Bit 30	-	-	-	"InClamping" 0: Axis is not clamped at a fixed stop. 1: Axis is clamped at a fixed stop.
Bit 31	-	-	-	Reserved

See also

Evaluating the technology data block (Page 295)

A.2.33 ErrorWord tag (positioning axis/synchronous axis)

The <TO>.ErrorWord tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 456)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4	-	-	-	"DriveFault" Error in drive
Bit 5	-	-	-	"SensorFault" Error in encoder system
Bit 6	-	-	-	"DynamicError" Specified dynamic values are limited to permissible values.
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8	-	-	-	"SWLimit" Software limit switch reached or overtraveled.
Bit 9	-	-	-	"HWLimit" Hardware limit switch reached or overtraveled.
Bit 10	-	-	-	"HomingError" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	"FollowingErrorFault" Following error limits exceeded
Bit 12	-	-	-	"PositioningFault" Positioning error

Tag	Data type	Values	W	Description
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14	-	-	-	Positioning axis technology object: Reserved Synchronous axis technology object: "SynchronousError" Error during synchronous operation The leading axis specified for the Motion Control instruction "MC_GearIn" was not configured as a possible leading axis.
Bit 15	-	-	-	"AdaptionError" Error in automatic data transfer
Bit 16... Bit 31	-	-	-	Reserved

See also

Evaluating the technology data block (Page 295)

A.2.34 ErrorDetail tags (positioning axis/synchronous axis)

The tag structure <TO>.ErrorDetail.<tag name> contains the alarm number and the effective local alarm reaction for the technology alarm that is currently pending for the technology object.

You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.

Tags

Legend (Page 456)

Tag		Data type	Values	W	Description
ErrorDetail.		STRUCT			
	Number	UDINT	-	RON	Alarm number
	Reaction	DINT	0 to 5	RON	Effective alarm reaction 0: No reaction 1: Stop with current dynamic values 2: Stop with maximum dynamic values 3: Stop with emergency stop ramp 4: Remove enable 5: Track setpoints

See also

Evaluating the technology data block (Page 295)

Technology alarms (Page 342)

A.2.35 WarningWord tag (positioning axis/synchronous axis)

The <TO>.WarningWord tag indicates pending warnings for the technology object.

Information on the evaluation of the individual bits (e.g. bit 13 "PeripheralWarning") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 456)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4	-	-	-	"DriveWarning" Error in drive
Bit 5	-	-	-	"SensorWarning" Error in encoder system
Bit 6	-	-	-	"DynamicError" Specified dynamic values are limited to permissible values.
Bit 7	-	-	-	"CommunicationWarning" Communication error Missing or faulty communication.
Bit 8	-	-	-	"SWLimitMin"
Bit 9	-	-	-	"SWLimitMax"
Bit 10	-	-	-	"HomingWarning" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	"FollowingErrorWarning" Warning limit of following error monitoring reached/exceeded
Bit 12	-	-	-	"PositioningWarning" Positioning error
Bit 13	-	-	-	"PeripheralWarning" Error accessing a logical address

Tag	Data type	Values	W	Description
Bit 14	-	-	-	Positioning axis technology object: Reserved Synchronous axis technology object: "SynchronousWarning" Error during synchronous operation The leading axis specified for the Motion Control instruction "MC_GearIn" was not configured as a possible leading axis.
Bit 15	-	-	-	"AdaptionWarning" Error in automatic data transfer
Bit 16... Bit 31	-	-	-	Reserved

See also

Evaluating the technology data block (Page 295)

A.2.36 ControlPanel tags (positioning axis/synchronous axis)

The tag structure <TO>.ControlPanel.<tag name> contains no user-relevant data. This tag structure is internally used.

See also

Evaluating the technology data block (Page 295)

A.2.37 InternalToTrace tags (positioning axis/synchronous axis)

The tag structure <TO>.InternalToTrace.<tag name> contains no user-relevant data. This tag structure is internally used.

See also

Evaluating the technology data block (Page 295)

A.3 Tags of the technology object external encoder

A.3.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed directly and take effect at the start of the next MC-Servo [OB91].
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC-Servo [OB91] after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

A.3.2 Actual values and setpoints (external encoder)

The following tags indicate the setpoint and actual values of the technology object.

Tags

Legend (Page 493)

Tag	Data type	Values	W	Description
ActualPosition	LREAL	-	RON	Actual position
ActualVelocity	LREAL	-	RON	Actual velocity
ActualAcceleration	LREAL	-	RON	Actual acceleration

A.3.3 Sensor tags (external encoder)

The tag structure <TO>.Sensor.<tag name> contains the controller-end configuration for the encoder, and the configuration for active and passive homing.

Tags

Legend (Page 493)

Tag			Data type	Values	W	Description
Sensor.			STRUCT			
	Type		DINT	-	RES	Encoder type 0: "INCREMENTAL" (incremental) 1: "ABSOLUTE" (absolute) 2: "CYCLIC_ABSOLUTE" (cyclic absolute)
	InverseDirection		BOOL	-	RES	Inversion of the actual value FALSE: no TRUE: Yes
	System		DINT	-	RES	Encoder system 0: "LINEAR" (linear encoder) 1: "ROTATORY" (rotary encoder)
	MountingMode		DINT	-	RES	Mounting type of encoder 0: On motor shaft 1: On load side 2: External measuring system
	DataAdaption		DINT	-	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque in the device 0: No automatic transfer, manual configuration of values 1: Automatic transfer of values configured in the drive to the configuration of the technology object
	Interface.					
		AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram
		AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram
		Number	UDINT	1 to 2	RON	Number of the encoder in the telegram

Tag			Data type	Values	W	Description
	Parameter.					
		Resolution	LREAL	-1.0E12 to 1.0E12	RES	Resolution of a linear encoder (offset between two encoder pulses)
		StepsPerRevolution	UDINT	1 to 8388608	RES	Increments per rotary encoder revolution
		FineResolutionXist1	UDINT	0 to 31	RES	Number of bits for fine resolution Gx_XIST1 (cyclic actual encoder value)
		FineResolutionXist2	UDINT	0 to 31	RES	Number of bits for fine resolution Gx_XIST2 (absolute value of encoder)
		Determinable-Revolutions	UDINT	0 to 8388608	RES	Number of differentiable encoder revolutions for a multi-turn absolute encoder (For a single-turn absolute encoder = 1; for an incremental encoder = 0)
		DistancePer-Revolution	LREAL	0.0 to 1.0E12	RES	Load distance per revolution of an externally mounted encoder
	PassiveHoming.		STRUCT			
		Mode	DINT	-	RES	Homing mode 0: Use zero mark via PROFIdrive telegram 1: Use zero mark via PROFIdrive telegram and reference cam 2: Use homing mark via digital input
		SideInput	BOOL	-	CAL	Side of digital input during passive homing: FALSE: Negative side TRUE: Positive side
		Direction	DINT	-	CAL	Homing direction / homing mark approach direction 0: Positive homing direction 1: Negative homing direction 2: Current homing direction
		DigitalInputAddress	VREF	0 to 65535	RES	Address of the digital input
		SwitchLevel	BOOL	-	RON	Signal level that is present at the digital input when homing mark is approached FALSE: Low level TRUE: High level

A.3.4 Extrapolation tag (external encoder)

The tag structure <TO>.Extrapolation.<tag name> contains the configuration of the actual value extrapolation.

Tags

Legend (Page 493)

Tag			Data type	Values	W	Description
Extrapolation.			STRUCT			
	LeadingAxis-DependentTime		LREAL	-	RON	Extrapolation time component (caused by leading axis) Results from the following times: • Time of actual value acquisition for the leading axis • Ipo cycle • Time of actual position filter of leading axis (T1 + T2)
	FollowingAxis-DependentTime		LREAL	0.001 to 1.0E12	DIR	Extrapolation time component (caused by following axis) Results from the following times: • For a following axis with set velocity precontrol: – Communication cycle – Ipo cycle – Speed control loop substitute time for the following axis – Output time of the setpoint for the following axis • For a following axis without velocity precontrol: – Communication cycle – Ipo cycle – Position control loop equivalent time (1/Kv from <TO>.PositionControl.Kv) – Output time of the setpoint for the following axis
	PositionFilter.		STRUCT			
		T1	LREAL	0.001 to 1.0E12	DIR	Position filter time constant T1
		T2	LREAL	0.001 to 1.0E12	DIR	Position filter time constant T2
	VelocityFilter.		STRUCT			
		T1	LREAL	0.001 to 1.0E12	DIR	Velocity filter time constant T1
	VelocityTolerance.		STRUCT			
		Range	LREAL	0.001 to 1.0E12	DIR	Tolerance band width for velocity
	Hysteresis.		STRUCT			
		Value	LREAL	0.001 to 1.0E12	DIR	Hysteresis value

A.3.5 LoadGear tags (external encoder)

The tag structure <TO>.LoadGear.<tag name> contains the configuration for the load gear.

Tags

Legend (Page 493)

Tag		Data type	Value range	W	Description
LoadGear.		STRUCT			
	Numerator	UDINT	1 to 4294967295	RES	Load gear counter
	Denominator	UDINT	1 to 4294967295	RES	Load gear denominator

A.3.6 Properties tags (external encoder)

The tag structure <TO>.Properties.<tag name> contains the configuration of the type of axis or motion.

Tags

Legend (Page 493)

Tag		Data type	Value range	W	Description
Properties.					
	MotionType	DINT	-	RON	Indication of axis or motion type: 0: Linear axis or motion 1: Rotary axis or motion

A.3.7 Units tag (external encoder)

The tag structure <TO>.Units.<tag name> shows the set technological units.

Tags

Legend (Page 493)

Tag		Data type	Values	W	Description	
Units.		STRUCT				
	LengthUnit	UDINT	-	RON	Unit for position	
					1010	m
					1013	mm
					1011	km
					1014	µm
					1015	nm
					1019	in
					1018	ft
					1021	mi
					1004	rad
					1005	°
	VelocityUnit	UDINT	-	RON	Unit for velocity	
					1521	°/s
					1522	°/min
					1086	rad/s
					1523	rad/min
					1062	mm/s
					1061	m/s
					1524	mm/min
					1525	m/min
					1526	mm/h
					1063	m/h
					1527	km/min
					1064	km/h
					1066	in/s
					1069	in/min
					1067	ft/s
					1070	ft/min
					1075	mi/h
	TimeUnit	UDINT	-	RON	Unit for time	
					1054	s

A.3.8 Mechanics tags (external encoder)

The tag structure <TO>.Mechanics.<tag name> contains the configuration of the mechanics.

Tags

Legend (Page 493)

Tag		Data type	Value range	W	Description
Mechanics.					
	LeadScrew	LREAL	0.0 to 1.0E12	RES	Leadscrew pitch

A.3.9 Modulo tags (external encoder)

The tag structure <TO>.Modulo.<tag name> contains the configuration of the modulo function.

Tags

Legend (Page 493)

Tag		Data type	Values	W	Description
Modulo.		STRUCT			
	Enable	BOOL	-	RES	FALSE: Modulo conversion disabled TRUE: Modulo conversion enabled When modulo conversion is enabled, a check is made for modulo length > 0.0
	Length	LREAL	0.001 to 1.0E12	RES	Modulo length
	StartValue	LREAL	-1.0E12 to 1.0E12	RES	Modulo start value

A.3.10 Homing tags (external encoder)

The tag structure <TO>.Homing.<tag name> contains the configuration for homing the TO.

Tags

Legend (Page 493)

Tag		Data type	Values	W	Description
Homing.		STRUCT			
	HomePosition	LREAL	-1.0E12 to 1.0E12	CAL	Home position

A.3.11 StatusSensor tags (external encoder)

The tag structure <TO>.StatusSensor.<tag name> indicates the status of the measuring system.

Tags

Legend (Page 493)

Tag		Data type	Values	W	Description
StatusSensor.		STRUCT			
	State	DINT	-	RON	Status of actual encoder value 0: "NOT_VALID" (not valid) 1: "WAITING_FOR_VALID" (waiting for valid status) 2: "VALID" (valid)
	CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and encoder FALSE: Not established TRUE: Established
	Error	BOOL	-	RON	FALSE: No error in the measuring system TRUE: Error in the measuring system.
	AbsEncoderOffset	LREAL	-	RON	Home point offset to the value of an absolute value encoder. The value will be retentively stored in the CPU.
	Control	BOOL	-	RON	FALSE: Encoder is not active TRUE: Encoder is active
	Position	LREAL	-	RON	Encoder position
	Velocity	LREAL	-	RON	Encoder velocity
	AdaptionState	DINT	-	RON	Status of automatic data transfer of encoder parameters 0: "NOT_ADAPTED" (Data not transferred) 1: "IN_ADAPTION" (Data transfer in progress) 2: "ADAPTED" (Data transfer complete) 3: "NOT_APPLICABLE" (Data transfer not selected, not possible) 4: "ADAPTION_ERROR" (Error during data transfer)

A.3.12 StatusExtrapolation tag (external encoder)

The tag structure <TO>.StatusExtrapolation.<tag name> indicates the status of the actual value extrapolation.

Tags

Legend (Page 493)

Tag		Data type	Values	W	Description
Extrapolation.		STRUCT			
	FilteredPosition	LREAL	-1.0E12 to 1.0E12	RON	Position after position filter
	FilteredVelocity	LREAL	-1.0E12 to 1.0E12	RON	Velocity according to tolerance band
	ExtrapolatedPosition	LREAL	-1.0E12 to 1.0E12	RON	Extrapolated position
	ExtrapolatedVelocity	LREAL	-1.0E12 to 1.0E12	RON	Extrapolated velocity

A.3.13 StatusWord tag (external encoder)

The <TO>.StatusWord tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 5 "HomingDone") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 493)

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status data of the technology object
Bit 0	-	-	-	"Enable" Enable status 0: Technology object disabled 1: Technology object enabled
Bit 1	-	-	-	"Error" 0: No error present 1: Error present
Bit 2	-	-	-	"RestartActive" 0: No "Restart" active 1: "Restart" active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" 0: "Restart" tags unchanged 1: Change to "Restart" tags. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"HomingDone" Homing status 0: Technology object not homed 1: Technology object homed
Bit 6	-	-	-	"Done" 0: Motion job is running, or axis control panel active 1: No motion job is running and axis control panel deactivated
Bit 7	-	-	-	Reserved
Bit 8	-		-	Reserved
Bit 9	-	-	-	Reserved
Bit 10	-	-	-	Reserved
Bit 11	-	-	-	"HomingCommand" 0: No "MC_Home" job is running 1: "MC_Home" job is running
Bit 12... Bit 31	-	-	-	Reserved

A.3.14 ErrorWord tag (external encoder)

The <TO>.ErrorWord tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 493)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"SensorFault" Error in encoder system
Bit 6	-	-	-	Reserved
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8	-	-	-	Reserved
Bit 9	-	-	-	Reserved
Bit 10	-	-	-	"HomingError" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	Reserved
Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.3.15 ErrorDetail tags (external encoder)

The tag structure <TO>.ErrorDetail.<tag name> contains the alarm number and the effective local alarm reaction for the technology alarm that is currently pending for the technology object.

You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.

Tags

Legend (Page 493)

Tag		Data type	Values	W	Description
ErrorDetail.		STRUCT			
	Number	UDINT	-	RON	Alarm number
	Reaction	DINT	0, 10	RON	Effective alarm reaction 0: No reaction 10: Remove enable For the technology object external encoder, only alarm reactions 0 and 4 are possible.

A.3.16 WarningWord tag (external encoder)

The <TO>.WarningWord tag indicates pending warnings for the technology object.

Information on the evaluation of the individual bits (e.g. bit 13 "PeripheralWarning") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 493)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"SensorWarning" Error in encoder system
Bit 6	-	-	-	Reserved
Bit 7	-	-	-	"CommunicationWarning" Communication error Missing or faulty communication.
Bit 8	-	-	-	Reserved
Bit 9	-	-	-	Reserved
Bit 10	-	-	-	"HomingWarning" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	Reserved
Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralWarning" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.3.17 InternalToTrace tags (external encoder)

The tag structure <TO>.InternalToTrace.<tag name> contains no application-relevant data. This tag structure is internally used.

Tags

Legend (Page 493)

Tag		Data type	Values	W	Description
InternalToTrace.		ARRAY [1..4] OF STRUCT			
	Id	DINT	-	DIR	-
	Value	LREAL	-	RON	-

A.4 Tags of the measuring input technology object

A.4.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed directly and take effect at the start of the next MC-Servo [OB91].
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC-Servo [OB91] after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

A.4.2 Display data (measuring input)

The <TO>.Status and <TO>.InputState tags show the status of the measuring input function and the input of the measuring input.

Tags

Legend (Page 507)

Tag	Data type	Values	W	Description
Status	DINT	-	RON	Measuring input function status 0: "INACTIVE" (measurement is not active) 1: "WAITING_FOR_TRIGGER" (measuring input is waiting for measuring event) 2: "TRIGGER_OCCURRED" (one or more measured values have been acquired) 3: "MEASURING_ERROR" (error during the measurement)
InputState	BOOL	-	RON	Measuring input input status FALSE: Input of measuring input not active TRUE: Input of measuring input active

A.4.3 Parameter tags (measuring input)

The tag structure <TO>.Parameter.<tag name> contains the configuration of the basic parameters of the measuring input technology object.

Tags

Legend (Page 507)

Tag		Data type	Values	W	Description
Parameter.		STRUCT			
	MeasuringInputType	DINT	-	RON	Measuring input type 0: "TIME_BASED" (measurement using time stamp) 1: "PROFIDRIVE" (measuring event using PROFIdrive telegram)
	PROFIdrive ProbeNumber	UDINT	1, 2	RES	Number of the measuring input to be used for a measurement using PROFIdrive telegram
	MeasuringRange ActivationTime	LREAL	0.0 to 1.0E12	RON	System share for activation time of measuring range
	MeasuringRange-AdditionalActivation-Time	LREAL	0.0 to 1.0E12	RES	Additional activation time when using measuring range limits [ms]
	CorrectionTime	LREAL	0.0 to 1.0E12	RES	Correction time for the measurement result [ms]

A.4.4 Interface tags (measuring input)

The tag structure <TO>.Interface.<tag name> contains the configuration of the input properties for the technology object measuring input.

Tags

Legend (Page 507)

Tag		Data type	Values	W	Description
Interface.		STRUCT			
	Address	VREF	-	RON	I/O address for the digital measuring input

A.4.5 Units tags (measuring input)

The tag structure <TO>.Units.<tag name> shows the set technological units.

Tags

Legend (Page 507)

Tag		Data type	Values	W	Description	
Units.		STRUCT				
	LengthUnit	UDINT	-	RON	Unit for position	
					1010	m
					1013	mm
					1011	km
					1014	µm
					1015	nm
					1019	in
					1018	ft
					1021	mi
					1004	rad
					1005	°
	TimeUnit	UDINT	-	RON	Unit for time	
					1056	ms

A.4.6 MeasuredValues tags (measuring input)

The tag structure <TO>.MeasuredValues.<tag name> displays the measurement results.

Tags

Legend (Page 507)

Tag		Data type	Values	W	Description
MeasuredValues.		STRUCT			
	MeasuredValue1	LREAL	-1.0E12 to 1.0E12	RON	First measured value
	MeasuredValue2	LREAL	-1.0E12 to 1.0E12	RON	Second measured value
	Measured-Value1Counter	UDINT	0 to 2147483647	RON	Count value for the first measured value
	Measured-Value2Counter	UDINT	0 to 2147483647	RON	Count value for the second measured value
	LostEdgeCounter1	UDINT	0 to 7	RON	LEC for measured value 1 (zero in the case of one-time measurement)
	LostEdgeCounter2	UDINT	0 to 7	RON	LEC for measured value 2 (zero in the case of one-time measurement)

A.4.7 StatusWord tag (measuring input)

The <TO>.StatusWord tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "RestartActive") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tags

Legend (Page 507)

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" 0: Technology object not in operation 1: Technology object in operation
Bit 1	-	-	-	"Error" 0: No error present 1: Error present
Bit 2	-	-	-	"RestartActive" 0: No "Restart" active 1: "Restart" active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" 0: "Restart" tags unchanged 1: Change to "Restart" tags. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"CommunicationOK" Communication between measuring input and measuring module 0: Not established 1: Established
Bit 6... Bit 31	-	-	-	Reserved

A.4.8 ErrorWord tag (measuring input)

The <TO>.ErrorWord tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tags

Legend (Page 507)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.4.9 ErrorDetail tags (measuring input)

The tag structure <TO>.ErrorDetail.<tag name> contains the alarm number and the effective local alarm reaction for the technology alarm that is currently pending for the technology object.

You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.

Tags

Legend (Page 507)

Tag		Data type	Values	W	Description
ErrorDetail.		STRUCT			
	Number	UDINT	-	RON	Alarm number
	Reaction	DINT	0, 8	RON	Effective alarm reaction 0: No reaction 8: End measuring input processing

A.4.10 WarningWord tag (measuring input)

The <TO>.WarningWord tag indicates pending warnings for the technology object.

Information on the evaluation of the individual bits (e.g. bit 1 "ConfigWarning") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 507)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13				"PeripheralWarning" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.5 Tags of the cam technology object

A.5.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed directly and take effect at the start of the next MC-Servo [OB91].
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC-Servo [OB91] after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

A.5.2 Display data (cam)

The <TO>.CamOutput tag indicates the switching state of the cam.

Tags

Legend (Page 515)

Tag	Data type	Values	W	Description
CamOutput	BOOL	-	RON	Switching state of output cam FALSE: not interconnected TRUE: Switched

A.5.3 Parameter tags (cam)

The tag structure <TO>.Parameter.<tag name> contains the configuration of the basic parameters of the output cam technology object.

Tags

Legend (Page 515)

Tag		Data type	Values	W	Description
Parameter.		STRUCT			
	OutputCamType	DINT	-	RES	Output cam type 0: Distance output cam 1: Time-based output cam
	PositionType	DINT	-	RES	Position reference 0: Position setpoint 1: Actual position
	OnCompensation	LREAL	0.0 to 1.0E12	DIR	Activation time Lead time for the switch-on edge
	OffCompensation	LREAL	0.0 to 1.0E12	DIR	Deactivation time Lead time for the switch-off edge
	Hysteresis	LREAL	0.0 to 1.0E12	DIR	Hysteresis value For output cams with reference to actual position, always enter a hysteresis value (> 0.0).

A.5.4 Interface tags (cam)

The tag structure <TO>.Interface.<tag name> contains the configuration of the output properties for the output cam technology object.

Tags

Legend (Page 515)

Tag		Data type	Values	W	Description
Interface.		STRUCT			
	EnableOutput	BOOL	-	RES	Activation of the output cam output FALSE: Output is deactivated TRUE: Output is activated
	Address	VREF	-	RON	I/O address of the output cam
	LogicOperation	DINT	-	RON	Logical operation of the output cam signals at the output 0: OR operation 1: AND operation

A.5.5 Units tags (cam)

The tag structure <TO>.Units.<tag name> shows the set technological units.

Tags

Legend (Page 515)

Tag		Data type	Values	W	Description	
Units.		STRUCT				
	LengthUnit	UDINT	-	RON	Unit for position	
					1010	m
					1013	mm
					1011	km
					1014	µm
					1015	nm
					1019	in
					1018	ft
					1021	mi
					1004	rad
					1005	°
	TimeUnit	UDINT	-	RON	Unit for time	
					1056	ms

A.5.6 StatusWord tag (output cam)

The <TO>.StatusWord tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "RestartActive") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tags

Legend (Page 515)

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" 0: Technology object not in operation 1: Technology object in operation
Bit 1	-	-	-	"Error" 0: No error present 1: Error present
Bit 2	-	-	-	"RestartActive" 0: No "Restart" active 1: "Restart" active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" 0: "Restart" tags unchanged 1: Change to "Restart" tags. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"OutputInverted" 0: Output cam output not inverted 1: Output cam output inverted
Bit 5	-	-	-	"CommunicationOK" Communication between output cam and output module 0: Not established 1: Established
Bit 6... Bit 31	-	-	-	Reserved

A.5.7 ErrorWord tag (output cam)

The <TO>.ErrorWord tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tags

Legend (Page 515)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.5.8 ErrorDetail tags (cam)

The tag structure <TO>.ErrorDetail.<tag name> contains the alarm number and the effective local alarm reaction for the technology alarm that is currently pending for the technology object.

You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.

Tags

Legend (Page 515)

Tag		Data type	Values	W	Description
ErrorDetail.		STRUCT			
	Number	UDINT	-	RON	Alarm number
	Reaction	DINT	0, 6	RON	Effective alarm reaction 0: No reaction 6: Output cam processing is complete.

A.5.9 WarningWord tag (output cam)

The <TO>.WarningWord tag indicates pending warnings for the technology object.

Information on the evaluation of the individual bits (e.g. bit 1 "ConfigWarning") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 515)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13				"PeripheralWarning" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.6 Tags of the cam track technology object

A.6.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed directly and take effect at the start of the next MC-Servo [OB91].
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC-Servo [OB91] after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

A.6.2 Display data (cam track)

The following tags indicate the status of the cam track:

Tags

Legend (Page 522)

Tag	Data type	Values	W	Description
Status	DINT	-	RON	0: "INACTIVE" (inactive) 1: "ACTIVE" (active) 2: "ACTIVE_WAITING_FOR_NEXT_CYCLE" (active and waiting for next track)
TrackOutput	BOOL	-	RON	FALSE: Cam track is not output. TRUE: Cam track is output.
SingleCamState	DWORD	16#0 to 16#FFFF_FFFF	RON	Switched on output cam (bit-masked) 0: Output cam is not switched on 1: Output cam is switched on
TrackPosition	LREAL	-1.0E12 to 1.0E12	RON	Display of the current position within the cam track
MatchPosition	LREAL	-1.0E12 to 1.0E12	RON	Reference position of the current cam track During cyclic processing of the cam track, the continued reference position of the current cam track is displayed. The unique detection and output of the position is only possible when the assigned technology object is in motion.

A.6.3 Parameter tags (cam track)

The tag structure <TO>.Parameter.<tag name> contains the configuration of the basic parameters of the cam track technology object.

Tags

Legend (Page 522)

Tag			Data type	Values	W	Description
Parameter.			STRUCT			
	CamTrackType		DINT	-	RES	Output cam type 0: Distance output cam 1: Time-based output cam
	PositionType		DINT	-	RES	Position reference 0: Position setpoint 1: Actual position
	ReferencePosition		LREAL	-1.0E12 to 1.0E12	DIR	Reference position
	CamTrackLength		LREAL	0.001 to 1.0E12	DIR	Track length
	CamMasking		DWORD	16#0 to 16#FFFF_FFFF	DIR	Bit masking of individual output cams
	OnCompensation		LREAL	0.0 to 1.0E12	DIR	Activation time Lead time for the switch-on edge
	OffCompensation		LREAL	0.0 to 1.0E12	DIR	Deactivation time Lead time for the switch-off edge
	Hysteresis		LREAL	0.0 to 1.0E12	DIR	Hysteresis value For output cams with reference to actual position, always enter a hysteresis value (> 0.0).
	Cam[1 … 32].		STRUCT			
		OnPosition	LREAL	0.0 to 1.0E12	CAL	Start position (distance and time-based output cams)
		Offposition	LREAL	0.0 to 1.0E12	CAL	End position (distance output cam)
		Duration	LREAL	0.001 to 1.0E12	CAL	Switch-on duration (time-based output cam)
		Existent	BOOL	-	CAL	FALSE: Output cam not used TRUE: Output cam is used

A.6.4 Interface tags (cam track)

The tag structure <TO>.Interface.<tag name> contains the configuration of the output properties for the cam track technology object.

Tags

Legend (Page 522)

Tag		Data type	Values	W	Description
Interface.		STRUCT			
	EnableOutput	BOOL	-	RES	Output cam output at the bit specified under "<TO>.Interface.Address" FALSE: No output TRUE: Output
	Address	VREF	-	RON	I/O address for digital cam output

A.6.5 Units tags (cam track)

The tag structure <TO>.Units.<tag name> shows the set technological units.

Tags

Legend (Page 522)

Tag		Data type	Values	W	Description	
Units.		STRUCT				
	LengthUnit	UDINT	-	RON	Unit for position	
					1010	m
					1013	mm
					1011	km
					1014	µm
					1015	nm
					1019	in
					1018	ft
					1021	mi
					1004	rad
					1005	°
	TimeUnit	UDINT	-	RON	Unit for time	
					1056	ms

A.6.6 StatusWord tag (cam track)

The <TO>.StatusWord tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "RestartActive") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tags

Legend (Page 522)

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" 0: Technology object not in operation 1: Technology object in operation
Bit 1	-	-	-	"Error" 0: No error present 1: Error present
Bit 2	-	-	-	"RestartActive" 0: No "Restart" active 1: "Restart" active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" 0: "Restart" tags unchanged 1: Change to "Restart" tags. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"OutputInverted" 0: Output cam output not inverted 1: Output cam output inverted
Bit 5	-	-	-	"CommunicationOK" Communication between cam track and output module 0: Not established 1: Established
Bit 6	-	-	-	"CamDataChanged" The data of individual output cams has been changed but not yet taken effect with Motion Control instruction "MC_CamTrack".
Bit 7... Bit 31	-	-	-	Reserved

A.6.7 ErrorWord tag (cam track)

The <TO>.ErrorWord tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tags

Legend (Page 522)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.6.8 ErrorDetail tags (cam track)

The tag structure <TO>.ErrorDetail.<tag name> contains the alarm number and the effective local alarm reaction for the technology alarm that is currently pending for the technology object.

You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.

Tags

Legend (Page 522)

Tag		Data type	Values	W	Description
ErrorDetail.		STRUCT			
	Number	UDINT	-	RON	Alarm number
	Reaction	DINT	0, 7	RON	Effective alarm reaction 0: No reaction 7: Cam track processing Is complete.

A.6.9 WarningWord tag (cam track)

The <TO>.WarningWord tag indicates pending warnings for the technology object.

Information on the evaluation of the individual bits (e.g. bit 1 "ConfigWarning") can be found in the Evaluating StatusWord, ErrorWord and WarningWord (Page 298) section.

Tag

Legend (Page 507)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13				"PeripheralWarning" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

A.7 Technology alarms

A.7.1 Overview

The following table shows an overview of the technology alarms and the corresponding alarm reactions. When a technology alarm occurs, evaluate the entire indicated alarm text, in order to find the precise cause.

Legend

No.	Number of the technology alarm (corresponds to <TO>.ErrorDetail.Number)
Reaction	Effective alarm reaction (corresponds to <TO>.ErrorDetail.Reaction)
Error bit	Bit that is set in <TO>.ErrorWord when the technology alarm occurs A description of the bits can be found in the appendix (Page 488).
Warning bit	Bit that is set in <TO>.WarningWord when the technology alarm occurs A description of the bits can be found in the appendix (Page 491).
Restart	To acknowledge the technology alarm, the technology object must be reinitialized (Restart).
Diagnostic buffer	The alarm is entered in the diagnostics buffer.
Alarm text	Displayed alarm test (limited)

List of the technology alarms

No.	Reaction	Error bit	Warning bit	Restart	Diagnostic buffer	Alarm text
101	Remove enable	X1	-	X	X	Configuration error.
102	Remove enable	X15	-	X	X	Drive configuration adaptation error.
103	Remove enable	X15	-	X	X	Encoder configuration adaptation error.
104	Stop with maximum dynamic values	X1	-	-	-	SW limit switch specification error.
105	Remove enable	X1	-	X	X	Drive configuration error.
106	Remove enable	X1	-	-	X	Drive connection configuration error.
107	Remove enable	X1	-	X	X	Encoder configuration error.
108	Remove enable	X1	-	-	X	Encoder connection configuration error.
109	Remove enable	X1	-	X	-	Configuration error.
110	No reaction	-	X1	-	-	Configuration is adjusted internally.
111	No reaction	-	X15	-	X	TO and drive configuration inconsistent.
112	No reaction	-	X15	-	X	TO and encoder configuration inconsistent.
113	Remove enable	X2	-	X	-	Isochronous mode not possible.
201	Remove enable	X0	-	X	X	Internal error.
202	No reaction	X0	-	X	-	Internal configuration error.
203	Remove enable	X0	-	X	-	Internal error.
204	Remove enable	X0	-	-	-	Commissioning error.
304	Stop with emergency stop ramp	X2	-	-	-	Velocity limit is zero.
305	Stop with emergency stop ramp	X2	-	-	-	• Acceleration limit is zero. • Deceleration limit is zero.
306	Stop with emergency stop ramp	X2	-	-	-	Jerk limit is zero.
307	Stop with maximum dynamic values	X2	-	-	X	• Negative numerical value range of the position reached. • Positive numerical value range of the position reached.
308	Remove enable	X2	-	-	X	• Negative numerical value range of the position exceeded. • Positive numerical value range of the position exceeded.
321	Stop with emergency stop ramp	X3	-	-	-	Axis not homed.
322	No reaction	-	X3	-	-	Restart not executed.
323	Remove enable	X3	-	-	-	MC_Home could not be performed.
341	Stop with maximum dynamic values	X10	-	-	-	Error in homing data.
342	Stop with emergency stop ramp	X10	-	-	-	Reference cam/encoder zero mark not found.
343	Remove enable	X1	-	-	-	Homing function not supported by device.

No.	Reaction	Error bit	Warning bit	Restart	Diagnostic buffer	Alarm text
401	Remove enable	X13	-	-	X	Error accessing logical address.
411	Remove enable	X5	-	-	X	Faulty encoder at the logical address.
412	Remove enable	X5	-	-	-	Permitted actual value range exceeded.
421	Remove enable	X4	-	-	X	Faulty drive at the logical address.
431	Remove enable	X7	-	-	X	Faulty communication with device at logical address.
501	No reaction	-	X6	-	-	Programmed velocity is limited.
502	No reaction	-	X6	-	-	• Programmed acceleration is being limited. • Programmed deceleration is being limited.
503	No reaction	-	X6	-	-	Programmed jerk is limited.
504	No reaction	-	X6	-	-	Speed setpoint monitoring active.
521	Remove enable	X11	-	-	-	Following error.
522	No reaction	-	X11	-	-	Warning following error tolerance.
531	Remove enable	X9	-	-	-	• Positive HW limit switch approached. • Negative HW limit switch approached. • Illegal free travel direction of active hardware limit switch. • HW limit switch polarity reversed, free travel not possible. • Both hardware limit switches active, retraction not possible.
533	Stop with maximum dynamic values	X8	-	-	-	• Negative SW limit switch approached. • Positive SW limit switch approached.
534	Remove enable	X8	-	-	-	• Negative SW limit switch is crossed. • Positive SW limit switch is crossed.
541	Remove enable	X12	-	-	-	Position monitoring error.
542	Remove enable	X2	-	-	-	Clamping monitoring error: Axis leaving clamping tolerance window.
550	Track setpoints	X4	-	-	-	Drive-autonomous motion is being executed.
551	No reaction	X2	X6	-	-	Maximum velocity cannot be reached with drive/axis parameters.
552	Remove enable	X15	-	-	-	Adaptation error of encoder during power-up.
601	Stop with maximum dynamic values	X14	-	-	-	Leading axis is not assigned or defective.
603	No reaction	-	X14	-	-	Leading axis is not in position-controlled mode.
608	Stop with maximum dynamic values	X14	-	-	-	Error during synchronization.
611	Remove enable	X2	-	-	-	The cam specified in the MC_CamIn.Cam parameter has not been configured or is not available or is not interpolated.
612	Remove enable	X2	-	-	-	Specified cam has not been interpolated.

No.	Reaction	Error bit	Warning bit	Restart	Diagnostic buffer	Alarm text
700	Remove enable	X2	-	-	-	Output cam limiting error.
701	Remove enable	X13	-	-	-	I/O output error.
702	Remove enable	X2	-	-	-	Position value valid.
703	Remove enable	X2	-	-	-	Cam track data faulty.
704	Remove enable	X2	-	-	-	Output cam data faulty.
750	Remove enable	X2	-	-	-	Measuring job not possible during homing of assigned axis.
752	Remove enable	X2	-	-	-	Validity range of measuring job not recognized.
753	Remove enable	X2	-	-	-	Only one measuring input can access an encoder at a time.
754	Remove enable	X2	-	-	-	Measuring input configuration in external device is not correct.
755	Remove enable	X13	-	-	-	Measuring job not possible.
758	No reaction	X2	-	-	-	A measuring edge was not evaluated.

See also

Technology alarms (Page 342)

A.7.2 Technology alarms 101-113

Technology alarm 101

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Configuration error.	
Value in Parameter.CamTrackType is invalid.	Adjust the specified value.
Value in InterpolationSettings.InterpolationMode is invalid.	
Faulty load gear factors.	
Value in Parameter.Cam[1..32] is invalid.	
Value in Sensor.Parameter.StepsPerRevolution is invalid.	
Value in Actor.InitialOperativeSensor is invalid.	
Value in Sensor.Interface.Number is invalid.	
Value in Sensor[N].Existent is invalid.	
At least one encoder required. Sensor[].existent	
Sensor[1] must be configured for DSC.	
Value in Sensor.Parameter.FineResolutionXist1 is invalid.	
Values in Sensor.Parameter.FineResolutionXist1 and P979 are not identical.	
Value in Actor.Interface.Telegram is invalid.	
Value in Sensor.Type is invalid.	
Value in Sensor.System is invalid.	
Value in Sensor.ActiveHoming.HomePositionOffset is invalid.	
Value in PositioningMonitoring.MinDwellTime is invalid.	
Value in PositioningMonitoring.Window is invalid.	
Value in Sensor.ActiveHoming.Mode is invalid.	
Value in Parameter.PositionType is invalid.	
Value in InterpolationSettings.BoundaryConditions is invalid.	
Value in Actor.DriveParameter.MaxSpeed is invalid.	
Value in Sensor.PassiveHoming.Mode is invalid.	
Value in Sensor.Interface.Telegram is invalid.	
Controller parameter incorrect.	
Value in StandStillSignal.VelocityThreshold is invalid.	
Value in PositioningMonitoring.ToleranceTime is invalid.	
Value in Actor.Type is invalid.	
PROFIBUS paramerization inconsistent; sum Ti+To greater than DP clock.	
Value in StandStillSignal.MinDwellTime is invalid.	
Value in FollowingError.MinValue is invalid.	
Drive or drive telegram type or encoder not suitable for DSC.	
Value in Interface.EnableOutput is invalid.	

Alarm text	Solution
Value in DynamicLimits.MaxVelocity is invalid.	
Value in DynamicLimits.MaxJerk is invalid.	
Value in DynamicLimits.MaxDeceleration is invalid.	
Value in Modulo.Length is invalid.	
Value in Modulo.StartValue is invalid.	
Value in Actor.DriveParameter.ReferenceSpeed is invalid.	
Value in Sensor.Parameter.FineResolutionXist2 is invalid.	
Value in Sensor.Parameter.DeterminableRevolutions is invalid.	
Value in Sensor.PassiveHoming.Direction is invalid.	
Value in DynamicDefaults.Velocity is invalid.	
Value in DynamicDefaults.Acceleration is invalid.	
Value in Interface.Address is invalid.	
Value in DynamicLimits.MaxAcceleration is invalid.	
Value in DynamicDefaults.Deceleration is invalid.	
Value in DynamicDefaults.Jerk is invalid.	
Value in DynamicDefaults.EmergencyDeceleration is invalid.	
Value in PositionLimits_SW.MinPosition is invalid.	
Value in PositionLimits_SW.MaxPosition is invalid.	
Value in Sensor.ActiveHoming.Direction is invalid.	
Value in Homing.ApproachVelocity is invalid.	
Value in Homing.ReferencingVelocity is invalid.	
Value in Homing.HomePosition is invalid.	
Value in FollowingError.MaxValue is invalid.	
Value in Parameter.ReferencePosition is invalid.	
Value in Mechanics.Leadscrew is invalid.	
Value in FollowingError.MinVelocity is invalid.	
Value in FollowingError.WarningLevel is invalid.	
Value in PositionControl.Kpc is invalid.	
Parameter Timeout outside limits.	
Parameter Simulation.Mode outside limits.	
Value in Actor.Interface.AddressIn is invalid.	
Value in Actor.Interface.AddressIn.RID is invalid.	
Value in VREF Actor.Interface.AddressOut is invalid.	
Value in Actor.Interface.AddressOut.RID is invalid.	
Telegram in Actor.Interface.AddressIn and Address Out not equal.	
Value in Parameter.CamTrackLength is invalid.	
Illegal combination for referencing data incremental encoder.	
Value in Sensor[].Interface.AddressIn is invalid.	
Value in Sensor.Interface.AddressIn.RID is invalid.	
Value in Sensor[].Interface.AddressOut is invalid.	

Alarm text	Solution
Value in Sensor.Interface.AddressOut.RID is invalid.	
Telegram in Sensor.Interface.AddressIn and AddressOut not equal.	
Value in Sensor.ActiveHoming.DigitalInputAddress is invalid.	
Value in Sensor.PassiveHoming.DigitalInputAddress is invalid.	
Value in PositionLimits_HW.MaxSwitchAddress is invalid.	
Value in PositionLimits_HW.MinSwitchAddress is invalid.	
Value in Actor.Interface.EnableDriveOutputAddress is invalid.	
Value in Parameter.OnCompensation is invalid.	
Value in Sensor.MountingMode is invalid.	
Value in Actor.Interface.DriveReadyInputAddress is invalid.	
Value in Parameter.MeasuringInputType is invalid.	
Value in Parameter.PROFIdriveProbeNumber is invalid.	
Value in Parameter.MeasuringRangeActivationTime is invalid.	
Value in Parameter.MeasuringRangeAdditionalActivationTime is invalid.	
Value in Parameter.CorrectionTime is invalid.	
Value in Interface.Address is invalid.	
Value in Parameter.OutputCamType is invalid.	
Value in Parameter.PositionType is invalid.	
Value in Simulation is invalid.	
Value in Parameter.OffCompensation is invalid.	
Value in Sensor.Parameter.DistancePerRevolution is invalid.	
Value in Interface.Address is invalid.	
Value in Interface.LogicOperation is invalid.	
Value in Parameter.OnCompensation is invalid.	
Value in Parameter.OffCompensation is invalid.	
Value in Parameter.Hysteresis is invalid.	
Value in Sensor[].DataAdaption is invalid.	
Illegal value for Actor.DataAdaption.	
Value in Clamping.FollowingErrorDeviation is invalid.	
Value in Clamping.PositionTolerance is invalid.	
Value in Parameter.Hysteresis is invalid.	
Value in Sensor.Parameter.Resolution is invalid.	
Illegal value for VirtualAxis.Mode.	
Illegal value for Actor.Efficiency.	
Value in PositionControl.ControlDifferenceQuantization. Value is invalid.	
Value in PositionControl.ControlDifferenceQuantization. Mode is invalid.	

Technology alarm 102

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Drive configuration adaptation error.	
Drive is not assigned to a SINAMICS device.	The drive adaptation is only available for SINAMICS drives.
Drive is not interconnected directly to I/O area.	During configuration of the axis, the log addresses were set to a data block or bit memory, for example. The adaptation is only possible when the encoder has been directly interconnected to an I/O area.
Adaptation canceled due to insufficient resources.	Check whether your device supports acyclic data communication according to PROFIdrive.
Parameter does not exist, value unreadable or invalid.	
Maximum speed	
Maximum torque	
Torque resolution	
Rated speed	
Rated torque	
Motor type	

Technology alarm 103

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Encoder configuration adaptation error.	
Encoder is not assigned to a SINAMICS device.	The encoder adaptation is only available for SINAMICS devices and external Siemens encoders.
Encoder is not interconnected directly to I/O area.	During configuration of the axis, the log addresses were set at a data block or bit memory. The adaptation is only possible when the encoder has been directly interconnected to an I/O area.
Adaptation canceled due to insufficient resources.	Check whether your device supports acyclic data communication according to PROFIdrive.
Parameter does not exist, value unreadable or invalid.	
Encoder system	
Encoder resolution	
Encoder fine resolution	
Encoder revolutions	

Technology alarm 104

Alarm reaction: Stop with maximum dynamic values

Restart: Not required

Alarm text	Solution
SW limit switch specification error.	
Neg. SW limit switch greater than pos. SW limit switch.	Change the position of the software limit switches.

Technology alarm 105

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Drive configuration error.	
HW Configuration.	• Connect a suitable device. • Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Contact customer service.
The TO needs a smaller servo cycle clock.	
Error in internal communication.	• Check the project for consistency and download it to the controller again. • Contact customer service.
Address for drive data does not exist in project.	Check the project for consistency and download it to the controller again.

Technology alarm 106

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Drive connection configuration error.	
System has no communication with drive.	Internal system error. • Check the project for consistency and download it to the controller again. • Contact customer service.
Drive not initialized during ramp-up.	To enable a technology object, the drive initialization must be complete. Trigger the job again later.

Technology alarm 107

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Encoder configuration error.	
HW Configuration	• Connect a suitable device. • Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Contact customer service.
The TO needs a smaller servo cycle clock.	
Error internal communication.	• Check the project for consistency and download it to the controller again. • Contact customer service.

Technology alarm 108

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Encoder connection configuration error.	
System without communication to encoder.	Internal system error. • Check the project for consistency and download it to the controller again. • Contact customer service.
Encoder not initialized during ramp-up.	To enable a technology object, the encoder initialization must be complete. Trigger the job again later.
Encoder data address missing in project.	Check the project for consistency and download it to the controller again.

Technology alarm 109

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Configuration error.	
Neg. HW limit switch.	• Connect a suitable device. • Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Contact customer service.
Pos. HW limit switch	
Reference cam "Active homing".	
Reference cam "Passive homing".	
Enable bit for the analog drive interface.	
DriveReady bit of the analog drive interface.	
Measurement sensing input is faulty.	
Output cam output faulty.	

Technology alarm 110

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
Configuration is adjusted internally.	
Actor.DriveParameter.MaxSpeed is limited.	• Correct the reference value in the drive and in the configuration of the technology object to <TO>.Actor.MaxSpeed /2. • With analog drive connection, correct the reference value in the drive and in the configuration of the technology object to <TO>.Actor.MaxSpeed /1.17. • The value can be set in the drive, for example, in p2000 = p1082.
PositioningMonitoring.ToleranceTime is limited.	Change the configuration data.
DynamicDefaults.EmergencyDeceleration is limited.	
DriveParameter.ReferenceTorque is too low.	

Technology alarm 111

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
TO and drive configuration inconsistent.	
Different telegram.	Match the telegram configuration for the technology object with the telegram configuration in the drive. (P922 in drive)
Incompatible torque resolution.	Adjust the high torque resolution for the drive.
Master application cycle and servo clock unequal.	Adjust the cycle of the master application in the device configuration for the PROFIBUS slave.
Servo cycle clock and drive cycle clock not equal.	
Linear motor configured.	Set round-frame motor (P300) in the drive.

Technology alarm 112

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
TO and encoder configuration inconsistent.	
Different telegram type.	Match the telegram configuration for the technology object with the telegram configuration in the drive. (P922 in drive)
Encoder is not an absolute encoder.	Configure the encoder for the technology object as an incremental encoder.
Master application cycle and servo clock unequal.	Adjust the cycle of the master application in the device configuration for the PROFIBUS slave.
Servo cycle clock and drive cycle clock not equal.	

Technology alarm 113

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Isochronous mode not possible.	• The configured output for the cam or cam track technology object or the input for the technology object measuring input cannot be used in isochronous mode. Configure the I/O in the device configuration as isochronous I/O. • Make sure that the organization block MC_Servo [OB91] is called synchronously with the bus system.

A.7.3 Technology alarms 201-204

Technology alarm 201

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Internal error.	Contact customer service.

Technology alarm 202

Alarm reaction: No reaction

Restart: Required

Alarm text	Solution
Internal configuration error.	Contact customer service.

Technology alarm 203

Alarm reaction: Remove enable

Restart: Required

Alarm text	Solution
Internal error.	Contact customer service.

Technology alarm 204

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Commissioning error.	
Connection to the TIA Portal interrupted.	Check the connection properties.

A.7.4 Technology alarms 304-343

Technology alarm 304

Alarm reaction: Stop with emergency stop ramp

Restart: Not required

Alarm text	Solution
Velocity limit is zero.	Enter a non-zero value for the maximum speed (DynamicLimits.MaxVelocity) in the dynamic limits.

Technology alarm 305

Alarm reaction: Stop with emergency stop ramp

Restart: Not required

Alarm text		Solution
Acceleration/deceleration limit is zero.		
	Acceleration	Enter a non-zero value for the maximum acceleration (DynamicLimits.MaxAcceleration) in the dynamic limits.
	Deceleration	Enter a non-zero value for the maximum deceleration (DynamicLimits.MaxDeceleration) in the dynamic limits.

Technology alarm 306

Alarm reaction: Stop with emergency stop ramp

Restart: Not required

Alarm text	Solution
Jerk limit is zero.	Enter a non-zero value for the maximum jerk (DynamicLimits.MaxJerk) in the dynamic limits.

Technology alarm 307

Alarm reaction: Stop with maximum dynamic values

Restart: Not required

Alarm text		Solution
Negative/positive numerical value range of the position reached.		
	Negative	Enable the "Modulo" setting for the technology object.
	Positive	

Technology alarm 308

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Negative/positive numerical value range of the position exceeded.	
Negative	Enable the "Modulo" setting for the technology object.
Positive	

Technology alarm 321

Alarm reaction: Stop with emergency stop ramp

Restart: Not required

Alarm text	Solution
Axis not homed.	To perform an absolute positioning motion, you must home the technology object.

Technology alarm 322

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
Restart not executed.	
TO is not ready for restart.	Download the project again.
Condition for TO restart not satisfied.	Disable the technology object.

Technology alarm 323

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
MC_Home could not be performed.	• Enable the "Modulo" setting for the technology object. • Adjust the position value for use of the Motion Control instruction "MC_Home".

Technology alarm 341

Alarm reaction: Stop with maximum dynamic values

Restart: Not required

Alarm text	Solution
Error in homing data.	
Approach velocity is zero.	Check the configuration for homing (Homing.ApproachVelocity).
Homing velocity is zero.	Check the configuration for homing (Homing.ReferencingVelocity).

Technology alarm 342

Alarm reaction: Stop with emergency stop ramp

Restart: Not required

Alarm text	Solution
Reference cam/encoder zero mark not found.	The reference cam configured for homing was not found in the traversing range of the axis.

Technology alarm 343

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Homing function not supported by device.	Configure a reference switch input for the pulse generator output used in the properties of the C-CPU. ("Pulse generators (PTO/PWM) > PTO[n]/PWN[n] > Hardware inputs/outputs") When homing across a zero mark, the CPU transfers the reference switch input as zero mark.

A.7.5 Technology alarms 401-431

Technology alarm 401

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Error accessing logical address.	
Invalid address. Input address is invalid. Output address is invalid.	• Connect a suitable device. • Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Contact customer service.

Technology alarm 411

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Faulty encoder at the logical address.	
Alarm message from encoder. HW error encoder. Encoder dirty.	Check the function, connections and I/Os of the encoder.
Read error encoder absolute value.	Compare the encoder type in the drive or encoder parameter P979 with the configuration data of the technology object.
Zero mark monitoring encoder.	Encoder signals error in zero mark monitoring (fault code 0x0002 in Gx_XIST2, see PROFIdrive profile).
Encoder in Parking state.	• Search for the cause of the error in the connected drive or encoder. • Check whether the alarm was possibly triggered by a commissioning action involving the drive or encoder.

Technology alarm 412

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Permitted actual value range exceeded.	
Positive.	Home the axis/encoder in a valid actual value range.
Negative.	
Modulo length.	Adjust the modulo length to the utilized encoder.

Technology alarm 421

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Faulty encoder at the logical address.	
Alarm message from drive.	• Check the functions and connections of the drive. • Enable and acknowledge safety function in the drive.
No drive control required.	
Drive has shut down.	
Drive enable not possible.	

Technology alarm 431

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Faulty communication with device at logical address.	
Drive failed.	Check the function, connections and I/Os of the drive .
Signs of life of drive faulty.	• Check the function, connections and I/Os of the drive . • Compare the clock parameters in the device configuration (PROFIBUS line, slave OM for drive or encoder) and the execution system. Tmapc and servo must be set to the same cycle time. (Incorrect parameter assignment is indicated by reason 0x0080.)
Encoder failed.	Check the function, connections and I/Os of the encoder.
Signs of life of encoder faulty.	• Check the function, connections and I/Os of the encoder. • Compare the clock parameters in the device configuration (PROFIBUS line, slave OM for drive or encoder) and the execution system. Tmapc and servo must be set to the same cycle time.

A.7.6 Technology alarms 501-552

Technology alarm 501

Alarm reaction: No reaction

Restart: Not required

Alarm text	Remedy
Programmed velocity is limited.	• Check the value for the velocity of the Motion Control instruction. • Check the configuration of the dynamic limits.

Technology alarm 502

Alarm reaction: No reaction

Restart: Not required

Alarm text		Remedy
Programmed acceleration/deceleration is being limited.		
	Acceleration	• Check the value for the acceleration of the Motion Control instruction. • Check the configuration of the dynamic limits.
	Deceleration	• Check the value for the deceleration of the Motion Control instruction. • Check the configuration of the dynamic limits.

Technology alarm 503

Alarm reaction: No reaction

Restart: Not required

Alarm text	Remedy
Programmed jerk is limited.	• Check the value for the jerk of the Motion Control instruction. • Check the configuration of the dynamic limits.

Technology alarm 504

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
Speed setpoint monitoring active.	• Check the mechanical configuration. • Check the encoder connection. • Check the configuration of the speed setpoint interface. • Check the configuration of the control loop. • Check the value for the maximum velocity DynamicLimits.MaxVelocity.

Technology alarm 521

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Following error.	• Check the configuration of the control loop. • Check the direction signal of the encoder. • Check the configuration of the following error monitoring.

Technology alarm 522

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
Warning following error tolerance.	• Check the configuration of the control loop. • Check the direction signal of the encoder. • Check the configuration of the following error monitoring.

Technology alarm 531

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Pos. HW limit switch reached.	Acknowledge the alarm. After the acknowledgment, motions in the negative direction are allowed.
Neg. HW limit switch reached.	Acknowledge the alarm. After the acknowledgment, motions in the positive direction are allowed.
Illegal free travel direction of active hardware limit switch.	The programmed direction of movement is disabled due to the active hardware limit switch. Retract the axis in the opposite direction.
HW limit switch polarity reversed, free travel not possible.	• Check the mechanical configuration of the hardware limit switch. • Check the limit switches. • The error can be acknowledged by switching the controller off and on or using "MC_Reset" with "Restart" = TRUE.
Both hardware limit switches active, retraction not possible.	

Technology alarm 533

Alarm reaction: Stop with maximum dynamic values

Restart: Not required

Alarm text	Solution
Negative/positive SW limit switch approached.	
Negative	The software limit switch was reached from an active motion. Move the axis away from the software limit switch in the positive direction.
Positive	The software limit switch was reached from an active motion. Move the axis away from the software limit switch in the negative direction.

Technology alarm 534

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Negative/positive SW limit switch is crossed.	
Negative	The SW limit switch was crossed. Acknowledge the alarm. After the acknowledgment, motions in the positive direction are allowed.
Positive	The SW limit switch was crossed. Acknowledge the alarm. After the acknowledgment, motions in the negative direction are allowed.

Technology alarm 541

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Position monitoring error.	
Target range not reached.	Target range was not reached within the positioning tolerance time. • Check the configuration of the position monitoring. • Check the configuration of the control loop.
Exit target range again.	The target range was exited within the minimum dwell time. • Check the configuration of the position monitoring. • Check the configuration of the control loop.

Technology alarm 542

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Clamping monitoring error: Axis leaving clamping tolerance window.	The axis has executed a motion greater than the permissible tolerance at the fixed stop. Check whether the fixed stop has broken away.

Technology alarm 550

Alarm reaction: Track setpoints

Restart: Not required

Alarm text	Solution
Drive-autonomous motion is being executed.	The drive is performing a motion that was not specified by the technology object. Check whether there is an active safety function in the drive.

Technology alarm 551

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
Maximum velocity cannot be reached with drive/axis parameters.	The configured maximum velocity cannot be reached with the configured mechanics of the axis. Check the configuration of the mechanics and the set reference speed.

Technology alarm 552

Alarm reaction: Remove enable

Restart: Not required

Alarm text		Solution
Adaptation error of encoder during power-up.		
	Encoder is not assigned to a SINAMICS device.	The encoder set as the operationally active encoder could not be adapted. Specify a different sensor for the initialization of the technology object.
	Encoder is not interconnected directly to I/O area.	During configuration of the axis, the log addresses were set to a data block area or bit memory area. The adaptation is only possible when the encoder has been directly interconnected to an I/O area.
	Adaptation canceled due to insufficient resources.	Check whether your device supports acyclic data communication according to PROFIdrive.
	Parameter does not exist, value unreadable or invalid.	
	Encoder system	
	Encoder resolution	
	Encoder fine resolution	
	Encoder revolutions	

A.7.7 Technology alarms 601-618

Technology alarm 601

Alarm reaction: Stop with maximum dynamic values

Restart: Not required

Alarm text	Solution
Leading axis is not assigned or defective.	Configure the possible leading value axes for the following axis under Configuration > Leading value interconnections.

Technology alarm 603

Alarm reaction: No reaction

Restart: Not required

Alarm text	Solution
Leading axis is not in position-controlled mode.	The following axis must be operated in position-controlled mode for synchronous operation functionality.

Technology alarm 608

Alarm reaction: Stop with maximum dynamic values

Restart: Not required

Alarm text	Solution
Error during synchronization.	Prevent a reversing leading value motion during the synchronization operation.

Technology alarm 611

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
The cam specified in the MC_CamIn.Cam parameter has not been configured or is not available.	Configure and interpolate the cam. Restart the job.

Technology alarm 612

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Solution
Specified cam has not been interpolated.	Interpolate the cam used for camming with the Motion Control instruction "MC_InterpolateCam".

A.7.8 Technology alarms 700-758

Technology alarm 700

Alarm reaction: Remove enable

Restart: Not required

Alarm text		Remedy
Output cam limiting error.		
	Cam position: OnPosition	The position for the OnPosition could not be calculated. Invalid positions (e.g. OnPosition > OffPosition) were calculated due to lead times. The output cam cannot be switched due to the axis dynamics and compensation times.
	Cam position: OffPosition	The position for the OffPosition could not be calculated. Invalid positions (e.g. OffPosition < OnPosition) were calculated due to lead times. The output cam cannot be switched due to the axis dynamics and compensation times.

Technology alarm 701

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
I/O output error.	The digital output for the output cam or cam track technology object cannot be addressed. Download the device configuration again.

Technology alarm 702

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Position value valid.	• A Motion Control job "MC_Reset" is being executed on the axis. Wait until the "Restart" of the technology object is complete. • The encoder values are invalid due to an encoder error. Check the encoder and adjust the configuration if necessary.

Technology alarm 703

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Output cam data faulty.	
Output cam: Output cam number	Check the configuration of the relevant output cam in the cam track and adjust the values if necessary. Examples of a correct configuration: • <TO>.Parameter.Cam[].OnPosition < <TO>.Parameter.Cam[].OffPosition • <TO>.Parameter.Cam[].Duration > <TO>.Parameter.OffCompensation - <TO>.Parameter.OnCompensation

Technology alarm 704

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Output cam data faulty.	Check the configuration of the output cam and adjust the values if necessary. Examples of a correct configuration: • MC_OutputCam.OnPosition < MC_OutputCam.OffPosition • MC_OutputCam.Duration > <TO>.Parameter.OffCompensation - <TO>.Parameter.OnCompensation

Technology alarm 750

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Measuring job not possible during homing of assigned axis.	Do not use the motion instructions "MC_Home" and "MC_MeasuringInput" simultaneously.

Technology alarm 752

Alarm reaction: No reaction

Restart: Not required

Alarm text	Remedy
Validity range of measuring job not recognized.	The measuring range specified in Motion Control instruction "MC_MeasuringInput" was not recognized. Adjust the measuring range.

Technology alarm 753

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Only one measuring input can access an encoder at a time.	Use only one Motion Control instruction "MC_MeasurinInput" for an encoder.

Technology alarm 754

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Measuring input configuration in external device is not correct.	Check the configuration of the measuring inputs on the external device.

Technology alarm 755

Alarm reaction: Remove enable

Restart: Not required

Alarm text	Remedy
Measuring job not possible.	
Device has reported an error.	The measurement was aborted with error. Check the measuring input functionality in the utilized device
Cyclic measuring is not possible with telegram 39x.	• Use the Motion Control instruction "MC_MeasuringInput" for starting a one-time measurement. • Cyclic measuring is only possible when measuring using TM Timer DIDQ. Change the configuration of the measuring input type to "TM Timer DIDQ".

Technology alarm 758

Alarm reaction: None

Restart: Not required

Alarm text	Remedy
A measuring edge was not evaluated.	An edge was already detected at the input of the measuring input even though the module was not yet ready. The measured value is provided at the next edge.

A.8 Error ID for Motion Control instructions

Errors in Motion Control instructions are signaled using the parameters "Error" and "ErrorID".

Under the following conditions, "Error" = TRUE and "ErrorID" = 16#8xxx are indicated for the Motion Control instruction:

- Illegal status of the technology object, which prevents the execution of the job.
- Illegal parameter assignment of the Motion Control instruction, which prevents the execution of the job.
- As a result of the alarm reaction for a technology object error.

The following tables list all "ErrorIDs" that can be indicated for Motion Control instructions. Besides the cause of the error, remedies for eliminating the error are also listed:

16#0000 - 16#800F

ErrorID	Description	Remedy
16#0000	No error	-
16#8001	A technology alarm (technology object error) occurred while processing the Motion Control instruction.	In the technology data block, an error message is output in the "ErrorDetail.Number" tag. You can find a list of the technology alarms and alarm reactions in the Technology alarms (Page 530) appendix.
16#8002	Illegal specification of the technology object	• Check the specification of the technology object for the "Axis", "Master", "SlaveOutputCamCamTrack-MeasuringInput" or "Cam" parameter. • For MC_MeasuringInputCyclic: Specify a valid measuring input type for parameter "MeasuringInputType".
16#8003	Illegal velocity specification	Specify a permissible value for the velocity for parameter "Velocity".
16#8004	Illegal acceleration specification	Specify a permissible value for the acceleration for parameter "Acceleration".
16#8005	Illegal deceleration specification	Specify a permissible value for the deceleration for parameter "Deceleration".
16#8006	Illegal jerk specification	Specify a permissible value for the jerk for parameter "Jerk".
16#8007	Illegal direction specification	Specify a permissible value for the rotation direction for parameter "Direction" or "SyncDirection".
	Invalid entry Both the "JogForward" and "JogBackward" parameters are set to TRUE at the same time. The axis is braked at the last valid deceleration.	Reset both the "JogForward" parameter and the "JogBackward" parameter.
16#800A	Illegal operating mode	Specify a permissible operating mode for parameter "Mode".
16#800C	Only one instance of the instruction is allowed per technology object.	The instruction is called at multiple points in the user program with identical value for parameter "Axis", "Master", "Slave" or "Cam". Ensure that only one instruction with the value for parameter "Axis", "Master", "Slave" or "Cam" is called.

ErrorID	Description	Remedy
16#800D	Job is not permitted in the current state. "Restart" is executed.	Wait until the "Restart" of the technology object is complete.
16#800E	If the technology object is enabled, a "Restart" is not possible.	Before a "Restart", deactivate the technology object with "MC_Power.Enable"FALSE.
16#800F	The technology object is disabled. Job cannot be executed.	Enable the technology object with "MC_Power.Enable" = TRUE. Restart the job.

16#8010 - 16#802F

ErrorID	Description	Remedy
16#8010	Invalid homing mode for incremental encoder.	Absolute value adjustment is not possible with an incremental encoder ("Mode" = 6, 7). Start a homing process for an incremental encoder using parameter "Mode" = 0, 1, 2, 3, 5, 8, 10.
16#8011	Invalid homing mode for absolute encoder.	Passive and active homing ("Mode" = 2, 3, 5, 8, 10) are not possible for an absolute value encoder. Start a homing process for an absolute encoder using parameter "Mode" = 0, 1, 6, 7.
16#8012	Job cannot be executed because axis control panel is active.	Return master control to your user program. Restart the job.
16#8013	The online connection between the CPU and the TIA Portal is down.	Check the online connection to the CPU.
16#8014	No internal job memory available.	The maximum possible number of Motion Control job has been reached. Reduce the number of jobs to be executed (parameter "Execute" = FALSE).
16#8015	Error acknowledgment with "MC_Reset" not possible. Error in the configuration of the technology object.	Check the configuration of the technology object.
16#8016	The actual values are not valid.	To execute a "MC_Home" command, the actual values must be valid. Check the status of the actual values. The technology object tag "<TO>.StatusSensor[n].State" must show the value 2 (valid).
16#8017	Illegal value for gear ratio numerator.	Specify a permissible value for the gear ratio numerator for parameter "RatioNumerator". Permitted integer values: -2147483648 to 2147483648 (value 0 not permitted)
16#8018	Illegal value for gear ratio denominator.	Specify a permissible value for the gear ratio denominator for parameter "RatioDenominator". Permitted integer values: 1 to 2147483648
16#8019	Command cannot be executed. The specified following axis is the original leading value for the synchronous operation chain.	Recursive interconnections are not possible. A leading axis cannot be interconnected as a following axis to its own leading value. Specify a permissible following axis for parameter "Slave".

ErrorID	Description	Remedy
16#8021	Illegal value for shift of the leading value range.	Specify a permissible value for the shift of the leading value range for parameter "MasterOffset".
16#8022	Illegal value for shift of the following value range.	Specify a permissible value for the shift of the leading value range for parameter "SlaveOffset".
16#8023	Illegal value for scaling of the leading value range.	Specify a permissible value for the scaling of the leading value range for parameter "MasterScaling".
16#8024	Illegal value for scaling of the following value range.	Specify a permissible value for the scaling of the following value range for parameter "SlaveScaling".
16#8026	Illegal value for leading value distance.	Specify a permissible value for the leading value distance for parameter "MasterStartDistance".
16#8027	Illegal value for use of cam.	Specify a permissible value for cyclic/acyclic use of the cam for parameter "ApplicationMode".

16#8030 - 16#807F

ErrorID	Description	Remedy
16#8034	Illegal value for synchronous position of the leading axis.	Specify a permissible value for the synchronous position of the leading axis for parameter "MasterSyncPosition".
16#8035	Illegal value for synchronous position of the following axis.	Specify a permissible value for the synchronous position of the following axis for parameter "SlaveSyncPosition".
16#8036	Illegal value for type of synchronization.	Specify a permissible value for the type of synchronization for parameter "SyncProfileReference".
16#8040	Illegal value for start position of output cam	Specify a permissible value for the start position of the output cam for parameter "OnPosition".
16#8041	Illegal value for end position of distance output cam	Specify a permissible value for the end position of the distance output cam for parameter "OffPosition".
16#8042	Illegal value for switch-on duration of time-based output cam	Specify a permissible value for the switch-on duration of the time-based output cam for parameter "Duration".
16#8043	Illegal value for parameter "Limit".	Select a value within the permitted value range. Permitted integer values: -2147483648 to 2147483648
16#8044	The axis is not configured for torque reduction.	Select drive telegram 102, 103, 105 or 106
16#8045	The job cannot be executed because travel to fixed stop job is active.	Switchover to non-position-controlled mode is not possible during active travel to fixed stop.
16#8046	The "MC_TorqueLimiting" job cannot be deactivated in the "InClamping" state.	Retract the axis and deactivate "MC_TorqueLimiting".
16#8047	Motion is towards the fixed stop.	Only motions away from the fixed stop are permitted.
16#8050	Illegal encoder number	Specify a permissible number of the new encoder (1 to 4) for parameter "MC_SetSensor.Sensor".
16#8051	Illegal number of the reference encoder	Specify a permissible number of the reference encoder for parameter "MC_SetSensor.ReferenceSensor".
16#8062	Illegal approach value.	Specify a permissible approach value for the searched for leading value for parameter "ApproachLeadingValue".

ErrorID	Description	Remedy
16#8063	A valid mapping to the definition range (leading values) does not exist for the specified following value.	Specify a permissible following value for parameter "FollowingValue".
16#8064	A valid mapping to the range of the function (following values) does not exist for the specified leading value.	Specify a permissible leading value for parameter "LeadingValue".
16#8070	Illegal value for leading value shift.	Specify a permissible value for the leading value shift for parameter "PhaseShift".
16#8071	The axis is not in position-controlled mode. The job cannot be executed.	Activate position-controlled mode.
16#8074	An "MC_Home" is active. The job cannot be executed.	During active or passive homing, an encoder switchover is rejected. Wait until the "MC_Home" job is complete. Restart the job.
16#8075	The job cannot be executed because synchronous operation is not active on the axis.	Switch on the synchronous operation function. Restart the job.
16#8076	Command cannot be executed. Synchronous operation is being simulated on the specified axis.	End the simulation of the synchronous operation. Restart the job.

16#80A0 - 16#80FF

ErrorID	Description	Remedy
16#80A1	Job cannot be executed because a synchronous operation job is active.	A "MC_Home" job on a following axis is not executed when a "MC_CamIn" or "MC_GearInPos" job is active. Exit the synchronous operation job. Restart the job.
16#80A2	For one-time measuring with measuring range, the measuring range was run without a measuring edge being detected.	Check and adjust the measuring input and adjust the measuring range positions, if necessary.
16#80A3	The measuring input job via PROFIdrive telegram could not be started because a homing job is active.	Simultaneous execution of a homing job and a measuring input job via PROFIdrive telegram is not possible. Wait until the homing job has ended. Restart the measuring job via PROFIdrive telegram.
16#80A5	Illegal value for start position of measuring range	Specify a permissible value for the start position of the measuring range for parameter "MC_MeasuringInput.StartPosition" or MC_MeasuringInputCyclic.StartPosition.
16#80A6	Illegal value for end position of measuring range	Specify a permissible value for the end position of the measuring range for parameter "MC_MeasuringInput.EndPosition" or MC_MeasuringInputCyclic.EndPosition.
16#80A7	A measurement took place during measuring with measuring range, but the calculated position is outside the specified measuring range. The measured value is discarded.	Check and adjust the measuring input and adjust the measuring range positions, if necessary.

ErrorID	Description	Remedy
16#80A8	Job cannot be executed because camming is active on the axis.	The Motion Control instructions "MC_PhasingRelative" and "MC_PhasingAbsolute" can only be applied to active gearing with "MC_GearIn" or "MC_GearInPos" ("MC_GearIn.InGear" = TRUE or "MC_GearInPos.InSync" = TRUE).
16#80A9	Job cannot be executed because the following axis is synchronized ("MC_GearInPos.StartSync" = TRUE).	The Motion Control instructions "MC_PhasingRelative" and "MC_PhasingAbsolute" can only be applied to active gearing with "MC_GearIn" or "MC_GearInPos" ("MC_GearIn.InGear" = TRUE or "MC_GearInPos.InSync" = TRUE).
16#80AA	The cam contains no points or segments and cannot be interpolated.	Fill the cam with points/segments. Restart the job.
16#80AB	The cam is currently being used and cannot be interpolated.	End the current use of the cam. Restart the job.
16#80AC	The cam contains incorrect points or segments and cannot be interpolated. (for example, the cam contains only one point.)	Fill the cam with permissible points/segments. Restart the job.
16#80AD	The specified synchronous position is outside the definition range of the cam.	Specify a permissible synchronous position for parameter "MasterSyncPosition". Restart the job.
16#8FFF	Unspecified error	Contact your local Siemens representative or support center. You will find contact information at: Contact information for Industry Automation and Drive Technologies (http://www.siemens.com/automation/partner)

See also

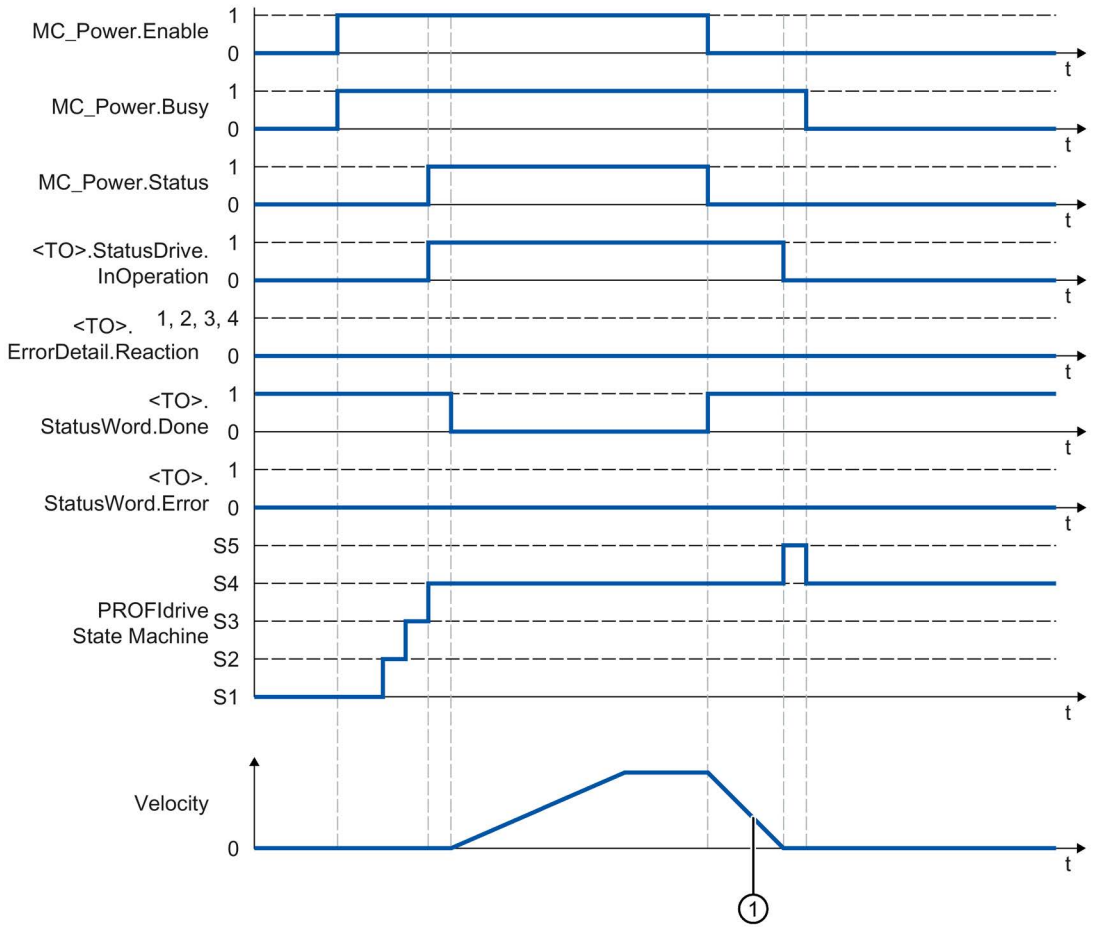
Errors in Motion Control instructions (Page 346)

A.9 MC_Power function chart

A.9.1 Drive connection via PROFIdrive

A.9.1.1 StopMode 0, 2

Function chart: Enabling a technology object and disabling with "StopMode" = 0, 2



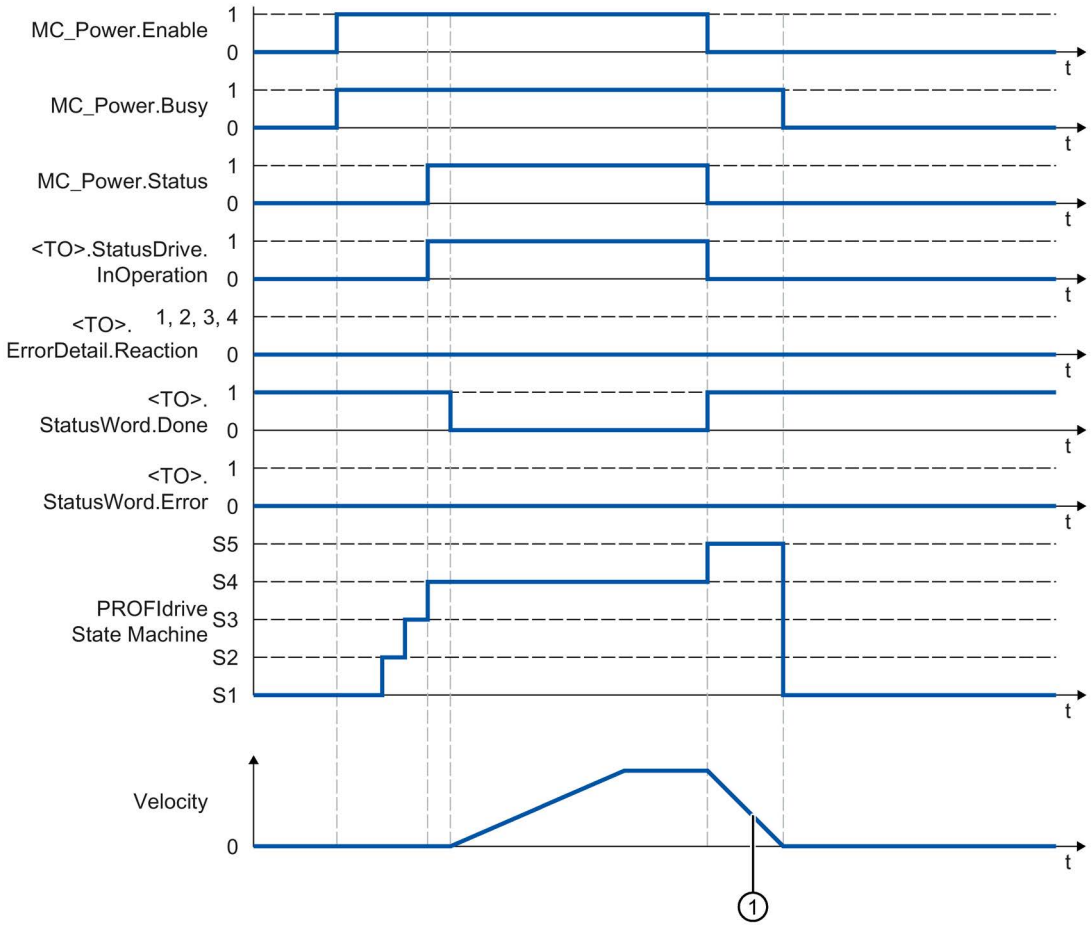
①
- "StopMode" = 0

  The axis is braked with the configured emergency stop deceleration.
- "StopMode" = 2

  The axis decelerates with the configured maximum deceleration.

A.9.1.2 StopMode 1

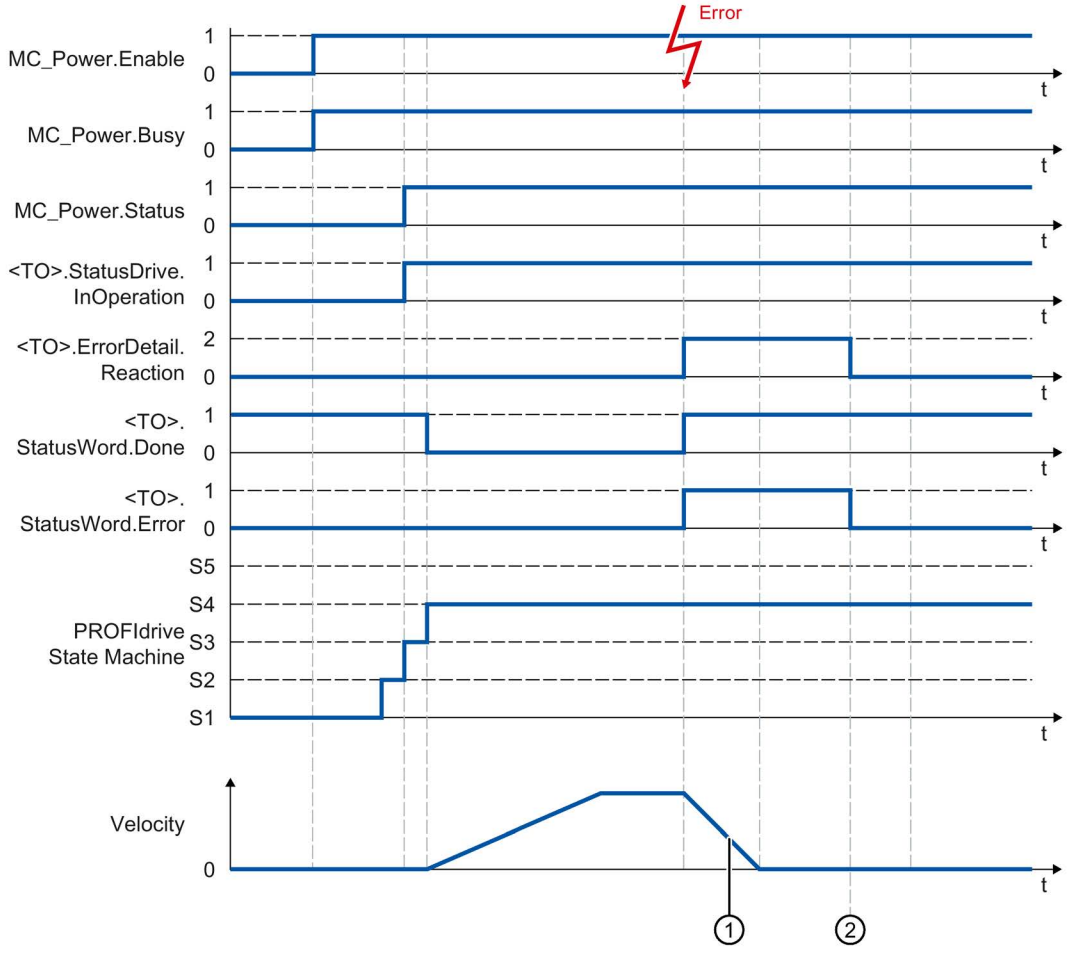
Function chart: Enabling a technology object and disabling with "StopMode" = 1



① The deceleration ramp depends on the configuration in the drive.

A.9.1.3 Alarm reactions with braking ramp via the technology object

Function chart: Enabling a technology object and occurrence of a technology alarm with braking ramp via the technology object



① The axis is braked based on the alarm reaction:

- Stop with current dynamic values (<TO>.ErrorDetail.Reaction = 1)

  The axis is braked with the deceleration in the Motion Control instruction.
- Stop with maximum dynamic values (<TO>.ErrorDetail.Reaction = 2)

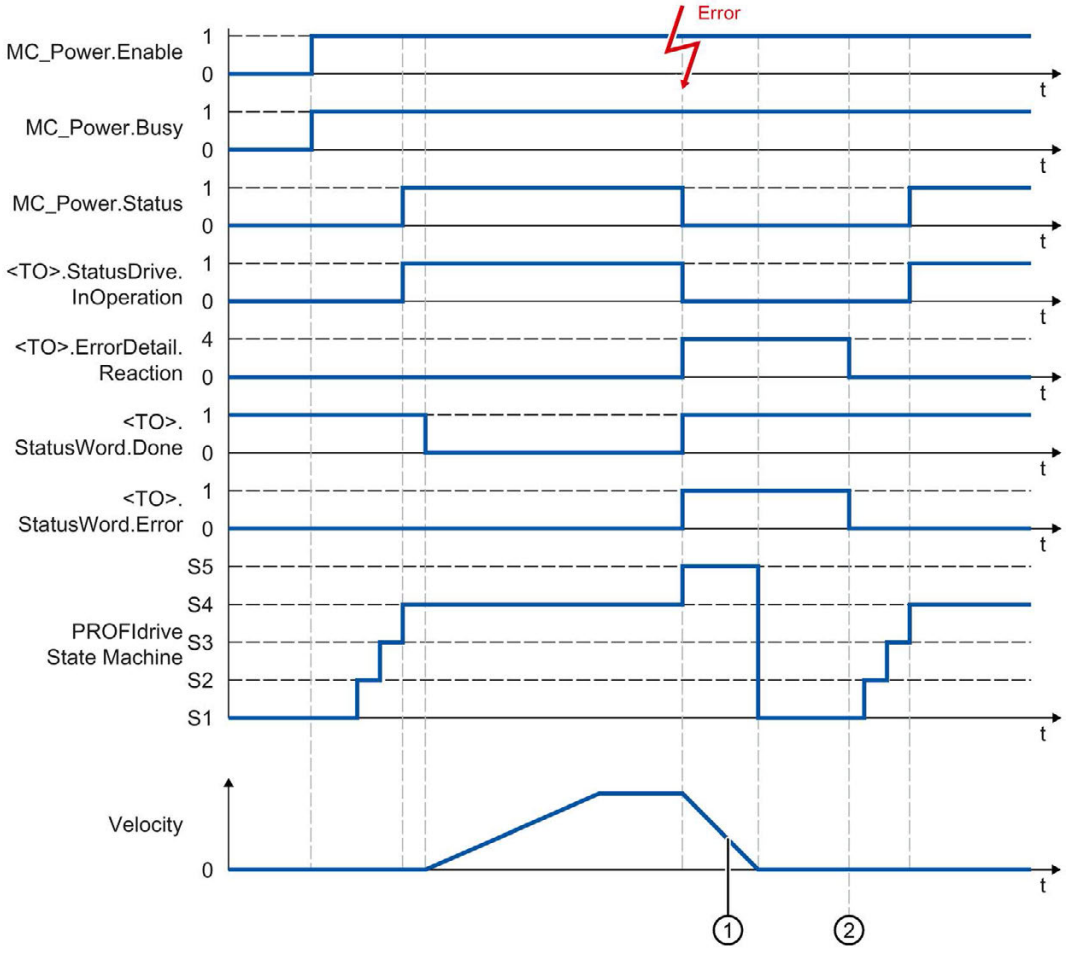
  The axis decelerates with the configured maximum deceleration.
- Stop with emergency stop ramp (<TO>.ErrorDetail.Reaction = 3)

  The axis is braked with the configured emergency stop deceleration.

② The technology alarm is acknowledged.

A.9.1.4 Alarm response "Remove enable"

Function chart: Enabling a technology object and occurrence of a technology alarm with alarm reaction "Remove enable"



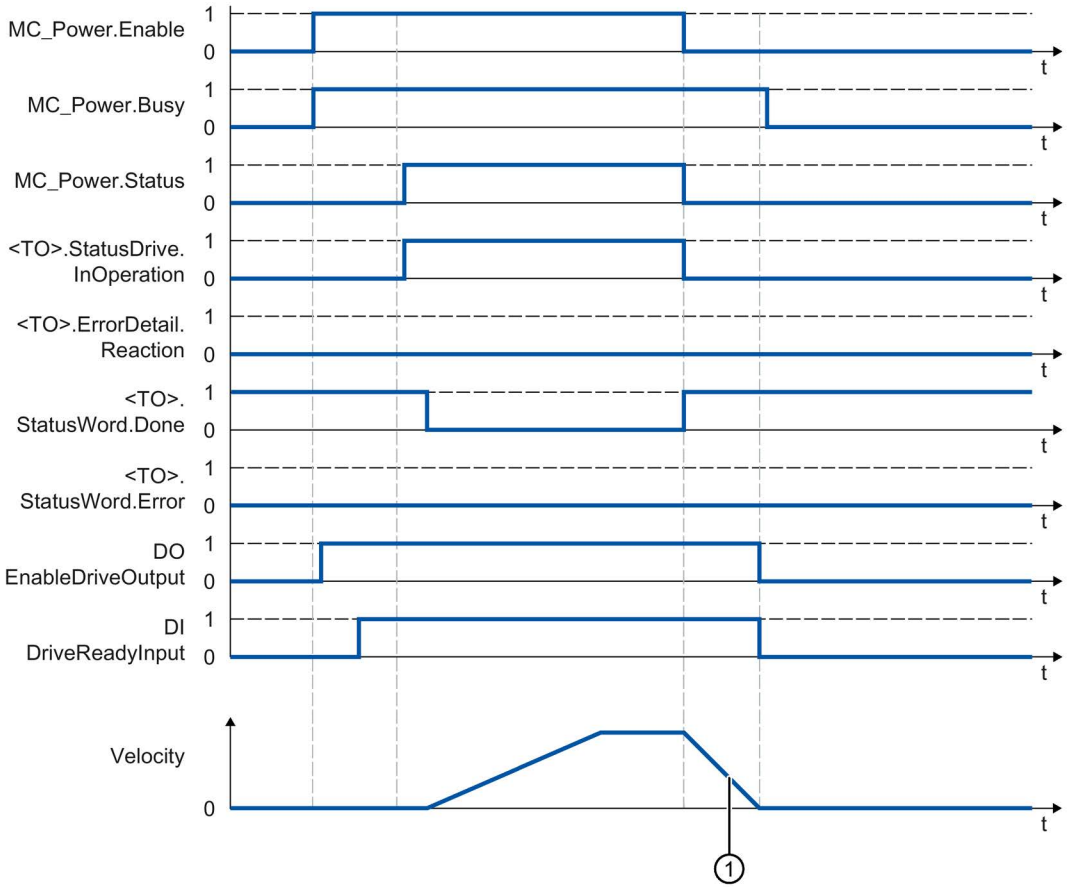
① The deceleration ramp depends on the configuration in the drive.

② The technology alarm is acknowledged at time ②.

A.9.2 Analog drive connection

A.9.2.1 StopMode 0, 2

Function chart: Enabling a technology object and disabling with "StopMode" = 0, 2



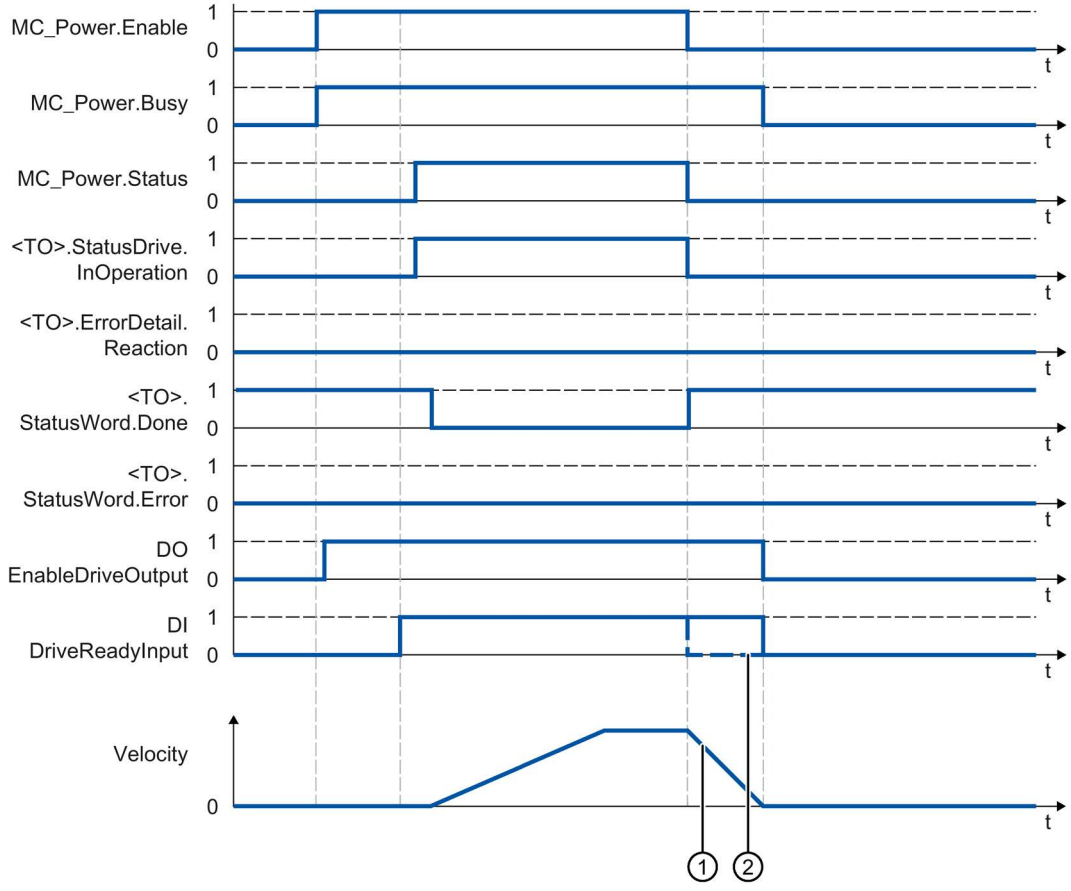
①
- "StopMode" = 0

  The axis is braked with the configured emergency stop deceleration.
- "StopMode" = 2

  The axis decelerates with the configured maximum deceleration.

A.9.2.2 StopMode 1

Function chart: Enabling a technology object and disabling with "StopMode" = 1

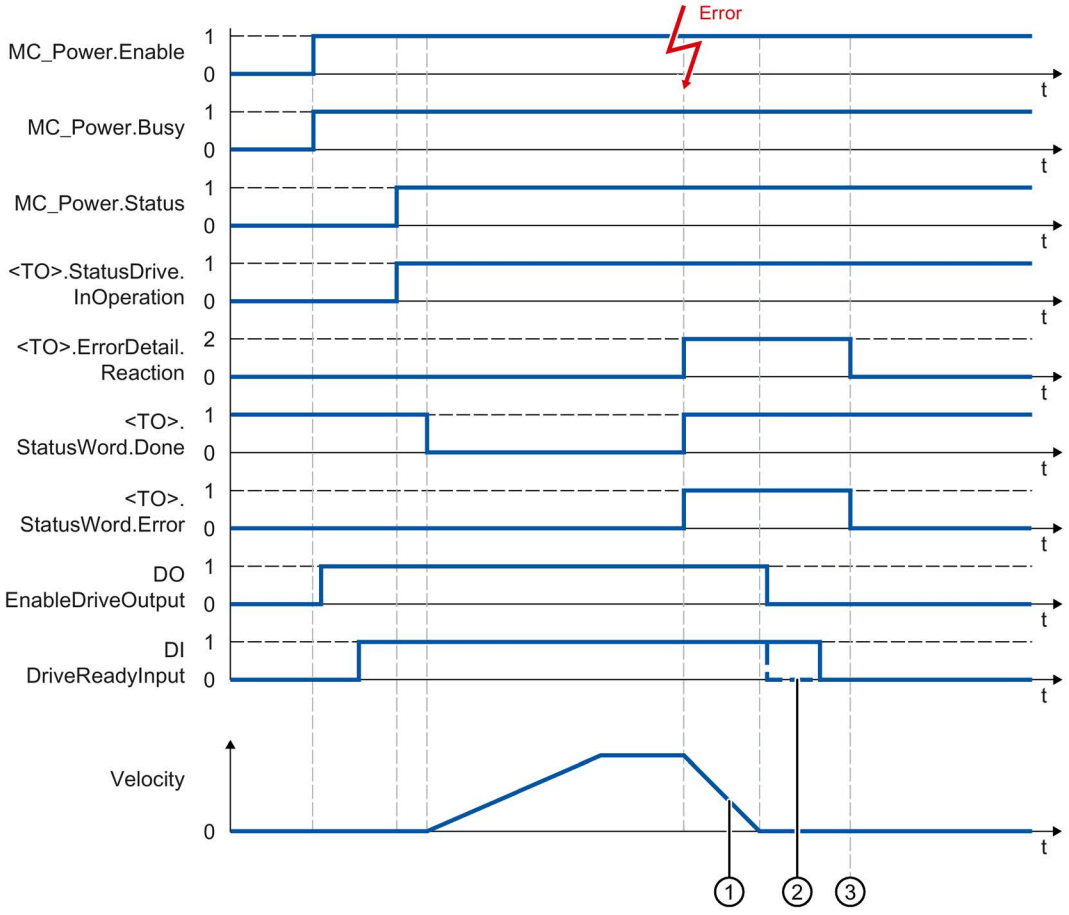


① The deceleration ramp depends on the configuration in the drive.

② The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

A.9.2.3 Alarm reactions with braking ramp via the technology object

Function chart: Enabling a technology object and occurrence of a technology alarm with braking ramp via the technology object



① The axis is braked based on the alarm reaction:

- Stop with current dynamic values (<TO>.ErrorDetail.Reaction = 1)

  The axis is braked with the deceleration in the Motion Control instruction.
- Stop with maximum dynamic values (<TO>.ErrorDetail.Reaction = 2)

  The axis decelerates with the configured maximum deceleration.
- Stop with emergency stop ramp (<TO>.ErrorDetail.Reaction = 3)

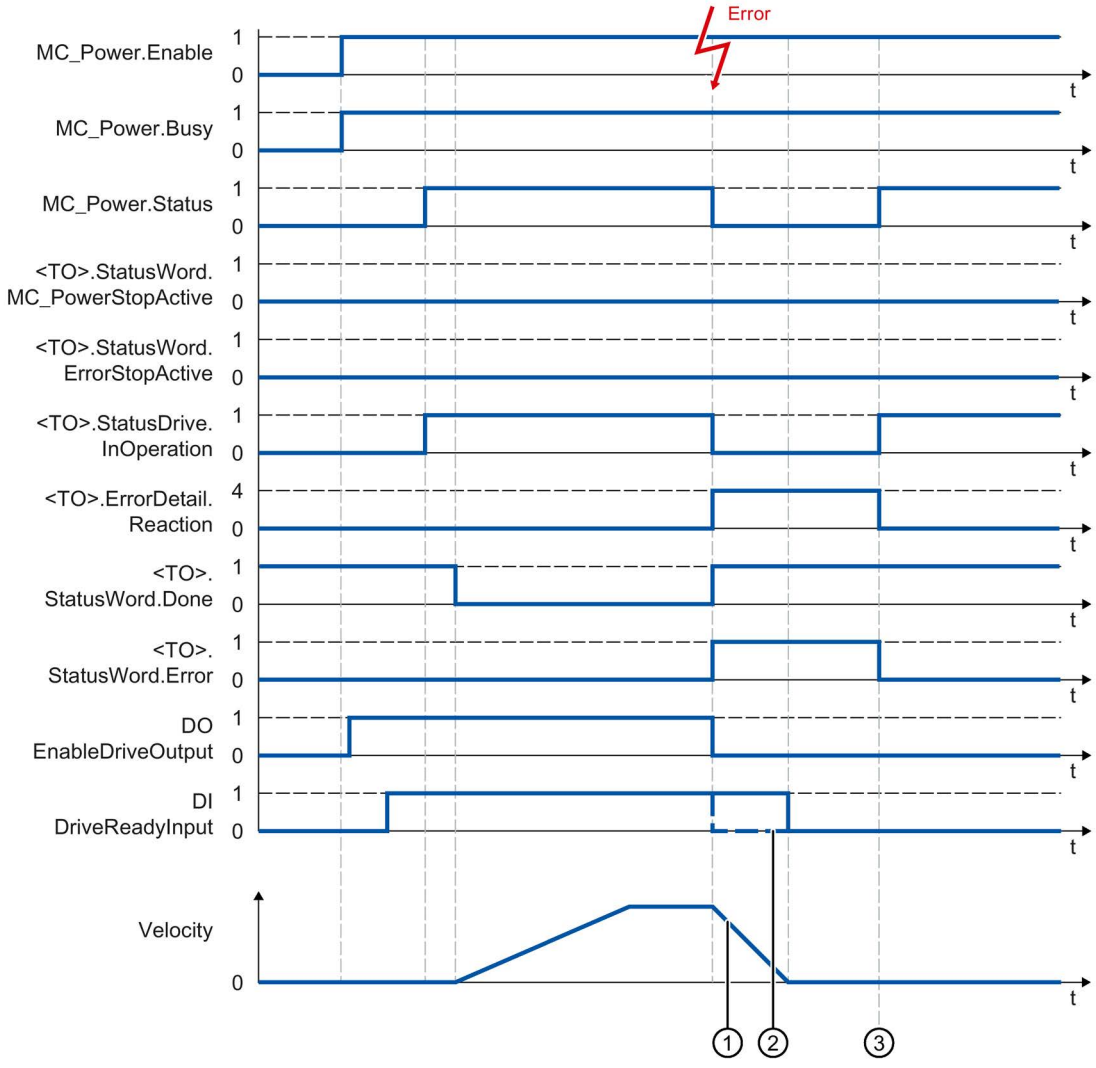
  The axis is braked with the configured emergency stop deceleration.

② The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

③ The technology alarm is acknowledged at time ③.

A.9.2.4 Alarm response "Remove enable"

Function chart: Enabling a technology object and occurrence of a technology alarm with alarm reaction "Remove enable"



① The deceleration ramp depends on the configuration in the drive.

② The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

③ The technology alarm is acknowledged at time ③.

A.10 SINAMICS drives

A.10.1 Homing SINAMICS drives with external zero marks

For SINAMICS drives with external zero marks, synchronization during homing must always occur on the left side of the external zero mark's signal. That is to say, with a positive direction of travel synchronization is done on a positive edge, and with a negative direction of travel synchronization is done on a negative edge.

By inverting the signal, synchronization can also be done on the right sight of the signal of the external zero mark. The inversion can be configured in the drive using SINAMICS parameter P490.

Homing to an encoder zero mark or an external zero mark is configured in SINAMICS parameter P495.

Glossary

Absolute synchronous operation

Function corresponds to the Motion Control instruction MC_GearInPos or MC_CamIn.

Absolute value encoder

Position encoder which outputs the position in the form of a digital numerical value. This numerical value is unique within the entire measuring range of the absolute value encoder.

Axis control panel

The axis control panel allows you to move the axis in manual mode, optimize the axis settings, and test the operation of the axis in your system.

Axis type

The axis type differs depending on the unit of measurement according to which the axis is positioned.

Depending on the execution of the mechanics, an axis is implemented as a linear axis or rotary axis:

- For linear axes, the position of the axis is specified as a linear measure, e.g. millimeters (mm).
- For rotary axes, the position of the axis is specified as an angular measure, e.g. degrees (°).

Communication processor (CP)

Module for expanded communications tasks covering special applications, for example in the area of security.

Communications module (CM)

Module for communications tasks which is used as an interface expansion of the CPU (for example PROFIBUS) or provides additional communications options (e.g. PtP) in an automation system.

Drive

The combination of motor (electric or hydraulic), actuator (converter, valve), control system, measuring system and supply (infeed, accumulator).

Dynamic Servo Control (DSC)

In drives that support DSC, you can optionally use the position controller in the drive. The position controller in the drive is usually implemented with a rapid speed-control cycle. This improves the control performance for digitally coupled drives.

Following error

The following error is the difference between the position setpoint and the actual position value. The transmission times of the setpoint to the drive, and of the actual position value to the controller, are taken into account in the calculation of the following error.

GSD file

As a Generic Station Description, this file contains all properties of a PROFINET or PROFIBUS device that are necessary for its configuration.

Hardware limit switch

Mechanical limit position switch that limits the maximum permissible traversing range of the axis.

Homing

With homing, you create the relationship between the position in the technology object and the mechanical position of the axis. The position value in the technology object is assigned to a homing mark at the same time. This homing mark represents a known mechanical position.

Incremental encoder

Position encoder which outputs the position change incrementally in the form of a digital numerical value.

Kv factor

Gain factor of the position controller

Master value

Input value for synchronous operation

Motion Control instruction

Use the Motion Control instructions to start Motion Control jobs at technology objects in your user program and thus execute the desired functionality at the technology objects. You track the status of running jobs with the output parameters of the Motion Control instructions.

Override

Percentage correction of the velocity/speed

Processing cycle clock

The processing of a technology object in the servo cycle clock.

PROFIdrive

PROFIdrive is a profile specified by the PNO (PROFIBUS user organization) for PROFIBUS DP and PROFINET IO for speed- and position-controlled drives.

PROFIdrive frame

Frame for communication according to PROFIdrive.

Proximity switch

Position switch which is activated with the moving part without mechanical contact.

Relative gearing

Function corresponds to the Motion Control instruction MC_GearIn.

Restart

The technology object is reinitialized with the current configuration parameters.

Safe Stop 1 (SS1)

The Safe Stop 1 (SS1) safety function brings a drive to standstill quickly and safely via an internal rapid stop ramp. Safe Torque Off (STO) is activated after standstill. STO ensures that no more torque generating energy acts on a drive. This prevents unintended startup of the drive.

You can use the SS1 safety function when a fast stop of the drive with a subsequent transition to STO is required. SS1 is used, for example, to quickly stop high inertia loads or to brake drives quickly and safely at high speeds

Safe Stop 2 (SS2)

The Safe Stop 2 (SS2) safety function brings a drive to standstill quickly and safely via an internal rapid stop ramp. After standstill is reached, the standstill position is monitored on the drive side. The drive can deliver full torque to maintain the standstill.

SS2, for example, is used for processing machines and machine tools.

Safe Torque Off (STO)

The Safe Torque Off (STO) safety function is the most commonly used and most basic drive-internal safety function. STO ensures that no more torque generating energy acts on a drive. This prevents unintended startup of the drive. The pulses of the drive are eliminated. The drive is reliably torque-free. This state is monitored internally in the drive.

You can use STO when the drive comes to a standstill in a sufficiently short time on its own due to the load torque or due to friction. Other areas of use are where "coasting" of the drive has no relevance for safety.

Software limit switch

A programmable position which limits the traversing range of an axis.

Synchronization

The phase of the following axis to reach synchronous movement.

Synchronous operation

Defined synchronous movement after synchronization of a following axis to a leading axis.

Technology alarm

If an error occurs at a technology object (e.g. approaching a hardware limit switch), a technology alarm is triggered and indicated.

The impact of a technology alarm on the technology object is specified by the alarm reaction (e.g. remove enable). The alarm reaction is specified by the system.

Technology data block

The technology data block represents the technology object and contains all configuration data, setpoint and actual values, and status information of the technology object.

Technology module (TM)

Module for technological tasks, e.g. counting, measuring and positioning.

Zero mark

Position reference for the movement of rotary and linear incremental encoders. The zero mark of an incremental encoder is used as a homing mark, for example.

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SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP

Counting, measurement and position detection

Function manual

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S7-1500, ET 200MP, ET 200SP Counting, measurement and position detection

Function Manual

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Service & Support A

09/2016

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

Purpose of the documentation

This documentation supports you in configuring and programming modules for counting and measurement tasks of the S7-1500, ET 200MP and ET 200SP, as well as in position feedback and position input.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Validity of the documentation

This documentation applies to the use of the following modules:

- S7-1500 modules
  - TM Count 2x24V
  - TM PosInput 2
  - TM Timer DIDQ 16x24V
  - CPU 1511C-1 PN
  - CPU 1512C-1 PN
  - DI 32x24VDC HF (as of firmware version V2.1.0)
  - DI 16x24VDC HF (as of firmware version V2.1.0)
- ET 200SP modules
  - TM Count 1x24V
  - TM PosInput 1
  - TM Timer DIDQ 10x24V
  - DI 8x24VDC HS

TM Count, TM PosInput and compact CPU are suitable for complex counting and measuring tasks and for position detection. TM Timer DIDQ and digital input modules are suitable for simple counting tasks.

Conventions

Please observe notes marked as follows:

Note

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Additional assistance

- You can find information about the technical support offerings in the appendix Service & Support (Page 196).
- The range of technical documentation for the individual SIMATIC products and automation systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (https://mall.industry.siemens.com).

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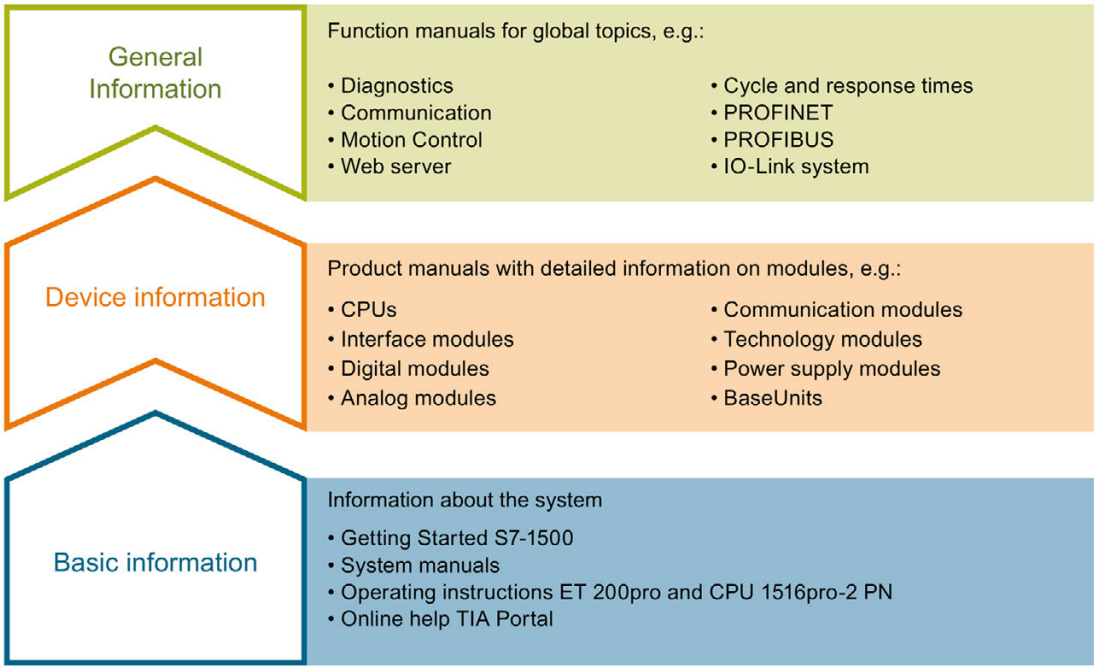
Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, for CPU 1516pro-2 PN based on SIMATIC S7-1500, and for the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.



Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems; use the corresponding operating instructions for CPU 1516pro-2 PN. The STEP 7 online help supports you in configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)
- ET 200AL (https://support.industry.siemens.com/cs/us/en/view/99494757)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

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You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on different SIMATIC S7 stations as a bulk operation, independently of the TIA Portal.

The SIMATIC automation tool provides a variety of functions:

- Scanning of a PROFINET/Ethernet plant network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- CPU localization by means of LED flashing
- Reading out CPU error information
- Reading of CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

The basics of counting, measurement and position detection

2

2.1 Overview of modules and properties

Modules

The table below summarizes the performance features of the modules for counting, measuring and position input for the S7-1500 and ET 200MP systems.

Property	S7-1500 / ET 200MP				
	Technology module			Digital input module	Compact CPU
	TM Count 2x24V	TM PosInput 2	TM Timer DIDQ 16x24V	DI 32x24VDC HF, DI 16x24VDC HF	CPU 1511C-1 PN, CPU 1512C-1 PN
Number of counters	2	2	4[1]	2	6
Use of counters can be activated/deactivated	—	—	X	X	X
Maximum signal frequency	200 kHz	1 MHz	50 kHz	1 kHz	100 kHz
Maximum count frequency for incremental encoders with quadruple evaluation (Page 70)	800 kHz	4 MHz	200 kHz	—	400 kHz
Maximum counting range	32 bits (Page 21)	32 bits (Page 21)	32 bits (Page 75)	32 bits (Page 80)	32 bits (Page 21)
Maximum position value range (Page 23)	—	31 bits	—	—	—
RS422/TTL incremental and pulse encoder (Page 67) connection	—	X	—	—	—
24 V incremental encoder connection	X (Page 65)	—	X (Page 77)	—	X (Page 65)
24 V pulse encoder connection	X (Page 65)	—	X (Page 77)	X (Page 88)	X (Page 65)
SSI absolute encoder (Page 69) connection	—	X	—	—	—
Position input for Motion Control (Page 65)	X	X	—	—	X

Property	S7-1500 / ET 200MP				
	Technology module			Digital input module	Compact CPU
	TM Count 2x24V	TM PosInput 2	TM Timer DIDQ 16x24V	DI 32x24VDC HF, DI 16x24VDC HF	CPU 1511C-1 PN, CPU 1512C-1 PN
5 V encoder supply	—	X	—	—	—
24 V encoder supply	X	X	X	—	X
Number of additional digital inputs per counter	3	2	—	—	2
Number of physical digital outputs per counter	2	2	—	—	1
Number of logical digital outputs per counter	2	2	—	1	2
Hysteresis (Page 61)	X	X	—	—	X
Software gate	X (Page 26)	X (Page 26)	—	X (Page 83)	X (Page 26)
Hardware gate	X (Page 26)	X (Page 26)	—	—	X (Page 26)
Capture function (Latch) (Page 29)	X	X	—	—	X
Synchronization (Page 34)	X	X	—	—	X
Comparison functions	X (Page 42)	X (Page 42)	—	X (Page 85)	X (Page 42)
Frequency, velocity and period duration measurement (Page 53)	X	X	—	—	X
Support for isochronous mode on PROFINET	X (Page 73)	X (Page 73)	X (Page 78)	X (Page 89)	—
Support for diagnostic interrupts for sensor signals	X (Page 64)	X (Page 64)	—	—	X (Page 64)
Hardware interrupt support	X (Page 64)	X (Page 64)	—	X (Page 87)	X (Page 64)
Configurable filter for count signals and digital inputs	X	X	—	X	X

[1] The number of available counters is dependent on the channel configuration. In order to use four counters, you must choose the use of eight inputs in the channel configuration. If you choose the use of three inputs, you can use one counter. Other channel configurations do not allow any counter use.

The following table provides an overview of the performance features of the modules for counting, measuring and position input for the ET 200SP system.

Property	ET 200SP			
	Technology module			Digital input module
	TM Count 1x24V	TM PosInput 1	TM Timer DIDQ 10x24V	DI 8x24VDC HS
Number of counters	1	1	3[1]	4
Use of counters can be activated/deactivated	—	—	X	X
Maximum signal frequency	200 kHz	1 MHz	50 kHz	10 kHz
Maximum count frequency for incremental encoders with quadruple evaluation (Page 70)	800 kHz	4 MHz	200 kHz	—
Maximum counting range	32 bits (Page 21)	32 bits (Page 21)	32 bits (Page 75)	32 bits (Page 80)
Maximum position value range (Page 23)	—	31 bits	—	—
RS422/TTL incremental and pulse encoder (Page 67) connection	—	X	—	—
24 V incremental encoder connection	X (Page 65)	—	X (Page 77)	—
24 V pulse encoder connection	X (Page 65)	—	X (Page 77)	X (Page 88)
SSI absolute encoder (Page 69) connection	—	X	—	—
Position input for Motion Control (Page 65)	X	X	—	—
5 V encoder supply	—	—	—	—
24 V encoder supply	X	X	X	X
Number of additional digital inputs per counter	3	2	—	1
Number of physical digital outputs per counter	2	2	—	—
Number of logical digital outputs per counter	2	2	—	1
Hysteresis	X	X	—	—
Software gate	X (Page 26)	X (Page 26)	—	X (Page 83)
Hardware gate	X (Page 26)	X (Page 26)	—	X (Page 83)
Capture function (Latch) (Page 29)	X	X	—	—
Synchronization (Page 34)	X	X	—	—
Comparison functions	X (Page 42)	X (Page 42)	—	X (Page 85)

Property	ET 200SP			
	Technology module			Digital input module
	TM Count 1x24V	TM PosInput 1	TM Timer DIDQ 10x24V	DI 8x24VDC HS
Frequency, velocity and period duration measurement (Page 53)	X	X	—	—
Support for isochronous mode on PROFINET	X (Page 73)	X (Page 73)	X (Page 78)	X (Page 89)
Support for diagnostic interrupts for sensor signals	X (Page 64)	X (Page 64)	—	—
Hardware interrupt support	X (Page 64)	X (Page 64)	—	—
Configurable filter for count signals and digital inputs	X	X	—	X

[1] One counter for incremental encoder (A, B phase-shifted) and two counters for pulse encoder

2.2 Basics of counting, measuring and position input (TM Count, TMPosInput, Compact CPU)

2.2.1 Convention

Technology module: We use the term "technology module" in this documentation both for the technology modules TM Count and TM PosInput and the technology component of the compact CPUs.

2.2.2 Overview of applications

Introduction

The technology module is configured and assigned parameters using the configuration software.

The technology module functions are controlled and monitored via the user program.

System environment for TM Count and TM PosInput

The technology modules can be used in the following system environments:

Application scenarios	Components required	Configuration software	In the user program
Central operation an S7-1500 system or distributed operation in an S7-1500 system with a corresponding ET 200 system	• S7-1500 automation system • ET 200 distributed I/O system • Technology module	STEP 7 (TIA Portal): • Device configuration with hardware configuration • Parameter settings with High_Speed_Counter technology object	Counting and measuring functions: High_Speed_Counter instruction for the technology object Position input with SSI absolute encoder: Direct access to technology module control and feedback interface in the I/O data
		STEP 7 (TIA Portal): Device configuration with hardware configuration in operating mode "Position input for Motion Control"	Control by a technology object

Application scenarios	Components required	Configuration software	In the user program
Distributed operation in an S7-300/400 or S7-1200 system	• S7-300/400 automation system • ET 200 distributed I/O system • Technology module	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter settings with HSP	Direct access to technology module control and feedback interface in the I/O data
Distributed operation in a third-party system	• Third-party automation system • ET 200 distributed I/O system • Technology module	Third-party configuration software: Device configuration and parameter settings with GSD file	Direct access to technology module control and feedback interface in the I/O data

System environment for a Compact CPU

The Compact CPUs can be used in the following system environments:

Application scenarios	Components required	Configuration software	In the user program
Central operation in an S7-1500 system	• S7-1500 automation system • Compact CPU	STEP 7 (TIA Portal): • Device configuration with hardware configuration • Parameter settings with High_Speed_Counter technology object	Counting and measuring functions: High_Speed_Counter instruction for the technology object
		STEP 7 (TIA Portal): Device configuration with hardware configuration in operating mode "Position input for Motion Control"	Control by the technology object

Parameter assignment options

In an S7-1500 system, you have two options for parameter assignment and control of technology module functions:

- Configuration using the High_Speed_Counter technology object and control with the corresponding High_Speed_Counter instruction
  The technology module control and feedback interface is accessed with the technology object.
- Parameter setting via hardware configuration
  The control and feedback interface of the technology module is accessed using direct access to the I/O data.

Configuration via technology object

For central and distributed use in an S7-1500 system, we recommend simple configuration with graphic support using a High_Speed_Counter technology object. A detailed description of this configuration can be found in section AUTOHOTSPOT and below.

You can define "Operating with technology object" for the technology module in the device configuration: see section Operating mode (Page 172).

You can assign the technology module and counting channel in the basic parameters of the technology object: see section Basic parameters (Page 96).

Parameter setting via hardware configuration

Additional support for parameter setting via hardware configuration is available in the context-sensitive help for the parameters in STEP 7 (TIA Portal). A description of the control and feedback interface is available in the following sections:

Assignment of the control interface (Page 182)

Assignment of the feedback interface (Page 185)

2.2.3 Recording of count signals

2.2.3.1 Counting with incremental or pulse encoder

Counting refers to the recording and adding up of events. The counters of the technology modules capture and evaluate pulse and incremental signals. The count direction can be specified using encoder or pulse signals or through the user program.

You can control counting processes using the digital inputs of the technology module. You can switch the digital outputs exactly at defined counter values, regardless of the user program.

You can configure the response of the counters using the functionalities described below.

Counter limits

The counter limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program.

The highest counter limit that can be set is 2147483647 (2^{31}–1). The lowest counter limit that can be set is –2147483648 (–2^{31}).

You can configure the response of the counter at the counter limits:

- Continue or stop counting upon violation of a counter limit (automatic gate stop)
- Set counter value to start value or to opposite counter limit upon violation of a counter limit

Start value

You can configure a start value within the counter limits. The start value can be modified during runtime by the user program.

The technology module can, as configured, set the current counter value to the start value upon synchronization, upon Capture function activation, upon violation of a counter limit or when the gate is opened.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured.

The hardware gate is controlled externally via a digital input of the technology module. The software gate is controlled via the user program. The hardware gate can be enabled through parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture (Latch)

You can configure an external reference signal edge that triggers the saving of the current counter value or position value as a Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of signal N at the encoder input (for incremental and pulse encoders)

For incremental and pulse encoders, you can configure whether counting continues from the current counter value or from the start value after the Capture function.

Synchronization

You can configure an external reference signal edge to load the counter with the specified start value. The following external signals can load the counter with the start value:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the counter value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

2.2.3.2 Position input with SSI absolute encoder

Description

You can use the TM PosInput technology modules with an SSI absolute encoder for position detection. The technology module reads the position value via a synchronous serial interface from the SSI absolute encoder and makes it available to the controller.

You can switch the digital outputs of the technology module exactly at defined position values, regardless of the user program. Position input with an SSI absolute encoder does not involve gate control. Due to system constraints, synchronization is not possible with an SSI absolute encoder.

Gray-dual conversion

Gray-code and dual-code SSI absolute encoders are supported.

Capture (Latch)

You can configure one or both edges of a digital input that triggers a saving of the current position value as Capture value.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the position value fluctuate around this position. If a comparison value or a limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

Range for position value

You can specify a frame length of 10 bits to 40 bits for the SSI absolute encoder. The configurable bit numbers of the LSB and the MSB of the position value in the frame define the value range. The technology module can read a position value with a maximum length of31 bits and communicate it to the controller. The position value is treated as unsigned positive value and can assume values between 0" and "$2^{(MSB-LSB+1)-1}$".

Complete SSI frame

Instead of having a measured variable returned, you can choose to have the least significant 32 bits of the current unprocessed SSI frame returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface.

2.2.4 Behavior at the counting limits

Violation of a counting limit

The high counting limit is violated when the current counter value is equal to the high counting limit and another upward count pulse is received. The counter low limit is violated when the current counter value is equal to the counter low limit and another downward count pulse is received.

The appropriate status bit is set in the feedback interface in the event of limit violation:

Counting limit violated	Status bit
High counting limit	EVENT_OFLW is set
Low counting limit	EVENT_UFLW is set

You can reset the status bits with RES_EVENT .

You can configure whether or not and from which counter value counting is to continue following counting limit violation.

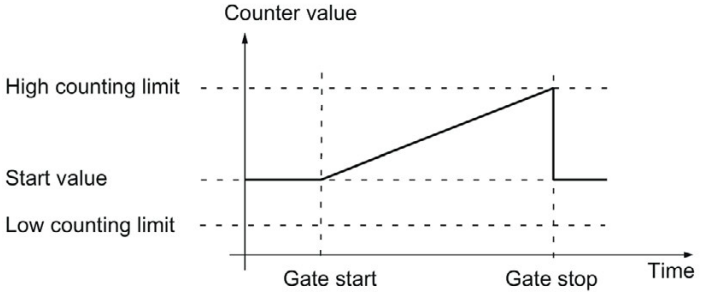
Note

The high counting limit and the start value define the value range of the counter:

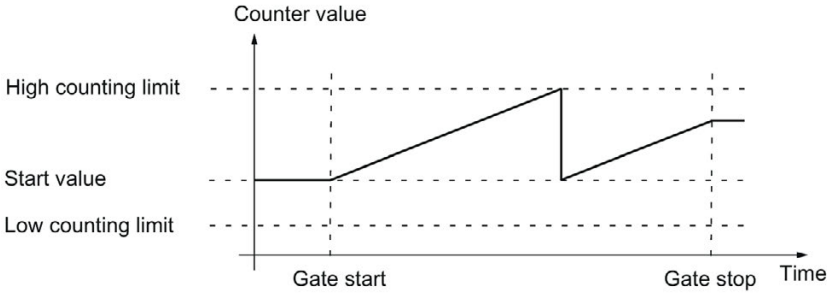
Value range of the counter = (high limit – start value) + 1

Examples

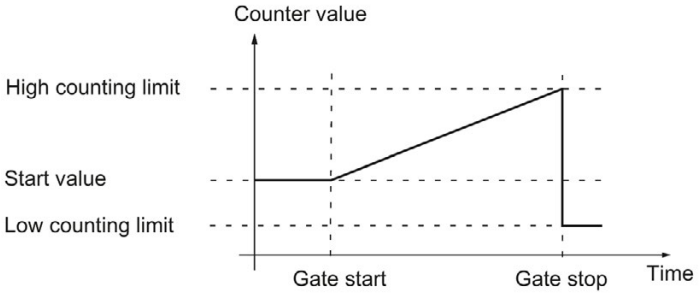
The figure below shows an example for terminating the counting process (automatic gate stop) after an overflow and setting the counter to the start value:



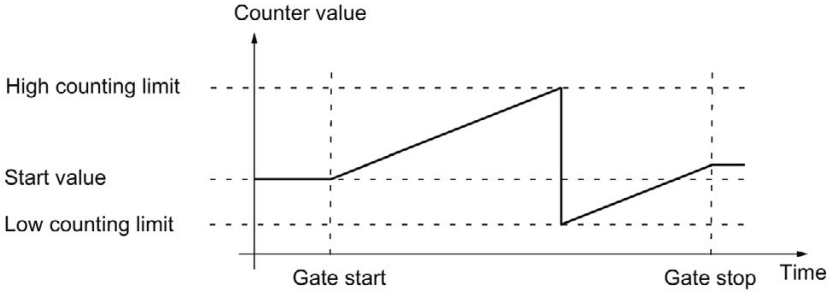
The figure below shows an example for continuing the counting process after an overflow and setting the counter to the start value:



The figure below shows an example for terminating counting after an overflow and setting the counter to the opposite counting limit:



The figure below shows an example for continuing the counting process after an overflow and setting the counter to the opposite counting limit:



2.2.5 Gate control with incremental or pulse encoder

Many applications require counting processes to be started or stopped in accordance with other events. In such cases, counting is started and stopped using the gate function.

The technology modules have two gates for each channel. These define the resulting internal gate:

- Software gate
- Hardware gate

2.2.5.1 Software gate

The software gate of the channel is opened and closed with the control bit (Page 182) SW_GATE. The status of the software gate is indicated by the feedback bit (Page 185) STS_SW_GATE .

2.2.5.2 Hardware gate

The hardware gate is optional. You open and close the hardware gate by means of signals at the configured digital inputs of the channel.

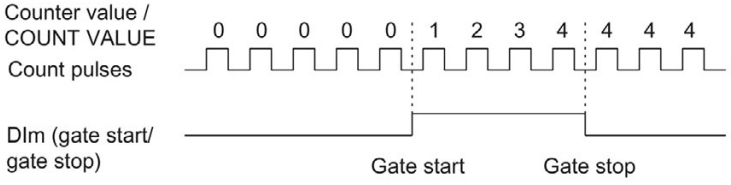
Note

The configured input filters delay the control signal of the digital input.

The status of a DIm digital input is indicated by the respective feedback bit (Page 185) STS_DIm .

Level-triggered opening and closing of the hardware gate with a digital input

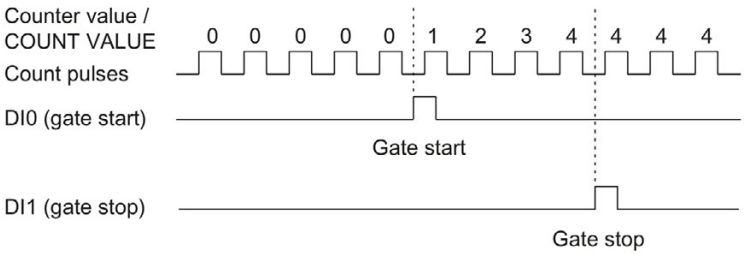
The figure below shows an example of level-triggered opening and closing with a digital input. The digital input is configured to be active with high level:



As long as the digital input is active, the hardware gate is open and the count pulses are counted. The hardware gate is closed when the digital input becomes inactive. The counter value stays constant and ignores any further count pulses.

Edge-triggered opening and closing of the hardware gate with two digital inputs

The figure below shows an example of opening and closing with two digital inputs. The two digital inputs are configured so that the rising edge of the hardware gate opens:



The hardware gate is opened with the configured edge at the digital input that is configured for opening. The hardware gate is closed with the configured edge at the digital input that is configured for closing.

2.2.5.3 Internal gate

Internal gate

The internal gate is open if the software gate is open and the hardware gate is open or has not been configured. The status of the internal gate is indicated by the feedback bit (Page 185) STS_GATE.

If the internal gate is open, counting is started. If the internal gate is closed, all other count pulses are ignored and counting is stopped.

If you want to control a counting process with the hardware gate only, the software gate must be open. If you do not configure a hardware gate, the hardware gate is considered to be always open. In this case, you open and close the internal gate with the software gate only.

Hardware gate	Software gate	Internal gate
Open/not configured	open	open
Open/not configured	closed	closed
closed	open	closed
closed	closed	closed

When you configure the counter behavior, you can specify whether the counting process is to start from the start value or from the current counter value when the internal gate is opened.

The internal gate can also be automatically closed upon violation of a counting limit. The software or hardware gate must then be closed and reopened to continue counting.

2.2.5.4 Counter behavior at gate start

You have the following configuration options for counter behavior upon gate start:

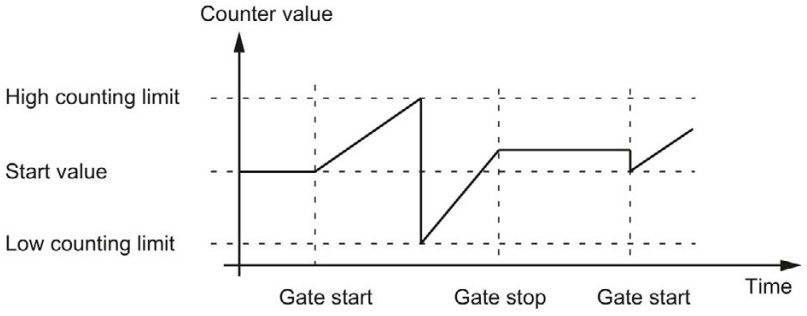
- Setting counter to start value
- Continuing with the current counter value

Setting counter to start value

Counter behavior is as follows for this configuration:

Each counting process starts with the start value when the internal gate is opened.

The figure below shows an example for continuing the counting process after counter is set to the start value:

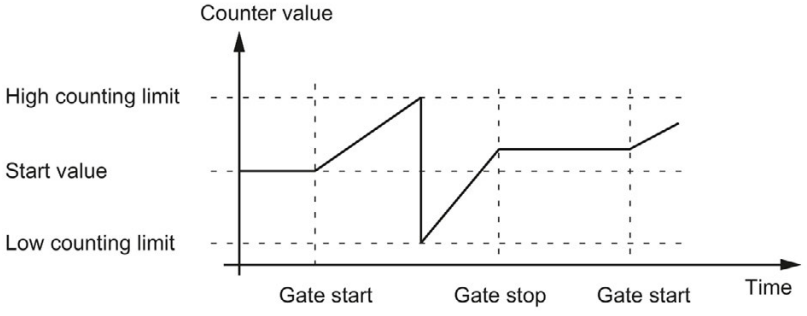


Continuing with the current counter value

Counter behavior is as follows for this configuration:

Each counting process starts from the current counter value after the internal gate is reopened.

The figure below shows an example for continuing the counting process with the current counter value:



2.2.6 Capture (Latch)

2.2.6.1 Capture with incremental or pulse encoder

Description

The "Capture" function is used to save the current counter value with an external reference signal. You can configure the Capture function for the following reference signals:

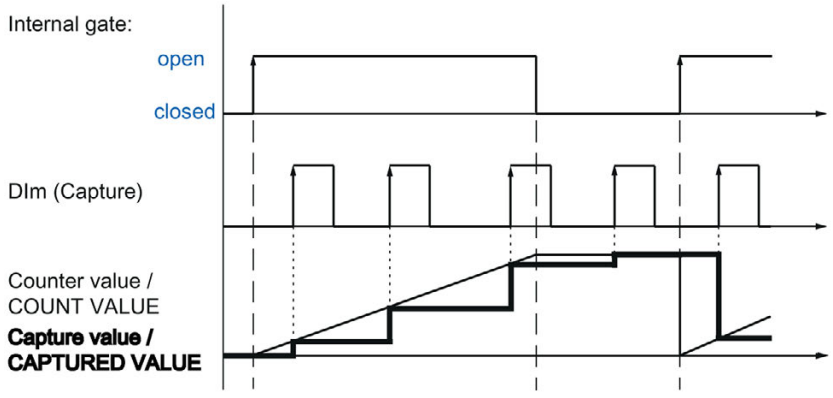
- Rising or falling edge at a digital input
- Rising and falling edge at a digital input
- Rising edge of signal N at the encoder input

Function principle

The Capture value is always the exact counter value at the time of the edge in question (delayed by the configured input filter time). The Capture function is effective regardless of the status of the internal gate. The unchanged counter value is saved when the gate is closed.

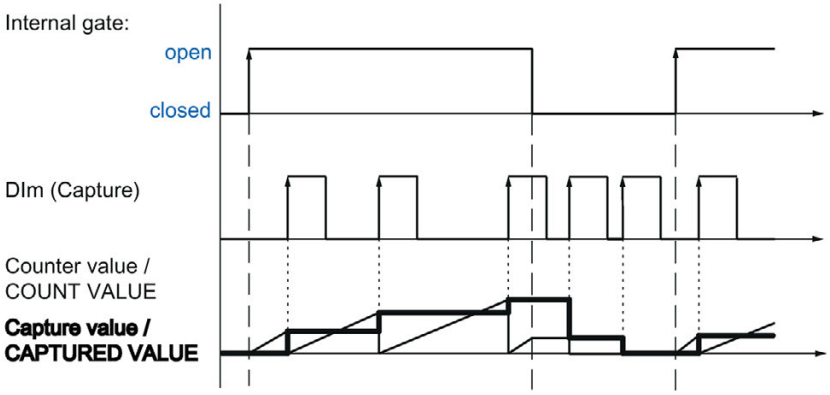
The figure below shows an example of the Capture function with the following configuration:

- Start value = 0
- Capture event upon rising edge at configured digital input
- Set counter to start value at gate start
- Continue counting after Capture event



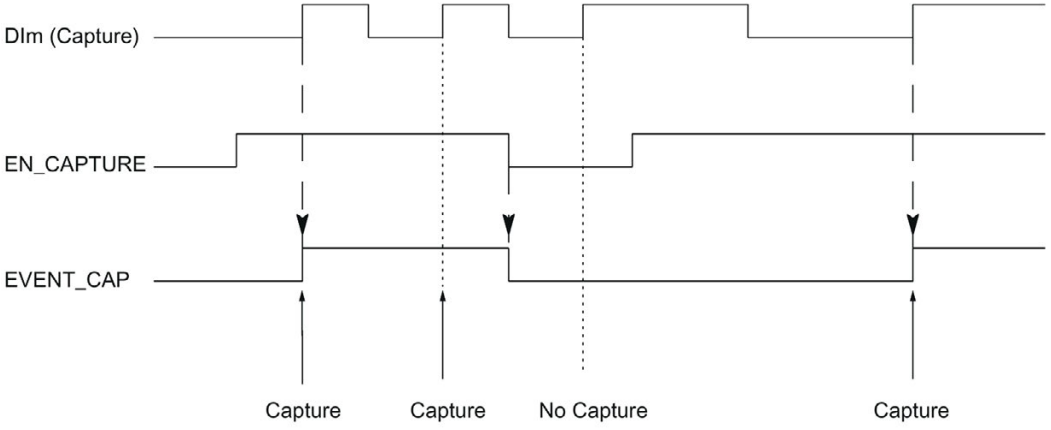
The figure below shows another example of the Capture function with the following configuration:

- Start value = 0
- Capture event upon rising edge at configured digital input
- Set counter to start value at gate start
- Reset counter value to start value after Capture event and continue counting.



The control bit (Page 182) EN_CAPTURE is used to enable the Capture function. The feedback bit (Page 185) EVENT_CAP indicates that a counter value has been saved as a Capture in the feedback interface. If you reset EN_CAPTURE, EVENT_CAP is also reset. The status of a digital input is indicated by the respective feedback bit (Page 185) STS_DIm .

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the Capture function by the rising edge at a digital input:



Note

The configured input filters delay the control signal of the corresponding digital input.

The Capture function has no effect on the feedback bit STS_CNT and the LEDs UP and DN.

Hardware interrupt

You can configure a hardware interrupt for the Capture function. Individual hardware interrupts may be lost if the hardware interrupt rate is higher than the system acknowledgement rate. You can signal a lost hardware interrupt with a diagnostic interrupt.

2.2.6.2 Capture with SSI absolute encoder

Description

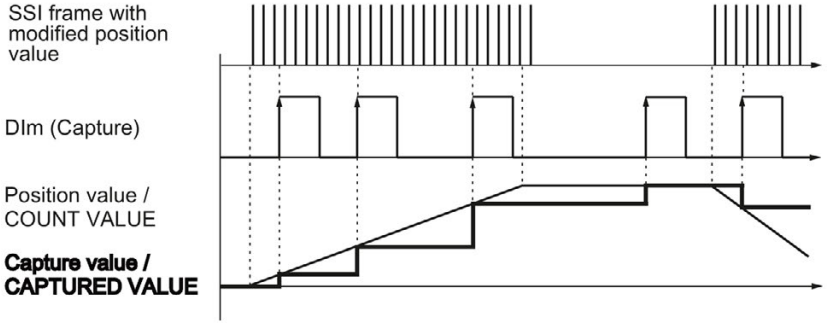
The "Capture" function is used to save the current position value using an external reference signal. You can configure the Capture function for the following reference signals:

- Rising or falling edge at a digital input
- Rising and falling edge at a digital input

Function principle

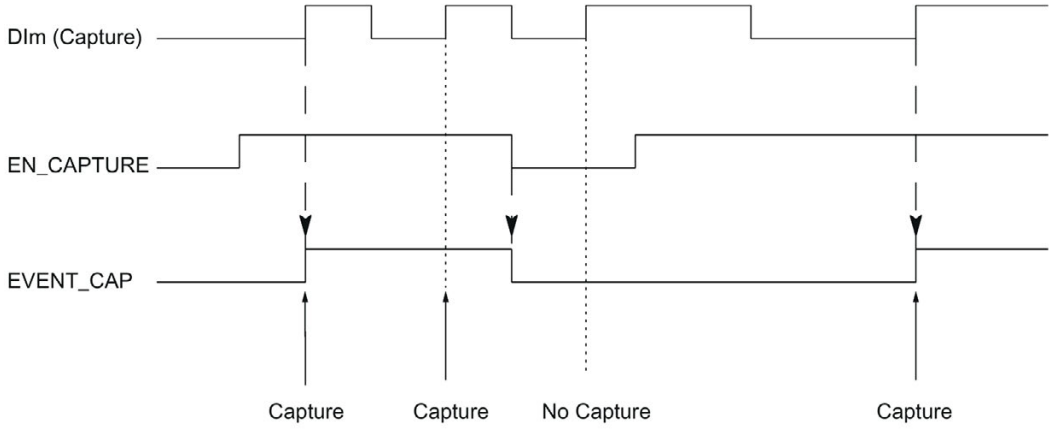
At the time of each edge, the position value of the last valid SSI frame is stored in the Capture value.

The figure below shows an example of the Capture event by a rising edge at the configured digital input:



The control bit (Page 182) EN_CAPTURE is used to enable the Capture function. The feedback bit (Page 185) EVENT_CAP indicates that a position value has been saved as Capture value in the feedback interface. If you reset EN_CAPTURE, EVENT_CAP is also reset. The status of a digital input is indicated by the respective feedback bit (Page 185) STS_DIm .

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the Capture function by the rising edge at a digital input:



Note

The configured input filters delay the control signal of the corresponding digital input.

Hardware interrupt

You can configure a hardware interrupt for the Capture function. Individual hardware interrupts may be lost if the hardware interrupt rate is higher than the system acknowledgement rate. You can signal a lost hardware interrupt with a diagnostic interrupt.

2.2.7 Synchronization

Description

You use the "Synchronization" function to set the counter to the pre-defined start value with an external reference signal. You can configure synchronization for the following reference signals:

- Rising or falling edges at a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input defined by the level of a digital input

Function principle

Synchronization always takes place exactly at the time of the reference signal. Synchronization is effective regardless of the status of the internal gate.

You use the control bit (Page 182) EN_SYNC_UP to enable synchronization for counting in an upwards direction. Use the control bit (Page 182) EN_SYNC_DN to enable synchronization for counting down. The feedback bit (Page 185) EVENT_SYNC indicates that synchronization has been performed. Resetting EN_SYNC_UP or EN_SYNC_DN also resets EVENT_SYNC.

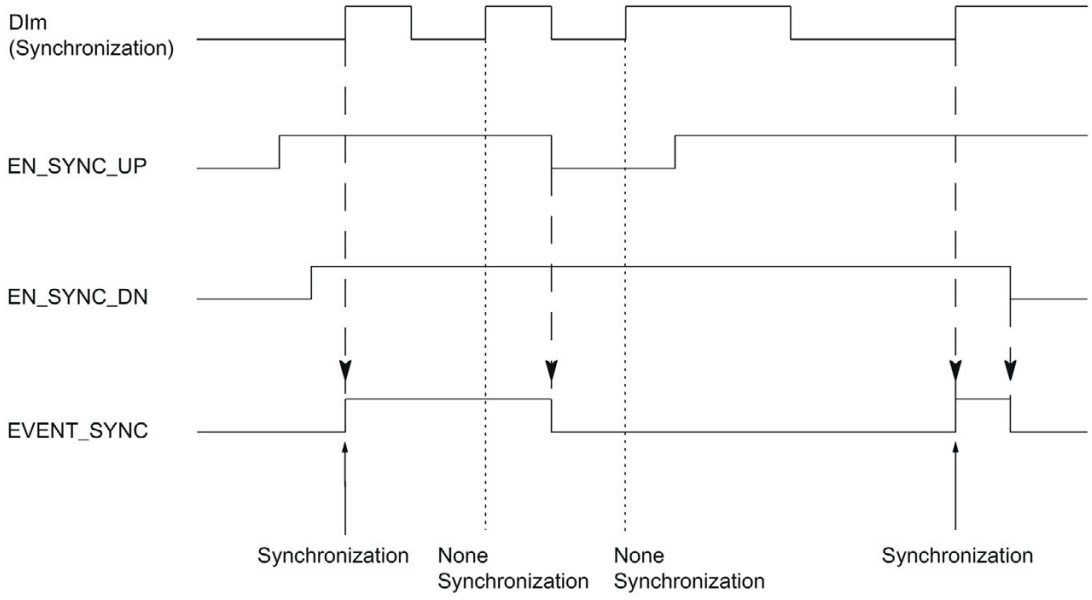
Note

The configured input filters delay the control signal of the corresponding digital input.

Synchronization has no effect on the feedback bit (Page 185) STS_CNT and the LEDs UP and DN.

Single synchronization

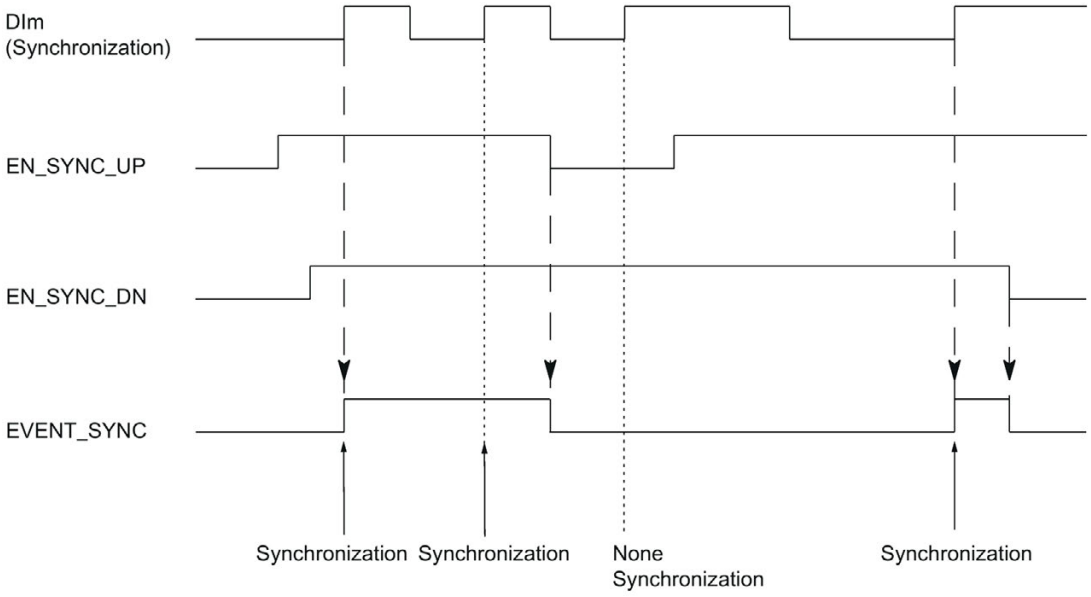
The figure below shows an example of the EN_SYNC_UP, EN_SYNC_DNand EVENT_SYNC bits with single synchronization by an edge at a digital input for count pulses in an upwards direction:



After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first rising edge at the configured digital input. The counter can only be synchronized again once the control bit (Page 182) EN_SYNC_UP has been reset and set again.

Periodic synchronization

The figure below shows an example of the EN_SYNC_UP, EN_SYNC_DN and EVENT_SYNC bits with periodic synchronization by an edge at a digital input for count pulses in an upwards direction:



As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each rising edge at the configured digital input.

Hardware interrupt

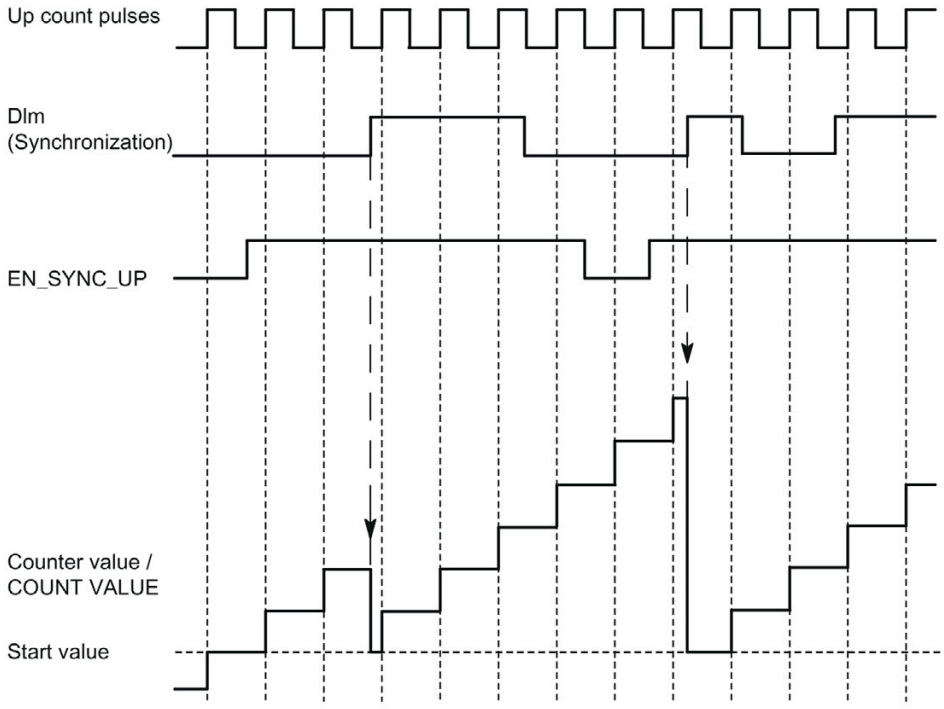
You can configure a hardware interrupt for the synchronization. The hardware interrupts will be lost if the interrupt rate is higher than the system acknowledgement rate. You can signal a lost hardware interrupt with a diagnostic interrupt.

2.2.7.1 Synchronization by digital input

You can trigger synchronization by edges at a digital input.

Single synchronization

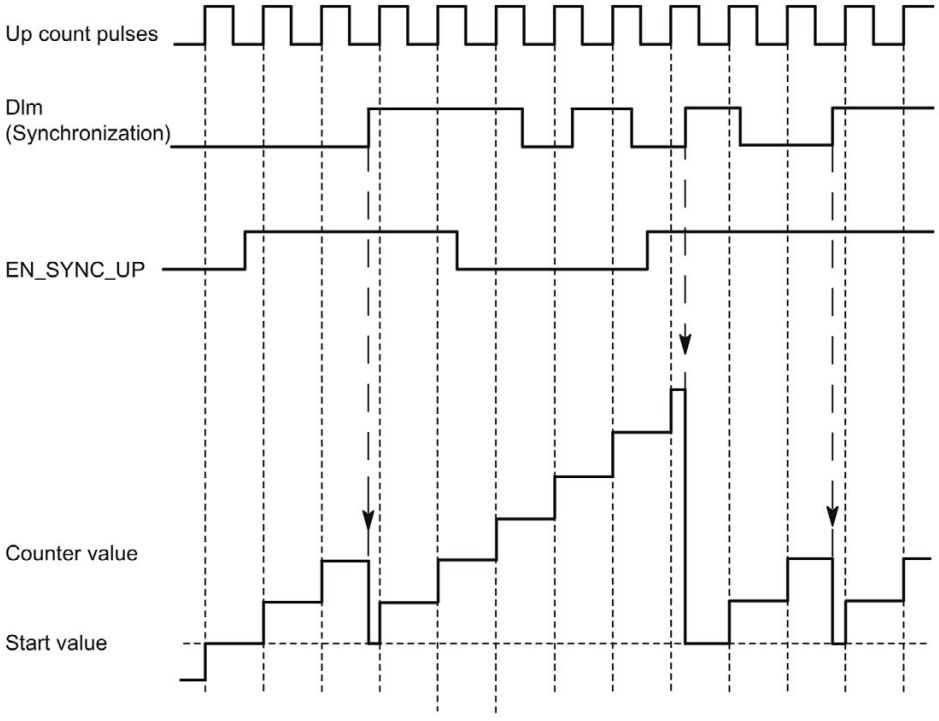
The figure below shows an example for single synchronization by an edge at a digital input:



After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first rising edge at the configured digital input. Until the control bit (Page 182) EN_SYNC_UP has been reset and set again, any additional rising edge at the digital output is ignored. The counter can then be synchronized again.

Periodic synchronization

The figure below shows an example for periodic synchronization by an edge at a digital input:



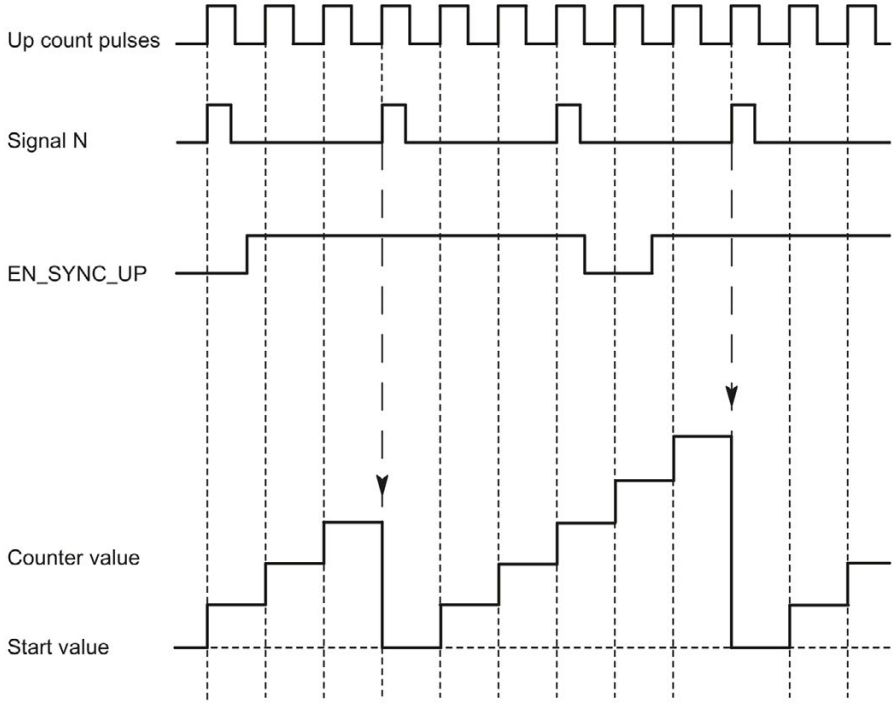
As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each rising edge at the configured digital input.

2.2.7.2 Synchronization at signal N

You can trigger synchronization at signal N at the encoder input either directly or depending on the status of a digital input.

Single synchronization

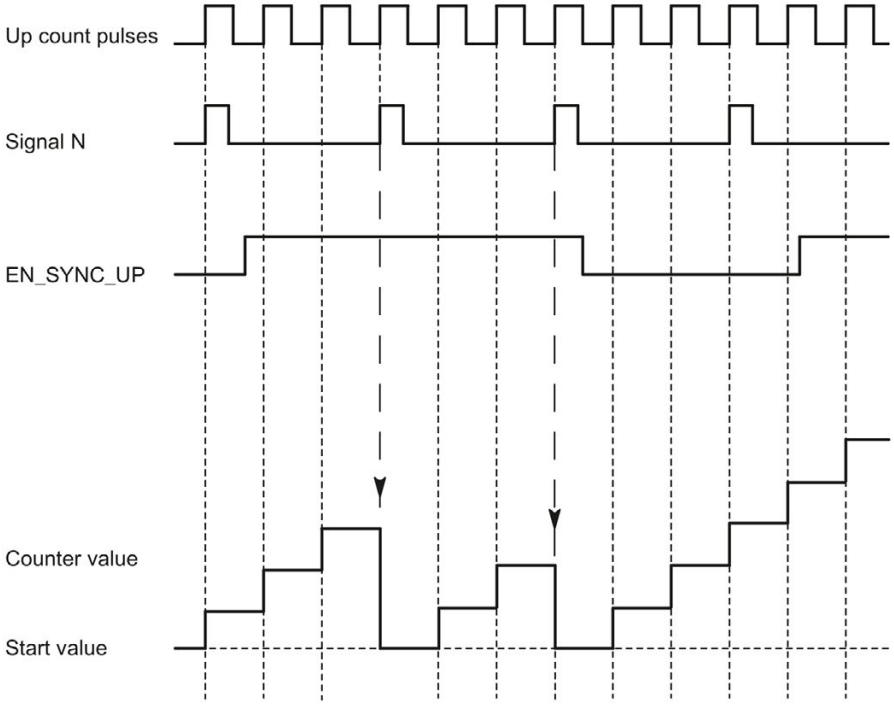
The figure below shows an example of single synchronization at signal N (not dependent on a digital input):



After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first signal N. After resetting and setting the control bit (Page 182) EN_SYNC_UP once again, the counter can be synchronized again.

Periodic synchronization

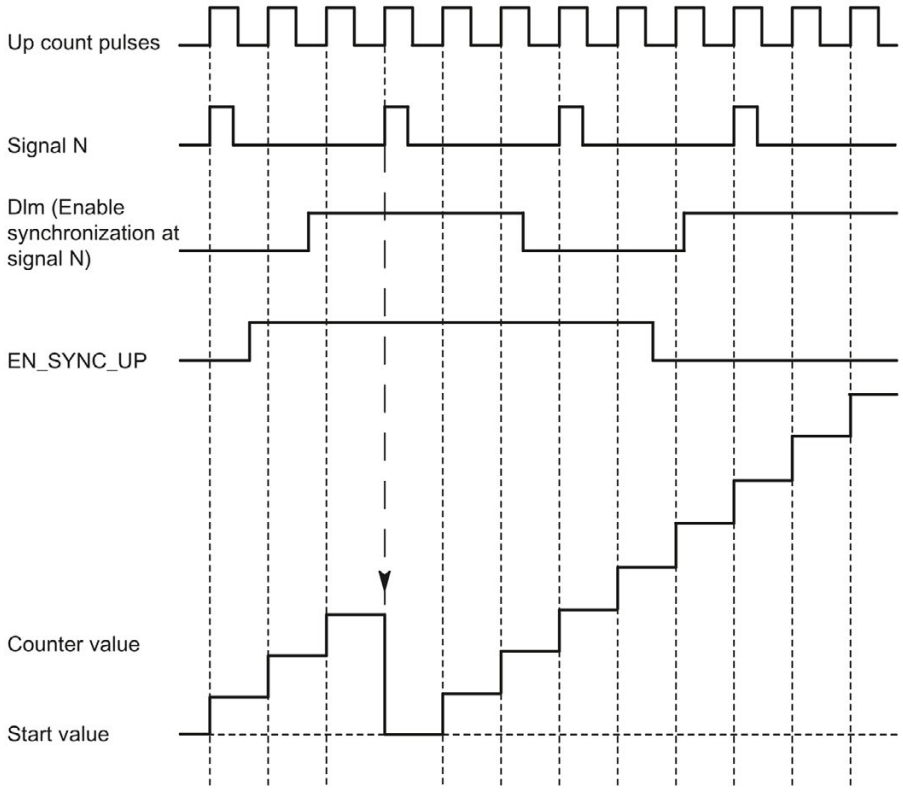
The figure below shows an example for periodic synchronization at signal N:



As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each signal N.

Enable by a digital input

The figure below shows an example for periodic synchronization at signal N depending on the status of a digital input:



As long as synchronization for counting up is enabled and the corresponding digital input is active, the counter is synchronized at each signal N. If one of the conditions is not met, the counter is not synchronized at the signal N.

2.2.8 Comparison values

2.2.8.1 Comparison values and outputs

Description

You can specify two comparison values to control both digital outputs of the channel independently of the user program:

- Comparison value 0 for digital output DQ0
- Comparison value 1 for digital output DQ1

Depending on the operating mode and the encoder used, define two position, counter or measured values as comparison value. Comparison value 1 must be greater than comparison value 0. The comparison values are configurable and can be modified during runtime using the user program.

Note

DQ0 of a counter of a Compact CPU

With a Compact CPU, the respective digital output DQ0 is available via the feedback interface, but not as a physical output.

Switching digital outputs from the user program

The control bits (Page 182) TM_CTRL_DQ0 and TM_CTRL_DQ1 are used to control use of the digital outputs.

If TM_CTRL_DQm is set to 0, you can control the relevant digital output from the user program with the control bit SET_DQm regardless of the configured technological function. If TM_CTRL_DQm is set to 1, the technological function of the controller of the respective digital output is enabled.

The status of a digital output is indicated by the respective STS_DQm feedback bit.

2.2.8.2 Switching at comparison values with counter value as reference

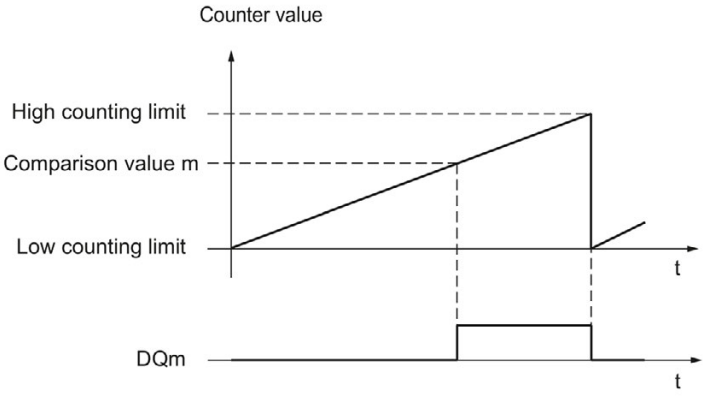
The comparison values are compared with the current counter value. If the counter value meets the assigned comparison condition and the technological function of the associated digital output is enabled, the digital output is set. If you assign "Between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

You can make switching for a digital output dependent on one of the following comparison events:

Setting between comparison value and high counting limit

The digital output is set to 1 if:

Comparison value <= counter value <= high counting limit

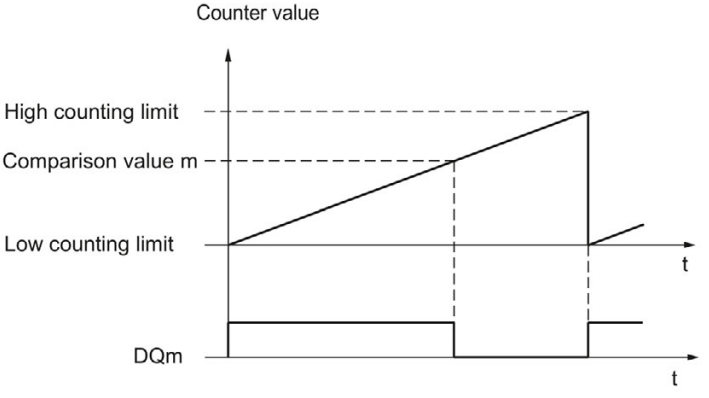


The comparison event is independent of the count direction.

Setting between comparison value and low limit

The digital output is set to 1 if:

Low counting limit <= counter value <= comparison value



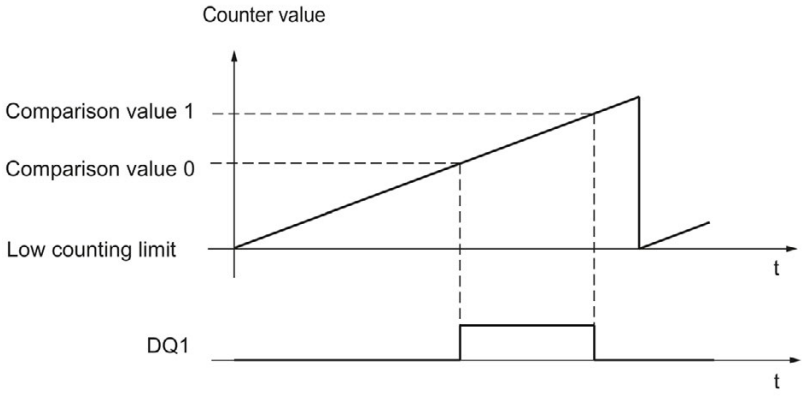
The comparison event is independent of the count direction.

Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 0 <= counter value <= comparison value 1



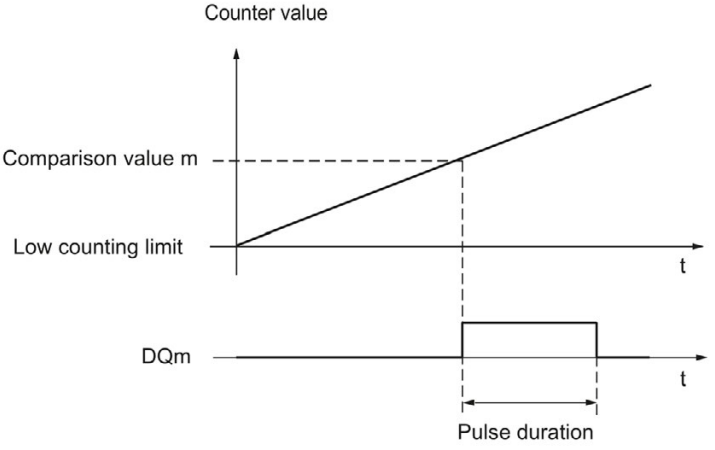
The comparison event is independent of the count direction.

Setting at comparison value for one pulse duration

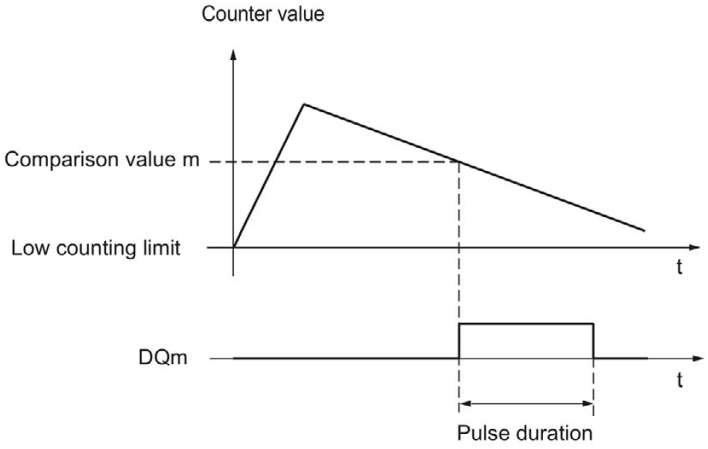
The respective digital output is set to 1 for a specified period of time when the following conditions are fulfilled:

- Counter value = comparison value
- Current count direction = configured count direction for the comparison event

The figure below shows an example of the comparison event when counting in an upwards direction:

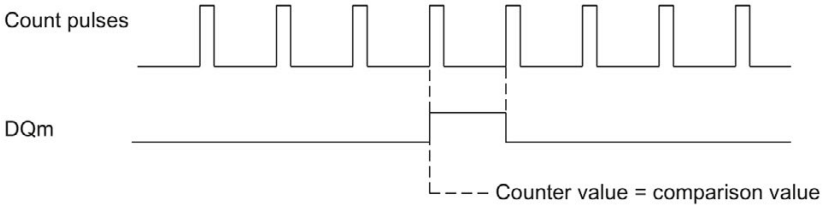


The figure below shows an example of the comparison event when counting in a downward direction:



To repeat the comparison event, the counter value must change and then correspond to the respective comparison value again.

If the pulse duration has been defined as "0" and the counter value is equal to the comparison value, the digital output is set to 1 until the next count pulse:



Note

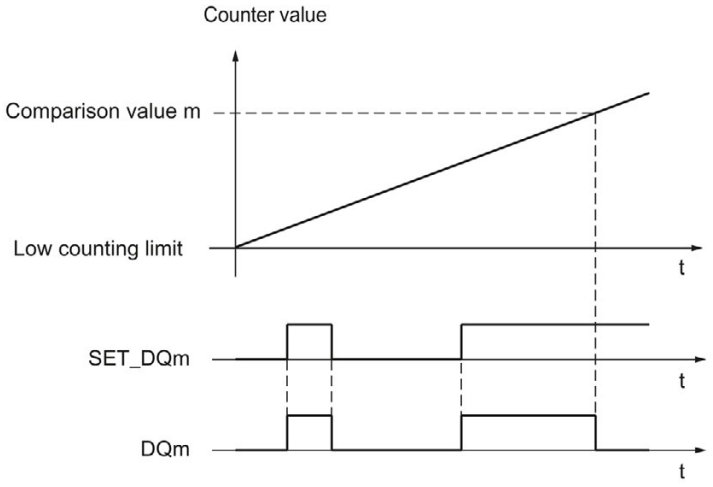
This comparison event switches the relevant digital output if a count pulse reaches the comparison value. The digital output does not switch when the counter value is set, by synchronization for example.

Setting by the user program up to comparison value

You can set the respective digital output to 1 (edge) by setting the control bit (Page 182) SET_DQm. The respective digital output is set to 0 by any of the following events:

- Match of the counter value and the comparison value in the configured direction of the comparison event
- Reset of the corresponding SET_DQm control bit.

The figure below shows an example of the comparison event when counting in an upwards direction:



You can disable the digital output before the counter value reaches the comparison value by setting the control bit SET_DQm to 0.

Note

If the comparison value is reached in the configured count direction, the feedback bit EVENT_CMPm is set independently of the state of the control bit SET_DQm.

The comparison event switches a digital output when a count pulse reaches the respective comparison value. The digital output does not switch when the counter value is set, by synchronization for example.

2.2.8.3 Switching at comparison values with position value (SSI absolute value) as reference

The comparison values are compared with the current position value. If the position value meets the assigned comparison condition and the technological function of the associated digital output is enabled, the digital output is set. If you assign "Between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

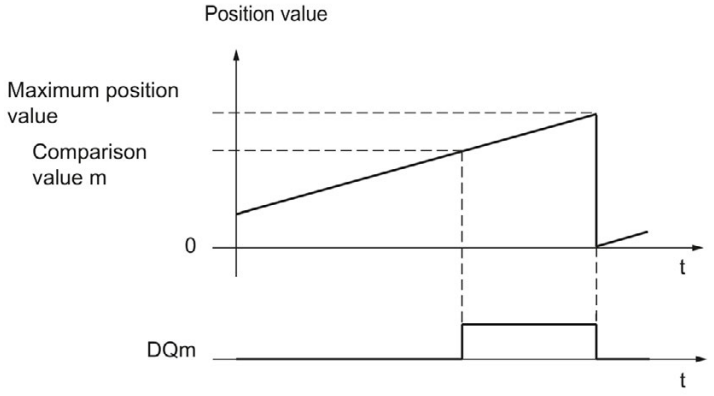
You can make switching for a digital output dependent on one of the following comparison events:

Setting between comparison value and high limit

The high limit corresponds to the maximum position value.

The digital output is set to 1 if:

Comparison value <= position value <= maximum position value



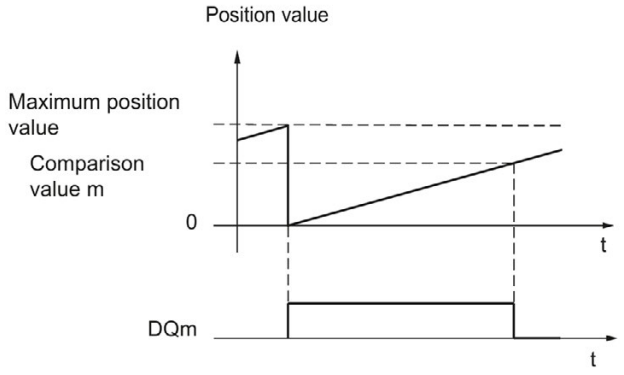
The comparison event is independent of the direction of the position value change. The maximum position value depends on the resolution of the SSI absolute encoder.

Setting between comparison value and low limit

The low limit corresponds to the position value "0".

The digital output is set to 1 if:

0 <= position value <= comparison value



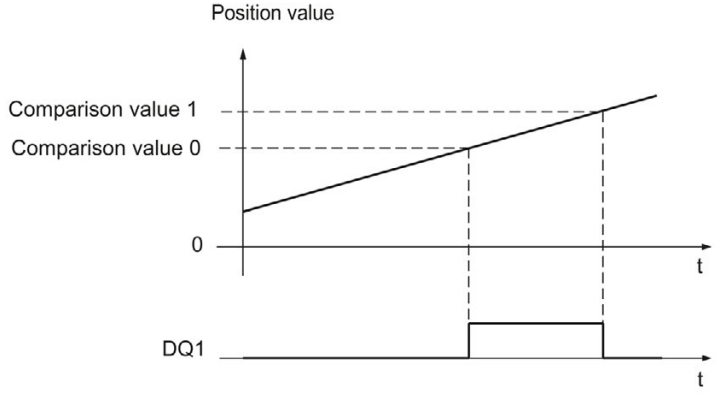
The comparison event is independent of the direction of the position value change.

Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 0 <= position value <= comparison value 1



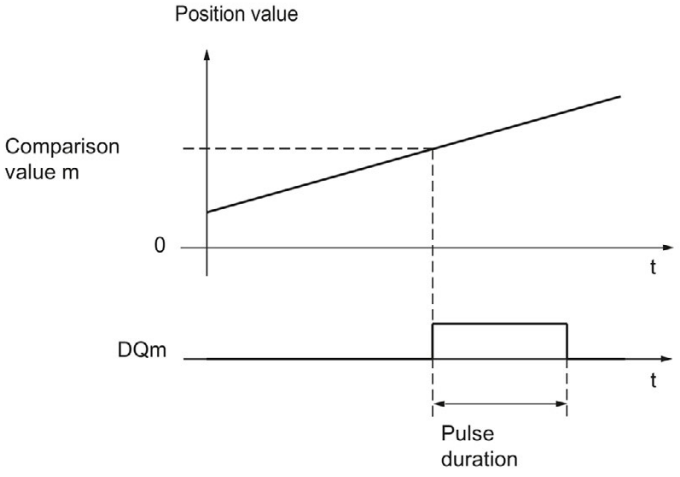
The comparison event is independent of the direction of the position value change.

Setting at comparison value for one pulse duration

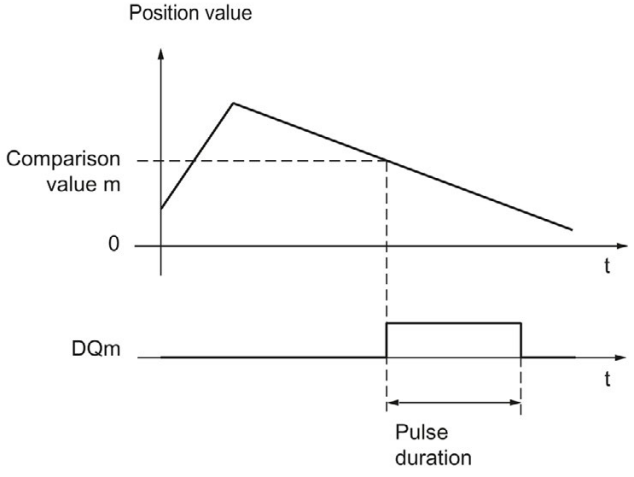
The respective digital output is set to 1 for a specified period of time when the following conditions are fulfilled:

- Matching of the position value and comparison value or crossing of the comparison value
- Current direction of the position value change = assigned direction for the comparison event

The figure below shows an example of the comparison event when counting up:



The figure below shows an example of the comparison event when counting down:



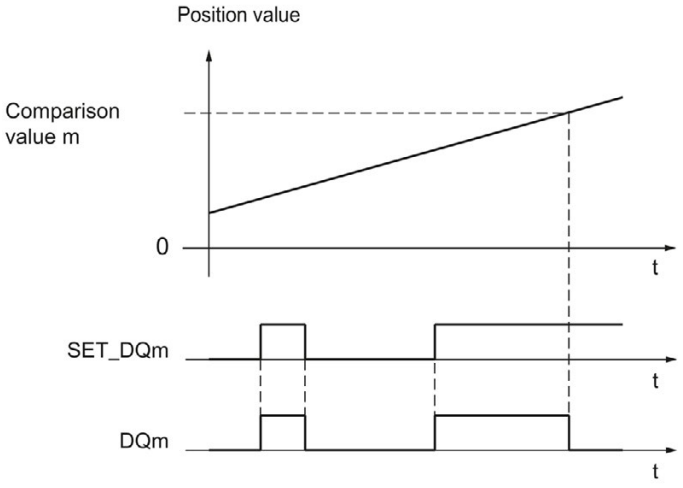
To repeat the comparison event, the position value must change and then correspond to or cross the respective comparison value again.

Setting by the user program up to comparison value

You can set each digital output to 1 (edge) by setting the control bit (Page 182) SET_DQm. The respective digital output is set to 0 by any of the following events:

- Matching of the position value and the comparison value or crossing of the comparison value in the configured direction of the comparison event
- Resetting of the SET_DQm control bit.

The figure below shows an example of the comparison event when counting up:



You can disable the digital output before the position value corresponds to or exceeds the comparison value by setting the control bit SET_DQm to 0.

Note

If the comparison value is reached or exceeded in the assigned direction, feedback bit EVENT_CMPm is set independently of the status of control bit SET_DQm.

2.2.8.4 Switching at comparison values with measured value as reference

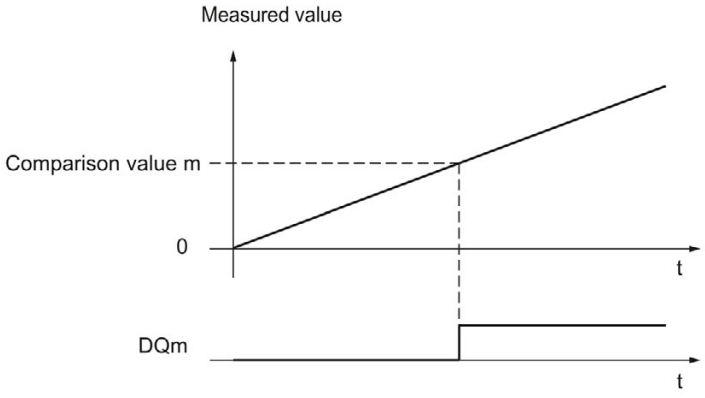
The comparison values are compared with the current measured value. If the measured value meets the configured comparison condition and the technological function of the corresponding digital output is enabled, the digital output is set. If you configure "Between comparison value 0 and 1" or "Not between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

You can make switching for a digital output dependent on one of the following comparison events:

Setting above the comparison value

The digital output is set to 1 if:

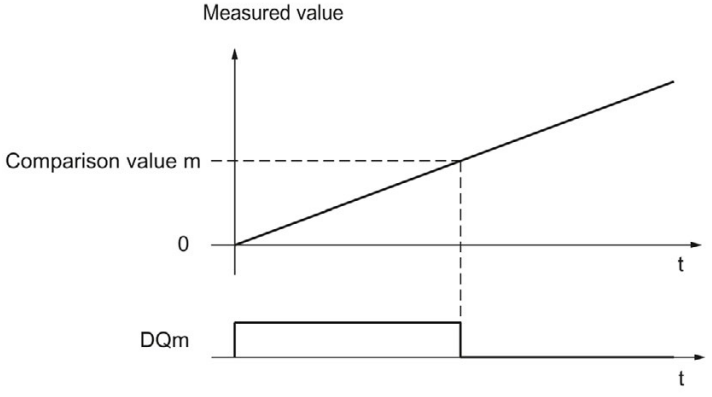
Measured value >= comparison value



Setting below the comparison value

The digital output is set to 1 if:

Measured value <= comparison value

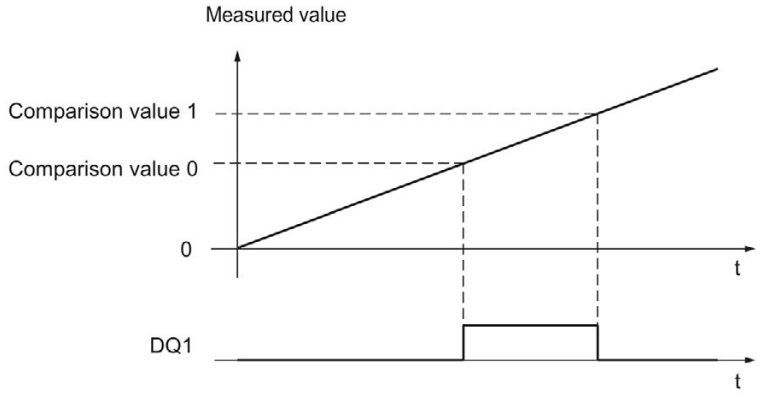


Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 0 <= measured value <= comparison value 1

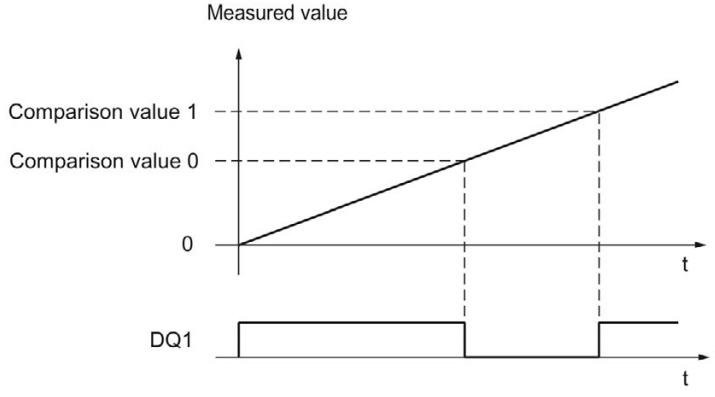


Not setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0.

DQ1 is set to 1 if:

Comparison value 1 <= measured value <= comparison value 0



2.2.9 Measured value determination

2.2.9.1 Overview of measuring functions

The following measuring functions are available:

Measurement type (Page 56)	Description
Frequency measurement	The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in Hertz as floating point number.
Period measurement	The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in seconds as floating point number.
Velocity measurement	The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and other parameters, and returned in the configured unit of measurement.

Measured values and counter values are available concurrently in the feedback interface.

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time. Setting longer update time intervals allows uneven measured variables to be smoothed and increases measuring accuracy.

Gate control for incremental and pulse encoders

Opening and closing the internal gate defines the period of time during which the count pulses are captured. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After the internal gate is closed, the last measured value captured is still returned.

2.2.9.2 Measured value determination with incremental or pulse encoder

Measuring ranges

Measuring range (TM Count and TM PosInput)

The measuring functions have the following measuring limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	800 kHz* / 4 MHz**
Period measurement	1.25 µs* / 0.25 µs**	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "time base for velocity measurement"	

* Applies to 24 V incremental encoders and "quadruple" signal evaluation.

** Applies to RS422 incremental encoders and "quadruple" signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

Measuring range (Compact CPU)

The measuring functions have the following measuring range limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	400 kHz*
Period measurement	2.5 µs*	25 s
Velocity measurement	Depends on the configured number of "Increments per unit" and the "Time base for velocity measurement"	

* Applies to 24 V incremental encoders and "quadruple“ signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

Measuring intervals

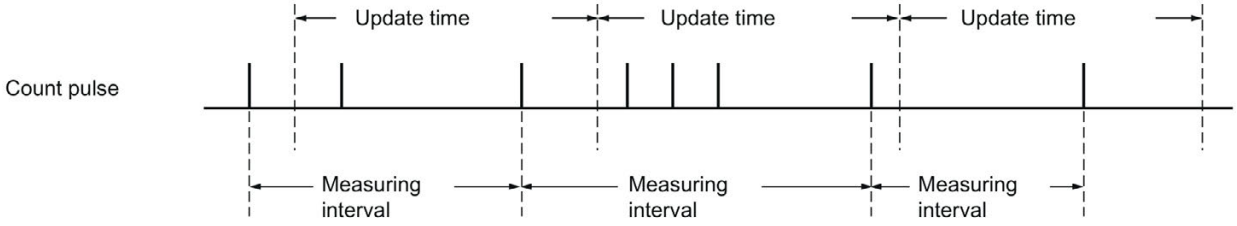
Measuring principle

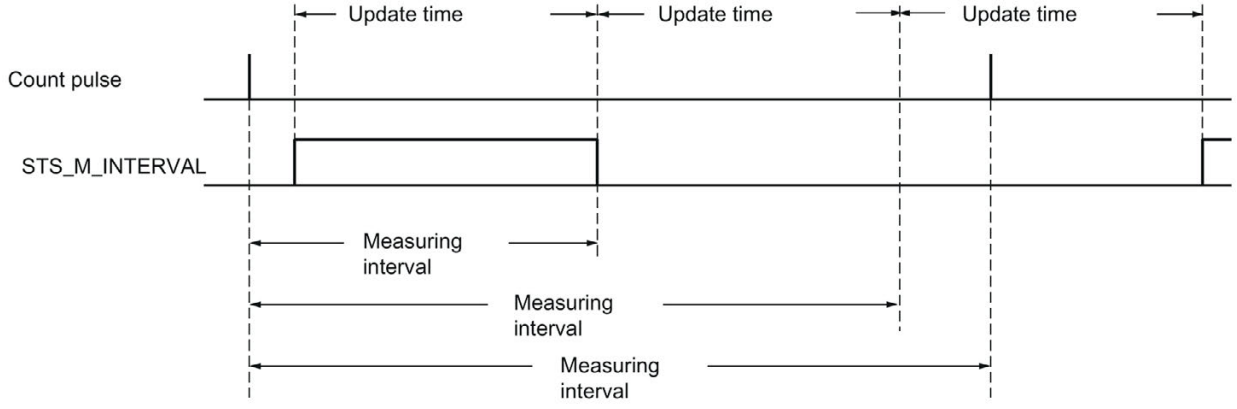
The technology module assigns a time value to each count pulse. The measuring interval is defined as the time between each last count pulse before and during the previous update time. The measuring interval and the number of pulses in the measuring interval are evaluated to calculate measured variables.

If there is no count pulse within an update time, the measuring interval is dynamically adjusted. In this case, a pulse is assumed at the end of the update time and the measuring interval is calculated as the time between that point and the last pulse which occurred. The number of pulses is then 1.

The feedback bit STS_M_INTERVAL indicates whether a count pulse occurred in the previous measuring interval. This allows for a differentiation between an assumed and an actual count pulse.

The following figures show the principle of measurement and the dynamic adjustment of the measuring interval:





Measuring types

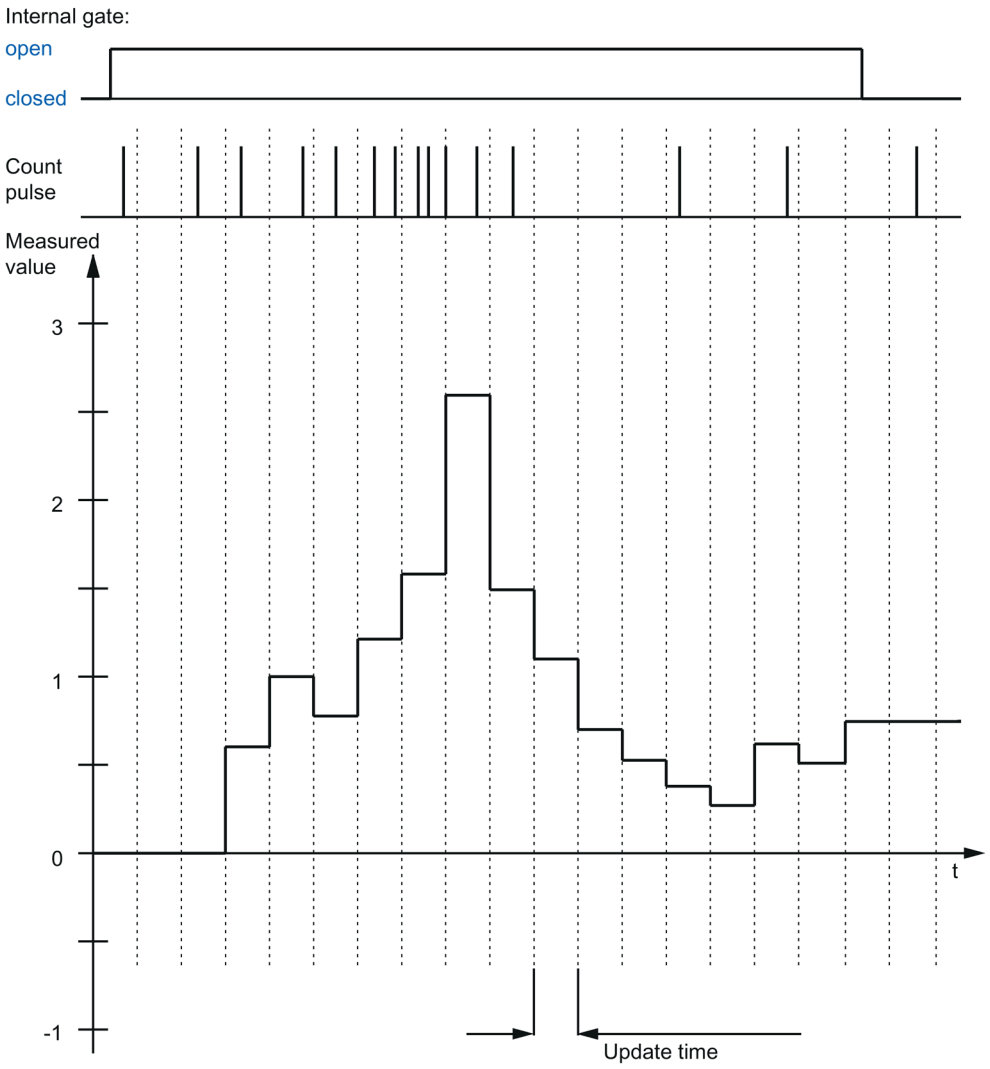
Frequency measurement

A value "0" is returned until the first measured value is available.

The measurement process begins with the first pulse detected once the internal gate has been opened. The first measured value can be calculated after the second pulse at the earliest.

The measured value is updated in the feedback interface (Page 185) upon completion of each update time. If the internal gate is closed, measuring stops and the measured value is no longer updated.

The figures below shows an example of frequency measurement with an update time of 1 s:



Period measurement

The reciprocal of the frequency is output as the measured value for period measurement.

A value "25 s" is returned until the first measured value is available.

Velocity measurement

The normalized frequency is output as the measured value in velocity measurement. You can configure the scaling using the time basis and the number of increments that your encoder delivers per unit.

Example:

Your encoder delivers 4000 increments per meter. The velocity is to be measured in meters per minute.

In this case, you need to configure 4000 Increments per unit and a time basis of one minute.

2.2.9.3 Measured value determination with SSI absolute encoder

Measuring ranges

Measuring range SSI absolute encoder

The measuring functions have the following measuring limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0,04 Hz	4 MHz
Period measurement	0,25 µs	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "time base for velocity measurement"	

All measured values are returned as signed values. The sign indicates whether the position value increased or decreased during the relevant time period.

Measuring intervals

Measuring principle

The technology module assigns a time value to each SSI frame. The measuring interval is defined as the time between the last SSI frame with a change of position value before and during the previous update time. The measuring interval and the total change in position value in the measuring interval are evaluated to calculate a measured variable. The total change in position value in a measuring interval corresponds to the number of encoder increments in the same measuring interval.

If there is no change in position value within an update time, the measuring interval is dynamically adjusted. In this case, a change in position value is assumed at the end of the update time and the measuring interval is calculated as the time between that point and the last SSI frame with a change in position value. The change in position value is then 1.

The feedback bit STS_M_INTERVAL indicates whether a change in position value occurred in the previous measuring interval. This allows for a differentiation between an assumed and an actual change in position value. If the technology module cannot calculate measured values because the measuring range limit has been violated, the feedback bit STS_M_INTERVAL is not set.

Measuring types

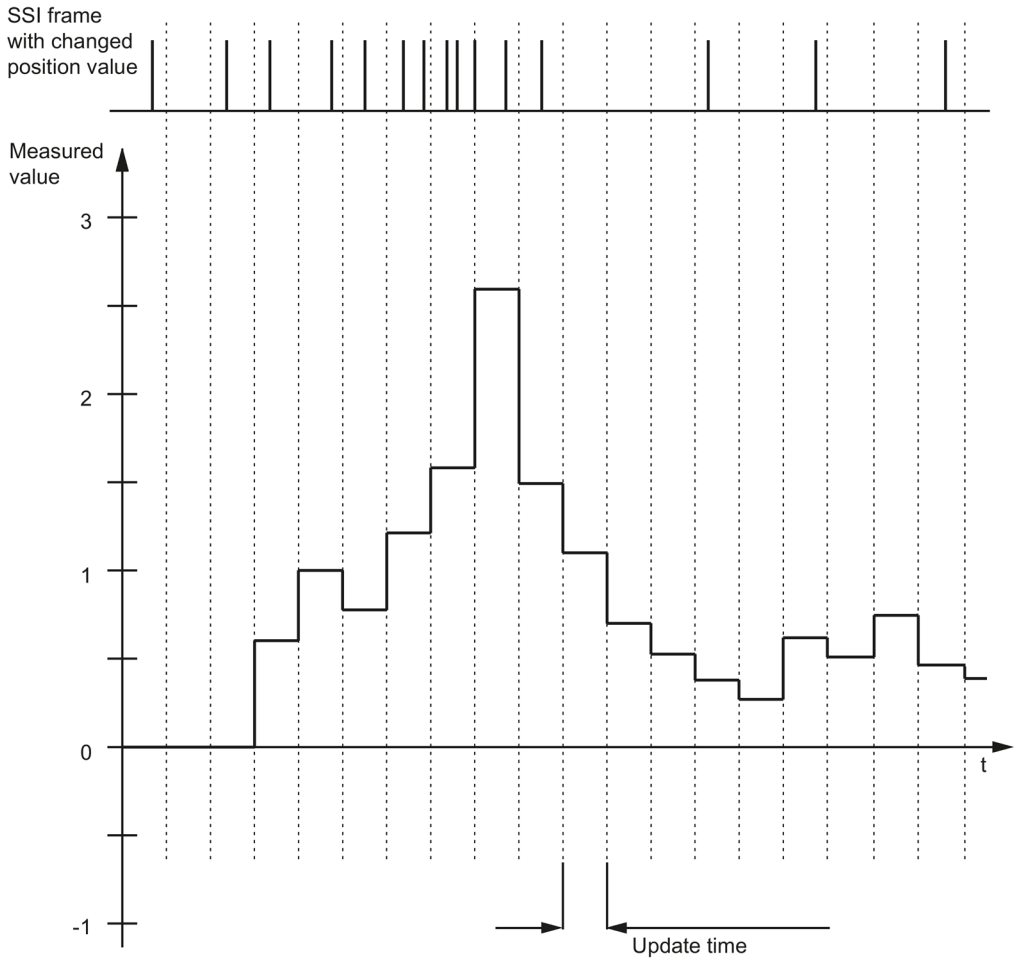
Frequency measurement

The value "0.0" is reported in the time up to the first available measured value.

The measuring process begins with the first detected change in position value. The first measured value can be calculated after the second detected change in position value at the earliest.

The measured value is updated in the feedback interface (Page 185) upon completion of each update time.

The figures below shows an example of frequency measurement with an update time of 1 s:



Period measurement

The reciprocal of the frequency is output as the measured value for period measurement.

A value "25 s" is returned until the first measured value is available.

Velocity measurement

The normalized frequency is output as the measured value in velocity measurement. You can configure the scaling using the time basis and the number of increments that your encoder delivers per unit.

Example:

Your SSI absolute encoder operates with a resolution of 12 bits per revolution and performs 4096 increments per revolution. The velocity should be measured in revolutions per minute.

In this case, you need to configure 4096 Increments per unit and a time basis of one minute.

2.2.10 Hysteresis

2.2.10.1 Hysteresis with incremental or pulse encoder

Description

Hysteresis allows you to specify a range around the comparison values within which the digital outputs are not to be switched again until the counter value has gone outside this range.

Slight movements by the encoder can result in the counter value fluctuating around a certain value. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. Hysteresis prevents this unwanted switching, and configured hardware interrupts when a comparison event occurs.

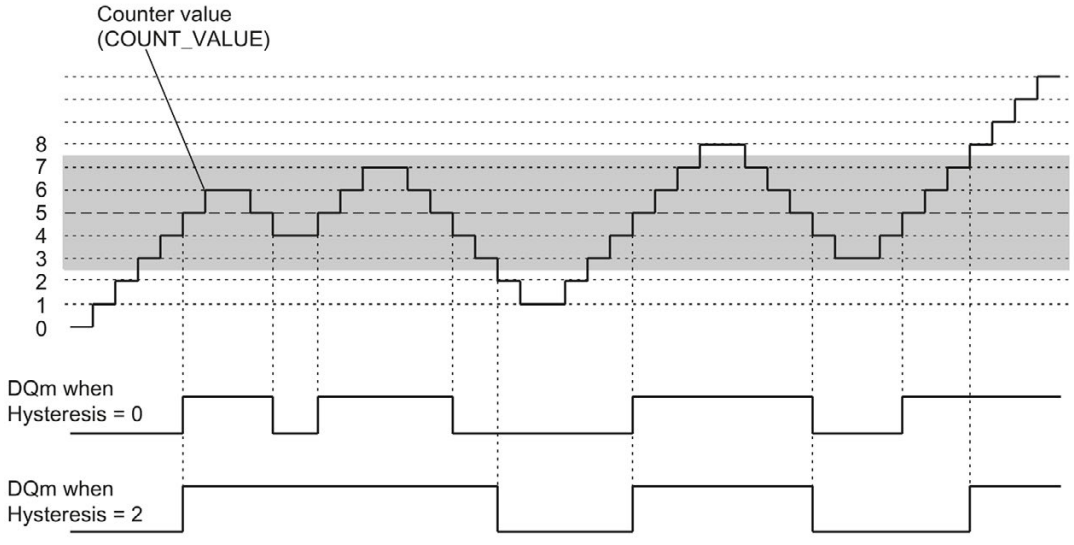
The hysteresis becomes active when the respective comparison value is reached by a count pulse. If the counter value is set to the start value during an active hysteresis, the hysteresis becomes inactive.

Regardless of the hysteresis value, the hysteresis range ends at the low/high counting limits.

Function principle

The figure below shows an example for the hysteresis with the following configuration:

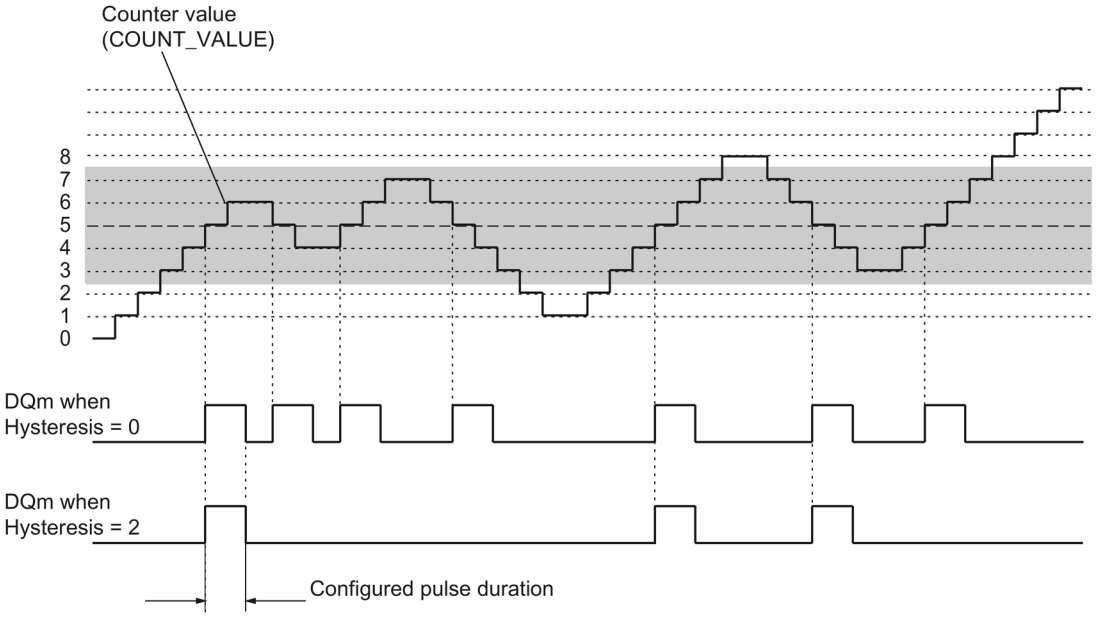
- Setting of a digital output between comparison value and high counting limit
- Comparison value = 5
- Hysteresis = 0 or 2 (gray background)



Hysteresis is enabled when the counter value 5 is reached. When the hysteresis is active, the comparison result remains unchanged. Hysteresis is disabled when the counter value 2 or 8 is reached.

The figure below shows an example for the hysteresis with the following configuration:

- Setting at comparison value for one pulse duration
- Comparison value = 5
- Comparison in both count directions
- Hysteresis = 0 or 2 (gray background)



2.2.10.2 Hysteresis with SSI absolute encoder

Description

Hysteresis allows you to specify a range around the comparison values within which the digital outputs are not to be switched again until the position value has gone outside this range.

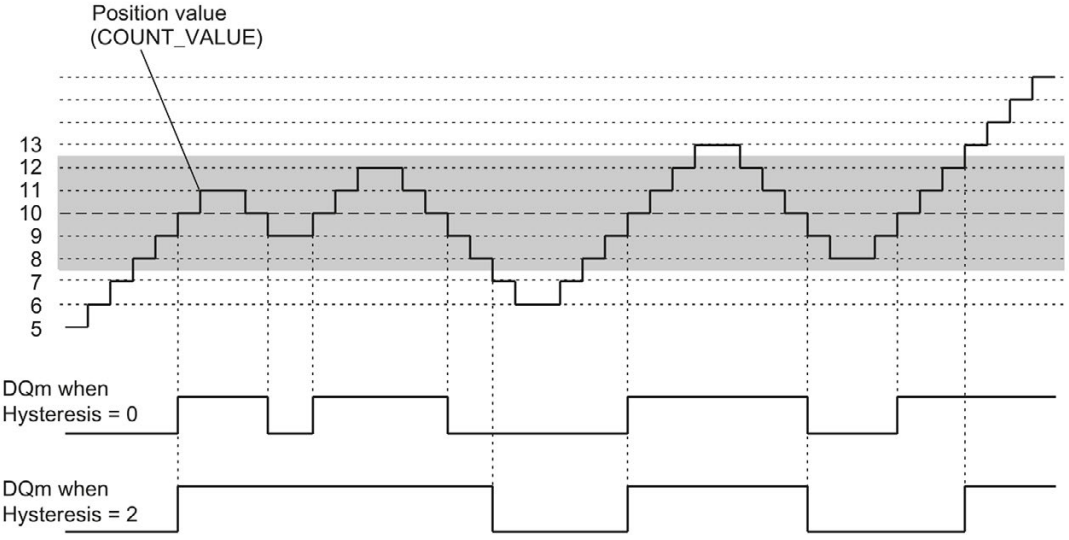
Slight movements by the encoder can result in the position value fluctuating around a certain value. If a comparison value, "0", or the respective maximum position value lies within this fluctuation range, the associated digital output is switched on and off with corresponding frequency if a hysteresis is not used. Hysteresis prevents this unwanted switching, and configured hardware interrupts when a compare event occurs.

Regardless of the hysteresis value, the hysteresis range ends at "0" and at the respective maximum position value.

Function principle

The figure below shows an example for the hysteresis with the following parameter assignment:

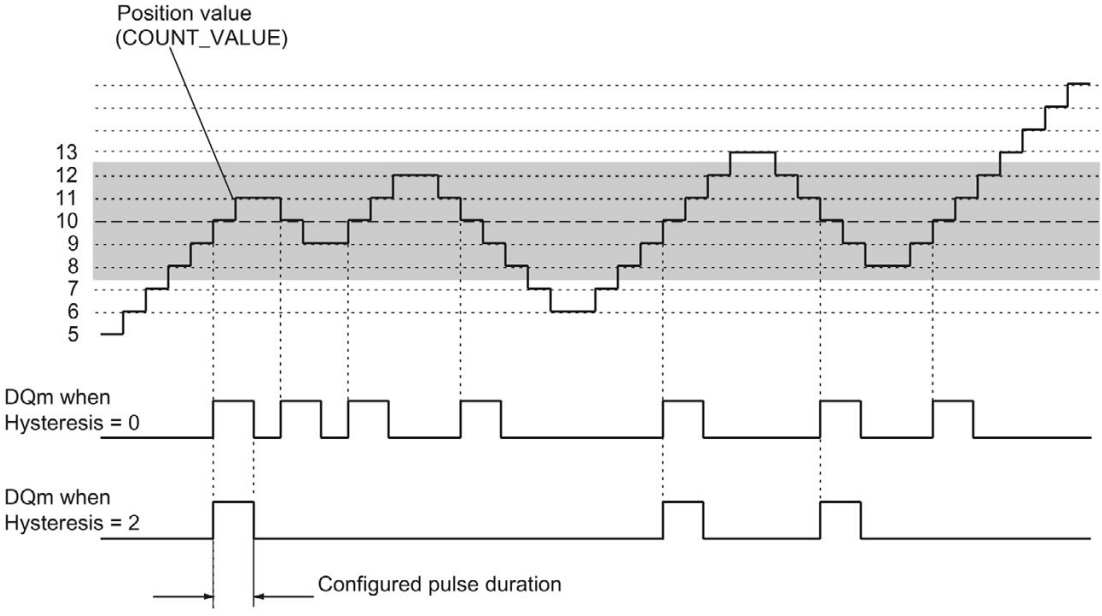
- Setting of a digital output between comparison value and high limit
- Comparison value = 10
- Hysteresis = 0 or 2 (gray background)



Hysteresis is enabled when the position value 10 is reached. When the hysteresis is active, the comparison result remains unchanged. Hysteresis is disabled when the position values 7 or 13 are reached.

The figure below shows an example for the hysteresis with the following parameter assignment:

- Setting at comparison value for one pulse duration
- Comparison value = 10
- Comparison in both directions of position value changes
- Hysteresis = 0 or 2 (gray background)



2.2.11 Interrupts

Hardware interrupt

The technology module can trigger a hardware interrupt in the CPU if, for example, a comparison event occurs; in the event of overflow or underflow; in the event of a zero crossing of the counter and/or of a change in count direction (direction reversal). You can specify which events are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The technology module can trigger diagnostic interrupts in the event of errors. You enable the diagnostic interrupts for certain errors in the device configuration. Refer to the device manual for the technology module to learn about the events that can trigger a diagnostic interrupt during operation.

2.2.12 Position detection for Motion Control

Description

You can use the technology module with S7-1500 Motion Control for position detection.

In the Device configuration of the technology module in STEP 7 (TIA Portal), select "Position input for Motion Control" mode. This reduces the configuration options to the parameters that are essential. For TM Count or TM PosInput, the mode automatically applies to all channels of the technology module. For a Compact CPU, the mode automatically applies to the respective channel.

When using an incremental or pulse encoder, the position input is based on the counting function of the technology module. With an SSI absolute encoder, the absolute value is read in via a synchronous, serial interface and prepared according to the parameter assignment and made available for S7-1500 Motion Control.

You can find information about the remaining configuring steps in the help for the axis technology objects of S7-1500 Motion Control.

2.2.13 Encoder signals

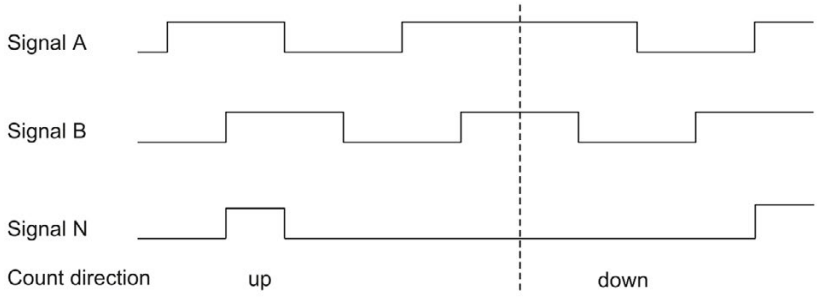
2.2.13.1 24 V and TTL count signals

24 V and TTL incremental encoder count signals

The 24 V incremental encoder returns the 24 V signals A, B, and N to the technology module. The A and B signals are phase-shifted by 90°. You can also connect incremental encoders without an N signal.

A 24 V incremental encoder uses the A and B signals for counting. If configured accordingly, the N signal is used for setting the counter to the start value or for saving the current counter value to the Capture value.

The figure below shows an example of the time profile of the signals of an 24 V incremental encoder:



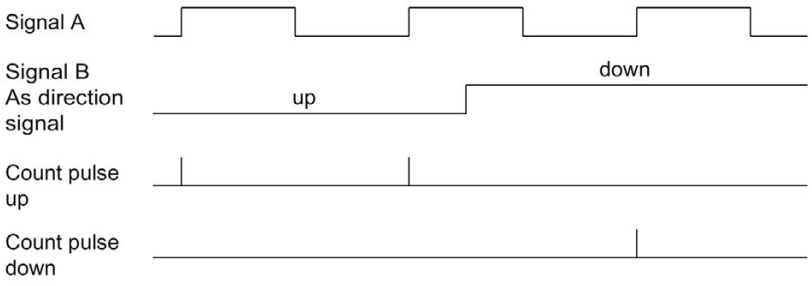
The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

24 V and TTL pulse encoder count signals without/with direction signal

The encoder, for example an initiator (BERO) or a light barrier, returns only a count signal that is connected to terminal A of the counter.

In addition, you can connect a signal for direction detection to terminal B of the counter. If your encoder does not return a corresponding signal, you can specify the count direction with the user program using the control interface.

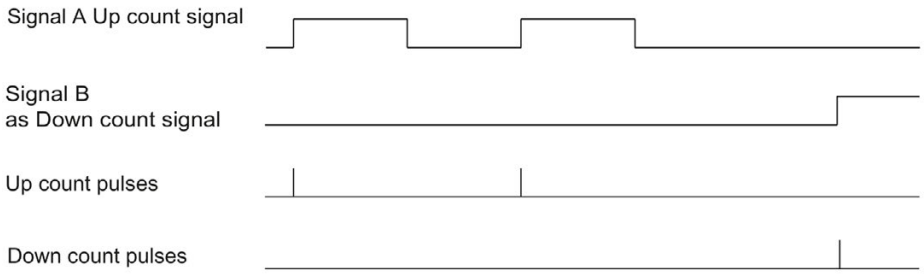
The figure below shows an example of the time profile of the signals of a 24 V pulse encoder with direction signal and the resulting count pulses:



24 V and TTL pulse encoder count signals with Up/Down count signal

The Up count signal is connected to terminal A. The Down count signal is connected to terminal B.

The figure below shows an example of the time profile of the signals of a pulse encoder with Up/Down count signal and the resulting count pulses:



Sourcing output/sinking output for 24 V counter signals (TM Count)

You can connect the following encoders/sensors to the counter inputs:

- Sourcing output:
  The A, B, and N inputs are wired to 24VDC .
- Sinking output:
  The A, B, and N inputs are wired to ground M .
- Push-pull (sourcing and sinking output):
  The A, B, and N inputs are wired alternately to 24VDC and ground M .

Sourcing output for 24 V counter signals (Compact CPU)

You can connect the sourcing output and push-pull encoders or sensors to the counter inputs.

Monitoring of the encoder signals (TM Count and TM PosInput)

The signals of push-pull 24 V sensors are monitored for wire breaks by the technology module. TTL signal are monitored for offset voltage by the technology module.

If you enable the diagnostic interrupt in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal errors.

2.2.13.2 RS422 count signals

RS422 incremental encoder count signals

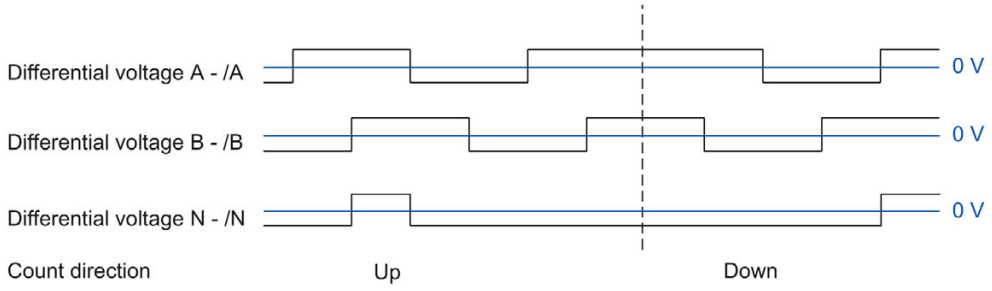
The RS422 incremental encoder sends the following differential signals to the technology module:

- A and /A
- B and /B
- N and /N

The signal information for RS422 signals is encoded in the differential voltage between A and /A, B and /B or N and /N. The A and B signals are phase-shifted by 90°. You can also connect incremental encoders without an N signal.

RS422 incremental encoders use the A and B signals for counting. If configured accordingly, the N signal is used for setting the counter to the start value or for saving the current counter value as the Capture value.

The figure below shows an example of the time profile of the signals of an RS422 incremental encoder:



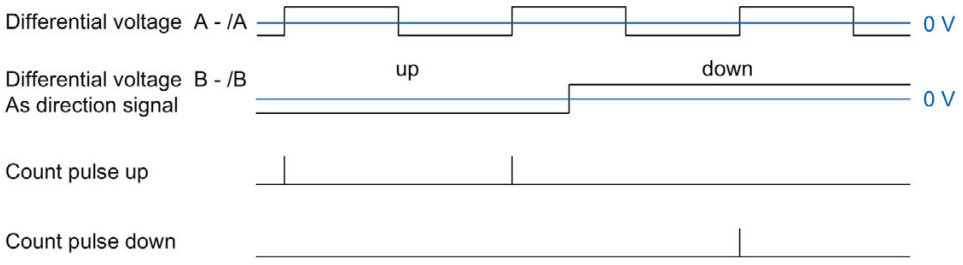
The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Count signals of RS422 pulse encoders without/with direction signal

The encoder, for example a light barrier, only returns a count signal that is connected to terminal A.

You can also connect a signal for direction detection to terminal B. If your encoder does not return a corresponding signal, you can specify the count direction with the user program using the control interface.

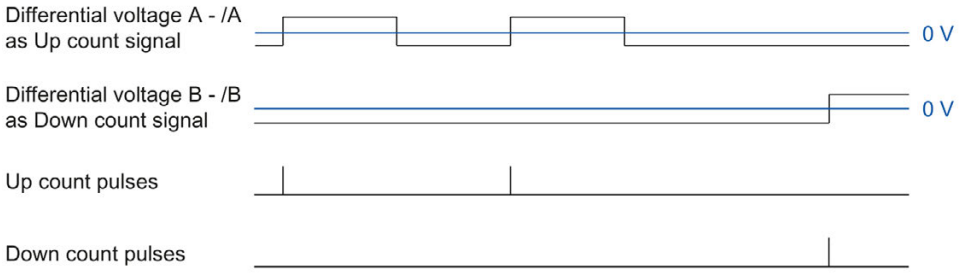
The figure below shows an example of the time profile of the signals of a RS422 pulse encoder with direction signal and the resulting count pulses:



Count signals of RS422 pulse encoders with Up/Down count signal

The Up count signal is connected to the A terminals. The Down count signal is connected to the B terminals.

The figure below shows an example of the time profile of the signals of an RS422 pulse encoder with Up/Down count signal and the resulting count pulses:



Monitoring of encoder signals

The technology module monitors RS422 signals for wire breaks, short-circuits, and offset voltages.

If you enable the diagnostic interrupt in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal errors.

2.2.13.3 SSI signals

Signals from SSI absolute encoders

The SSI absolute encoder and the technology module communicate via SSI data signals DAT and /DAT (D) and the SSI clock signals CLK and /CLK (C). SSI uses the RS422 signal standard. The signal information is coded in the respective differential voltage between C and /C as well as D and /D.

Monitoring of the encoder signals and the SSI frames

The technology module monitors the signals of an SSI absolute encoder for wire breaks, short-circuits, and offset voltages. The technology module also monitors SSI frames for errors.

If you enable the diagnostic interrupts in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal or SSI frame errors.

2.2.14 Signal evaluation of incremental signals

2.2.14.1 Overview

The technology module counter counts the edges of encoder signals A and B. For incremental encoders with phase-shifted signals A and B, you can select either single or multiple evaluation to improve the resolution.

You can configure the following signal evaluations:

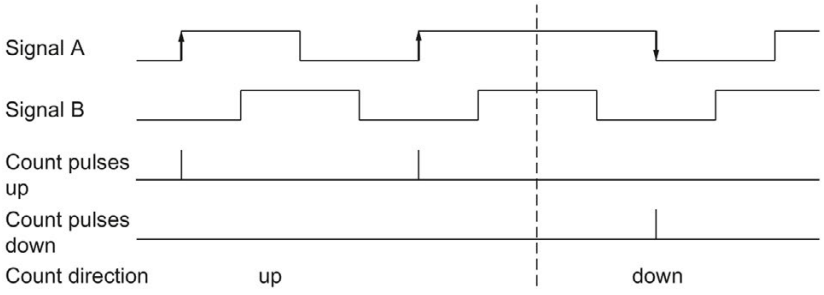
- Single evaluation (Page 70)
- Double evaluation (Page 71)
- Quadruple evaluation (Page 72)

2.2.14.2 Single evaluation

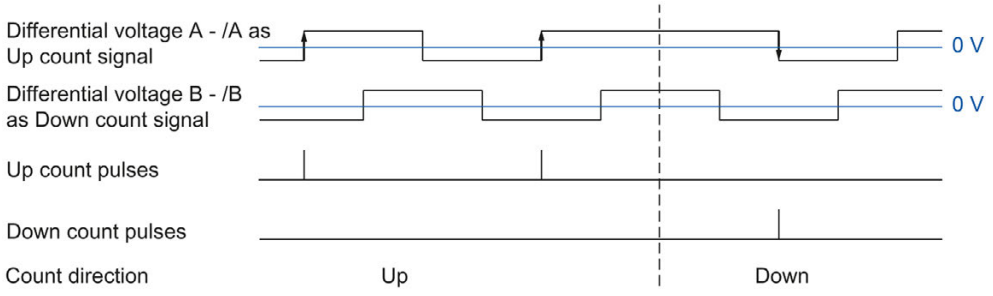
Single evaluation evaluates the rising and falling edge at signal A when signal B has a low level.

Count pulses in an upwards direction are generated with a rising edge at signal A during a low level at signal B. Count pulses in a downwards direction are generated with a falling edge at signal A during a low level of signal B.

The following figure shows an example for single evaluation of 24 V and TTL count signals:



The following figure shows an example for single evaluation of RS422 count signals:

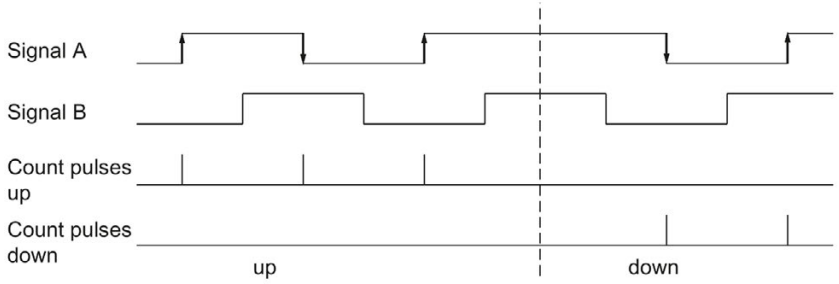


2.2.14.3 Double evaluation

With double evaluation, the rising and falling edges of signal A are evaluated.

The edge direction of signal A and the level at signal B determines whether count pulses are generated in an upward or downward direction.

The following figure shows an example for double evaluation of 24 V and TTL count signals:



The following figure shows an example for double evaluation of RS422 count signals:

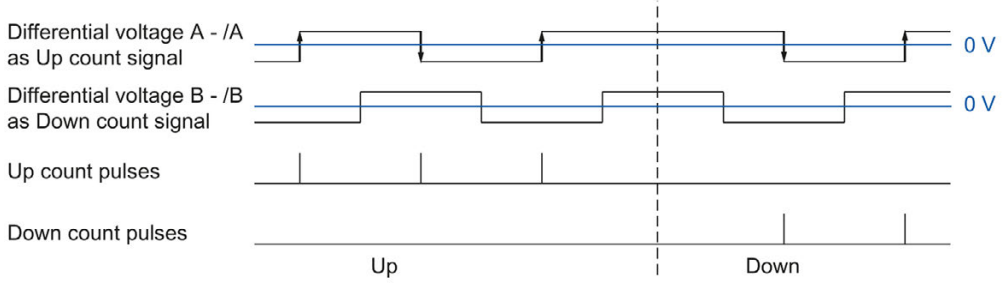


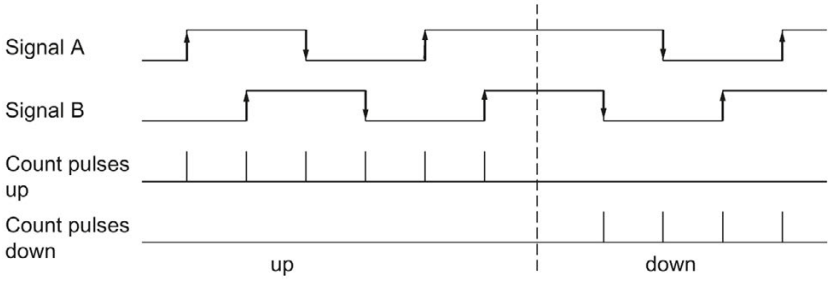
Figure 2-1 Double

2.2.14.4 Quadruple evaluation

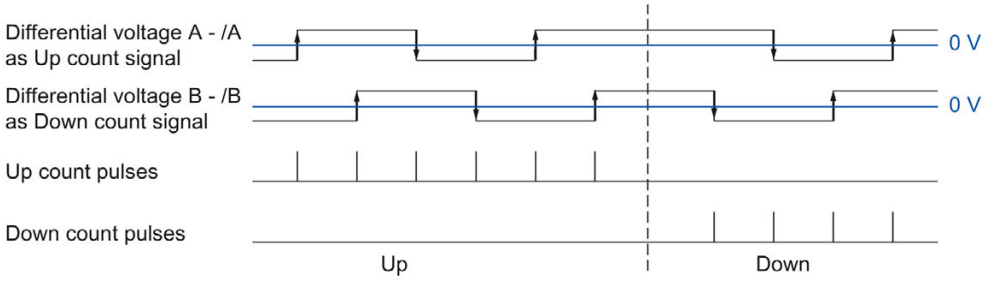
With quadruple evaluation, the rising and falling edges of signals A and B are evaluated.

The edge direction of one signal and the level of the other signal determines whether count pulses are generated in an upward or downward direction.

The figure below shows an example for quadruple evaluation of 24 V and TTL count signals:



The figure below shows an example for quadruple evaluation of RS422 count signals:



2.2.15 Clock synchronization (TM Count and TM PosInput)

The technology module supports the "isochronous mode" system function in distributed mode. This system function enables position, count and measured values to be recorded in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A change in the state of a digital input immediately affects the planned reaction of the technology module and changes the status bit of the digital input in the feedback interface.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. The position or counter value and, if required, the measured value and the status bits as well are captured at the time T_i and made available in the feedback interface for retrieval in the current bus cycle.

Additional information

For a detailed description of isochronous mode, refer to the PROFINET with STEP 7 function manual, which is available as download at Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

2.3 Basics of counting (TM Timer DIDQ)

2.3.1 Overview of applications

Introduction

You configure the TM Timer DIDQ and assign its parameters with the configuration software.

The module's functions are controlled and monitored via the user program.

System environment

The respective module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central and distributed mode in an S7-1500 system with a corresponding ET 200 system	• S7-1500 automation system • ET 200 distributed I/O system • TM Timer DIDQ	STEP 7 (TIA Portal) and STEP 7: Device configuration and parameter setting with hardware configuration	Direct access to feedback interface of the technology module in the I/O data
Distributed operation in an S7-300/400 system	• S7-300/400 automation system • ET 200 distributed I/O system • TM Timer DIDQ		
Distributed operation in a third-party system	• Third-party automation system • ET 200 distributed I/O system • TM Timer DIDQ	Third-party configuration software: Device configuration and parameter settings with GSD file	

Note

A description of the control and feedback interface is available in the device manual for the TM Timer DIDQ.

2.3.2 Counting with incremental encoder

You can use a few channels of a TM Timer DIDQ for simple counting tasks with an incremental encoder. Counting refers to the recording and adding up of events. The channels configured as counters each acquire the two incremental signals and evaluate these accordingly.

Count direction

The technology module can count up and down with an incremental encoder. You change the count direction by inverting it.

Counting limits

The counting limits define the counter value range used.

The minimum counter value is -2147483648 (-2^{31}). The maximum counter value is 2147483647 ($2^{31}-1$). The respective counter counts continuously. At an overflow, the counter jumps to the other counting limit in each case and continues counting.

The counter value cannot be influenced by the user program.

Parameter assignment

For use of a counter for an incremental encoder, two digital inputs each of a channel group are combined. For this purpose, you choose the configuration "Incremental encoder (A, B phase-shifted)" in the channel parameters for the respective group.

Note

Counters of the TM Timer DIDQ 16x24V

The number of available counters of the TM Timer DIDQ 16x24V is dependent on the channel configuration. In order to use 4 counters, you must choose the use of 8 inputs in the channel configuration. If you choose the use of 3 inputs, you can use 1 counter. Other channel configurations do not allow any counter use.

Counter value feedback

The current counter value is indicated in the feedback interface in the TEC_IN value (DIm). DIm corresponds to the first of the two grouped digital inputs in each case. For the second digital input, "0" is returned in the value TEC_IN (DIm+1).

2.3.3 Counting with pulse encoder

You can use a few channels of a TM Timer DIDQ for simple counting tasks with a pulse encoder. Counting refers to the recording and adding up of events. The channels configured as counters each acquire one pulse signal and evaluate this accordingly.

Count direction

The technology module can count up and down with a pulse encoder.

Counting limits

The counting limits define the counter value range used.

The minimum counter value is -2147483648 (-2^{31}). The maximum counter value is 2147483647 ($2^{31}-1$). The respective counter counts continuously. At an overflow, the counter jumps to the other counting limit in each case and continues counting.

The counter value cannot be influenced by the user program.

Parameter assignment

For use of a counter for a pulse encoder, you choose the configuration "Use inputs individually" or "Use input/output individually" in the channel parameters for the respective group. You can configure the first digital input of a group as a counter.

Note

Counters of the TM Timer DIDQ 16x24V

The number of available counters of the TM Timer DIDQ 16x24V is dependent on the channel configuration. In order to use 4 counters, you must choose the use of 8 inputs in the channel configuration. If you choose the use of 3 inputs, you can use 1 counter. Other channel configurations do not allow any counter use.

Counter value feedback

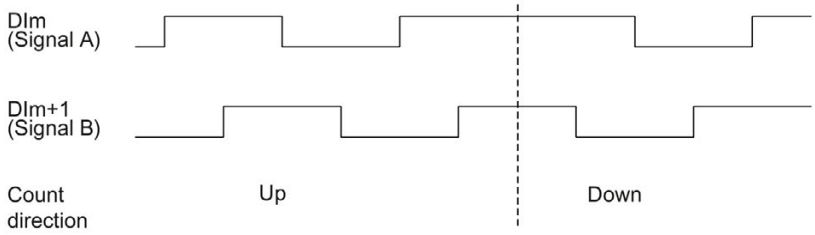
The current counter value is indicated in the feedback interface in the TEC_IN value (DIm). DIm corresponds to the respective digital input.

2.3.4 24 V count signals

Count signals of 24 V incremental encoders

The 24 V incremental encoder returns the 24 V signals A and B to the technology module. The A and B signals are phase-shifted by 90°.

The figure below shows an example of the time profile of the signals of an 24 V incremental encoder:



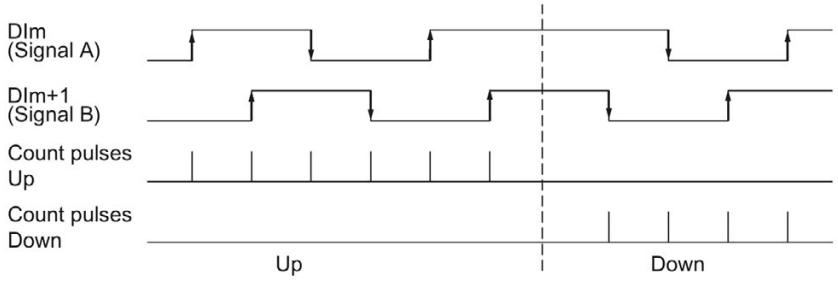
The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Signal evaluation

The two phase-shifted signals of an incremental encoder are evaluated four times. With quadruple evaluation, the positive and negative edges of signal A and signal B are evaluated.

Whether count pulses are generated in an upward or downward direction depends on the edge direction of the one signal and the level of the other signal in the meantime.

The figure below shows an example of the quadruple evaluation of 24 V count signals:



Count signals of 24 V pulse encoders

The encoder, for example, a proximity switch (BERO) or a light barrier, returns only a count signal that is connected to the digital input of a counter.

You can count the positive or the negative edges of the signal.

2.3.5 Isochronous mode

The TM Timer DIDQ supports the "Isochronous mode" system function in decentralized operation. This system function enables counter values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the module are synchronized.

Data processing

The data that was transmitted to the module in the current bus cycle via the control interface takes effect when it is processed in the module's internal cycle. The counter value and status bits are detected at time T_i and made available in the feedback interface for retrieval in the current bus cycle.

Additional information

For a detailed description of isochronous mode, refer to the PROFINET with STEP 7 function manual, which is available as download at Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

2.4 Basics of counting (digital input modules)

2.4.1 Overview of applications

Introduction

The digital input module is configured and assigned parameters using the configuration software.

The module's functions are controlled and monitored via the user program.

System environment

The respective module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central and distributed mode in an S7-1500 system with a corresponding ET 200 system	• S7-1500 automation system • ET 200 distributed I/O system • Digital input module	STEP 7 (TIA Portal) and STEP 7: Device configuration and parameter setting with hardware configuration	Direct access to technology module control and feedback interface in the I/O data
Distributed operation in an S7-300/400 system	• S7-300/400 automation system • ET 200 distributed I/O system • Digital input module		
Distributed operation in a third-party system	• Third-party automation system • ET 200 distributed I/O system • Digital input module	Third-party configuration software: Device configuration and parameter settings with GSD file	

Note

A description of the control and feedback interface is available in the device manual for the digital input module.

2.4.2 Counting with pulse encoders

Counting refers to the detection and summation of events. The modules' counters record and evaluate pulse signals. The counting direction can be specified using encoder or pulse signals or through the configuration.

You can use feedback bits to switch the digital outputs of digital output modules exactly at defined counter values, independent of the user program.

You can configure the characteristics of the counters using the functionalities described below.

Counter limits

The counter limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program. See the module's device manual for the maximum and minimum configurable counter limits.

You can configure whether the counting processes are terminated or continue when a counter limit is violated (automatic gate stop).

Start value

You can configure a start value within the counter limits. The start value can be modified during runtime with the user program.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are recordd.

The hardware gate is controlled externally via a digital input of the technology module. The hardware gate can be enabled through parameter assignment. The software gate is controlled via the user program. A description of the control and feedback interface is available in the device manual for the digital input module.

2.4.3 Behavior at the counting limits

Violation of a counting limit

The high counting limit is violated when the current counter value is equal to the high counting limit and another upward count pulse is received. The counter low limit is violated when the current counter value is equal to the counter low limit and another downward count pulse is received.

With digital input modules for ET 200SP, the corresponding event bit is set in the feedback interface when the limit is violated. You can reset an event bit with the respective control bit:

Counting limit violated	Event bit	Reset bit
High counting limit	EVENT_OFLW	RES_EVENT_OFLW
Low counting limit	EVENT_UFLW	RES_EVENT_UFLW

Note

A description of the control and feedback interface is available in the device manual for the digital input module.

You can configure whether or not you want to continue counting to another counter limit after a counting limit violation.

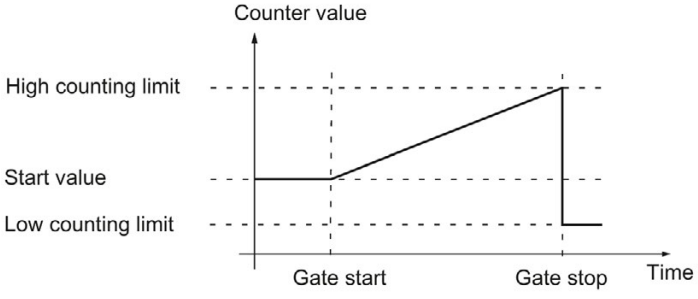
Note

The high counting limit and the start value define the value range of the counter:

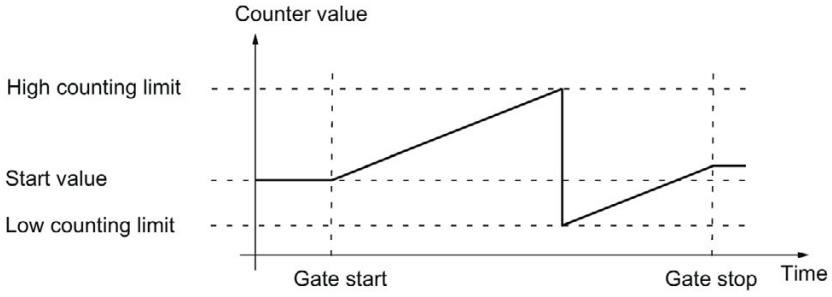
Value range of the counter = (high limit – start value) + 1

Examples

The figure below shows an example for terminating counting after overflow and setting the counter to the opposite counting limit:



The figure below shows an example for continuing the counting process after an overflow and setting the counter to the opposite counting limit:



2.4.4 Gate control

Many applications require counting processes to be started or stopped in accordance with other events. In such cases, counting is started and stopped using the gate function.

The digital input modules have two gates for each counting channel. These define the resulting internal gate:

- Software gate
- Hardware gate

Note

The hardware gate is not configurable for all digital input modules.

2.4.4.1 Software gate

The software gate of the channel is opened and closed with the SW_GATEcontrol bit.

See the module's device manual for information on the design of the control and feedback interface.

2.4.4.2 Hardware gate

The hardware gate is optional. You open and close the hardware gate using signals at the corresponding digital input.

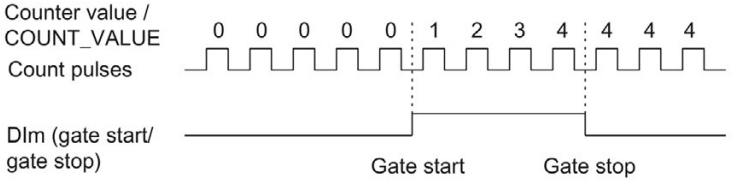
Note

A configurable input delay delays the control signal of the digital input.

The status of a DIm digital input is indicated by the respective STS_DIm feedback bit. A description of the control and feedback interface is available in the device manual for the digital input module.

Opening and closing the hardware gate

The figure below shows an example of opening and closing with a digital input:



As long as the digital input is set, the hardware gate is open and the count pulses are counted. The hardware gate is closed when the digital input is reset. The counter value stays constant and ignores any further count pulses.

2.4.4.3 Internal gate

Internal gate

The internal gate is open if the software gate is open and the hardware gate is open or has not been configured. The status of the internal gate is indicated by the STS_GATE feedback bit. See the module's device manual for information on the design of the control and feedback interface.

If the internal gate is open, counting is started. If the internal gate is closed, all other count pulses are ignored and counting is stopped.

If you want to control a counting process with the hardware gate only, the software gate must be open. If you do not configure a hardware gate, the hardware gate is considered to be always open. In this case, you open and close the internal gate with the software gate only.

Hardware gate	Software gate	Internal gate
Open/not configured	open	open
Open/not configured	closed	closed
closed	open	closed
closed	closed	closed

The internal gate can also be automatically closed upon violation of a counting limit. The software or hardware gate must then be closed and reopened to continue counting.

2.4.5 Comparison values

Depending on the module, you can define up to two comparison values that control a reset bit for the channel, independent of the user program.

When there are two comparison values, comparison value 1 must be greater than comparison value 0. The comparison values are configurable and can be changed at runtime by the user program.

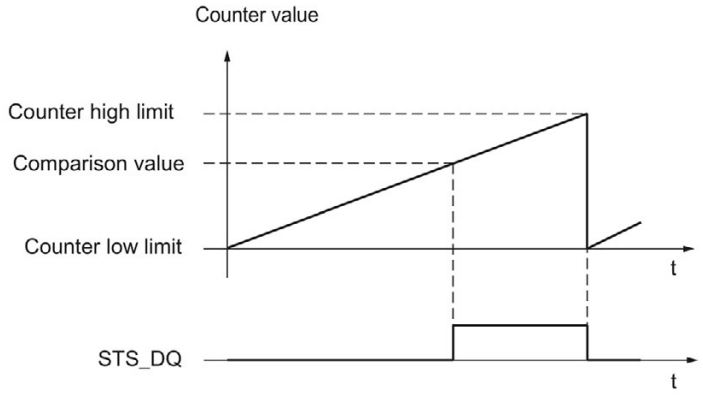
The comparison values are compared with the current counter value. If the counter value meets the configured comparison condition, the respective STS_DQ reset bit is set.

You can use the respective reset bit in order to switch a digital output module's digital output. You can make setting the respective STS_DQ reset bit dependent on one of the following comparison events. See the device manual for the technology module to find out which comparison events can be configured.

Setting between comparison value and high counter limit

The respective STS_DQ feedback bit is set to 1 when:

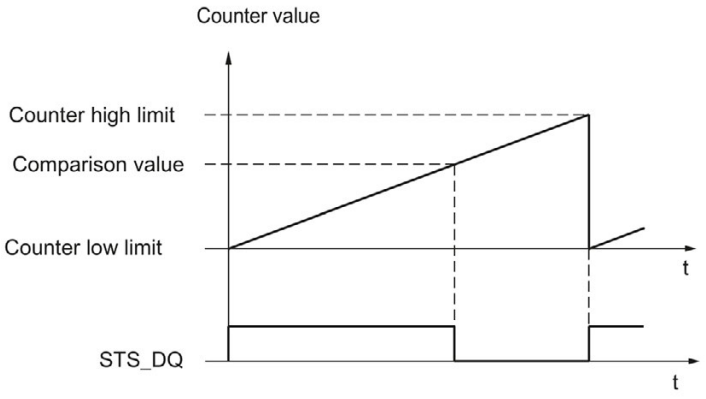
Comparison value <= counter value <= high counter limit



Setting between comparison value and low counter limit

The respective STS_DQ feedback bit is set to 1 when:

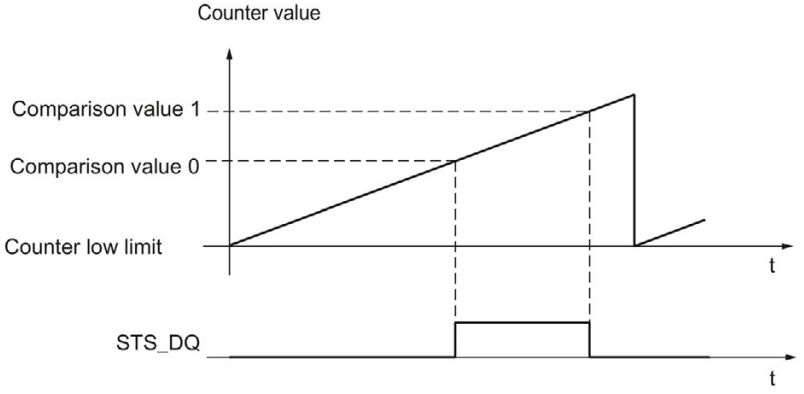
Low counter limit <= counter value <= comparison value



Setting between comparison value 0 and comparison value 1

The respective STS_DQ feedback bit is set to 1 when:

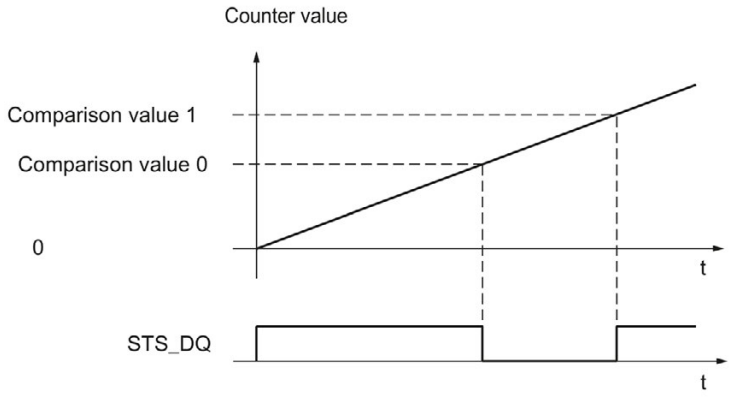
Comparison value 0 <= counter value <= comparison value 1



Not setting between comparison value 0 and comparison value 1

The respective STS_DQ feedback bit is set to 1 when:

Comparison value 0 <= counter value <= comparison value 1



2.4.6 Interrupts

Hardware interrupt

The module can trigger a hardware interrupt in the CPU during operation for certain events. The hardware interrupts can be enabled in the configuration. Refer to the device manual for the module to learn about the events that can trigger a hardware interrupt during operation.

Note

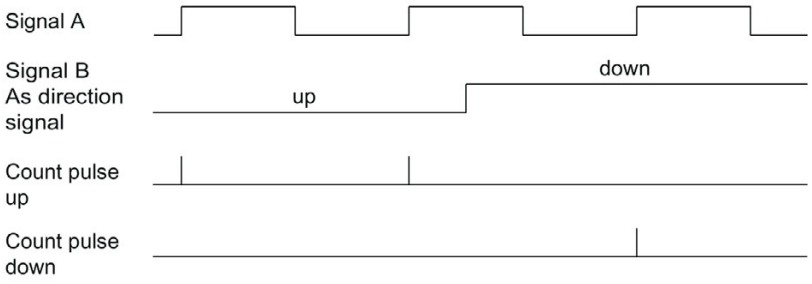
Hardware interrupts for counting are not configurable for all digital input modules.

2.4.7 24 V count signals

24 V pulse encoder count signals

The encoder, for example an initiator (BERO) or a light barrier, returns a count signal that is connected to the terminal (signal A) of the counter. You can also connect a signal for direction detection (signal B).

The figure below shows an example of the time profile of the signals of a 24 V pulse encoder with direction signal and the resulting count pulses:



Note

A signal for direction detection cannot be connected for all digital input modules.

Monitoring of encoder signals

If you enable the respective diagnostic interrupt in the device configuration, the module triggers a diagnostic interrupt in the event of an encoder signal error.

2.4.8 Isochronous mode

The digital input module supports the "isochronous mode" system function in distributed mode. This system function enables counter values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the module are synchronized.

Data processing

The data that was transmitted to the module in the current bus cycle via the control interface takes effect when it is processed in the module's internal cycle. The counter value and status bits are detected at time T_i and made available in the feedback interface for retrieval in the current bus cycle.

Additional information

For a detailed description of isochronous mode, refer to the PROFINET with STEP 7 function manual, which is available as download at Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

Using the High_Speed_Counter technology object 3

3.1 Convention

Technology module: We use the term "technology module" in this documentation both for the technology modules TM Count and TM PosInput and the technology component of the compact CPUs.

3.2 High_Speed_Counter technology object

STEP 7 (TIA Portal) supports you in the configuration, commissioning and diagnostics of counting and measuring functions for the following technology modules with the "Technology objects" function:

- You configure the High_Speed_Counter technology object in STEP 7 (TIA Portal) with the settings for the counting and measuring functions.
- The corresponding High_Speed_Counter instruction is programmed in the user program. This instruction supplies the control and feedback interface of the technology module.

The High_Speed_Counter technology object corresponds to the instance DB of the High_Speed_Counter instruction. The configuration of the counting and measuring functions is saved in the technology object. The technology object is located in the folder "PLC > Technology objects".

The High_Speed_Counter technology object can be used for technology modules of both the S7-1500 and ET 200SP systems.

Operating mode

In order to assign the technology module parameters using a technology object, you specify the operating mode (Page 172) "Operating with technology object" in the hardware configuration of the technology module. This selection is already preset.

3.3 Overview of the configuration steps

Introduction

The overview below shows the basic procedure for configuring the counting and measuring functions of the technology module with the High_Speed_Counter technology object.

Requirement (TM Count and TM PosInput)

Before you can use the High_Speed_Counter technology object, a project with an S7-1500 CPU or an ET 200SP CPU must be created in STEP 7 (TIA Portal) .

Requirement (Compact CPU)

Before you can use the High_Speed_Counter technology object, a project with a Compact CPU S7-1500 must be created in STEP 7 (TIA Portal).

Procedure

Proceed in the recommended sequence outlined below:

Step	Description
1	Configure a technology module (Page 166)
2	Add technology object (Page 92)
3	Configure a technology object according to your application (Page 94)
4	Call instruction in the user program (Page 116)
5	Load to CPU
6	Commissioning the technology object (Page 129)
7	Diagnostics of the technology object (Page 131)

3.4 Add technology object

Add technology object in the project navigator

When a technology object is added, an instance DB is created for the instruction of this technology object. The configuration of the technology object is stored in this instance DB.

Requirement (TM Count and TM PosInput)

A project with a CPU S7-1500 has been created.

Requirement (Compact CPU)

A project with a Compact CPU S7-1500 has been created.

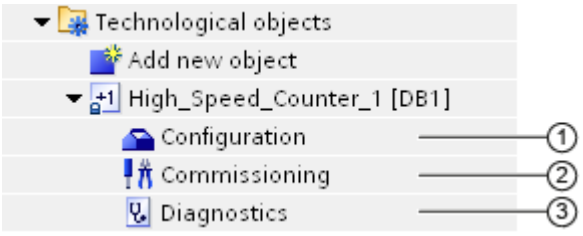
Procedure

To add a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Double-click on "Add new object".
   The "Add new object" dialog opens.
4. Select the "Counting and measurement" technology.
5. Select the "High_Speed_Counter" object.
6. Enter an individual name for the technology object in the "Name" text box.
7. Click "Additional information" if you want to add your own information to the technology object.
8. Confirm with "OK".

Result

The new technology object has now been created and stored in the project tree in the "Technology objects" folder.



	Object	Description
①	Configuration (Page 94)	In the configuration dialog: • Assignment of technology module and channel • Technology object parameter settings for counting and measurement functions When you change the configuration of the technology object, you must download the technology object **and** the hardware configuration to the CPU.
②	Commissioning (Page 129)	Commissioning and function test of the technology object: Simulating parameters of the High_Speed_Counter instruction and monitoring the effects
③	Diagnostics (Page 131)	Monitoring the counting and measuring functions

3.5 Configuring the High_Speed_Counter

3.5.1 Working with the configuration dialog

You configure the properties of the technology object in the configuration window. Proceed as follows to open the configuration window of the technology object:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click on the "Configuration" object.

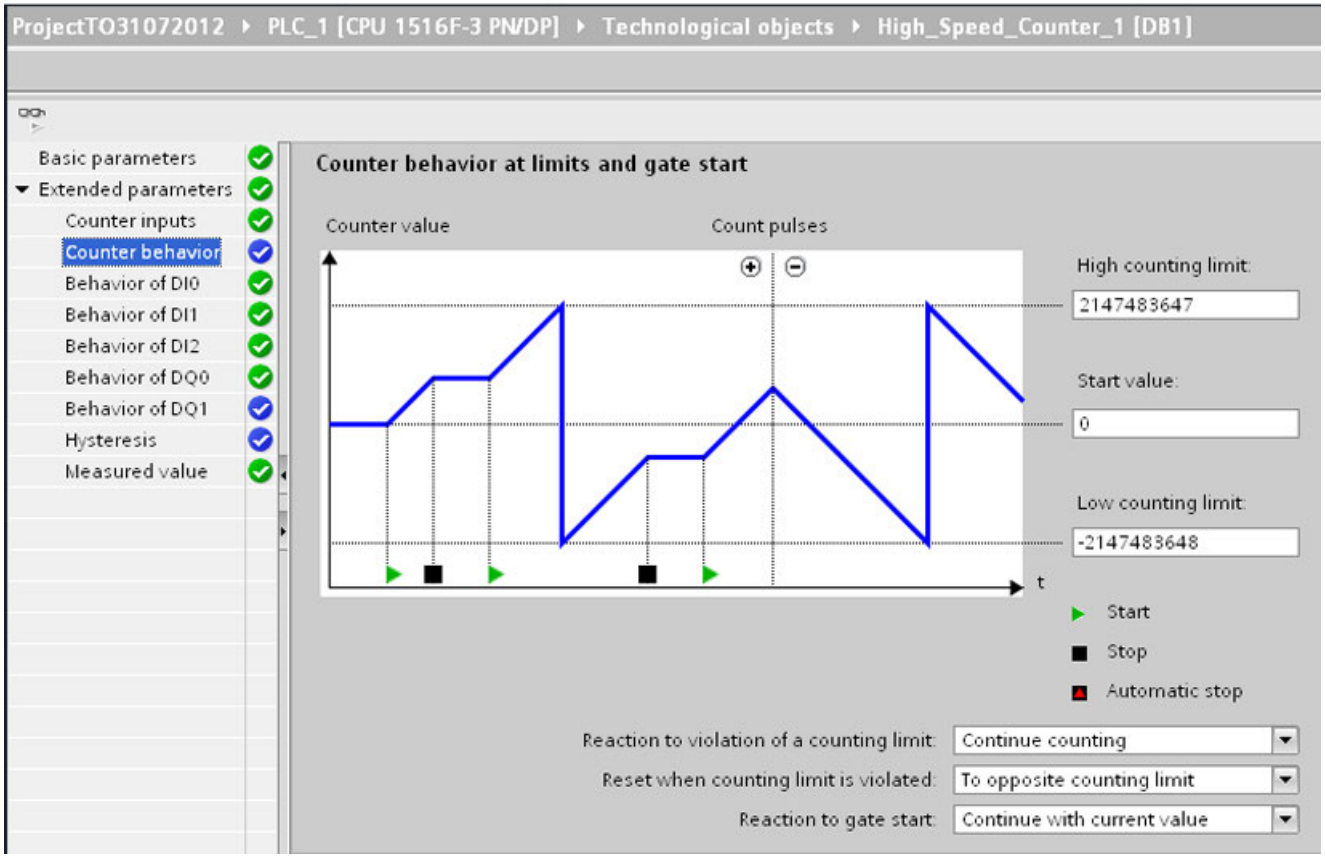
The configuration is divided into the following categories:

- **Basic parameters**

  The basic parameters include the selection of the technology module and the number of the counting channel for which the technology object is configured.

- **Extended parameters**

  The extended parameters include the parameters for adapting the counting and measuring functions and for setting the characteristics of the digital inputs and digital outputs.



Configuration window icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values, you can use the technology object without additional changes.
	The configuration contains values set by the user or automatically adapted values and is complete All text boxes of the configuration contain valid values and at least one default value was changed.
	The configuration is incomplete or incorrect At least one text box or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the roll-out error message to indicate the cause of error.

3.5.2 Basic parameters

You can establish the connection between the High_Speed_Counter technology object and the technology module under "Basic parameters".

Module (TM Count and TM PosInput)

You select the technology module in a subsequent dialog box. You can choose any of the technology modules (central or distributed) which are configured in the S7-1500 CPU for use with a technology object from "Counting and measuring".

After selecting the technology module, you can open the device configuration associated with the technology module by clicking the"Device configuration" button.

The technology module parameter settings required for the use of the technology object are made in the "Extended parameters" of the technology object.

Module (Compact CPU)

You can select a high-speed counter for the Compact CPU in a subsequent dialog. You can choose any of the high-speed counters which are enabled and configured for use with a technology object from "Counting and measuring".

After selecting the high-speed counter, you can open the device configuration associated with the Compact CPU by clicking the"Device configuration" button.

The parameter settings of the high-speed counter required for the use of the technology object are made in the "Extended parameters" of the technology object.

Channel

For a technology module with several counting channels, you can also select the number of the counting channel for which the High_Speed_Counter technology object is to be valid.

Note

A channel can be assigned to only *one* technology object. A channel that is already assigned to a technology object can no longer be selected.

Synchronization of the parameter values

If, after assignment of the channel to the technology object, there is an inconsistency between the parameter values under "Parameters" and in the technology object, a button with a corresponding inquiry appears. When you click the button, the parameter values under "Parameters" are overwritten by the parameter values of the technology object within STEP 7 (TIA Portal). The current parameter values of the technology object are displayed under "Parameters".

3.5.3 Counter inputs (High_Speed_Counter)

Signal type

You can choose from the following signal types (Page 65):

Symbol	Signal type	Meaning	Additional option-specific parameters
	Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.	• Invert direction • Signal evaluation • Filter frequency • Sensor type or Interface standard
	Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.	• Invert direction • Signal evaluation • Filter frequency • Sensor type or Interface standard • Reaction to signal N • Frequency
	Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.	• Filter frequency • Sensor type or Interface standard
	Pulse (A)	A pulse encoder (signal A) without direction signal is connected. You can specify the count direction by means of the control interface (Page 182).	• Filter frequency • Sensor type or Interface standard
	Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.	• Filter frequency • Sensor type or Interface standard

Invert direction

You can invert the counting direction to adapt it to the process.

The inverting of the direction is configurable and active for the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Signal evaluation

By configuring signal evaluation (Page 70), you can specify which edges of the signals are counted.

You can select from the following options:

Symbol	Signal evaluation	Meaning
	Single (Page 70) (default)	The edges of signal A are evaluated during a low level of signal B.
	Double (Page 71)	Each edge of signal A is evaluated.
	Quadruple (Page 72)	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counting inputs A, B and N.

The selected filter frequency is based on a pulse-break ratio of between 40:60 and 60:40. This results in a specific minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Filter frequency	Minimum pulse/break time
100 Hz	4.0ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz (preset for Compact CPU)	4.0 µs

Filter frequency	Minimum pulse/break time
200 kHz** (preset for TM Count)	2.0 µs
500 kHz*	0.8 µs
1 MHz* (default at TM PosInput)	0.4 µs

* Only available with TM PosInput

*** Only available with TM Count and TM PosInput

Sensor type (TM Count)

By configuring the sensor type, you specify how the counter inputs are switched for the TM Count.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder/sensor switches the inputs A, B and N to 24VDC.
Sinking output	The encoder/sensor switches the inputs A, B and N to M.
Push-pull (sinking and sourcing output)	The encoder/sensor alternately switches the inputs A, B and N to M and 24VDC.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "sourcing output" or "sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

Note

If you use a push-pull encoder and the sensor type "Push-pull (sinking and sourcing output)" is configured, you can monitor the encoder signals for wire break.

Sensor type (Compact CPU)

The "Sourcing output" sensor type is set for the Compact CPU and cannot be changed. The encoder or sensor switches the inputs A, B and N to 24V DC.

You can operate both sourcing output encoders as well as push-pull encoders on the Compact CPU. You can find additional information on the sensor type in the data sheet for the encoder.

Interface Standard (TM PosInput)

You use this parameter to specify whether the encoder outputs symmetric (RS422) or asymmetric (TTL) signals for the TM PosInput.

You can select from the following options:

Interface standard	Meaning
RS422, symmetrical	The encoder outputs symmetric signals according to the RS422 standard (Page 67).
TTL (5 V), asymmetrical	The encoder outputs asymmetric 5 V signals according to the TTL standard (Page 65).

Note

The RS422 standard provides greater interference immunity than the TTL standard. If your incremental or pulse encoder supports the RS422 standard **and** the TTL standard, we recommend using the RS422 standard.

Reaction to signal N

You use this parameter to specify which reaction is triggered to signal N.

You can select from the following options:

Option	Meaning
No reaction to signal N (default)	The counter is not affected by signal N.
Synchronization at signal N (Page 39)	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.
Capture at signal N (Page 29)	The counter value is stored in the Capture value at signal N.

Note

You can only select the reaction to signal N if you have selected the "Incremental encoder (A, B, N)" signal type.

Note

If "Synchronization at signal N" is selected, you can select the function "Enable synchronization at signal N" for a digital input (Page 104).

Note

For High_Speed_Counter as of V3.0, the following applies:

You can choose "Capture at signal N" only in operating mode "Use count value as reference":

Frequency

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

3.5.4 Counter behavior

3.5.4.1 Counting limits and start value

High counting limit

You limit the counting range by setting the high counting limit. You can enter a value up to 2147483647 (2^{31}-1). You must enter a value that lies above the low counting limit.

The default setting is "2147483647".

Low counting limit

You limit the counting range by setting the low counting limit. You can enter a value up to -2147483648 (-2^{31}). You must enter a value below the high counting limit.

The default setting is "-2147483648".

Start value

By configuring the start value, you specify the value at which counting is to start and where it is to continue in the case of defined events. You must enter a value between the counting limits or equal to the counting limits.

The default setting is "0".

Additional information

For more information, see Behavior at the counting limits (Page 24) and Counter behavior at gate start (Page 28).

3.5.4.2 Counter behavior at limits and gate start

Reaction to violation of a counting limit

You can configure the following characteristics for violation of a counting limit (Page 24):

Reaction	Meaning
Stop counting	If a counting limit is violated, counting is stopped and the internal gate is closed. To restart counting, you must also close and reopen the software/hardware gate.
Continue counting (default)	Counting continues either with the start value or at the opposite counting limit, depending on the additional parameter assignment.

Reset when counting limit is violated

You can reset the counter to the following values when a counting limit is violated:

Reset the value	Meaning
To start value	The counter value is set to the start value.
To opposite counting limit (default)	The counter value is set to the opposite counting limit.

Reaction to gate start

You can set the following Reaction to gate start (Page 28):

Reaction	Meaning
Set to start value	When the gate is opened, the counter value is set to the start value.
Continue with current value (default)	When the gate is opened, counting is continued with the last counter value.

3.5.5 Behavior of a DI (High_Speed_Counter)

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the hardware gate (Page 26).	• Input delay • Select level
Gate start (edge-triggered)	The configured edge at the respective digital input opens the hardware gate (Page 26).	• Input delay • Edge selection
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the hardware gate (Page 26).	• Input delay • Edge selection
Synchronization (Page 34)	The configured edge at the respective digital input sets the counter to the start value. The technology object indicates whether a synchronization has occurred at the output parameter SyncStatus.	• Input delay • Edge selection
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N (Page 39).	• Input delay • Select level
Capture	The configured edge at the respective digital input saves the current counter value (Page 29) as a Capture value. The technology object displays the Capture value at the output parameter CapturedValue.	• Input delay • Edge selection • Behavior of counter value after Capture
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective static variable of the technology object: • UserStatusFlags.StatusDI0 • UserStatusFlags.StatusDI1 • UserStatusFlags.StatusDI2	• Input delay

Note

With the exception of "Digital input without function", each function can only be used once for each counter, and if used for one digital input is not available to the others.

Note

For High_Speed_Counter as of V3.0, the following applies:

You can choose the "Capture" function only in operating mode "Use count value as reference".

Input delay (TM Count and TM PosInput)

By configuring the input delay, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured input delay are suppressed.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Note

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1".

Input delay (Compact CPU)

By configuring the input delay, you suppress faults at the digital inputs of the DIn signal. Signals with a pulse duration below the configured input delay are suppressed.

You can configure the input delay for a digital input of a Compact CPU in the Inspector window of the device configuration under "Properties > DI 16/DQ 16 > Inputs > Channel n".

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms
- 0.4 ms
- 1.6 ms
- 3.2 ms (default)
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level (default)	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be set for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered.

The following options may be available depending on the function selected:

- At rising edge (default)
- At falling edge
- At rising and falling edge

The parameter can be set for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization
- Capture

Note

At rising and falling edge" can only be configured for the "Capture" function.

Behavior of counter value after Capture

You can configure the following characteristics for the counter after a capture event (Page 29):

	Meaning
Continue counting (default)	After saving the current counter value as Capture value, counting is continued unchanged.
Set to start value and continue counting	After saving the current counter value as Capture value, counting is continued with the start value.

Note

This parameter can be assigned only for the "Capture" function.

See also

Assignment of the feedback interface (Page 185)

3.5.6 Behavior of a DQ (High_Speed_Counter)

Operating mode (High_Speed_Counter V3.0 or higher)

The operating mode determines which value comparison functions work.

Operating mode	Meaning
Use count value as reference (default)	The comparison functions and hardware interrupts for compare events work with the counter value. This functionality corresponds to the functionality of the High_Speed_Counter in versions before V3.0.
Use measured value as reference	The comparison functions and hardware interrupts for compare events work with the measured value.

Note

You configure the operating mode under "Behavior of DQ0" for both digital outputs together. The operating mode is also displayed under "Behavior of DQ1".

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options:

Function of a digital output (Page 43) in operating mode "Use count value as reference"	Meaning	Additional option-specific parameters
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= counter value <= high counting limit	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: Low counting limit <= counter value <= comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= counter value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
At comparison value for a pulse duration	The respective digital output is active once for the configured time and count direction when the counter value reaches the comparison value.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)

Function of a digital output (Page 43) in operating mode "Use count value as reference"	Meaning	Additional option-specific parameters
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active until the counter value is equal to the comparison value.	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 42).	—

Note

DQ0 of a counter of a Compact CPU

With a Compact CPU, the respective digital output DQ0 is available via the feedback interface, but not as a physical output.

Note

You can only select the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Note

The "At comparison value for a pulse duration" and "After set command from CPU until comparison value" functions only switch the digital output in question if a count pulse reaches the comparison value. When the counter value is set, e.g. by synchronization, the digital output does not switch.

Function of a digital output (Page 51) in operating mode "Use measured value as reference"	Meaning	Additional option-specific parameters
Measured value >= comparison value (default)	The respective digital output is active if the measured value is greater than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Measured value <= comparison value	The respective digital output is active if the measured value is less than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= measured value <= comparison value 1	• Comparison value 0 • Comparison value 1
Not between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 1 <= measured value <= comparison value 0	• Comparison value 0 • Comparison value 1
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 42).	—

Note

You can select the "Between comparison value 0 and 1" and "Not between comparison value 0 and 1" functions only for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Comparison value 0(TM Count und TM PosInput)

Operating mode "Use count value as reference"

With the parameter assignment of the comparison value (Page 43), you specify the counter value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than or equal to the low counting limit and less than comparison value 1. The default setting is "0".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 51), you specify the measured value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a floating point number (REAL) that is less than comparison value 1. The minimum value is -7.922816 x 10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 0(Compact CPU)

Operating mode "Use count value as reference"

With the parameter assignment of the comparison value (Page 43), you specify the counter value at which the STS_DQ0 bit is set in the feedback interface. The digital output DQ0 is not available as a physical output in a Compact CPU.

You must enter an integer (DINT) that is greater than or equal to the low counting limit and less than comparison value 1. The default setting is "0".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 51), you specify the measured value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a floating point number (REAL) that is less than comparison value 1. The minimum value is -7.922816 x 10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 1

Operating mode "Use count value as reference"

With the parameter assignment of the comparison value (Page 43), you specify the counter value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than comparison value 0 and less than or equal to the high counting limit. The default setting is "10".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 51), you specify the measured value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter a floating point number (REAL) that is greater than comparison value 0. The maximum value is 7.922816 x 10^{28}. The default setting is "10.0". The unit of the comparison value depends on the measured variable.

Count direction

You use this parameter to specify the count direction for which the selected function is valid.

You can select from the following options:

Count direction	Meaning
In both directions (default)	The comparison and switching of the respective digital output take place regardless of the count direction.
Up	The comparison and switching of the respective digital output only takes place when the counter counts up.
Down	The comparison and switching of the respective digital output only takes place when the counter counts down.

The parameter can be configured for the following functions:

- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

If you enter "0" and the counter value corresponds to the comparison value, the digital output remains active until the next count pulse.

You can enter a value between 0.0 and 6553.5.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 61), you can define a range around the comparison values. Within the hysteresis range, the digital outputs cannot switch again until the counter value is outside the range.

Regardless of the hysteresis value, the hysteresis range ends at the low/high counting limits. If you enter "0", the hysteresis is turned off. You can enter a value between 0and 255. The default setting is "0".

Note

For High_Speed_Counter as of V3.0, the following applies:

You configure the hysteresis under "Behavior of DQ0" for both digital outputs together. The hysteresis is also displayed under "Behavior of DQ1".

The hysteresis is only available in operating mode "Use count value as reference".

3.5.7 Specify measured value (High_Speed_Counter)

Measured variable

This parameter is used to specify the measured variable (Page 56) to be provided by the technology module. The technology object displays the measured value at the output parameter MeasuredValue.

You can select from the following options:

Measured variable	Meaning	Additional option-specific parameters
Frequency (default)	The measured variable shows the number of increments per second. The value is a floating point number (REAL). The unit is Hz.	• Update time
Period	The measured variable is the average period between two increments. The value is an integer (DINT). The unit is s.	• Update time
Velocity	The measured variable is a velocity. Examples of a velocity measurement can be found in the explanation of the "Increments per unit" parameter.	• Update time • Time base for velocity measurement • Increments per unit

Update time

By configuring the update time (Page 55) in milliseconds, you can specify the time interval between two measured value updates.

The update time and the signal type effect the accuracy of the measurement. In the case of update times of at least 100 ms, the effect of the signal type is negligible.

In the case of update times of less than 100 ms, you achieve maximum measurement accuracy using the following signal types:

- Incremental encoder (A, B phase-shifted) with Signal evaluation "Single"
- Incremental encoder (A, B, N) with Signal evaluation "Single"
- Pulse (A) and direction (B)
- Pulse (A)

In the case of other signal types, measurement accuracy depends on the encoder and cable used.

If you enter "0", the measured value is updated once per module-internal cycle. Up to three decimal places can be entered. A value from 0.0 to 25000.0 is permissible. The default setting is "10.0".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s/1 min
- The default setting is "60 s/1 min".

Increments per unit

You can use this parameter to define the number of count pulses per relevant unit that the incremental or absolute encoder supplies for the velocity measurement.

The number of count pulses depends on the configured signal evaluation. You can enter a value between 1 and 65535.

Example 1:

You encoder delivers 4000 count pulses for travel over one meter. The velocity is to be measured in meters per second. "Double" is configured as signal evaluation.

In this case, you need to assign the following parameters:

- Increments per unit: 8000
- Time base for velocity measurement: 1 s

Example 2:

Your encoder delivers 4096 count pulses per revolution. The velocity is to be measured in revolutions per minute. "Single" is configured as the signal evaluation.

In this case, you need to assign the following parameters:

- Increments per unit: 4096
- Time base for velocity measurement: 60 s/1 min

3.6 Programming the High_Speed_Counter

3.6.1 High_Speed_Counter instruction

High_Speed_Counter

The High_Speed_Counter instruction is part of the High_Speed_Counter technology object. It supplies the control and feedback interface of the technology module.

The High_Speed_Counter instruction thereby forms the software interface between the user program and the technology module. It must be called cyclically from the user program in order to synchronize the input and output data.

The High_Speed_Counter instruction can be used for the technology modules of both S7-1500 and ET 200SP. The modules can be used centrally and decentrally. The instruction applies in each case to the channel of the technology module that was assigned to the associated technology object.

Additional information

Description High_Speed_Counter (Page 117)

High_Speed_Counter input parameters (Page 122)

High_Speed_Counter output parameters (Page 123)

Error codes of parameter ErrorID (Page 125)

High_Speed_Counter static variables (Page 127)

3.6.2 Call instruction in the user program

The High_Speed_Counter instruction can be called once for each counter in the cycle or, alternatively, in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Procedure

Proceed as follows to call the instruction in the user program:

1. Open the CPU folder in the project tree.
2. Open the "Program blocks" folder.
3. Double-click the OB for cyclic program execution.
   The block is opened in the work area.
4. In the "Instructions" window, open the "Technology" group and the "Counting and measurement" folder.
   The instructions are located in the folder.
5. Select an instruction and drag it to your OB.
   The "Call options" dialog opens.
6. Select a technology object from the "Name" list or enter the name for a new technology object.
7. Confirm with "OK".

Result

If the technology object does not exist yet, it is added. The instruction is added in the OB. The technology object is assigned to this call of the instruction.

Note

If you click one of the buttons "Configuration", "Commissioning" or "Diagnostics" in the user interface of the instruction, the respective editor opens.

3.6.3 Description High_Speed_Counter

Description

The High_Speed_Counter instruction is used to control the technology module counting and measuring functions via the user program.

Call

The instruction High_Speed_Counter must be called once per counter, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Operating principle

Counter value: The counter value is available at the output parameter CountValue. The counter value is updated at every call of the High_Speed_Counter instruction.

Measured value: The technology module updates the measured value asynchronously to the instruction call based on the configured update time. The measured value last determined by the technology module is updated at the output parameter MeasuredValue each time the instruction is called.

The measured value and the counter value are available in parallel in the feedback interface.

Capture: The output parameter CaptureStatus = TRUE indicates a valid Capture value at the output parameter CapturedValue.

- A Capture value is captured under the following conditions:
  - A digital input has the parameter assignment "Capture"
  - CaptureEnable = TRUE
  - Edge at digital input with the Capture function
- The output parameter CaptureStatus is reset by a negative edge at the input parameter CaptureEnable.

Synchronization: The output parameter SyncStatus = TRUE indicates that a synchronization has occurred.

- The counter value is synchronized under the following conditions:
  - A digital input has the parameter assignment "Synchronization" **or** the incremental encoder has the parameter assignment "Synchronization at signal N"
  - SyncEnable = TRUE
  - SyncUpDirection (or SyncDownDirection) = TRUE
  - Edge at the digital input with the synchronization function **or** positive edge of the signal N at the encoder input

- The output parameter SyncStatus is reset by a negative edge at
  - the input parameter SyncEnable or
  - the static tag SyncDownDirection or
  - the static tag SyncUpDirection

Parameter changes via the user program

Proceed as follows to modify parameters using the user program:

1. Check based on the respective Set tag to determine whether the technology object is ready for the parameter change (Set tag = FALSE) or whether a change job is still running (Set tag = TRUE).
   The following Set tags in UserCmdFlags are available for this in the static tags of the technology object instance DB:
   - SetReferenceValue0
   - SetReferenceValue1
   - SetUpperLimit
   - SetLowerLimit
   - SetCountValue
   - SetStartValue
   - SetNewDirection
2. If the technology object is ready for the parameter change, modify the relevant static tag.
   The following static tags of the technology object instance DB are available for this:
   - NewReferenceValue0 / NewReferenceValue0_M (for SetReferenceValue0)
   - NewReferenceValue1 / NewReferenceValue1_M (for SetReferenceValue1)
   - NewUpperLimit
   - NewLowerLimit
   - NewCountValue
   - NewStartValue
   - NewDirection
3. Set the relevant Set tag for execution of the change command.
4. Use the output parameter Error to check whether an error has occurred.
   If no errors have occurred and the Set tag has been automatically reset by the technology object, the parameter change was successful.

Note

Changed counting limit

If the new high counting limit is less than the current counter value, the counter value is set to the low counting limit or the start value according on the parameter assignment. If the new low counting limit is greater than the current counter value, the counter value is set to the high counting limit or the start value according to the parameter assignment.

Operating mode (High_Speed_Counter V3.0 or higher)

Configure the operating mode in the technology object under "Behavior of DQ0".

The operating mode is indicated by the output parameter CompareMeasuredValue:

State	Description
FALSE	Operating mode "Use count value as reference" The comparison functions work with the counter value. The following static variables are specifically used in this operating mode: • NewReferenceValue0 • NewReferenceValue1 • CurReferenceValue0 • CurReferenceValue1 The four specific static variables of operating mode "Use measured value as reference" are ignored.
TRUE	Operating mode "Use measured value as reference": The comparison functions work with the measured value. The following static variables are specifically used in this operating mode: • NewReferenceValue0_M • NewReferenceValue1_M • CurReferenceValue0_M • CurReferenceValue1_M The four specific static variables of operating mode "Use count value as reference" are ignored.

Acknowledgment of events

You acknowledge signaled events using the positive edge of the input parameter EventAck . EventAck must stay set until the technology object has reset the status bits of the following events of the count channel:

- CompResult0
- CompResult1
- ZeroStatus
- PosOverflow
- NegOverflow

Status of the digital inputs (TM Count and TM PosInput)

You can obtain the status of the digital inputs with the static tags StatusDI0, StatusDI1 or StatusDI2.

Status of the digital inputs (Compact CPU)

You can obtain the status of the digital inputs with the static tags StatusDI0 and StatusDI1. When a digital input of the Compact CPU is not used for a counter, you can use it via the user program.

Use of digital outputs by the user program (TM Count and TM PosInput)

You can set the digital outputs with the High_Speed_Counter instruction,

- If the "Use by user program" setting is configured for "Set output".
- If the "After set command from CPU until comparison value" setting is configured for "Set output".
- if you set the corresponding static tag ManualCtrlDQm (temporary overwrite).

The static tags SetDQ0 and SetDQ1 only have an effect in these cases. In the first and third case, DQm follows the value of SetDQm. In the second case, DQm is set with a positive edge of SetDQm. DQm is reset when the counter value corresponds to the comparison value or at a negative edge of SetDQm.

Use digital outputs by user program (Compact CPU)

You can set the DQ1 digital output with the High_Speed_Counter instruction.

- If the "Use by user program" setting is configured for "Set output".
- If the "After set command from CPU until comparison value" setting is configured for "Set output".
- if you set the corresponding static tag ManualCtrlDQ1 (temporary overwrite).

The static tag SetDQ1 only has an effect in these cases. In the first and third case, DQ1 follows the value of SetDQ1. In the second case, DQ1 is set and reset with a positive edge of SetDQ1 when the counter value corresponds to the comparison value or at a negative edge of SetDQ1.

Note

Before you can set a physical digital output of the Compact CPU with the High_Speed_Counter instruction, you have to assign the DQ1 signal to the desired digital output.

You can set the DQ0 signal using the High_Speed_Counter instruction with the static tag StatusDQ0.

- If the "Use by user program" setting is configured for "Set output".
- If the "After set command from CPU until comparison value" setting is configured for "Set output".
- If you set the static tag ManualCtrlDQ0 (temporary overwrite).

The static tag SetDQ0 only has an effect in these cases. In the first and third case, DQ0 follows the value of SetDQ0. In the second case, StatusDQ0 is set and reset with an edge (positive or negative) by SetDQ0 and is reset when the counter value corresponds to the comparison value.

Note

The digital output DQ0 is not available as a physical output.

Reaction to error

If an error has occurred during the call of the instruction or in the technology module, the output parameter Error is set. More detailed error information can be read at the output parameter ErrorID.

Eliminate the cause of the error and acknowledge the error message by setting the input parameter ErrorAck. When no more errors are pending, the technology object resets the output parameter Error . No new error is signaled until you acknowledge the previous error.

Changing the count direction

The count direction can only be changed by the user program if "Pulse (A)" is configured as the signal type. In all other cases, the count direction is determined by the input signals of the technology module. The count direction is controlled by the static tag NewDirection:

- +1: Upward count direction
- -1: Downward count direction

To execute the change command, you need to set the tag SetNewDirection = TRUE.

3.6.4 High_Speed_Counter input parameters

Parameter	Declaration	Data type	Default	Description
SwGate	INPUT	BOOL	FALSE	Control software gate: • Positive edge: Software gate opens • Negative edge: Software gate closes Together with the hardware gate, the SwGate enables the internal gate.
SetCountValue	INOUT	BOOL	FALSE	A positive edge starts the transfer of the new counter value in the static tag NewCountValue to the technology module. The counter value takes effect immediately after the transfer.
CaptureEnable	INPUT	BOOL	FALSE	Enable Capture function After the enable, a Capture event occurs at the next configured edge at the relevant digital input. A negative edge at CaptureEnable resets the output parameter CaptureStatus. A negative edge at CaptureEnable resets the enable even if no Capture event has occurred. Irrespective of CaptureEnable the last value is retained at the output parameter CapturedValue until the next Capture event.
SyncEnable	INPUT	BOOL	FALSE	Enable synchronization The direction enabled for synchronization is indicated in the static tags SyncUpDirection and SyncDownDirection. A negative edge at SyncEnable resets the output parameter SyncStatus .
ErrorAck	INPUT	BOOL	FALSE	A positive edge acknowledges the error status reported.
EventAck	INPUT	BOOL	FALSE	A positive edge resets the following output parameters: • CompResult0 • CompResult1 • ZeroStatus • PosOverflow • NegOverflow

3.6.5 High_Speed_Counter output parameters

Parameter	Declaration	Data type	Default	Description
StatusHW	OUTPUT	BOOL	FALSE	Status bit technology module: The module is configured and ready for operation. The module data is valid.
StatusGate	OUTPUT	BOOL	FALSE	Status bit: Internal gate is released if parameter is set
StatusUp	OUTPUT	BOOL	FALSE	Status bit: The last count pulse incremented the counter and took place no more than 0.5 s ago
StatusDown	OUTPUT	BOOL	FALSE	Status bit: The last count pulse decremented the counter and took place no more than 0.5 s ago
CompResult0	OUTPUT	BOOL	FALSE	Status bit: Compare event for DQ0 occurred (status change) based on the selected comparison condition. If the counter value is set to the start value in operating mode "Use count value as reference", CompResult0 is not set. The positive edge of the input parameter EventAck is used to reset CompResult0 .
CompResult1	OUTPUT	BOOL	FALSE	Status bit: Compare event for DQ1 occurred (status change) based on the selected comparison condition. If the counter value is set to the start value in operating mode "Use count value as reference", CompResult1 is not set. The positive edge of the input parameter EventAck is used to reset CompResult1 .
SyncStatus	OUTPUT	BOOL	FALSE	Status bit: Synchronization event occurred If the input parameter SyncEnable is set, the configured edge sets the status bit SyncStatus at the respective digital input . SyncStatus is reset by a negative edge at • SyncEnable (input parameter) or • SyncUpDirection (static tag) or • SyncDownDirection (static tag)
CaptureStatus	OUTPUT	BOOL	FALSE	Status bit: Capture event occurred, the output parameter CapturedValue has a valid Capture value If the input parameter CaptureEnable is set, the configured edge sets the status bit CaptureStatus. at the respective digital input. You reset CaptureStatus using the negative edge of the input parameter CaptureEnable .
ZeroStatus	OUTPUT	BOOL	FALSE	Status bit: CountValue has reached the value "0" irrespective of the count direction You reset ZeroStatus using the positive edge of the input parameter EventAck.
PosOverflow	OUTPUT	BOOL	FALSE	Status bit: CountValue has violated high counting limit in the positive direction You reset PosOverflow using the positive edge of the input parameter EventAck.

Parameter	Declaration	Data type	Default	Description
NegOverflow	OUTPUT	BOOL	FALSE	Status bit: CountValue has violated low counting limit in the negative direction You reset NegOverflow using the positive edge of the input parameter EventAck.
Error	OUTPUT	BOOL	FALSE	An error has occurred. Refer to the output parameter ErrorID for the cause of the error.
ErrorID	OUTPUT	WORD	0	The ErrorID (Page 125) parameter displays the number of the error message. ErrorID = 0000_H: There is no error.
CountValue	OUTPUT	DINT	0	Current counter value
CapturedValue	OUTPUT	DINT	0	The last acquired Capture value The value is retained until the next Capture event, irrespective of the input parameter CaptureEnable. If a new Capture event has occurred, CaptureStatus is set and is reset by you using the negative edge of the input parameter CaptureEnable .
MeasuredValue	OUTPUT	REAL	0.0	Current measured value for frequency, period duration or velocity (depending on configuration)
CompareMeaspareMeasuredValue[1]	OUTPUT	BOOL	FALSE	Status bit: FALSE: Operating mode "Use count value as reference"; comparison functions work with counter value TRUE: Operating mode "Use measured value as reference"; comparison functions work with measured value

[1] Available for High_Speed_Counter version V3.0 or higher

3.6.6 Error codes of parameter ErrorID

Error code (W#16#...)	Description
0000	No error
Error messages from technology module	
80A1	POWER_ERROR from feedback interface: Incorrect supply voltage L+
80A2	ENC_ERROR from feedback interface: Incorrect encoder signal
80A3	LD_ERROR from feedback interface: Error when loading via control interface
Error messages of the instruction High_Speed_Counter	
80B1	Invalid count direction
80B4	For operating mode "Use count value as reference", the following applies: New low counting limit does not meet the following conditions: • Low counting limit < high counting limit • Low counting limit <= comparison value/start value For operating mode "Use measured value as reference", the following applies: New low counting limit does not meet the following conditions: • Low counting limit < high counting limit • Low counting limit <= start value
80B5	For operating mode "Use count value as reference", the following applies: New high counting limit does not meet the following conditions: • Low counting limit < high counting limit • High counting limit >= comparison value/start value For operating mode "Use measured value as reference", the following applies: New high counting limit does not meet the following conditions: • Low counting limit < high counting limit • High counting limit >= start value
80B6	New start value does not meet the following condition: • Low counting limit <= start value <= high counting limit
80B7	New counter value does not meet the following condition: • Low counting limit <= counter value <= high counting limit
80B8	For operating mode "Use count value as reference", the following applies: New comparison value 0 does not meet the following conditions: • Low counting limit <= comparison value 0 <= high counting limit • Comparison value 0 < comparison value 1 For operating mode "Use measured value as reference", the following applies: New comparison value 0 does not meet the following conditions: • Comparison value 0 < comparison value 1

Error code (W#16#...)	Description
80B9	For operating mode "Use count value as reference", the following applies: New comparison value 1 does not meet the following conditions: • Low counting limit <= comparison value 1 <= high counting limit • Comparison value 0 < comparison value 1 For operating mode "Use measured value as reference", the following applies: New comparison value 1 does not meet the following conditions: • Comparison value 0 < comparison value 1
80C0	Instruction High_Speed_Counter was called multiple times with the same instance (DB)
80C1	Communication with technology module failed (read data records): Error information of internal instruction RDREC saved in static tag AdditionalErrorID
80C2	Communication with technology module failed (write data records): Error information of internal instruction WRREC saved in static tag AdditionalErrorID
80C3	Access to input data (feedback interface) failed: Error information of internal instruction GETIO_PART saved in static tag AdditionalErrorID
80C4	Access to output data (control interface) failed: Error information of internal instruction SETIO_PART saved in static tag AdditionalErrorID
80C5	Reading of the current start information of the OB failed: Error information of internal instruction RD_SINFO saved in static tag AdditionalErrorID
80C6	Failed to get I/O addresses of the technology module: Error information of internal instruction RD_ADDR saved in static tag AdditionalErrorID

3.6.7 High_Speed_Counter static variables

Tag	Data type	Default	Access	Description
NewCountValue	DINT	L#0	Write	New counter value
NewReferenceValue0	DINT	L#0	Write	New comparison value 0
NewReferenceValue1	DINT	L#10	Write	New comparison value 1
NewReferenceValue0_M[1]	REAL	L#0.0	Write	New comparison value 0 in measuring mode
NewReferenceValue1_M[1]	REAL	L#10.0	Write	New comparison value 1 in measuring mode
NewUpperLimit	DINT	L#2147483647	Write	New high counting limit
NewLowerLimit	DINT	L#-2147483648	Write	New low counting limit
NewStartValue	DINT	L#0	Write	New start value
CurReferenceValue0	DINT	L#0	Read	Current comparison value 0
CurReferenceValue1	DINT	L#10	Read	Current comparison value 1
CurReferenceValue0_M[1]	REAL	L#0.0	Read	Current comparison value 0 in measuring mode
CurReferenceValue1_M[1]	REAL	L#10.0	Read	Current comparison value 1 in measuring mode
CurUpperLimit	DINT	L#2147483647	Read	Current high counting limit
CurLowerLimit	DINT	L#-2147483648	Read	Current low counting limit
CurStartValue	DINT	L#0	Read	Current start value
NewDirection	INT	0	Write	New count direction: +1: Upward count direction -1: Downward count direction
AdditionalErrorID	DWORD	W#16#0000	Read	Error information of an internal instruction, e.g.,RDREC

Tag		Data type	Default	Access	Description
UserCmdFlags		STRUCT	-		
	SetNewDirection	BOOL	FALSE	Write	Set new count direction
	SetUpperLimit	BOOL	FALSE	Write	Set high counting limit
	SetLowerLimit	BOOL	FALSE	Write	Set low counting limit
	SetReferenceValue0	BOOL	FALSE	Write	Set comparison value 0
	SetReferenceValue1	BOOL	FALSE	Write	Set comparison value 1
	SetCountValue	BOOL	FALSE	Write	Set new counter value
	SetStartValue	BOOL	FALSE	Write	Set start value
	SyncDownDirection	BOOL	TRUE	Write	Enable synchronization in downward count direction
	SyncUpDirection	BOOL	TRUE	Write	Enable synchronization in upward count direction
	SetDQ0	BOOL	FALSE	Write	Set digital output DQ0
	SetDQ1	BOOL	FALSE	Write	Set digital output DQ1
	ManualCtrlDQ0	BOOL	FALSE	Write	Enable setting of digital output DQ0: TRUE: • SetDQ0 sets DQ0 • Control bit TM_CTRL_DQ0 = FALSE FALSE: • Setting not enabled • Control bit TM_CTRL_DQ0 = TRUE
	ManualCtrlDQ1	BOOL	FALSE	Write	Enable setting of digital output DQ1: TRUE: • SetDQ1 sets DQ1 • Control bit TM_CTRL_DQ1 = FALSE FALSE: • Setting not enabled • Control bit TM_CTRL_DQ1 = TRUE
UserStatusFlags		STRUCT	-		
	StatusDI0	BOOL	FALSE	Read	Current status of digital input DI0
	StatusDI1	BOOL	FALSE	Read	Current status of digital input DI1
	StatusDI2	BOOL	FALSE	Read	Current status of digital input DI2
	StatusDQ0	BOOL	FALSE	Read	Current status of digital output DQ0
	StatusDQ1	BOOL	FALSE	Read	Current status of digital output DQ1

[1] Available for High_Speed_Counter version V3.0 or higher

3.7 Commissioning the High_Speed_Counter

3.7.1 Commissioning the technology object

A graphic display of the block in the commissioning editor helps you with commissioning and the function test for the technology object. You can change specific parameters of the High_Speed_Counter instruction in CPU/IM online mode and monitor their effects.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The corresponding High_Speed_Counter instruction is called cyclically from the user program.
- The parameters of the technology object are not overwritten by the user program.

Procedure

To open the commissioning editor of a technology object and to simulate a parameter value change, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the High_Speed_Counter technology object in the project tree.
3. Double-click on the "Commissioning" object.
   The functions for commissioning the High_Speed_Counter technology object are displayed.
4. In the commissioning dialog, click on the "Monitor all" button.
   The parameters (online values) of the High_Speed_Counter technology object are loaded and displayed.
5. If the parameter you want to change has a text box, enter the new value there.
6. Select the check box of the parameter.
   The new parameter value becomes effective and the effects of the change are simulated.

Online mode

In online mode, you can modify the following parameters to test the technology object function:

- New counter value (NewCountValue)
- New high counting limit (NewUpperLimit)
- New low counting limit (NewLowerLimit)
- New comparison value 0 (NewReferenceValue0 or NewReferenceValue0_M)
- New comparison value 1 (NewReferenceValue1 or NewReferenceValue1_M)
- New start value (NewStartValue)
- Start and stop counter (SwGate)
- Enable Capture (CaptureEnable)
- Enable synchronization (SyncEnable)
- Acknowledgment of signaled error states (ErrorAck)
- Resetting the status flag (EventAck)

3.8 High_Speed_Counter diagnostics

3.8.1 Monitoring counter values, measured values, DIs and DQs

You use the diagnostic functions to monitor the counting and measuring functions.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.

Procedure

To open the display editor for the diagnostic functions, follow these steps:

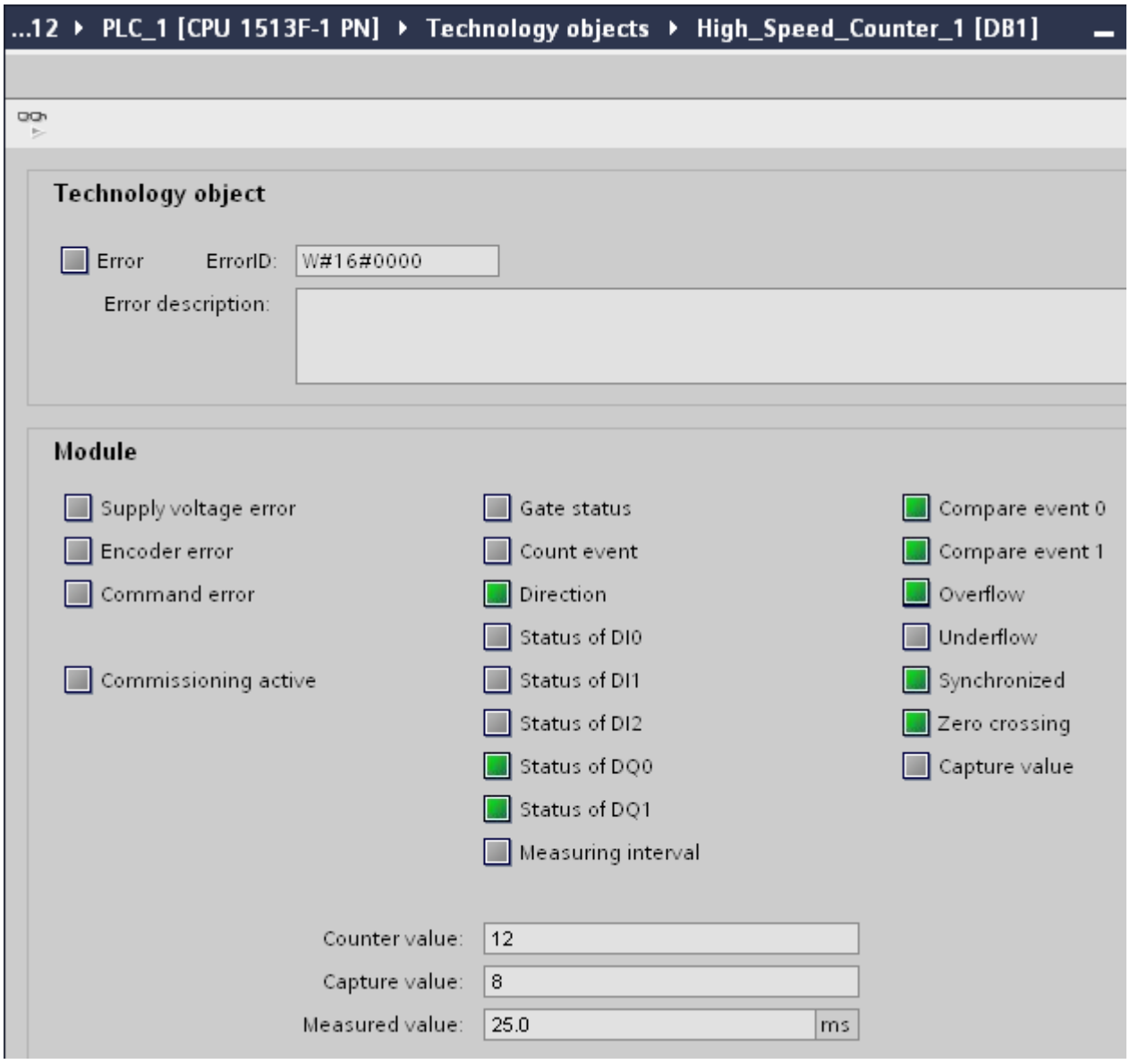
1. Open the "Technology objects" folder in the project tree.
2. Open the High_Speed_Counter technology object in the project tree.
3. Double-click on the "Diagnostics" object.

Display

The following values are read by the technology object from the feedback interface and displayed:

- Event display/diagnostics information
- Signal states of the digital inputs and digital outputs
- Counter value
- Capture value
- Measured value

Additional information on status displays is available in the context-sensitive help for each event in STEP 7 (TIA Portal). When the CPU is in STOP, the status display is not updated.



Using the SSI_Absolute_Encoder technology object 4

4.1 Technology object SSI_Absolute_Encoder

STEP 7 (TIA Portal) supports you in the configuration, commissioning and diagnostics of counting and measuring functions for the technology module TM PosInput: with the "Technology objects" function

- In STEP 7 (TIA Portal), you configure the SSI_Absolute_Encoder technology object with the settings for the position input with an SSI absolute encoder.
- The corresponding SSI_Absolute_Encoder instruction is programmed in the user program. This instruction supplies the control and feedback interface of the technology module.

The SSI_Absolute_Encoder technology object corresponds to the instance DB of the SSI_Absolute_Encoder instruction. The configuration of the position input and measuring functions is saved in the technology object. The technology object is located in the folder "PLC > Technology objects".

The SSI_Absolute_Encoder technology object can be used for the TM PosInput of both the S7-1500 and ET 200SP systems alike.

Operating mode

In order to configure a TM PosInput using the technology object, you specify the operating mode (Page 172) "Operating with technology object" in the hardware configuration of the TM PosInput. This selection is already preset.

4.2 Overview of the configuration steps

Introduction

The overview below shows the basic procedure for configuring the position input and measuring functions of the technology module with the SSI_Absolute_Encoder technology object.

Requirement

Before you can use the technology object, a project with an S7-1500 CPU or an ET 200SP CPU must be created in STEP 7 (TIA Portal).

Procedure

Proceed in the recommended sequence outlined below:

Step	Description
1	Configure a technology module (Page 166)
2	Add technology object (Page 135)
3	Configure a technology object according to your application (Page 137)
4	Call instruction in the user program (Page 154)
5	Load to CPU
6	Commissioning the technology object (Page 163)
7	Diagnostics of the technology object (Page 164)

4.3 Add technology object

Add technology object in the project navigator

When a technology object is added, an instance DB is created for the instruction of this technology object. The configuration of the technology object is stored in this instance DB.

Requirement

A project with a CPU S7-1500 has been created.

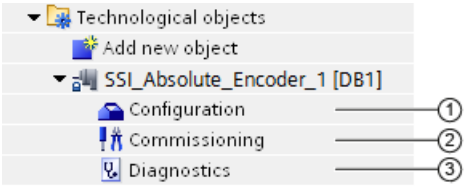
Procedure

To add a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Double-click on "Add new object".
   The "Add new object" dialog opens.
4. Select the "Counting and measurement" technology.
5. Select the "SSI_Absolute_Encoder" object.
6. Enter an individual name for the technology object in the "Name" text box.
7. Click "Additional information" if you want to add your own information to the technology object.
8. Confirm with "OK".

Result

The new technology object has now been created and stored in the project tree in the "Technology objects" folder.



	Object	Description
①	Configuration (Page 137)	In the configuration dialog: • Assignment of technology module and channel • Technology object parameter settings for position input and measurement functions When you change the configuration of the technology object, you must download the technology object **and** the hardware configuration to the CPU.
②	Commissioning (Page 163)	Commissioning and function test of the technology object: Simulating parameters of the SSI_Absolute_Encoder instruction and monitoring the effects
③	Diagnostics (Page 164)	Monitoring of the position input and measurement functions

4.4 Configuring SSI_Absolute_Encoder

4.4.1 Working with the configuration dialog

You configure the properties of the technology object in the configuration window. Proceed as follows to open the configuration window of the technology object:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click on the "Configuration" object.

The configuration is divided into the following categories:

- **Basic parameters**

  The basic parameters include the selection of the technology module and the number of the channel for which the technology object is configured.

- **Extended parameters**

  The extended parameters include the parameters for adapting the position input and measuring functions and for setting the characteristics of the digital inputs and digital outputs.

Configuration window icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values, you can use the technology object without additional changes.
	The configuration contains values set by the user or automatically adapted values and is complete All text boxes of the configuration contain valid values and at least one default value was changed.
	The configuration is incomplete or incorrect At least one text box or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the roll-out error message to indicate the cause of error.

4.4.2 Basic parameters

Under "Basic parameters", you can establish the connection between the technology object and the TM PosInput technology module.

Module

You select the technology module in a subsequent dialog box. You can choose any of the TM PosInput technology modules (central or distributed) under the CPU S7-1500 that are configured for use with a technology object from "Counting and measurement" in operating mode "Operating with technology object"

After selecting the technology module, you can open the device configuration associated with the technology module by clicking the"Device configuration" button.

The technology module parameter settings required for the use of the technology object are made in the "Extended parameters" of the technology object.

Channel

For a technology module with several channels, you select the number of the channel for which the technology object is valid.

Note

A channel can be assigned to only *one* technology object. A channel that is already assigned to a technology object can no longer be selected.

Synchronization of the parameter values

If, after assignment of the channel to the technology object, there is an inconsistency between the parameter values under "Parameters" and in the technology object, a button with a corresponding inquiry appears. When you click the button, the parameter values under "Parameters" are overwritten by the parameter values of the technology object within STEP 7 (TIA Portal). The current parameter values of the technology object are displayed under "Parameters".

4.4.3 SSI absolute encoder

Frame length

With the parameter assignment of the frame length, you specify the number of bits of an SSI frame of the SSI absolute encoder (Page 23) used. You can find the frame length of your SSI absolute encoder in the data sheet of the encoder. Special bits are also included in the frame length. A parity bit does not count in the frame length.

A frame length of between 10 bits and 40 bits is permitted. The default setting is "13 Bit".

You can find two examples of the SSI frame format at Examples of the frame format (Page 150).

Code type

You use the parameter assignment of the code type to specify whether the encoder supplies Dual code or Gray code.

You can select from the following options:

Code type	Meaning
Gray (default)	The gray-coded position value returned by the SSI absolute encoder is converted to dual code.
Dual	The value returned by the SSI absolute encoder is not converted.

Transmission rate

With the parameter assignment of the transmission rate, you specify the data transmission rate between the technology module and the SSI absolute encoder. You can select from several options between 125 kHz and 2 MHz. The default setting is "125 kHz".

The maximum transmission rate depends on the cable length and the technical specifications of the SSI absolute encoder. For additional information, refer to the product manual of the TM PosInput and the encoder description.

Monoflop time

With the parameter assignment of the monoflop time, you specify the idle time between two SSI frames.

The configured monoflop time must be at least equal to the monoflop time of the SSI absolute encoder used. You can find this value in the technical specifications of the SSI absolute encoder.

You can select from the following options:

- Automatically (default)
- 16 µs
- 32 µs
- 48 µs
- 64 µs

Note

If you select the "Automatic" option, the monoflop time automatically adapts to the encoder used.

In isochronous mode, the "Automatic" option corresponds to a monoflop time of 64 µs. If the monoflop time of the employed SSI absolute value encoder is less than 64 µs, you can select the value of the encoder to achieve faster isochronous times.

Parity

With the parameter assignment of the parity, you specify whether the SSI absolute encoder transfers a parity bit.

If, for example, a 25-bit encoder with parity is assigned, the technology module reads 26 bits. The bit following the LSB (least significant bit) in the SSI frame is evaluated as a parity bit. A parity error is reported in the feedback interface (Page 185) by means of the ENC_ERROR bit.

Bit number LSB of the position value

This parameter is used to specify the bit number of the LSB (least significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the bit number of the MSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 31.

The default setting is "0".

Note

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Bit number MSB of the position value

This parameter is used to specify the bit number of the MSB (most significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the frame length and higher than the bit number of the LSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 31.

The default setting is "12".

Note

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Invert direction

You can use this parameter to invert the values supplied by the SSIabsolute encoder. This allows you to adapt the detected direction of the encoder to the motor's direction of rotation.

Note

This parameter acts only on the range from the LSB to the MSB of the position value in the frame.

SSI frame

You can also set the following parameters in the graphic with drag-and-drop:

- Frame length
- Bit number LSB of the position value
- Bit number MSB of the position value

Complete SSI frame

If the "Complete SSI frame" measured variable is selected, the module returns the least significant 32 bits of the unprocessed current SSI frame. The graphic shows the corresponding meaning of a supplied bit. The following abbreviations are used:

V	Value: Position value as gray or dual code
S	Special: Special bit
P	Parity: Parity bit When you have configured a parity bit, the module returns the least significant 31 bits of the SSI frame *and* the parity bit.

4.4.4 Behavior of a DI (SSI_Absolute_Encoder)

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Capture (Page 32)	The configured edge at the respective digital input saves the current position value as a Capture value. The technology object displays the Capture value at the output parameter CapturedValue. The function can only be used for one of the two digital inputs.	• Input delay • Edge selection
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective static variable of the technology object: • UserStatusFlags.StatusDI0 • UserStatusFlags.StatusDI1	• Input delay

Note

You can choose the "Capture" function only in operating mode "Use position value (SSI absolute value) as reference".

Input delay

By configuring the input delay, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured input delay are suppressed.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

Note

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Note

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1".

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered for the "Capture" function.

You can select from the following options:

- At rising edge (default)
- At falling edge
- At rising and falling edge

4.4.5 Behavior of a DQ (SSI_Absolute_Encoder)

Operating mode

With the operating mode, you specify the reference value with which the comparison functions work.

Operating mode	Meaning
Use position value (SSI absolute value) as reference (default)	The comparison functions and hardware interrupts for compare events work with the position value.
Use measured value as reference	The comparison functions and hardware interrupts for compare events work with the measured value.

Note

You configure the operating mode under "Behavior of DQ0" for both digital outputs together. The operating mode is also displayed under "Behavior of DQ1".

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options depending on the operating mode:

Function of a digital output (Page 47) in operating mode "Use position value (SSI absolute value) as reference"	Meaning	Additional option-specific parameters
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= position value <= maximum position value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: 0 <= position value <= comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= position value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
At comparison value for a pulse duration	The respective digital output is active once for the assigned time and direction of the position value change when the position value is equal to the comparison value or has fallen below or exceeded it.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)

Function of a digital output (Page 47) in operating mode "Use position value (SSI absolute value) as reference"	Meaning	Additional option-specific parameters
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active for the assigned direction of the position value change until the position value is equal to the comparison value or has fallen below or exceeded it.	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 42).	—

Note

You can only select the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Function of a digital output (Page 51) in operating mode "Use measured value as reference"	Meaning	Additional option-specific parameters
Measured value >= comparison value (default)	The respective digital output is active if the measured value is greater than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Measured value <= comparison value	The respective digital output is active if the measured value is less than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= measured value <= comparison value 1	• Comparison value 0 • Comparison value 1
Not between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 1 <= measured value <= comparison value 0	• Comparison value 0 • Comparison value 1
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 42).	—

Note

You can select the "Between comparison value 0 and 1" and "Not between comparison value 0 and 1" functions only for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Comparison value 0

Operating mode "Use position value (SSI absolute value) as reference"

With the parameter assignment of the comparison value (Page 47), you specify the position value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a positive integer (DINT) that is less than comparison value 1. The default setting is "0".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 51), you specify the measured value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a floating point number (REAL) that is less than comparison value 1. The minimum value is -7.922816×10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 1

Operating mode "Use position value (SSI absolute value) as reference"

With the parameter assignment of the comparison value (Page 47), you specify the position value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than comparison value 0 and less than or equal to the high counting limit (maximum position value) The default setting is "10".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 51), you specify the measured value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter a floating point number (REAL) that is greater than comparison value 0. The maximum value is 7.922816×10^{28}. The default setting is "10.0". The unit of the comparison value depends on the measured variable.

Count direction

You use this parameter to specify the direction of position value change for which the selected function is valid.

You can select from the following options:

Direction of position value change	Meaning
In both directions (default)	The comparison and switching of the respective digital output is carried out regardless of whether the position value increases of decreases.
Up	The comparison and switching of the respective digital output only takes place when the position value increases.
Down	The comparison and switching of the respective digital output only takes place when the position value decreases.

The parameter can be configured for the following functions:

- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

A value from 0.1 to 6553.5 ms is permissible.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 63), you can define a range around the comparison values. Within the hysteresis range, the digital outputs cannot switch again until the position value has left this range once.

If you enter "0", the hysteresis is turned off. You can enter a value between 0and 255. The default setting is "0".

Note

You configure the hysteresis under "Behavior of DQ0" for both digital outputs together. The hysteresis is also displayed under "Behavior of DQ1".

Note

The hysteresis is only available in operating mode "Use position value (SSI absolute value) as reference".

4.4.6 Specify measured value (SSI_Absolute_Encoder)

Measured variable

With this parameter you specify whether the technology module is to provide a certain measured variable (Page 59) or the complete SSI frame.

You can select from the following options:

Option	Meaning	Additional option-specific parameters
Frequency (default)	The measured variable shows the number of increments per second, where each increment corresponds to one position value change. The value is a floating point number (REAL). The unit is Hz. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time
Period	The measured variable is the average period between two increments of the position value. The value is an integer (DINT). The unit is s. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time
Velocity	The measured variable is a velocity. Examples of a velocity measurement can be found in the explanation of the "Increments per unit" parameter. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time • Time base for velocity measurement • Increments per unit
Complete SSI frame	Instead of a measured variable, the first 32 bits of the SSI frame are returned (bit 0 to bit 31). In so doing, special bits that do not belong to the position information are also supplied. A configured inversion of the direction is ignored. The technology object displays the value at the output parameter CompleteSSIFrame. You can find examples under Examples of the frame format (Page 150). This option is only available in operating mode "Use position value (SSI absolute value) as reference".	—

Update time

By configuring the update time (Page 58) in milliseconds, you can specify the time interval between two measured value updates. Unsteady measured variables can be smoothed through longer update times

If you enter "0", the measured value is updated once per module-internal cycle. Up to three decimal places can be entered. A value from 0.0 to 25000.0 is permissible. The default setting is "10.0".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s/1 min

The default setting is "60 s/1 min".

Increments per unit

With this parameter you define the number of increments per relevant unit that the SSI absolute encoder supplies for the velocity measurement.

You can enter a value between 1 and 65535.

Example 1:

Your absolute encoder operates with a resolution of 12 bits per revolution and performs 4096 increments per revolution. The velocity should be measured in revolutions per minute.

In this case, you need to assign the following parameters:

- Increments per unit: 4096
- Time base for velocity measurement: 60 s/1 min

Example 2:

You encoder delivers 10000 increments for travel over one meter. The velocity is to be measured in meters per second.

In this case, you need to assign the following parameters:

- Increments per unit: 10000
- Time base for velocity measurement: 1 s

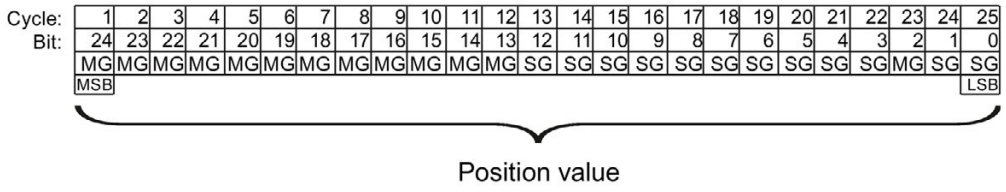
4.4.7 Examples of the frame format

Example 1

In this example the SSI absolute encoder has the following specification:

- The encoder has a resolution of 13 bits per revolution and a value range of 12 bits of revolutions. The SSI frame has a length of 25 bits.
- The MSB of the position value is bit 24.
- The LSB of the position value is bit 0.
- The position value is Gray coded.
- A parity bit is not available.

The frame has the following format:



MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Complete SSI frame

If you configure "Complete SSI frame", the technology module returns the unprocessed SSI frame in the return interface right-justified:

Cycle:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG

MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Position value feedback value

The position value supplied in Gray code is converted into binary code by the technology module and returned right-justified in the feedback interface:

Cycle:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD

MD Multiturn bit as binary code

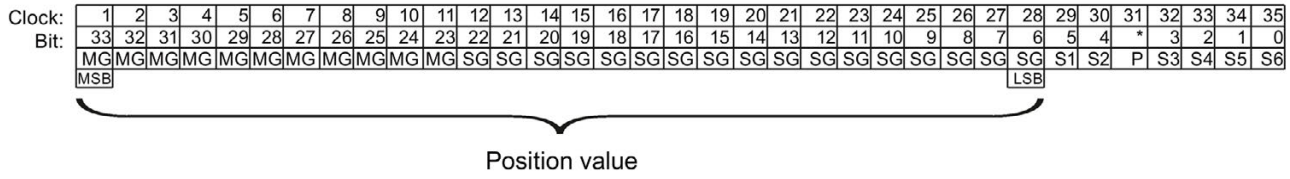
SD Singleturn bit as binary code

Example 2

In this example the SSI absolute encoder has the following specification:

- The encoder has a resolution of 17 bits per revolution and a value range of 11 bits of revolutions. The SSI frame has a length of34 bits.
- The MSB of the position value is bit 33.
- The LSB of the position value is bit 6.
- The position value is Gray coded.
- The SSI frame has six special bits.
- A parity bit is available. A parity bit does not count in the frame length.

The frame has the following format:



MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Sn Special bit n

P Parity bit

Complete SSI frame

If you configure "Complete SSI frame", the technology module returns the least significant 32 bits of the SSI frame as an unprocessed bit string. The technology module returns the bit following the LSB as parity bit. In this example, the technology module therefore returns only the least significant 31 bits of the SSI frame. With the complete SSI frame, you can evaluate the additional special bits in your application.

The returned bit string is structured as follows:

MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Sn Special bit n

P Parity bit

Position value

The position value supplied in Gray code is converted into binary code by the technology module and returned right-justified in the feedback interface: The special bits are ignored in this case. The parity bit is evaluated but is not returned with the position value:

Cycle:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD

MD Multiturn bit as binary code

SD Singleturn bit as binary code

4.5 Programming the SSI_Absolute_Encoder

4.5.1 Instruction SSI_Absolute_Encoder

SSI_Absolute_Encoder

The SSI_Absolute_Encoder instruction is part of the SSI_Absolute_Encoder technology object. It supplies the control and feedback interface of the TM PosInput technology module.

The SSI_Absolute_Encoder instruction thereby forms the software interface between the user program and the technology module. It must be called cyclically from the user program in order to synchronize the input and output data.

The SSI_Absolute_Encoder instruction can be used for the TM PosInput of both the S7-1500 and ET 200SP systems alike. The TM PosInput modules can be used centrally and decentrally. The instruction applies in each case to the channel of the technology module that was assigned to the associated technology object.

Additional information

DescriptionSSI_Absolute_Encoder (Page 155)

Input parameter SSI_Absolute_Encoder (Page 158)

Output parameter SSI_Absolute_Encoder (Page 159)

Error codes of parameter ErrorID (Page 161)

Static tags SSI_Absolute_Encoder (Page 162)

4.5.2 Call instruction in the user program

The SSI_Absolute_Encoder instruction can be called once per channel, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Procedure

Proceed as follows to call the instruction in the user program:

1. Open the CPU folder in the project tree.
2. Open the "Program blocks" folder.
3. Double-click the OB for cyclic program execution.
   The block is opened in the work area.
4. In the "Instructions" window, open the "Technology" group and the "Counting and measurement" folder.
   The instructions are located in the folder.
5. Select an instruction and drag it to your OB.
   The "Call options" dialog opens.
6. Select a technology object from the "Name" list or enter the name for a new technology object.
7. Confirm with "OK".

Result

If the technology object does not exist yet, it is added. The instruction is added in the OB. The technology object is assigned to this call of the instruction.

Note

If you click one of the buttons "Configuration", "Commissioning" or "Diagnostics" in the user interface of the instruction, the respective editor opens.

4.5.3 DescriptionSSI_Absolute_Encoder

Description

The SSI_Absolute_Encoder instruction is used to control the position input and measuring functions of the technology module TM PosInput via the user program.

Call

The instruction must be called once per channel, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Operating principle

Position value: The position value is available at the output parameter PositionValue. The position value is updated every time the instruction is called.

Measured value: The technology module updates the measured value asynchronously to the instruction call based on the configured update time. The measured value last determined by the technology module is updated at the output parameter MeasuredValue each time the instruction is called.

Measured value and position value are available in parallel as output parameters.

Instead of a measured value, the complete SSI frame can be returned at the output parameter CompleteSSIFrame. Either MeasuredValue or CompleteSSIFrame is valid, depending on the parameter assignment.

Capture: The output parameter CaptureStatus = TRUE indicates a valid Capture value at the output parameter CapturedValue.

- A Capture value is captured under the following conditions:
  - A digital input has the parameter assignment "Capture"
  - CaptureEnable = TRUE
  - Edge at digital input with the Capture function
- The output parameter CaptureStatus is reset by a negative edge at the input parameter CaptureEnable.

Parameter changes via the user program

Proceed as follows to modify parameters using the user program:

1. Check the relevant Set tag to establish whether the technology object is ready for the parameter change (Set tag = FALSE) or whether a change job is still running (Set tag = TRUE).
   The following Set tags in UserCmdFlags are available for this in the static tags of the technology object instance DB:
   - SetReferenceValue0
   - SetReferenceValue1
2. If the technology object is ready for the parameter change, modify the relevant static tag.
   The following static tags of the technology object instance DB are available for this:
   - NewReferenceValue0 / NewReferenceValue0_M (for SetReferenceValue0)
   - NewReferenceValue1 / NewReferenceValue1_M (for SetReferenceValue1)
3. Set the relevant Set tag for execution of the change job.
4. Use the output parameter Error to check whether an error has occurred.
   If no errors have occurred and the Set tag has been automatically reset by the technology object, the parameter change was successful.

Operating mode

Configure the operating mode in the technology object under "Behavior of DQ0".

The operating mode is indicated by the output parameters CompareMeasuredValue:

State	Description
FALSE	Operating mode "Use position value (SSI absolute value) as reference": The comparison functions work with the position value. The following static variables are specifically used in this operating mode: • NewReferenceValue0 • NewReferenceValue1 • CurReferenceValue0 • CurReferenceValue1 The four specific static variables of operating mode "Use measured value as reference" are ignored.
TRUE	Operating mode "Use measured value as reference": The comparison functions work with the measured value. The following static variables are specifically used in this operating mode: • NewReferenceValue0_M • NewReferenceValue1_M • CurReferenceValue0_M • CurReferenceValue1_M The four specific static tags of operating mode "Use position value (SSI absolute value) as reference" are ignored.

Acknowledgment of events

You acknowledge signaled events using the positive edge of the input parameter EventAck . EventAck must stay set until the technology object has reset the status bits of the following events of the count channel:

- CompResult0
- CompResult1
- ZeroStatus
- PosOverflow
- NegOverflow

Status of the digital inputs

You obtain the status of the digital inputs via the static tags StatusDI0 and StatusDI1.

Using digital outputs with user program

In the following cases you can set the digital outputs via the instruction:

Case	Description
The setting "Use by user program" is configured for "Set output".	The respective digital output DQM follows the value of SetDQm.
The setting "After set command from CPU until comp. value" is configured for "Set output".	The respective digital output DQm is set with a negative edge of SetDQm. DQm is reset when the position value corresponds to the comparison value or at a negative edge of SetDQm.
Set the respective static variable ManualCtrlDQm (temporary overwrite).	The respective digital output DQM follows the value of SetDQm.

Reaction to error

If an error has occurred during the call of the instruction or in the technology module, the output parameter Error is set. More detailed error information can be read at the output parameter ErrorID (Page 161).

Eliminate the cause of the error and acknowledge the error message by setting the input parameter ErrorAck. When no more errors are pending, the technology object resets the output parameter Error . No new error is signaled until you acknowledge the previous error.

4.5.4 Input parameter SSI_Absolute_Encoder

Parameter	Declaration	Data type	Default	Description
CaptureEnable	INPUT	BOOL	FALSE	Enable Capture function After the enable, a Capture event occurs at the next configured edge at the relevant digital input. A negative edge at CaptureEnable resets the output parameter CaptureStatus. A negative edge at CaptureEnable resets the enable even if no Capture event has occurred. Irrespective of CaptureEnable the last value is retained at the output parameter CapturedValue until the next Capture event.
ErrorAck	INPUT	BOOL	FALSE	A positive edge acknowledges the error status reported.
EventAck	INPUT	BOOL	FALSE	A positive edge resets the following output parameters: • CompResult0 • CompResult1 • ZeroStatus • PosOverflow • NegOverflow

4.5.5 Output parameter SSI_Absolute_Encoder

Parameter	Declaration	Data type	Default	Description
StatusHW	OUTPUT	BOOL	FALSE	Status bit technology module: The module is configured and ready for operation. The module data is valid.
StatusUp	OUTPUT	BOOL	FALSE	Status bit: Last position value has changed in the positive direction and took place no more than 0.5 s ago.
StatusDown	OUTPUT	BOOL	FALSE	Status bit: Last position value has changed in the negative direction and took place no more than 0.5 s ago.
CompResult0	OUTPUT	BOOL	FALSE	Status bit: Comparison event for DQ0 (change of state) occurs as a result of the selected comparison condition. The positive edge of the input parameter EventAck is used to reset CompResult0 .
CompResult1	OUTPUT	BOOL	FALSE	Status bit: Comparison event for DQ1 (change of state) occurs as a result of the selected comparison condition. The positive edge of the input parameter EventAck is used to reset CompResult1 .
CaptureStatus	OUTPUT	BOOL	FALSE	Status bit: Capture event occurred, the output parameter CapturedValue has a valid Capture value If the input parameter CaptureEnable is set, the configured edge sets the status bit CaptureStatus. at the respective digital input. You reset CaptureStatus using the negative edge of the input parameter CaptureEnable .
ZeroStatus	OUTPUT	BOOL	FALSE	Status bit: PositionValue has reached or exceeded the value "0" irrespective of the count direction. You reset ZeroStatus using the positive edge of the input parameter EventAck.
PosOverflow	OUTPUT	BOOL	FALSE	Status bit: PositionValue has exceeded the high limit of the position value range of the encoder in the positive direction. You reset PosOverflow using the positive edge of the input parameter EventAck.
NegOverflow	OUTPUT	BOOL	FALSE	Status bit: PositionValue has exceeded the low limit of the position value range of the encoder in the negative direction. You reset NegOverflow using the positive edge of the input parameter EventAck.
Error	OUTPUT	BOOL	FALSE	An error has occurred. Refer to the output parameter ErrorID for the cause of the error.
ErrorID	OUTPUT	WORD	0	The ErrorID (Page 161) parameter displays the number of the error message. ErrorID = 0000_H: There is no error.
PositionValue	OUTPUT	DINT	0	Current position value
CapturedValue	OUTPUT	DINT	0	The last acquired Capture value The value is retained until the next Capture event, irrespective of the input parameter CaptureEnable. If a new Capture event has occurred, CaptureStatus is set and is reset by you using the negative edge of the input parameter CaptureEnable .

Parameter	Declaration	Data type	Default	Description
MeasuredValue	OUTPUT	REAL	0.0	Current measured value for frequency, period duration or velocity (depending on configuration) Either MeasuredValue or CompleteSSIFrame is valid, depending on the parameter assignment in the technology object under "Measured value".
CompleteSSIFrame	OUTPUT	DWORD	0	Last received complete SSI frame (least significant 32 bits) Either MeasuredValue or CompleteSSIFrame is valid, depending on the parameter assignment in the technology object under "Measured value".
CompareMeasuredValue	OUTPUT	BOOL	FALSE	Status bit: FALSE: Operating mode "Use position value (SSI absolute value) as reference"; position value is used as reference TRUE: Operating mode "Use measured value as reference"; measured value is used as reference

4.5.6 Error codes of parameter ErrorID

Error code (W#16#...)	**Description**
0000	No error
Error messages from technology module	
80A1	POWER_ERROR from feedback interface: Incorrect supply voltage L+
80A2	ENC_ERROR from feedback interface: Incorrect encoder signal
80A3	LD_ERROR from feedback interface: Error when loading via control interface
Error messages of the instruction SSI_Absolute_Encoder	
80B8	New comparison value 0 does not meet the following conditions: • Low counting limit <= comparison value 0 <= high counting limit • Comparison value 0 < comparison value 1
80B9	New comparison value 1 does not meet the following conditions: • Low counting limit <= comparison value 1 <= high counting limit • Comparison value 0 < comparison value 1
80C0	Instruction was called multiple times with the same instance (DB)
80C1	Communication with technology module failed (read data records): Error information of internal instruction RDREC saved in static tag AdditionalErrorID
80C2	Communication with technology module failed (write data records): Error information of internal instruction WRREC saved in static tag AdditionalErrorID
80C5	Reading of the current start information of the OB failed: Error information of internal instruction RD_SINFO saved in static tag AdditionalErrorID
80C6	Failed to get I/O addresses of the technology module: Error information of internal instruction RD_ADDR saved in static tag AdditionalErrorID

4.5.7 Static tags SSI_Absolute_Encoder

Tag		Data type	Default	Access	Description
NewReferenceValue0		DINT	L#0	Write	New comparison value 0 in position input mode
NewReferenceValue1		DINT	L#10	Write	New comparison value 1 in position input mode
NewReferenceValue0_M		REAL	L#0.0	Write	New comparison value 0 in measuring mode
NewReferenceValue1_M		REAL	L#10.0	Write	New comparison value 1 in measuring mode
CurReferenceValue0		DINT	L#0	Read	Current comparison value 0 in position input mode
CurReferenceValue1		DINT	L#10	Read	Current comparison value 1 in position input mode
CurReferenceValue0_M		REAL	L#0.0	Read	Current comparison value 0 in measuring mode
CurReferenceValue1_M		REAL	L#10.0	Read	Current comparison value 1 in measuring mode
AdditionalErrorID		DWORD	W#16#0000	Read	Error information of an internal instruction, e.g.,RDREC
UserCmdFlags		STRUCT	-		
	SetReferenceValue0	BOOL	FALSE	Write	Set comparison value 0
	SetReferenceValue1	BOOL	FALSE	Write	Set comparison value 1
	SetDQ0	BOOL	FALSE	Write	Set digital output DQ0
	SetDQ1	BOOL	FALSE	Write	Set digital output DQ1
	ManualCtrlDQ0	BOOL	FALSE	Write	Enable setting of digital output DQ0. TRUE: SetDQ0 sets DQ0[1] FALSE: Setting not enabled
	ManualCtrlDQ1	BOOL	FALSE	Write	Enable setting of digital output DQ1: TRUE: SetDQ1 sets DQ1[1] FALSE: Setting not enabled
UserStatusFlags		STRUCT	-		
	StatusDI0	BOOL	FALSE	Read	Current status of digital input DI0
	StatusDI1	BOOL	FALSE	Read	Current status of digital input DI1
	StatusDQ0	BOOL	FALSE	Read	Current status of digital output DQ0
	StatusDQ1	BOOL	FALSE	Read	Current status of digital output DQ1

[1] The instruction sets the TM_CTRL_DQm bit to FALSE. in the control interface of the module. The static tag SetDQm acts on the control bit SET_DQm.

4.6 Commissioning SSI_Absolute_Encoder

4.6.1 Commissioning the technology object

A graphic display of the block in the commissioning editor helps you with commissioning and the function test for the technology object. You can change specific parameters of the SSI_Absolute_Encoder instruction in CPU/IM online mode and monitor their effects.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The corresponding SSI_Absolute_Encoder instruction is called cyclically from the user program.
- The parameters of the technology object are not overwritten by the user program.

Procedure

To open the commissioning editor of a technology object and to simulate a parameter value change, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the SSI_Absolute_Encoder technology object in the project tree.
3. Double-click on the "Commissioning" object.
   The functions for commissioning the SSI_Absolute_Encoder technology object are displayed.
4. In the commissioning dialog, click on the "Monitor all" button.
   The parameters (online values) of the SSI_Absolute_Encoder technology object are loaded and displayed.
5. If the parameter you want to change has a text box, enter the new value there.
6. Select the check box of the parameter.
   The new parameter value becomes effective and the effects of the change are simulated.

Online mode

In online mode, you can modify the following parameters to test the technology object function:

- New comparison value 0 (NewReferenceValue0 or NewReferenceValue0_M)
- New comparison value 1 (NewReferenceValue1 or NewReferenceValue1_M)
- Enable Capture (CaptureEnable)
- Acknowledgment of signaled error states (ErrorAck)
- Resetting the status flag (EventAck)

4.7 SSI_Absolute_Encoder diagnostics

4.7.1 Monitoring counter values, measured values, DIs and DQs

The diagnostic functions are used to monitor the position input and measuring functions.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.

Procedure

To open the display editor for the diagnostic functions, follow these steps:

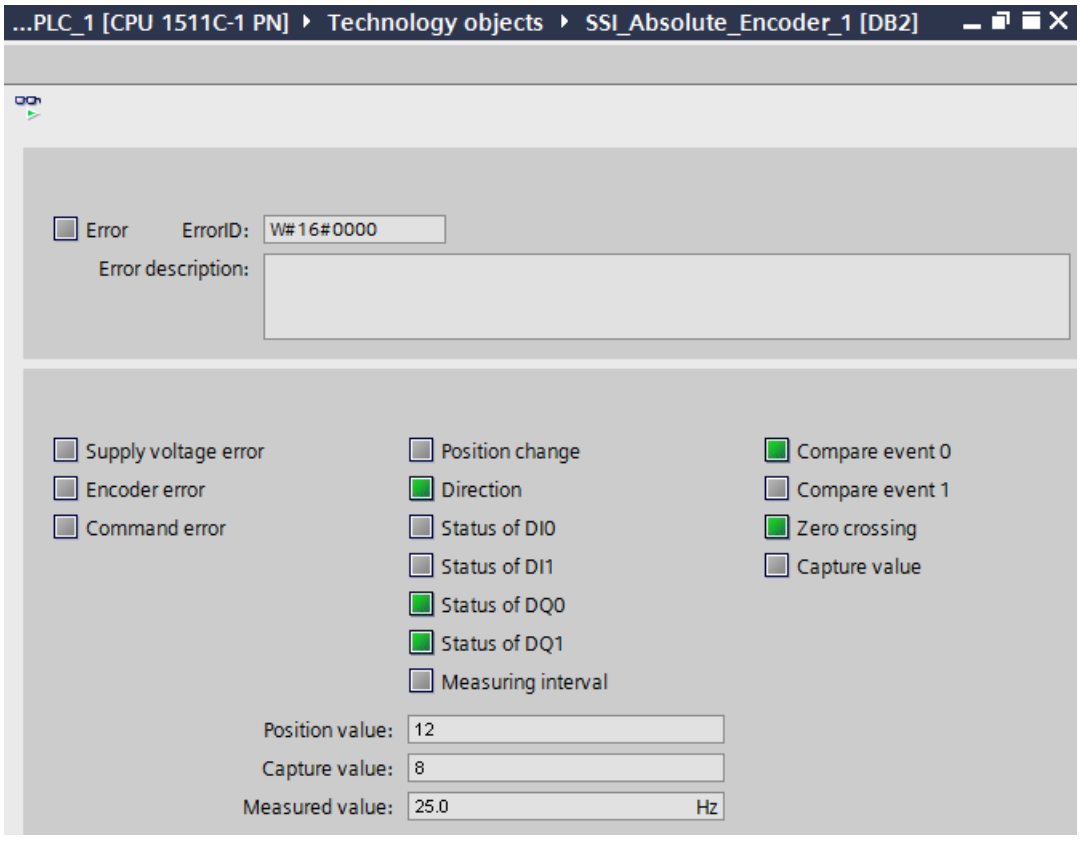
1. Open the "Technology objects" folder in the project tree.
2. Open the SSI_Absolute_Encoder technology object in the project tree.
3. Double-click on the "Diagnostics" object.

Display

The following values are read by the technology object from the feedback interface and displayed:

- Event display/diagnostics information
- Signal states of the digital inputs and digital outputs
- Position value
- Capture value
- Measured value

Additional information on status displays is available in the context-sensitive help for each event in STEP 7 (TIA Portal). When the CPU is in STOP, the status display is not updated.



Using the module

5

5.1 Using the technology module

5.1.1 Convention

Technology module: We use the term "technology module" in this documentation both for the technology modules TM Count and TM PosInput and the technology component of the compact CPUs.

5.1.2 Configuring a module

5.1.2.1 Adding a technology module for hardware configuration (TM Count and TM PosInput)

Requirement

A project with a CPU S7-1500 has been created.

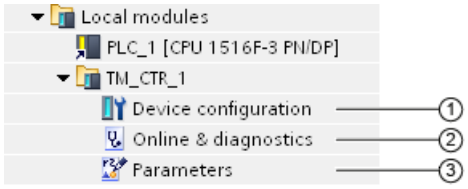
Procedure

To add a technology module to the hardware configuration, proceed as follows:

1. Open the device configuration of the CPU or IM.
2. Select a module rack.
3. Select the technology module from the module catalog:
   "Technology module > Counting or Position input > Technology module > Article number"
4. Drag the technology module to the required slot in the module rack.

Result

The new technology module is now displayed with the following objects under "Local modules" or "Distributed I/O" in the project tree. Double-click to open the required editor.



	Object	Description
①	Device configuration (Page 170)	In the Inspector window (per channel): • Setting the reaction to CPU STOP (Page 170) • Enable diagnostic interrupts (Page 171) • Setting the operating mode (Page 172) • Enable hardware interrupts (Page 175) • Setting the module addresses
②	Online & Diagnostics (Page 181)	• Hardware diagnostics • Obtain information on technology module • Run firmware update
③	Parameter (Page 180)	Display and, if applicable, parameter settings for the counting and measuring functions in the hardware configuration, if parameter assignment and control are not implemented using the technology object.

5.1.2.2 Adding a technology module to hardware configuration (Compact CPU)

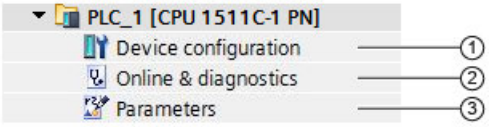
Procedure

To add a Compact CPU to the project tree, follow these steps:

1. Double-click "Add new device".
   The "Add new object" dialog opens.
2. Select Controller".
3. Select the Compact CPU:
   "SIMATIC S7-1500 > CPU > Compact CPU > Article number"
4. Confirm with "OK".

Result

The new Compact CPU is displayed with the following objects in the project tree. Double-click to open the required editor.



	Object	Description
①	Device configuration (Page 170)	In the Inspector window (per channel): • Activation of the counter (Page 178) • Assign signals to inputs and outputs (Page 179) • Setting the reaction to CPU STOP (Page 170) • Enable diagnostic interrupts (Page 172) • Setting the operating mode (Page 172) • Enable hardware interrupts (Page 175) • Setting the module addresses
②	Online & Diagnostics (Page 181)	• Hardware diagnostics • Obtain information about the Compact CPU • Run firmware update
③	Parameter (Page 180)	Display and, if applicable, parameter settings for the counting and measuring functions in the hardware configuration, if parameter assignment and control are not implemented using the technology object.

5.1.2.3 Parameter assignment options

Counting, measuring and position input with SSI absolute encoder

For the counting and measuring function and the position input with an SSI absolute encoder, you have two options for parameter assignment and control of the technology module:

- Configuration of a technology object and control using the related instruction:

  When using an incremental or pulse encoder, we recommend the simple configuration with graphic support using thee High_Speed_Counter technology object. A detailed description of this configuration can be found in section High_Speed_Counter technology object (Page 90) and below.

  When using an SSI absolute value encoder, we recommend the simple configuration with graphic support using the SSI_Absolute_Encoder technology object. A detailed description of this configuration can be found in section AUTOHOTSPOT and below.

  For configuration of a technology object, select the operating mode (Page 172) "Operating with technology object".

- Parameter setting via hardware configuration (Page 180) and control via the control and feedback interface of the technology module:

  Select the operating mode (Page 172) "Manual operation" for this.

  A description of the control and feedback interface for TM Count and TM PosInput is available in the following sections:

  Assignment of the control interface (Page 182)

  Assignment of the feedback interface (Page 185)

Position input for Motion Control

Alternatively, you have the option of using the technology module for position input for Motion Control.

Select the operating mode (Page 172) "Position input for Motion Control" and assign the parameters of the encoder using themodule parameters (Page 173) in the device configuration of the technology module. You perform the rest of the configuration of this application using an axis technology object of S7-1500 Motion Control .

Feedback from the technology module is returned by means of the feedback interface.

5.1.2.4 Basic parameters

Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module for each channel to CPU STOP in the basic parameters of the device configuration.

Table 5- 1 Reaction of the technology module to CPU STOP depending on parameter assignment (by channel)

Basic parameters	Reaction to CPU STOP
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the actual position is read. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the function "In case of comparison value for a pulse duration" is set at CPU stop, the digital output is reset after expiry of pulse duration. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

Substitute value for DQ0 (TM Count und TM PosInput)

This parameter lets you specify which value the technology module is to output to the digital output DQ0 in the event of a CPU STOP under "Output substitute value".

Note

In "Operation with technology object" mode you define this parameter using the technology object.

Substitute value for DQ0 (Compact CPU)

You can use this parameter to specify the value to be output for a STOP of the Compact CPU in the feedback interface for DQ0 in the context of the "Substitute value for DQ0" behavior.

Note

In "Operation with technology object" mode, you can define this parameter using the technology object.

Substitute value for DQ1

This parameter lets you specify which value the technology module is to output to the digital output DQ1 in the event of a CPU STOP under "Output substitute value".

Note

In "Operation with technology object" mode you define this parameter using the technology object.

Diagnostic interrupts (TM Count and TM PosInput)

The technology module can trigger additional diagnostic interrupts when you enable the diagnostic interrupts in the basic parameters. These diagnostic interrupts are processed in an interrupt OB.

Enable diagnostic interrupt on wire break

You use this parameter to specify whether a diagnostic interrupt is to be triggered in the event of wire breaks of the utilized signals for the following encoders:

- Push-pull 24 V encoder (Page 65)
- RS422 encoder (Page 67) (also monitored for short-circuits and offset voltages)
- SSI absolute encoder (Page 69) (also monitored for short-circuits and faulty voltages)

Note

If you use an encoder with a different sensor type or interface standard, wire break cannot be detected.

Enable additional diagnostic interrupts

You use this parameter to specify whether diagnostic interrupts are to be triggered for additional errors.

See the device manual for the technology module to find out which errors during operation can trigger a diagnostic interrupt.

Diagnostics interrupts (Compact CPU)

Enable diagnostic interrupts

A Compact CPU can trigger diagnostic interrupts for certain faults if you have enabled diagnostic interrupts. These diagnostic interrupts are processed in an interrupt OB.

You use this parameter to determine if the Compact CPU should trigger diagnostic interrupts when a given error occurs.

See the device manual for the Compact CPU to find out which errors can trigger a diagnostic interrupt during operation. The diagnostic interrupts are not enabled in the default setting.

Operating mode

Selection of the operating mode for the channel

This setting defines how the channel counting and measuring functions are to be configured and controlled.

Operating mode	Description
Operating with technology object	A technology object is used for the parameter assignment of the channel. The related instruction in the user program provides the access to the control and feedback interfaces of the technology module. You specify the assignment between the technology module/channel and technology object in the basic parameters of the technology object.
Position input for Motion Control	The technology module is used for position input for a higher-level Motion Control controller. This operating mode effects all channels of the technology module for TM Count and TM PosInput. Setting the operating mode only effects the given channel of the Compact CPU. Parameter assignment is implemented via the Device configuration of the technology module. Parameter assignment of the encoder signals is implemented by means of the Module parameters (Page 173).
Manual operation	The channel is configured using the parameter setting (hardware configuration) (Page 180) of the technology module. You have direct access to the control and feedback interface of the channel through the user program.
Fast Mode	The technology module is used for very fast detection of the count or position value. No control interface is available. The parameter setting (hardware configuration) of the module is used for the parameter assignment of the channel. This operating mode is not supported by every technology module.

Selection of the operating mode for the channel

You use this parameter in "Manual operation" to specify the main task for which the channel of the technology module is used. This defines the setting options under "Parameters" (hardware configuration).

Operating mode	Description
Counting (Page 21) / Position input (Page 23)	The main function of the channel is counting or position input. The comparison functions and hardware interrupts work with the counter value or position value. The measured values are available concurrently.
Measuring (Page 53)	The main function of the channel is counting. The comparison functions (Page 51) and hardware interrupts for compare events work with the measured value. The counter value is available concurrently.

Module parameters (position input for Motion Control)

In the operating mode "Position input for Motion Control" mode, the parameters for the encoder signals of the channel are assigned under "Module parameters". The parameters depend on the encoder used.

Module parameters for incremental encoders and pulse encoders

If you use an incremental or pulse encoder, you need to configure the following parameters for the encoder signals of the channel.

- Signal type
- Invert direction
- Signal evaluation
- Filter frequency
- Sensor type (for TM Count)
- Interface standard (for TM PosInput)
- Signal selection for reference mark 0
- Steps per revolution and
- Reference speed

You can find a description of the first six parameters in section AUTOHOTSPOT.

Module parameters for SSI absolute encoders

If you use an TM PosInput with an SSI absolute encoder, you need to configure the following parameters for the encoder signals of the channel.

- Signal type
- Invert direction
- Frame length
- Code type
- Transmission rate
- Monoflop time
- Parity
- Bit number LSB of the position value
- Bit number MSB of the position value
- Steps per revolution and
- Reference speed

You can find additional information on the first new parameters in section AUTOHOTSPOT.

Signal selection for reference mark 0

You can use this parameter to specify the external reference signal upon which a new reference mark is saved for the encoder position.

You can select from the following options:

Option	Meaning
None[1]	No external reference signal is used.
DI0 (preset for TM Count and TM PosInput)	The current counter value is saved as the new encoder position reference mark upon a positive edge at digital input DI0.
Signal N of incremental encoder (default for Compact CPU[2])	The current counter value is saved as the new encoder position reference mark upon a positive edge of the signal N of incremental encoder.

1 Only available with Compact CPU

2 Exceptions: "DI0" is the default for HSC 3 and HSC 6 on the 1511C as well as on the 1512C in compatibility mode

Steps per revolution

When using an incremental encoder or pulse encoder, you specify the number of count pulses per encoder revolution with this parameter. When you use an SSI absolute encoder, you use this parameter to specify the number of increments the encoder delivers per revolution.

The number of count pulses depends on the configured signal evaluation. You can enter a value between 1 and 65535.

Example of an incremental or pulse encoder:

Your incremental or pulse encoder delivers 2048 increments per revolution. Depending on the signal evaluation, you need to assign the following in this case:

Signal evaluation	Increments per unit
Single	2048
Double	4096
Quadruple	8192

Reference speed

The encoder transmits the process value of the speed as a percentage of the reference speed. This parameter defines the speed in rpm which is to be correspond to the value 100 % . The reference speed must be identical to the setting in the controller.

You can enter a value between 6.00 and 210000.00. The default setting is "3000.00".

Further configuring

You can perform additional configuration using an axis technology object of S7-1500 Motion Control . See the S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279) function manual for further details on configuring and commissioning position input.

Hardware interrupts

You can set for each channel the events which are to trigger a hardware interrupt during operation when assigning the basic parameters of the technology module.

In an S7-1500 system, you enter a matching event name for each enabled hardware interrupt and assign a corresponding hardware interrupt OB to each hardware interrupt. If a hardware interrupt is triggered, the corresponding OB is started to evaluate the hardware interrupt data.

A hardware interrupt is triggered if the condition for changing the respective status bit or event bit in the feedback interface is fulfilled.

Lost hardware interrupt

If an event occurs which is supposed to trigger a hardware interrupt but the previous, identical event has not yet been processed, no further hardware interrupt is triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostic interrupt, depending on the parameter assignment.

Hardware interrupts that can be activated

Hardware interrupt	Available in counting mode using		Available in measuring mode using		Available in position input for Motion Control mode	Description	EventType number
	Incremental or pulse encoder	SSI absolute encoder	Incremental or pulse encoder	SSI absolute encoder			
New Capture value available	Yes	Yes	No	No	No	Hardware interrupt when current counter value or position value is saved as Capture value	8
Synchronization of the counter by an external signal	Yes	No	Yes	No	No	Hardware interrupt upon synchronization of the counter by signal N or DI edge	9
Gate start	Yes	No	Yes	No	No	Hardware interrupt when internal gate opens	1
Gate stop	Yes	No	Yes	No	No	Hardware interrupt when internal gate closes	2
Overflow (high counting limit violated)	Based on counter value	No	Based on counter value	No	No	Hardware interrupt when counter value exceeds high counting limit	3
Underflow (low counting limit violated)	Based on counter value	No	Based on counter value	No	No	Hardware interrupt when counter value falls below low counting limit	4
Direction reversal*	Based on counter value	Based on position value	Based on counter value	Based on position value	No	Hardware interrupt when counter value or position value changes direction	10
Zero crossing	Based on counter value	Based on position value	Based on counter value	Based on position value	No	Hardware interrupt with zero crossing of counter value or position value	7

Hardware interrupt	Available in counting mode using		Available in measuring mode using		Available in position input for Motion Control mode	Description	EventType number
	Incremental or pulse encoder	SSI absolute encoder	Incremental or pulse encoder	SSI absolute encoder			
Comparison event for DQ0 occurred	Based on counter value	Based on position value	Based on measured value	Based on measured value	No	Hardware interrupt when a comparison event for DQ0 occurs as a result of the selected comparison condition. No hardware interrupt when the change of the counter value for an incremental or pulse encoder was not caused by a count pulse	5
Comparison event for DQ1 occurred	Based on counter value	Based on position value	Based on measured value	Based on measured value	No	Hardware interrupt when a comparison event for DQ1 occurs as a result of the selected comparison condition. No hardware interrupt when the change of the counter value for an incremental or pulse encoder was not caused by a count pulse	6

* The feedback bit STS_DIR has the default value "0". A hardware interrupt is not triggered when the first change to the counter value or position value immediately after the technology module is switched on is in the down direction.

Default setting

No hardware interrupts are enabled in the default setting.

5.1.2.5 Additional parameters for Compact CPU

Introduction

When using a Compact CPU, the following parameters are additionally available for the signals of the high-speed counter.

Compatibility 1511C (high-speed counters of Compact CPU 1512C-1 PN)

Front connector assignment same as CPU 1511C

You can use this parameter to specify if the pin assignment for the front connector of the CPU 1511C-1 PN is to be used for the high-speed counter of the CPU 1512C-1 PN:

Option	Meaning
Disabled (default)	CPU 1512C-1 PN uses the pin assignment of the onboard front connector. 1512C-1 PN supports the use of the connections of both front connectors of the digital onboard I/Os for the high-speed counter. The assignment of hardware inputs and outputs for the HSC channels is described in the CPU 1512C-1 PN manual.
Enabled	CPU 1512C-1 PN uses the pin assignment of the front connector of the CPU 1511C-1 PN. 1511C-1 PN supports the use of the connections of the first front connector of the digital onboard I/Os for the high-speed counter. The assignment of hardware inputs and outputs for the HSC channels is described in the CPU 1511C-1 PN manual.

General

Activate this high-speed counter

You can use this parameter to specify whether the respective high speed counter is to be used:

Option	Meaning
Disabled (default)	The high-speed counter is not used. The counter uses no connections of the onboard front connector and can not trigger interrupts. Writing to its control interface is ignored and its feedback interface returns zero values.
Enabled	The high-speed counter is used. The assignment of HSC addresses to the connections of the onboard front connector is described in the device manual of the Compact CPU.

Hardware inputs/outputs

Clock generator input (A) / Pulse input (A) / Clock generator forward (A)

This parameter specifies which input is used for the encoder signal A for the respective counter. The value cannot be changed.

Clock generator input (B) / Pulse input (B) / Clock generator forward (B)

If you use an encoder with multiple signals for the respective counter, this parameter specifies which input is used for the encoder signal B. The value cannot be changed.

Reset input (N)

If you use an incremental encoder for the respective counter, this parameter specifies which input is used for the reset input (encoder signal N). The value cannot be changed.

HSC DI0 / HSC DI1

This parameter determines which digital input of the Compact CPU is to be used as the DIm of the counter.

Note

You can configure the input delay for a digital input in the Inspector window of the device configuration under "Properties > DI 16/DQ 16 > Inputs > Channel n".

HSC DQ0

You can read the status of the DQ0 via the feedback interface. You cannot assign DQ0 to a physical digital output of the Compact CPU.

HSC DQ1

This parameter determines which digital output of the Compact CPU is to be used as DQ1. You can select an output with an output delay of 5 µs or 500 µs.

You can find an overview of the output delay for all digital outputs in the device manual of the Compact CPU.

5.1.3 Parameter assignment of module

5.1.3.1 Parameter setting (hardware configuration) Opening (TM Count and TM PosInput)

Opening via the project tree

Proceed as follows:

1. Open the "Local modules" or "Distributed I/O" folder in the project tree.
2. Open the technology module in the project tree.
3. Double-click on the "Parameters" object.

Opening from the device view

Proceed as follows:

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Right-click on the technology module and select "Parameters".

5.1.3.2 Parameter setting (hardware configuration) Opening (Compact CPU)

Opening via the project tree

Proceed as follows:

1. Open the Compact CPU folder in the project tree.
2. Double-click on the "Parameters" object.

Opening from the device view

Proceed as follows:

1. Open the device configuration of the Compact CPU.
2. Select the device view.
3. Right-click on the CPU section of the Compact CPU and select "Parameters".

5.1.4 Online & diagnostics module

5.1.4.1 Displaying and evaluating diagnostics

The online and diagnostics view enables hardware diagnostics. You can also

- Obtain information on the technology module (e.g., Firmware version and serial number)
- Execute a firmware update if required

Procedure (TM Count and TM PosInput)

To open the display editor for the diagnostic functions, follow these steps:

1. Open the "Local modules" or "Distributed I/O" folder in the project tree.
2. Open the technology module in the project tree.
3. Double-click on the "Online & diagnostics" object.
4. Select the required display in the diagnostics navigation.

Procedure (Compact CPU)

To open the display editor for the diagnostic functions, follow these steps:

1. Open the Compact CPU folder in the project tree.
2. Double-click on the "Online & diagnostics" object.
3. Select the required display in the diagnostics navigation.

Additional information

Additional information on the diagnostic alarms and possible remedies can be found in the technology module device manual.

Note

Position input for Motion Control

In the operating mode "Position input for Motion Control", channel diagnostics is not available for the technology module.

5.1.5 Control and feedback interface (TM Count, TM PosInput)

Information on using the control and feedback interface can be found under Overview of application options (Page 18).

5.1.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows control interface assignment:

Offset to the start address	Parameter	Meaning				
Bytes 0 to 3	Slot 0	Load value (significance of the value is specified in LD_SLOT_0)				
Bytes 4 to 7	Slot 1	Load value (significance of the value is specified in LD_SLOT_1)				
Byte 8	LD_SLOT_0*	Specifies the significance of the value in Slot 0				
		Bit 3	**Bit 2**	**Bit 1**	**Bit 0**	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Reserve
		0	0	1	1	Load start value (with incremental or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counter limit (with incremental or pulse encoder)
		0	1	1	1	Load high counter limit (with incremental or pulse encoder)
		1	0	0	0	Reserve
		to				
		1	1	1	1	

Offset to the start address	Parameter	Meaning				
Byte 8	LD_SLOT_1*	Specifies the significance of the value in Slot 1				
		Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
		0	0	0	0	No action, idle
		0	0	0	1	Load count value (with incremental or pulse encoder)
		0	0	1	0	Reserve
		0	0	1	1	Load start value (with incremental or pulse encoder)
		0	1	0	0	Load comparison value 0
		0	1	0	1	Load comparison value 1
		0	1	1	0	Load low counting limit (with incremental or pulse encoder)
		0	1	1	1	Load high counting limit (with incremental or pulse encoder)
		1	0	0	0	Reserve
		to				
		1	1	1	1	
Byte 9	EN_CAPTURE	Bit 7: Capture function enable				
	EN_SYNC_DN	Bit 6: Enable downward synchronization (with incremental or pulse encoder)				
	EN_SYNC_UP	Bit 5: Enable upward synchronization (with incremental or pulse encoder)				
	SET_DQ1	Bit 4: Set DQ1				
	SET_DQ0	Bit 3: Set DQ0				
	TM_CTRL_DQ1	Bit 2: enable technological function DQ1				
	TM_CTRL_DQ0	Bit 1: Enable technological function DQ0				
	SW_GATE	Bit 0: Software gate (with incremental or pulse encoder)				
Byte 10	SET_DIR	Bit 7: Count direction (for encoders without direction signal)				
	–	Bits 2 to 6: Reserve; bits must be set to 0				
	RES_EVENT	Bit 1: Reset of saved events				
	RES_ERROR	Bit 0: Reset of saved error states				
Byte 11	–	Bits 0 to 7: Reserve; bits must be set to 0				

* If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the first value is taken internally from Slot 0 and then the value from Slot 1 is taken. This may lead to unexpected intermediate states.

Notes on the control bits

Control bit	Notes
EN_CAPTURE	Use this bit to enable the Capture function. Resetting this bit resets a set EVENT_CAP in the feedback interface.
EN_SYNC_DN	Use this bit to enable the synchronization of the counter when counting in downward direction with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
EN_SYNC_UP	Use this bit to enable the synchronization of the counter when counting in upward direction with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
RES_EVENT	Use this bit to trigger the reset of the saved events in the EVENT_ZERO, EVENT_OFLW, EVENT_UFLW, EVENT_CMP0, EVENT_CMP1 feedback bits.
RES_ERROR	Use this bit to trigger the reset of the saved error states LD_ERROR and ENC_ERROR .
SET_DIR	Use this bit to specify the count direction for signal type "Pulse (A)". 0 means: Up 1 means: Down
SET_DQ0	Use this bit to set digital output DQ0 when TM_CTRL_DQ0 is set to 0. In the case of the function "After set command from CPU until comparison value",SET_DQ0 is effective regardless of TM_CTRL_DQ0 as long as the counter value is not equal to the comparison value.
SET_DQ1	Use this bit to set digital output DQ1 when TM_CTRL_DQ1 is set to 0. In the case of the function "After set command from CPU until comparison value",SET_DQ1 is effective regardless of TM_CTRL_DQ1 as long as the counter value is not equal to the comparison value.
SW_GATE	Use this bit to open and close the software gate when using an incremental encoder or pulse encoder. Together, the software gate and the hardware gate form the internal gate. The technology module only counts when the internal gate is open. 0 means: Software gate closed 1 means: Software gate open
TM_CTRL_DQ0	Use this bit to enable the technological function of digital output DQ0. 0 means: SET_DQ0 defines the state of DQ0 1 means: assigned function defines the state of DQ0
TM_CTRL_DQ1	Use this bit to enable the technological function of digital output DQ1. 0 means: SET_DQ1 defines the state of DQ1 1 means: assigned function defines the state of DQ1

5.1.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Offset to the start address	Parameter	Meaning
Bytes 0 to 3	COUNT_VALUE	DINT: Current counter value or position value
Bytes 4 to 7	CAPTURED_VALUE	DINT: The last acquired Capture value
Bytes 8 to 11	MEASURED_VALUE	REAL: Current measured value or DWORD: Full SSI frame
Byte 12	–	Bits 3 to 7: Reserve; set to 0
	LD_ERROR	Bit 2: Error when loading via control interface
	ENC_ERROR	Bit 1: Faulty encoder signal or SSI frame
	POWER_ERROR	Bit 0: S7-1500 module: Incorrect supply voltage L+ / ET 200SP module: Supply voltage L+ too low
Byte 13	–	Bits 6 to 7: Reserve; set to 0
	STS_SW_GATE	Bit 5: Software gate status (with incremental or pulse encoder)
	STS_READY	Bit 4: Technology module started up and configured
	LD_STS_SLOT_1	Bit 3: Load request for Slot 1 detected and executed (toggling)
	LD_STS_SLOT_0	Bit 2: Load request for Slot 0 detected and executed (toggling)
	RES_EVENT_ACK	Bit 1: Reset of event bits active
	–	Bit 0: Reserve; set to 0
Byte 14	STS_DI2	Bit 7: TM Count: Status DI2 / TM PosInput, Compact CPU: Reserve; set to 0
	STS_DI1	Bit 6: Status DI1
	STS_DI0	Bit 5: Status DI0
	STS_DQ1	Bit 4: Status DQ1
	STS_DQ0	Bit 3: Status DQ0
	STS_GATE	Bit 2: Internal gate status (with incremental or pulse encoder)
	STS_CNT	Bit 1: Count pulse or position value change detected within the last ca. 0.5 s
	STS_DIR	Bit 0: Direction of last counter value or position value change
Byte 15	STS_M_INTERVAL	Bit 7: Count pulse or position value change detected in previous measurement interval
	EVENT_CAP	Bit 6: Capture event occurred
	EVENT_SYNC	Bit 5: Synchronization has occurred (with incremental or pulse encoder)
	EVENT_CMP1	Bit 4: Comparison event for DQ1 has occurred
	EVENT_CMP0	Bit 3: Comparison event for DQ0 has occurred
	EVENT_OFLW	Bit 2: An overflow has occurred
	EVENT_UFLW	Bit 1: An underflow has occurred
	EVENT_ZERO	Bit 0: A zero pass has occurred

Notes on the feedback bits

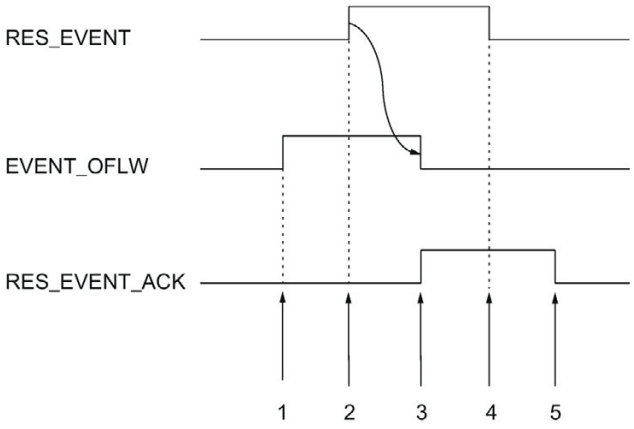
Feedback bit	Notes
ENC_ERROR	This bit indicates that one of the following errors has occurred at the encoder signals (retentive) for the respective technology module: TM Count: • Wire break of digital input A, B, or N (with push-pull encoder) • Invalid transition of A/B signals (with incremental encoder) TM PosInput: • Invalid transition of A/B signals (with incremental encoder) • RS422/TTL error • SSI encoder error or SSI frame error (with SSI absolute encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostic interrupts, refer to the manual for the respective technology module. The bit is reset once you have acknowledged the error with RES_ERROR .
EVENT_CAP	This bit indicates that a Capture event has occurred and a counter value has been saved in CAPTURED_VALUE . You reset the status by resetting EN_CAPTURE .
EVENT_CMP0	This bit indicates the saved status that a comparison event (status change) has occurred for the digital output DQ0 based on the selected comparison condition. You reset the status by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting mode, EVENT_CMP0 is not set.
EVENT_CMP1	This bit indicates the saved status that a comparison event (status change) has occurred for the digital output DQ1 based on the selected comparison condition. You reset the status by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting mode, EVENT_CMP1 is not set.
EVENT_OFLW	This bit indicates the saved state which shows that there was a counter value overflow. You reset the status by acknowledgment with RES_EVENT.
EVENT_SYNC	This bit indicates the saved status for which the counter was loaded with the start value by an external reference signal (synchronization) when using an incremental or pulse encoder. You reset the state by resetting EN_SYNC_UP or EN_SYNC_DN .
EVENT_UFLW	This bit indicates the saved state which shows that there was a counter value underflow. You reset the status by acknowledgment with RES_EVENT.
EVENT_ZERO	This bit indicates the saved status with which the counter value or position value experienced a zero crossing. You reset the status by acknowledgment with RES_EVENT.
LD_ERROR	This bit indicates that an error occurred (latching) during loading via the control interface. The loaded values were not applied. When using an incremental or pulse encoder, one of the following conditions is not fulfilled: • Low counting limit <= counter value <= high counting limit • Low counting limit <= start value <= high counting limit • Low counting limit <= comparison value 0/1 <= high counting limit • Comparison value 0 < comparison value 1 When using an SSI absolute encoder, one of the following conditions is not fulfilled: • 0 <= position value <= maximum position value • 0 <= comparison value 0/1 <= maximum position value • Comparison value 0 < comparison value 1 The bit is reset once you have acknowledged the error with RES_ERROR .

Feedback bit	Notes
LD_STS_SLOT_0	This bit indicates by a status change (toggling) that the load request for Slot 0 (LD_SLOT_0) has been detected and executed.
LD_STS_SLOT_1	This bit indicates by a status change (toggling) that the load request for Slot 1 (LD_SLOT_1) has been detected and executed.
POWER_ERROR	For an S7-1500 technology module, this bit indicates that the supply voltage L+ is not available or too low or that the front plug is not plugged in. For an ET 200SP technology module, this bit indicates that the supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of errors in the supply voltage. For details on the diagnostic interrupts and the corrective measures they require, refer to the device manual for the respective technology module. If the supply voltage L+ is available at a sufficient level once again, POWER_ERROR is automatically set to 0.
RES_EVENT_ACK	This bit indicates that the reset of event bit EVENT_SYNC, EVENT_CMP0, EVENT_CMP1, EVENT_OFLW, EVENT_UFLW, EVENT_ZERO is active.
STS_CNT	This bit indicates that at least one count pulse or a position value change has occurred in the last ca. 0.5 s.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DI1	This bit indicates the status of digital input DI1.
STS_DI2	This bit indicates the status of digital input DI2 of the TM Count .
STS_DIR	This bit indicates the count direction of the last count pulse or the direction of the last position value change. 0 means: Down 1 means: Up The LED stays illuminated for around 0.5 s after a standstill.
STS_DQ0	This bit indicates the status of digital output DQ0.
STS_DQ1	This bit indicates the status of digital output DQ1.
STS_GATE	This bit indicates the status of the internal gate when using an incremental or pulse encoder. 0 means: Gate closed 1 means: Gate open
STS_M_INTERVAL	This bit indicates that at least one count pulse or a position value change was detected in the previous measurement interval.
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.
STS_SW_GATE	This bit indicates the status of the software gate. 0 means: Gate closed 1 means: Gate open

Complete acknowledgment principle

Saving bits are acknowledged according to the complete acknowledgment principle.

The figure below shows an example of the sequence of the complete acknowledgment principle in the event of an overflow:



① The EVENT_OFLW feedback bit is set as a saving event upon overflow.
② You set the RES_EVENT control bit to trigger EVENT_OFLW reset.
③ The RES_EVENT_ACK feedback bit is set when reset of EVENT_OFLW is detected.
④ You then rest the control bit RES_EVENT .
⑤ The RES_EVENT_ACK feedback bit is reset.

5.2 Using the digital input module

5.2.1 Configuring and assigning parameters to the module

5.2.1.1 Adding a module to the hardware configuration

Requirements

- The project has been created.
- The CPU has been created.
- The ET 200 distributed I/O has been created.

Procedure

1. Open the device configuration of the CPU or IM.
2. Select a module rack.
3. Select the digital input module from the module catalog:
   "DI > Digital input module > Article number"
4. Drag the module to the required slot in the module rack.

Result

The new module is displayed under "Local modules" or "Distributed I/O" in the project tree.

5.2.1.2 Open hardware configuration

Opening via the project tree

Proceed as follows:

1. Open the "Local modules" or "Distributed I/O" folder in the project tree.
2. Double-click the module in the project tree.

Opening from the device view

Proceed as follows:

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Click on the module.

5.2.1.3 Counting operating mode

In counting operating mode, you can set the following parameters for each channel.

Note

Some of the parameters and options are not available for all digital input modules. See the module's device manual for the associated parameters and options.

Channel enabled

You use this parameter to specify whether the respective channel is enabled or disabled.

Each channel is enabled by default.

Input delay

By configuring the input delay, you suppress signal errors at the digital inputs. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Isochronous configuration is only possible if there is an input delay of 0.05 ms configured for at least one channel. In isochronous mode, the feedback interface is updated at the time T_i (time for reading the input data).

You can select from the following options:

- 0.05 ms
- 0.1 ms
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms (default)
- 12.8 ms
- 20 ms

Note

If you select the "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Reaction to violation of a counting limit

The following behavior can be configured for Violation of the counter high limit in the upward direction or the counter low limit in the downward direction (Page 81):

Reaction	Meaning
Stop counting (default)	After a counting limit is violated, the internal gate is closed (automatic gate stop). As a result, the counting process is stopped and the module ignores any further counting signals. The counter value is set to the opposite counting limit. To restart counting, you must close and reopen the software/hardware gate.
Continue counting	After a counting limit is violated, the counter value is set to the opposite counting limit and counting continues.

Edge selection

This parameter is used to specify which edge the respective counter counts:

Edge selection	Meaning
At rising edge (default)	The respective counter counts all rising edges at the digital input.
At falling edge	The respective counter counts all falling edges at the digital input.
At rising and falling edge	The respective counter counts all edges at the digital input.

Count direction

Use this parameter to specify the counting direction of the respective counter.

You can select from the following options:

- Up
- Down

Note

This parameter has no effect if the "Invert direction" option is selected in "Set function of DI".

Set output

Use this parameter to specify the Function (Page 85) that controls the STS_DQ feedback bit. You can use the STS_DQ reset bit in order to control a digital output module's digital output.

You can select from the following options:

Option	Meaning
Off (DQ = 0)	Regardless of the counter value, STS_DQ is permanently not set.
Off (DQ = 1)	Regardless of the counter value, STS_DQ is permanently set.
Between comparison value 0 and 1	STS_DQ is set if the counter value between comparison values 0 and 1.
Not between comparison value 0 and 1	STS_DQ is set if the counter value is outside the range between comparison values 0 and 1.
Between comparison value and counter high limit	STS_DQ is set if the counter value is between the comparison value and the counter high limit.
Between comparison value and counter low limit	STS_DQ is set if the counter value is between the comparison value and the counter low limit.

Setting function of the DI

Use this parameter to specify which function the respective digital input DI_{n+4} triggers.

You can select from the following options:

Option	Meaning
Digital input without function	No function is assigned to the respective digital input DI_{n+4}. The signal status of DI_{n+4} can be read by the CPU using the feedback interface.
Gate start/stop	Setting the respective digital input DI_{n+4} opens the hardware gate (Page 83) for DI_n. Resetting the respective digital input DI_{n+4} closes the hardware gate for DI_n.
Invert direction	The respective DI_{n+4} digital input reverses the counting direction at DI_n, in order to adjust it to the process. If DI_{n+4} is not set, DI_n counts up. If DI_{n+4} is set, DI_n counts down.

Note

If "Invert direction" is selected and the counting direction in the process changes, the counting edge is automatically adjusted (opposite edges).

High counting limit

You limit the counting range by setting the counter high limit. The maximum value for the counter high limit depends on the module:

High counting limit	DI 8x24VDC HS	DI 32x24VDC HF, DI 16x24VDC HF
Maximum value	2147483647 (2^{31}–1)	4294967295 (2^{32}–1)
Default	2147483647	4294967295

You must enter a value that lies above the counter low limit.

Counter low limit

You limit the counting range by setting the counter low limit. The minimum value for the counter low limit depends on the module:

Counter low limit	DI 8x24VDC HS	DI 32x24VDC HF, DI 16x24VDC HF
Minimum value	–2147483648 (–2^{31})	0 (not configurable)
Default	–2147483648	0

You must enter a value below the counter high limit.

Start value

By configuring the start value, you specify the value at which counting is to start. You must enter a value between the counting limits or equal to the counting limits.

The default setting is "0".

Comparison value 0

By configuring a comparison value (Page 85), you specify the counter value that controls the STS_DQ reset bit based on the comparison function that was selected under "Set output".

You must enter a value which is greater than or equal to the counter low limit and less than comparison value 1.

The default setting is "0".

Comparison value 1

By configuring the second comparison value (Page 85), you specify the additional counter value that controls the STS_DQ reset bit based on the comparison function that was selected under "Set output".

You must enter a value which is greater than comparison value 0 and less than or equal to the counter high limit.

The default setting is "10".

Hardware interrupt: Comparison event for DQ occurred

This parameter specifies whether a hardware interrupt is generated when a comparison event occurs based on the comparison function that was selected under "Set output".

The hardware interrupt is not enabled in the default setting.

5.2.2 Online & diagnostics module

5.2.2.1 Displaying and evaluating diagnostics

The online and diagnostics view enables hardware diagnostics. You can also

- Obtain information on the module (e.g., Firmware version and serial number)
- Execute a firmware update if required

Procedure

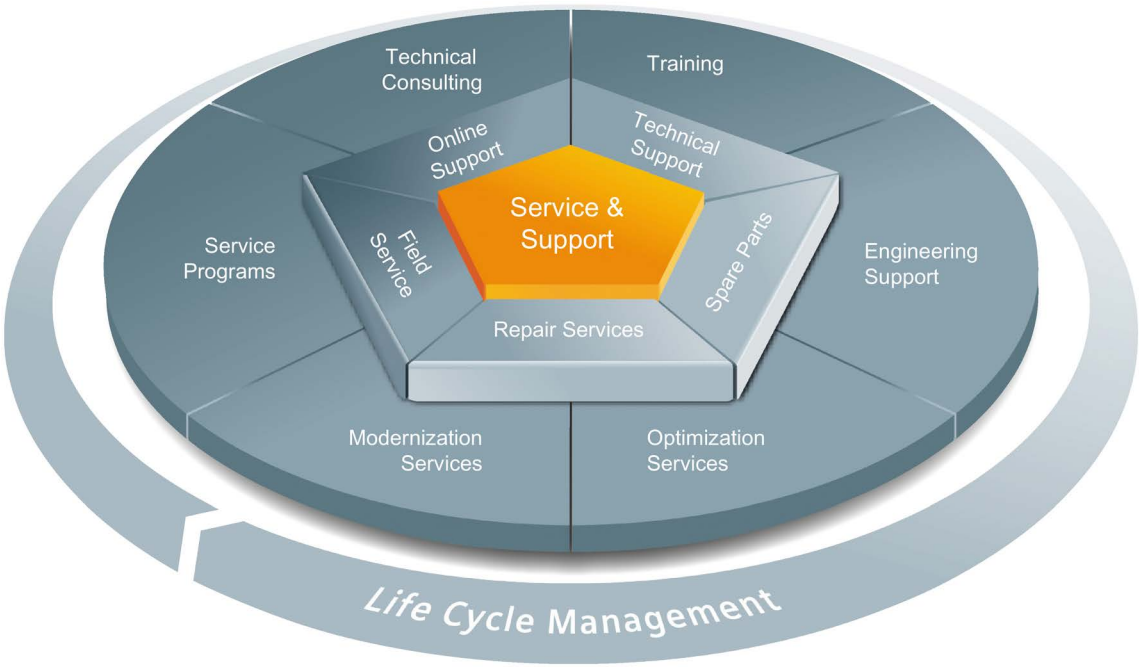
To open the display editor for the diagnostic functions, follow these steps:

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Right-click on the module and select "Online & Diagnostics".
4. Select the required display in the diagnostics navigation.

Additional information

Additional information on the diagnostic alarms and possible remedies can be found in the module's device manual.

Service & Support



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Our service programs are select service packages for an automation and drives system or product group. The individual services are coordinated with each other to ensure smooth coverage of the entire life cycle and support optimum use of your products and systems.

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Examples of service programs:

- Service contracts
- Plant IT Security Services
- Life Cycle Services for Drive Engineering
- SIMATIC PCS 7 Life Cycle Services
- SINUMERIK Manufacturing Excellence
- SIMATIC Remote Support Services

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- Reduced downtimes for increased productivity
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- Comprehensive service from a single source, fewer interfaces and greater expertise

Contact

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You can find your personal contact in our contacts database on the Internet (http://www.siemens.com/automation/partner).

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Industrial Software

SIMATIC Safety - Configuring and Programming

Programming and operating manual

Edition 09/2016

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Industrial Software SIMATIC Safety - Configuring and Programming

Programming and Operating Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Important notes

Purpose of this documentation

The information in this documentation enables you to configure (Page 39) and program (Page 90) SIMATIC Safety fail-safe systems. In addition, you will obtain information on acceptance (Page 308) of a SIMATIC Safety F-system.

Note

The Programming and Operating Manual "SIMATIC Safety - Configuring and Programming" in its latest version (possibly including product information for the manual) is the relevant source of all information on functional safety regarding configuring and programming. This also applies in the event of discrepancies between this manual and other documentation on functional safety regarding configuring and programming

You must heed all warnings in the Programming and Operating manual "SIMATIC Safety - Configuring and Programming".

Basic knowledge requirements

General basic knowledge of automation engineering is needed to understand this documentation. Basic knowledge of the following is also necessary:

- Fail-safe automation systems
- Automation systems S7-300/400/1200/1500/1500 Software Controller/WinAC RTX F
- Distributed I/O systems on PROFIBUS DP/PROFINET IO
- Totally Integrated Automation Portal, including:
  - Hardware configuration with the *hardware and network editor*
  - Programming in the LAD and FBD programming languages using the *program editor*.
  - Communication between CPUs

Scope of this documentation

This documentation is valid for the optional packages *STEP 7 Safety Advanced V14* and *STEP 7 Safety Basic V14*.

The optional packages *STEP 7 Safety Advanced V14* and *STEP 7 Safety Basic V14* are used for configuration and programming of the fail-safe SIMATIC Safety system.

In this context, integration of the fail-safe I/O listed below in SIMATIC Safety is also addressed:

- S7-1500/ET 200MP fail-safe modules
- ET 200SP fail-safe modules
- ET 200S fail-safe modules
- ET 200eco fail-safe I/O modules
- ET 200pro fail-safe modules
- ET 200iSP fail-safe modules
- S7-300 fail-safe signal modules
- S7-1200 fail-safe modules
- Fail-safe GSD based DP slaves
- Fail-safe GSD based I/O devices

Approvals

The SIMATIC Safety F-system is certified for use in safety mode up to:

- Safety integrity level SIL3 in accordance with IEC 61508:2010
- Performance Level (PL) e and category 4 in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

Incorporation in the information landscape

Depending on your application, you will need the following supplementary documentation when working with *STEP 7 Safety*.

This documentation includes references to the supplementary documentation where appropriate.

Documentation	Brief description of relevant content
For the SIMATIC Safety F-system	Depending on which F-CPU you are using, you will need the following documentation: • For the F-CPUs S7-1200/1500, a Product Information (http://support.automation.siemens.com/WW/view/en/109478599) describes all deviations from the respective standard CPUs. • Each F-CPU S7-300/400 that can be used has its own product information. The product information describes the deviations from the respective standard CPUs. • The Device manuals (http://support.automation.siemens.com/WW/view/en/67295862/133300) describe the S7-1500 CPUs. • The "S7-300, CPU 31xC and CPU 31x: Installation" (http://support.automation.siemens.com/WW/view/en/13008499) operating instructions describe the installation and wiring of S7-300 systems. • The "CPU 31xC and CPU 31x, Technical Data" (http://support.automation.siemens.com/WW/view/en/12996906) device manual describes the CPUs 315-2 DP and PN/DP, the CPU 317-2 DP and PN/DP, and the CPU 319-3 PN/DP. • The "S7-400 Automation System, Installation (http://support.automation.siemens.com/WW/view/en/1117849) installation manual describes the installation and wiring of S7-400 systems. • The "S7-400 Automation System, CPU Data" (http://support.automation.siemens.com/WW/view/en/23904550) reference manual describes the CPUs 414-3 PN/DP, the CPU 416-2, and the CPU 416-3 PN/DP. • The "ET 200S Interface Module IM 151-7 CPU" (http://support.automation.siemens.com/WW/view/en/12714722) manual describes the IM 151-7 CPU. • The "ET 200S, Interface Module IM 151-8 PN/DP CPU" (http://support.automation.siemens.com/WW/view/en/47409312) manual describes the IM 151-8 PN/DP CPU. • The "ET 200S, Interface Module IM 154-8 CPU" (http://support.automation.siemens.com/WW/view/de/24363739/0/en) manual describes the IM 154-8 CPU. • The Manual "Windows Automation Center RTX WinAC RTX (F) 2010 (http://support.automation.siemens.com/WW/view/en/43715176)" describes the WinAC RTX 2010 and the WinAC RTX F 2010. • The "S7-1500 Software Controller CPU 1505SP, CPU 1507S (http://support.automation.siemens.com/WW/view/en/109249299)" manual describes the SIMATIC S7-1500 Software Controller 1505SP and CPU 1507S.

Documentation	Brief description of relevant content
"S7-1200 Functional Safety manual (http://support.automation.siemens.com/WW/view/en/104547552)" system manual	Describes the F-CPUs S7-1200 and the fail-safe modules S7-1200 (including installation, wiring, and technical specifications)
"S7-1500/ET200MP system manual (http://support.automation.siemens.com/WW/view/en/59191792)" system manual and the product manuals (https://support.industry.siemens.com/cs/ww/en/ps/14141/man) for the corresponding S7-1500/ET 200MP fail-safe modules	Describes the hardware of the S7-1500 systems and the S7-1500/ET 200MP fail-safe modules (including installation, wiring, and technical specifications)
"ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)" system manual and the product manuals (https://support.industry.siemens.com/cs/ww/en/ps/14059/man) for the corresponding ET 200SP fail-safe modules	Describes the hardware of the ET 200SP fail-safe modules (including installation, wiring, and technical specifications)
"ET 200eco Distributed I/O Station Fail-safe I/O Block (http://support.automation.siemens.com/WW/view/en/19033850)" manual	Describes the hardware of the ET 200eco fail-safe I/O module (including installation, wiring, and technical specifications)
"Distributed I/O System ET 200S, Fail-Safe Modules (http://support.automation.siemens.com/WW/view/en/27235629)" operating instructions	Describes the hardware of the ET 200S fail-safe modules (including installation, wiring, and technical specifications)
"S7-300 Automation System, ET 200M Distributed I/O System, Fail-safe Signal Modules (http://support.automation.siemens.com/WW/view/en/19026151)" manual	Describes the hardware of the S7-300 fail-safe signal modules (including installation, wiring, and technical specifications)
"Distributed I/O system ET 200pro, fail-safe I/O modules (http://support.automation.siemens.com/WW/view/en/22098524)" operating instructions	Describes the hardware of the ET 200pro fail-safe modules (including installation, wiring, and technical specifications)
"ET 200iSP distributed I/O device - Fail-safe modules (http://support.automation.siemens.com/WW/view/en/47357221)" operating instructions	Describes the hardware of the ET 200iSP fail-safe modules (including installation, wiring, and technical specifications)
Online help for *STEP 7*	• Describes the operation of the standard tools in *STEP 7* • Contains information regarding configuration and parameter assignment of hardware • Contains a description of the FBD and LAD programming languages

The complete *SIMATIC S7* documentation is available on DVD. You can find more information on the Internet (http://www.automation.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/manual-collection/Pages/Default.aspx).

Guide

This documentation describes how to work with the optional packages *STEP 7 Safety.* It includes instructions and reference sections (description of the instructions for the safety program).

The following topics are addressed:

- Configuration of SIMATIC Safety
- Access protection for SIMATIC Safety
- Programming of the safety program (safety-related user program)
- Safety-related communication
- Instructions for the safety program
- Support for the system acceptance
- Operation and maintenance of SIMATIC Safety
- Monitoring and response times

Conventions

In this documentation, the terms "safety engineering" and "fail-safe engineering" are used synonymously. The same applies to the terms "fail-safe" and "F-".

When *"STEP 7 Safety Advanced V14", "STEP 7 Safety Basic V14"* appears in italics, it refers to the optional package for the "SIMATIC Safety" F-system.

"STEP 7 Safety V14" stands for the optional package *"STEP 7 Safety Advanced V14"* and the optional package *"STEP 7 Safety Basic V14"*.

"(S7-300)" indicates that the section **only** applies to S7-300 F-CPUs. S7-300 F-CPUs also includes the F-CPUs ET 200S and ET 200pro (IM F-CPUs).

"(S7-400)" indicates that the section **only** applies to S7-400 as well as WinAC RTX F.

"(S7-1200)" indicates that the section **only** applies to S7-1200 F-CPUs.

"(S7-1500)" indicates that the section **only** applies to S7-1500 F-CPUs. S7-1500 F-CPUs also includes ET 200SP F-CPUs, the CPU 1516pro F-2 PN and the S7-1500 F Software Controller.

The scopes can be combined.

The term "Safety program" refers to the fail-safe portion of the user program and is used instead of "fail-safe user program," "F-program," etc. For purposes of contrast, the non-safety-related part of the user program is referred to as the "standard user program".

All fail-safe modules and instructions are highlighted in yellow to distinguish them from the modules and instructions of the standard user programs on the software interface (e.g., in the project tree). Similarly, the fail-safe parameters of F-CPUs and F-I/O are highlighted in yellow in the hardware configuration.

Each warning is marked with a unique number at the end of the text. This enables you to easily reference other documents, for example, to obtain an overview of the safety requirements for the system.

Additional support

If you have further questions about the use of products presented in this manual, contact your local Siemens representative.

You can find information on whom to contact on the Web (http://www.siemens.com/automation/partner).

A guide to the technical documentation for the various SIMATIC products and systems is available on the Web (http://www.siemens.com/simatic-tech-doku-portal).

You can find the online catalog and online ordering system on the Web (www.siemens.com/industrymall).

Training center

We offer courses to help you get started with the S7 automation system. Contact your regional training center or the central training center in Nuremberg (90327), Federal Republic of Germany.

You can find more information on the Internet (http://www.sitrain.com).

Technical Support

To contact Technical Support for all Industry Automation products, use the Support Request Web form (http://www.siemens.com/automation/support-request).

You can find additional information about our Technical Support on the Web (http://www.siemens.com/automation/service).

Important note for maintaining the operational safety of your system

Note

The operators of systems with safety-related characteristics must adhere to operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log in in the Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Software Controller (https://support.industry.siemens.com/cs/products?pnid=13911&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=14340&lc=en-WW)

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Product Overview

1

1.1 Overview

SIMATIC Safety fail-safe system

The SIMATIC Safety fail-safe system is available to implement safety concepts in the area of machine and personnel protection (for example, for emergency STOP devices for machining and processing equipment) and in the process industry (for example, for implementation of protection functions for safety devices of instrumentation and controls and of burners).

⚠ WARNING

The SIMATIC Safety F-system is used to control processes and to force the system into a safe state after shutdown.

SIMATIC Safety can only be used for controlling processes in which an immediate shutdown does not pose a danger to persons or the environment.*(S062)*

Achievable safety requirements

SIMATIC Safety F-systems can satisfy the following safety requirements:

- Safety integrity level SIL3 in accordance with IEC 61508:2010
- Performance Level (PL) e and category 4 in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

Principles of safety functions in SIMATIC Safety

Functional safety is implemented principally through safety functions in the software. Safety functions are executed by the SIMATIC Safety system in order to bring the system to a safe state or maintain it in a safe state in case of a dangerous event. Safety functions are contained mainly in the following components:

- In the safety-related user program (safety program) in the F-CPU
- In the fail-safe inputs and outputs (F-I/O)

The F-I/O ensure the safe processing of field information (sensors: e.g. emergency STOP pushbutton, light barriers; actuators, e.g. for motor control). They have all of the required hardware and software components for safe processing, in accordance with the required Safety Integrity Level. The user only has to program the user safety function. The safety function for the process can be provided through a user safety function or a fault reaction function. In the event of an error, if the F-system can no longer execute its actual user safety function, it executes the fault reaction function; for example, the associated outputs are shut down, and the F-CPU switches to STOP mode, if necessary.

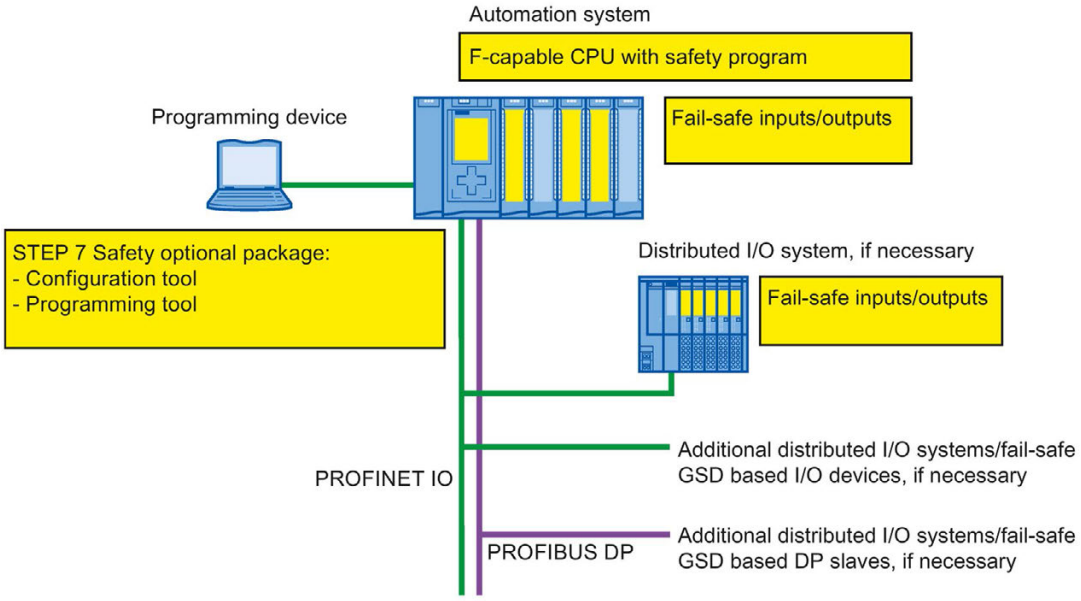
Example of user safety function and fault reaction function

In the event of overpressure, the F-system will open a valve (user safety function). In the event of a dangerous malfunction of the F-CPU, all outputs are shut down (fault reaction function). This means that the valve opens in the event of overpressure and the other actuators also switch to safe mode. For a non-faulty F-system, only the valve would be opened.

1.2 Hardware and Software Components

Hardware and software components of SIMATIC Safety

The following figure provides an overview of the hardware and software components required to configure and operate a SIMATIC Safety F-system.



Hardware components for PROFIBUS DP

You can use the following fail-safe components in SIMATIC Safety F-systems on PROFIBUS DP:

- F-CPUs with DP interface, such as CPU 1516F-3 PN/DP
- Fail-safe inputs and outputs (F-I/O), such as:
  - S7-300 fail-safe signal modules in ET 200M
  - S7-1500/ET 200MP fail-safe modules
  - ET 200SP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200iSP fail-safe modules
  - Fail-safe I/O modules ET 200eco (S7-300, S7-400)
  - Fail-safe GSD based DP slaves (light grid, laser scanner, etc.)

You have the option to expand the configuration with standard I/O.

The following CPs/CMs can be used in a SIMATIC Safety F-system on PROFIBUS DP for connection to distributed F-I/O:

- CP 443-5 Extended
- CM 1243-5
- CM 1542-5
- CP 1542-5
- SP CM DP

Hardware components for PROFINET IO

You can use the following fail-safe components in SIMATIC Safety F-systems on PROFINET IO:

- F-CPUs with PN interface, e.g., CPU 1214FC DC/DC/DC
- Fail-safe inputs and outputs (F-I/O), such as:
  - S7-300 fail-safe signal modules in ET 200M
  - S7-1500/ET 200MP fail-safe modules
  - ET 200SP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200iSP fail-safe modules
  - Fail-safe GSD based I/O devices (light grid, laser scanner, etc.)

You have the option to expand the configuration with standard I/O.

The following CPs/CMs can be used in a SIMATIC Safety F-system on PROFINET IO for connection to distributed F-I/O:

- CP 443-1
- CP 443-1 Advanced-IT
- CM 1542-1

Hardware components for central configuration

You can use the following fail-safe components in SIMATIC Safety F-systems centrally on an F-CPU:

- S7-300 fail-safe signal modules
- S7-1200 fail-safe modules
- S7-1500 fail-safe modules
- ET 200SP fail-safe modules
- ET 200S fail-safe modules
- ET 200pro fail-safe modules (can also be used with CPU 1516proF-2)

You have the option to expand the configuration with standard I/O.

Required software components

You require the following software components:

- *SIMATIC STEP 7 Basic V14* with the *STEP 7 Safety Basic V14* optional package

  or

- *SIMATIC STEP 7 Professional V14* with the *STEP 7 Safety Basic V14* optional package

  or

- *SIMATIC STEP 7 Professional V14* with the *STEP 7 Safety Advanced V14* optional package

STEP 7 Safety optional packages

This documentation describes the optional packages *STEP 7 Safety Advanced V14* and *STEP 7 Safety Basic V14*. The *STEP 7 Safety* optional packages are the configuration and programming software for the SIMATIC Safety F-system. With *STEP 7 Safety*, you receive the following:

- Support for configuring the F-I/O in the *hardware and network editor* of the TIA Portal
- Support for creating the safety program using LAD and FBD and integrating error detection functions into the safety program
- Instructions for programming your safety program in LAD and FBD, which you are familiar with from the standard user programs
- Instructions for programming your safety program in LAD and FBD with special safety functions

Moreover, *STEP 7 Safety* offers functions for comparing safety programs and for assisting you with the system acceptance.

⚠ WARNING

The F-CPU and F-I/O must be configured in the *hardware and network editor* of the TIA Portal as described in this documentation. F-blocks must be created with the *program editor* of the TIA Portal as described in this documentation. For system acceptance, you have to use the safety summary created according to this documentation. Any other procedures are not permitted. *(S056)*

Additional optional packages

In addition to the *STEP 7 Safety* optional packages, you can use additional optional packages with F-I/O and F-CPUs and use instructions for programming your safety program with special safety functions within the SIMATIC Safety F-system. For example, SINUMERIK or Failsafe HMI Mobile Panels.

The installation, parameter assignment and programming as well as what is important to note during system acceptance, is described in the documentation for the specific optional packages.

Please also read the notes in Configurations supported by the SIMATIC Safety F-system (Page 54).

TIA Portal Cloud Connector

⚠ WARNING

Use of the TIA Portal Cloud Connector is only intended for engineering work with the TIA Portal. This means online access in productive operation (e.g. SCADA) is not permitted. This is particularly true for safety programs. *(S068)*

Openness

In *STEP 7 Safety*, as in the standard version, you can use the Openness set of commands. Requirement for this is that no password is created for the safety-related project data. The use of Openness in productive operation is not permitted.

⚠ WARNING

Also when using Openness, you must recognize and document the correctness of the security-related project data provided via Openness (e.g. F-blocks) on the basis of the safety summary. *(S070)*

Virtual environments

⚠ WARNING

Use of virtual environments in the engineering system

Note that a HYPERVISOR or a client software of a HYPERVISOR is not permitted to perform any function that reproduces recorded message frame sequences with correct time behavior in the network with accessible systems.

Make sure that this condition is met, for example, when using the following functions:

- Reset of captured statuses (snapshots) of the virtual machines (VMs)
- Suspending and resuming the virtual machines
- Replay of recorded sequences in the virtual machines
- Moving VMs between hosts in productive operation (e.g. Fault Tolerance (FT))
- Digital twins of VMs in the virtual environment

If in doubt, disable these functions in the settings (HYPERVISOR administration console). *(S067)*

Safety program

You can create a safety program using the *program editor*. You can program fail-safe FBs and FCs in the FBD or LAD programming languages using the instructions from the optional package and create fail-safe DBs.

Safety checks are automatically performed and additional fail-safe blocks for error detection and fault reaction are inserted when the safety program is compiled. This ensures that failures and errors are detected and appropriate reactions are triggered to maintain the F-system in the safe state or bring it to a safe state.

In addition to the safety program, a standard user program can be run on the F-CPU. A standard program can coexist with a safety program in an F-CPU because the safety-related data of the safety program are protected from being affected unintentionally by data of the standard user program.

Data can be exchanged between the safety program and the standard user program in the F-CPU by means of bit memory or data of a standard DB or by accessing the process image input and output.

See also

Data Transfer from the Safety Program to the Standard User Program (Page 166)

1.3 Installing/uninstalling the STEP 7 Safety Basic V14 optional package

Software requirements for *STEP 7 Safety Basic V14*

At a minimum, one of the following software packages must be installed on the programming device or PC:

- *SIMATIC STEP 7 Basic V14*
- *SIMATIC STEP 7 Professional V14*

Reviewing the Readme file

The readme file contains important up-to-date information about the software (for example, Windows versions supported). You can display the readme file in the setup program or open it later in the *SIMATIC STEP 7* information system.

Installing *STEP 7 Safety Basic V14*

1. Start the programming device or PC on which the *"SIMATIC STEP 7 Basic V14"* or *"SIMATIC STEP 7 Professional V14*" software package has been installed, and make sure that *SIMATIC STEP 7 Basic V14 or SIMATIC STEP 7 Professional V14* is closed.
2. Insert the optional package product DVD.
3. Initiate the *SETUP.EXE* program on the DVD.
4. Follow the instructions of the Setup program, bearing in mind the information in the readme file.

Displaying integrated Help

The help on *STEP 7 Safety Basic V14* is completely integrated into the information system of *SIMATIC STEP 7 Basic V14 or SIMATIC STEP 7 Professional V14*. You have the following two options to open the integrated help:

- In the "Help" menu, select the "Show help" command or press <F1> to show the appropriate help for the context.
- Click on the link within a tool tip cascade to go directly to a place with more information within the help.

Uninstalling *STEP 7 Safety Basic V14*

To uninstall *STEP 7 Safety Basic V14*, proceed as described in the *STEP 7 Help* under "Uninstall".

Post-uninstall procedures

After uninstalling the *STEP 7 Safety Basic V14* optional package, you can still open projects with F-CPUs whose F-capability is enabled but you can no longer edit the safety program. F-I/O is no longer supported.

1.4 Installing/uninstalling the STEP 7 Safety Advanced V14 optional package

Software requirements for *STEP 7 Safety Advanced V14*

At a minimum, the following software package must be installed on the programming device or PC:

- *SIMATIC STEP 7 Professional V14*

Reviewing the Readme file

The readme file contains important up-to-date information about the software (for example, Windows versions supported). You can display the readme file in the setup program or open it later in the *SIMATIC STEP 7* information system.

Installing *STEP 7 Safety Advanced V14*

1. Start the programming device or PC on which the *"SIMATIC STEP 7 Professional V14"* software package has been installed, and make sure that *SIMATIC STEP 7 Professional V14* is closed.
2. Insert the optional package product DVD.
3. Initiate the *SETUP.EXE* program on the DVD.
4. Follow the instructions of the Setup program, bearing in mind the information in the readme file.

Displaying integrated Help

The help on *STEP 7 Safety Advanced V14* is completely integrated into the information system of *SIMATIC STEP 7 Professional V14*. You have the following two options to open the integrated help:

- In the "Help" menu, select the "Show help" command or press <F1> to show the appropriate help for the context.
- Click on the link within a tool tip cascade to go directly to a place with more information within the help.

Uninstalling *STEP 7 Safety Advanced V14*

To uninstall *STEP 7 Safety Advanced V14*, proceed as described in the *STEP 7 Help* under "Uninstall".

Post-uninstall procedures

After uninstalling the *STEP 7 Safety Advanced V14* optional package, you can still open projects with F-CPUs whose F-capability is enabled but you can no longer edit the safety program. F-I/O is no longer supported

1.5 Installing/uninstalling STEP 7 Safety PowerPack

After the installation of the *STEP 7 Safety PowerPack* the functional scope of *STEP 7 Safety Advanced V14* is available to you.

Software requirements for *STEP 7 Safety PowerPack*

At a minimum, the following software package must be installed on the programming device or PC:

- *SIMATIC STEP 7 Safety Basic V14*
- *SIMATIC STEP 7 Professional V14*

Installing *STEP 7 Safety PowerPack*

1. Start the *Automation License Manager* on the programming device/PC on which the *"SIMATIC STEP 7 Professional V14"* software package is installed.
2. Install the license included in the *STEP 7 Safety PowerPack* as described in the *Automation License Manager help*.

Uninstalling *STEP 7 Safety PowerPack*

To uninstall the license included in the *STEP 7 Safety PowerPack*, proceed as described in the *Automation License Manager help*.

1.6 Migrating projects from S7 Distributed Safety V5.4 SP5 to STEP 7 Safety Advanced

Introduction

In *STEP 7 Safety Advanced*, you can continue to use projects with safety programs that you created with *S7 Distributed Safety V5.4 SP5*.

Requirement

STEP 7 Safety Advanced, *S7 Distributed Safety V5.4 SP5*, and the *F-Configuration Pack* used to create the project must all be installed on the computer you are using for migration. The *F-Configuration Pack V5.4 SP5* to *V5.5 SP12* is supported.

To that end, the projects must have been compiled in *S7 Distributed Safety V5.4 SP5* and with the *F-Configuration Pack*.

Prior to migration

Delete all F-blocks not required by the safety program in your *S7 Distributed Safety V5.4 SP5* project prior to migration.

Procedure as in *STEP 7 Professional*

Proceed just as you would for standard projects to migrate projects from *S7 Distributed Safety V5.4 SP5* to *STEP 7 Safety Advanced*. Once the migration is complete, you should verify using the collective F-signature whether the project was migrated unchanged.

Note

If you use the safety program to migrate F-blocks with know-how protection, remove the know-how protection prior to migration.

You can assign the F-blocks know-how protection again once the migration is completed.

This migration approach is described in the "Migration" section of the *STEP 7 Professional* Help. Special considerations about *STEP 7 Safety Advanced* are described below.

Note

We recommend that you enable the "Include hardware configuration" option in the "Migrating project" window.

Older hardware versions

Older versions of F-hardware may not be supported by *STEP 7 Safety Advanced*.

If you have used and configured versions of F-CPUs and F-I/O in S7 Distributed Safety projects that are not approved for *STEP 7 Safety Advanced*, you will need to upgrade this hardware to the new version in *S7 Distributed Safety V5.4 SP5* and the corresponding *F-Configuration Pack*. Once the upgrade is completed, migration to *STEP 7 Safety Advanced* is feasible. A Product Information with a list of approved hardware is available on the Internet (https://support.industry.siemens.com/cs/ww/de/view/109481784):

Particularities for safety-related CPU-CPU communication via S7 connections

You can find information about the special considerations for migrated projects with safety-related CPU-CPU communication via S7 connections in Safety-related communication via S7 connections (Page 215). Please also note Communication with S7 Distributed Safety via S7 connections (Page 225).

Particularities for ESTOP1 or FDBACK instructions

Information on the special considerations when using the ESTOP1 and FDBACK instructions can be found in the "Instruction versions" section in ESTOP1: Emergency STOP/OFF up to stop category 1 (STEP 7 Safety V14) (Page 373) and FDBACK: Feedback monitoring (STEP 7 Safety V14) (Page 419).

Post-migration procedures

Once migration is complete, you have a complete project with a safety program which has retained the program structure of *S7 Distributed Safety* and the collective F-signature. F-blocks from the S7 Distributed Safety F-library (V1) are converted into instructions that are provided by *STEP 7 Safety Advanced*.

The migrated project therefore does not need to be re-accepted; it can be loaded as is to the F-CPU as long as it has not been modified or compiled since migration.

Note

Safety summary

You cannot create a safety summary in *STEP 7 Safety Advanced* for a migrated project. The printout of the project created with *S7 Distributed Safety V5.4 SP5* and the corresponding acceptance documents are still valid, because the collective F-signature has been retained.

Compiling of the migrated hardware configuration

If you receive an error message after migration and subsequent compilation of the hardware configuration stating that the F-source address does not match the "Central F-source address" parameter of the F-CPU, change the "Central F-source address" parameter. The F-source addresses of all F-I/Os assigned to the F-CPU are reassigned in the process.

If after migration of an SM 326; DI 24 x DC 24V (6ES7 326-1BK01-0AB0 and 6ES7 326-1BK02-0AB0) and subsequent compilation of the hardware configuration, the error message "F_IParam_ID_1: Value outside the permitted range" is displayed, delete the F-SM and reinsert it.

In both cases, subsequent compilation of the safety program is required.

Compiling the migrated safety programs

As a result of compilation of the migrated project with *STEP 7 Safety Advanced*, the existing program structure (with F-CALL) is converted to the new program structure of *STEP 7 Safety Advanced* (with main safety block). This changes the collective F-signature and a new acceptance for the safety program may be required.

Note

Changing the Safety system version

Before compiling with *STEP 7 Safety Advanced* for the first time, you must change the safety system version to a version which is not equal to 1.0 in the "Settings" area of the *Safety Administration Editor*. We recommend that you use the highest available version.

Note

Using the latest version of instructions

If you want to expand the migrated safety program, we recommend that you update to the latest version of the instructions used before compiling with *STEP 7 Safety Advanced* for the first time. Read the information on instruction versions for each instruction.

Note

Note that compiling the migrated safety program extends the runtime of the F-runtime group(s) and increases the memory requirements of the safety program (see also Excel file for calculating response time (http://support.automation.siemens.com/WW/view/en/49368678/133100)).

See also

Application example "Migration of a safety program to TIA Portal" (https://support.industry.siemens.com/cs/ww/en/view/109475826)

1.7 Migrating PLC programs to a n F-CPU S7-1500

To migrate an F-CPU S7-300/400 onto an F-CPU S7-1500, proceed as with the migration of a standard CPU S7-300/400 onto a CPU S7-1500.

Points to note after migration:

- Non-automatable actions
  - Creating an F-runtime group and assigning it to the main safety block.
  - The hardware configuration including the I/O of the initial F-CPU is not automatically transferred to an S7-1500 F-CPU. Implement the hardware configuration of the new CPU manually after migration.

    Please also read the sections "Specify F-destination address for F-I/O of PROFIsafe address type 1" and "Specify F-destination address for F-I/O of PROFIsafe address type 2“ in chapter "Configuring an F-CPU (Page 44)“. Otherwise, this can lead to a reassignment of the F-destination addresses in the configuration.
  - When using S7-1500/ET200MP F-modules keep in mind that you need one byte more in the address area of S7-1200/1500 F-CPUs than in S7-300/400 F-CPUs.
- Instructions not supported:
  - OV
  - MUTING
  - TWO_HAND
  - WR_FDB
  - RD_FDB
  - OPN
  - SENDS7
  - RCVS7
- Data types not supported
  - DWORD
- Changes to safety program programming
  - F_GLOBDB.VKE0/1 replaced by FALSE/TRUE (Page 97).
  - Readable values from the F_GLOBDB replaced by the F-runtime group information DB. Additional information is available under F-shared DB (S7-300, S7-400) (Page 118) and F-runtime group information DB (S7-1200, S7-1500) (Page 118).
  - Replacement of the QBAD_I_xx or QBAD_O_xx tag by the value status. Additional information is available under Value status (S7-1200, S7-1500) (Page 130) and F-I/O DB (Page 135).
- F-runtime group communication is not supported.
- New naming convention when naming the F-I/O DBs
- Modified behavior of QBAD and PASS_OUT (Page 141) tags for F-I/O with "RIOforFA-Safety" profile.

Compile the safety program and eliminate any compilation errors displayed.

Note

A new acceptance must be carried out following F-CPU migration.

See also

Programming (Page 90)

1.8 Upgrading projects to STEP 7 Safety V14

If you want to upgrade from a project **prior to** *STEP 7 Safety V13 SP1*, you must first upgrade the project to *STEP 7 Safety V13 SP1* via an intermediate step.

1.8.1 Upgrading projects from STEP 7 Safety V13 SP1 to V14

If you want to continue to work with a project from *STEP 7 Safety V13 SP1*, you must first upgrade the project to *STEP 7 Safety V14*.

Perform the upgrade following the usual procedure for *STEP 7*. After upgrading to V14, you have to compile your safety program.

(S7-300/400): After compilation, the safety program is consistent and the collective F-signature of the migrated safety program corresponds to the collective F-signature of the safety program from V13 SP1. Acceptance of changes is not required

(S7-1200/1500): After compiling, your safety program is consistent and the collective F-signature of the migrated safety program has changed for system reasons. The new collective F-signature of the safety program with *STEP 7 Safety V14* replaces the former collective F-signature of the safety program with *STEP 7 Safety V13 SP1*.

You can find an overview of all system-related changes under "Common data/Protocols/F-Convert Log+CPU name+time stamp". One of the system-related changes is that *STEP 7 Safety V14* automatically replaces versions of instructions no longer supported with new, functionally identical versions. The overview contains a comparison of the previous signatures with *STEP 7 Safety V13 SP1* to the new signatures with *STEP 7 Safety V14* and displays the automatically changed instruction versions. Print out the overview and store this printout with your acceptance documents or your machine documentation. Change acceptance is not required, since the "Collective F-signature with *STEP 7 Safety V13 SP1"* contained in the overview matches the collective F-signature in your current acceptance documents.

Keep in mind that existing change histories are not upgraded. All previous entries are deleted after the upgrade. If necessary, print out the change log before you upgrade.

Special features for user acknowledgment and reintegration of F-I/O after F-I/O or channel faults and PASS_ON = 1 (S7-1200, S7-1500)

The following applies to F-I/Os:

- S7-300 fail-safe signal modules
- ET 200S fail-safe modules
- ET 200pro fail-safe modules
- ET 200iSP fail-safe modules

Keep in mind the changed behavior for user acknowledgment and reintegration when configuring "Behavior after channel fault" = "Passivation of the channel" and tag ACK_NEC (F-I/O DB) = 1. The behavior was adapted to the behavior when configuring "Behavior after channel fault" = "Passivate the entire module":

As of *STEP 7 Safety V14* or higher, user acknowledgment of a corrected F-I/O or channel fault is **possible** even when the tag PASS_ON (F-I/O DB) = 1. A reintegration (provision of process values) takes place **as soon as the tag PASS_ON = 0**.

Until *STEP 7 Safety V13 SP1*, user acknowledgment of a corrected F-I/O or channel fault was **not possible** as long as the tag PASS_ON (F-I/O DB) = 1. A user acknowledgment was only possible once the tag PASS_ON = 0. The reintegration (provision of process values) took place immediately after the user acknowledgment.

Special features when using instruction profiles

If you want to use an instruction profile in your project from *STEP 7 Safety V13 SP1*, delete the instruction profile before you upgrade to *STEP 7 Safety V14*. Before deleting, make a note of your settings. After upgrading create a new instruction profile, if required, and enter the noted settings there, if applicable. Please note that some instruction versions are no longer supported under *STEP 7 Safety V14*. You will find additional information about the supported instruction versions in the description of the respective instruction.

1.8.2 Upgrading projects from STEP 7 Safety prior to V13 SP1

If you want to upgrade from a project **prior to** *STEP 7 Safety V13 SP1* to STEP 7 Safety V14, you must upgrade the project, as in standard, to *STEP 7 Safety V13 SP1* via an intermediate step.

The safety program signature does not change after upgrading the safety program to *STEP 7 Safety V13 SP1*. Acceptance of changes is therefore not required.

Perform the upgrade following the usual procedure for *STEP 7 Professional*.

When upgrading a project that was created with *STEP 7 Safety Advanced V11* . please note the following information:

Note

Adjustments are required before you can continue working on a project upgraded from *STEP 7 Safety Advanced V11*:

There was a product warning for *STEP 7 Safety Advanced V11* regarding setting the parameters "Discrepancy behavior" and "Reintegration after discrepancy error" for the fail-safe digital input and output modules 4F-DI/3F-DO DC24V/2A (6ES7138-4FC01-0AB0, 6ES7138-4FC00-0AB0). These parameters could be displayed incorrectly in certain combinations.

Based on the handling instructions in this product warning, you used a conversion table to set the affected parameters so that they were displayed incorrectly in the safety summary and hardware configuration in order for them to have the correct effect in the F-module. You also corrected the safety summary by hand to document the actual behavior of F-modules.

To reverse these changes, follow these steps:

1. Compile the upgraded project with *STEP 7 Safety Advanced V13 SP1*. An error message is displayed for each F-module in *STEP 7 Safety Advanced V11* the parameters of which you have corrected: "The CRC (F_Par_CRC) of the module (xxx) does not match the calculated value (yyy)."
2. Adapt the parameter assignment of each F-module for which this error message is displayed to match your handwritten corrections in the safety summary.
3. Do this for each F-CPU and then compile the safety program.
4. If the collective F-signature following compiling corresponds to the collective F-signature on the safety summary, you have made all the necessary corrections.

Use of CPs

F-I/Os operated downstream from a CP443-5 Extended, CP443-1 or CP 443-1 Advanced-IT were not automatically assigned a unique F-destination address.

As soon as you compile the hardware in a project with such F-I/Os in *STEP 7 Safety V13 SP1*, you are notified for the affected F-I/Os. You have to assign new, unique F-destination addresses for the reported F-I/Os. Additional information is available under PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 56), PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 58) and Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 65).

This changes the collective F-signature of the safety program. However, you can verify that only the changed F-destination addresses have caused this change:

- The F-parameter signature (without address) for each changed F-I/O remains the same.
- Only the affected F-I/O DBs are listed in the comparison editor of the safety program with the filter set to "Compare only F-blocks relevant for certification".

1.9 First steps

Getting Started in SIMATIC Safety

Three Getting Started documents are available to help you begin using SIMATIC Safety.

The Getting Started documentation is an instruction manual that provides a step-by-step description of how to create a project with SIMATIC Safety. It gives you the opportunity to quickly become familiar with the scope of features of SIMATIC Safety.

Contents

The Getting Started documentation describes the creation of a single, continuous project that is extended with each section. Based on the configuration, you program a fail-safe shutdown, make changes to the programming, and accept the system.

In addition to the step-by-step instructions, the Getting Started documentation also gives you background information for every new topic, which explains the functions used in more detail and how they interrelate.

Target audience

The Getting Started documentation is intended for beginners but is also suitable for users who are switching from *S7 Distributed Safety*.

Download

Three Getting Started documents are available as PDF files for free download in the Industry Online Support:

- STEP 7 Safety Advanced V11 with S7-300/400 F-CPUs (http://support.automation.siemens.com/WW/view/en/49972838)
- STEP 7 Safety Basic V13 SP1 with S7-1200 F-CPUs (http://support.automation.siemens.com/WW/view/en/34612486/133300) (part of the manual "S7-1200 Functional Safety manual")
- STEP 7 Safety Advanced V13 with S7-1500 F-CPUs (http://support.automation.siemens.com/WW/view/en/101177693)

Configuring

2

2.1 Overview of Configuration

Introduction

You configure a SIMATIC Safety F-system basically in the same way as a standard S7-300, S7-400, S7-1200, S7-1500 or ET 200MP, ET 200SP, ET 200S, ET 200iSP, ET 200eco or ET 200pro automation system in *STEP 7.*

This section presents only the essential differences compared to standard configuration you encounter when configuring a SIMATIC Safety F-system.

This documentation distinguishes between two groups of F-I/O:

F-I/Os of PROFIsafe address type 1

F-I/Os which ensure the uniqueness of the PROFIsafe address solely with the F-destination address, for example, ET 200S F-modules. The PROFIsafe address is usually assigned by DIP switches.

F-I/Os of PROFIsafe address type 2

F-I/Os which can ensure the uniqueness of the PROFIsafe address with a combination of F-source address and F-destination address, for example, S7-1500/ET 200MP F-modules. The PROFIsafe address is usually assigned with *STEP 7 Safety*.

Which F-components can you configure with the *STEP 7 Safety* optional package?

The table below shows you which F-CPUs you can configure with *STEP 7 Safety Basic* and which with *STEP 7 Safety Advanced*:

F-CPUs	*STEP 7 Safety Basic*	*STEP 7 Safety Advanced*
S7-300	—	x
S7-400	—	x
S7-1200	x	x
S7-1500	—	x
WinAC RTX F	—	x
S7-1500 F Software Controller	—	x

The table below shows you which F-I/Os you can configure with *STEP 7 Safety Basic* and which with *STEP 7 Safety Advanced* as well as which PROFIsafe address type they support:

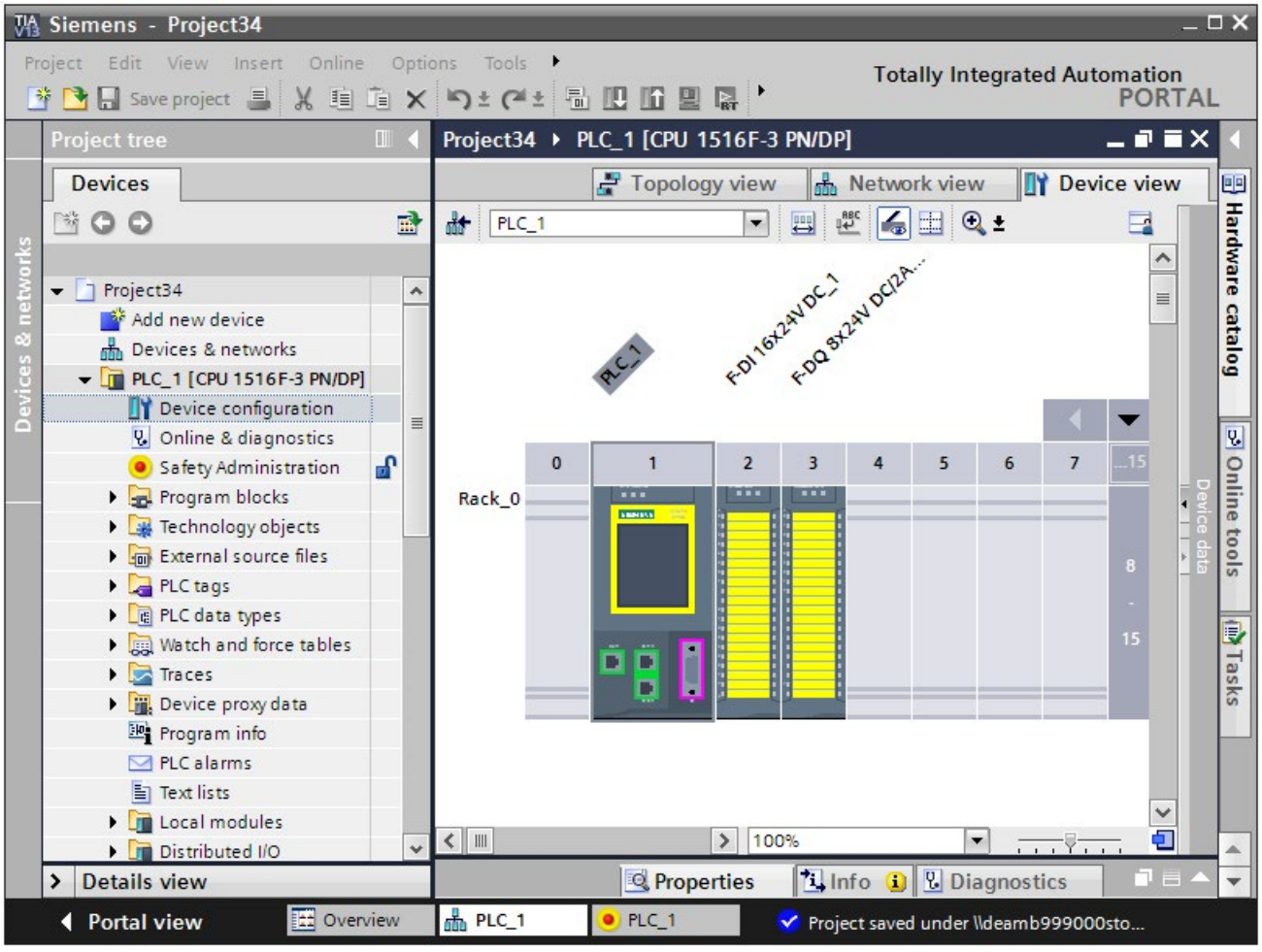
F-I/O	*STEP 7 Safety Basic*	*STEP 7 Safety Advanced*	*PROFIsafe address type*
S7-300 F-SMs	x**	x**	1
ET 200S F-modules	x	x	1
ET 200pro F-modules	x	x	1
ET 200iSP F-modules	x	x	1
ET 200eco F-I/O modules	—	with S7-300/400 F-CPUs	1
S7-1200 F-modules (centrally on S7-1200 F-CPUs)	x	x	2
ET 200SP F-modules	x	x	2
S7-1500/ET 200MP F-modules	x	x	2
fail-safe GSD based DP slaves	x	x	*
fail-safe GSD based I/O devices	x	x	*

* Consult the respective documentation to determine the PROFIsafe address type of a GSD based DP slave/GSD based I/O device. If in doubt, assume that the PROFIsafe address is type 1.

*** F-SMs that only support PROFIsafe V1 mode can only be used on F-CPUs S7-300/400.

Example: Configured F-system in *STEP 7 Professional*

The following figure presents a configured F-system. You choose the fail-safe components in the "Hardware catalog" task card as you would do with standard components and place them in the work area of the network or device view. F-components are shown in yellow.



Additional information

For detailed information on F-I/O, refer to the *manuals for the relevant F-I/O*.

Which safety-related communication options can you configure?

You need to use the *hardware and network editor* to configure the following safety-related communication options (see Configuring and programming communication (S7-300, S7-400) (Page 170) or Configuring and programming communication (S7-1200, S7-1500) (Page 229)):

- Safety-related master-master communication
- Safety-related master-master communication for S7 Distributed Safety
- Safety-related master-I-slave communication
- Safety-related I-slave-I-slave communication
- Safety-related I-slave-slave communication
- Safety-related IO controller-IO controller communication
- Safety-related IO controller-IO controller communication for S7 Distributed Safety
- Safety-related IO controller-I-device communication
- Safety-related IO controller-I-slave communication
- Safety-related communication via S7 connections
- Safety-related communication via S7 connections for S7 Distributed Safety or S7 F Systems

2.2 Particularities for configuring the F-System

Configuring is the same as for standard components

You configure a SIMATIC Safety F-system in the same way as a standard S7 system. This means that you configure and assign parameters for the hardware in the *hardware and network editor* in a centralized system (F-CPU and F-IO if required e.g. CPU 1516F-3 PN/DP and F-module S7-1500/ET 200MP) and/or as distributed system (F-CPU, F-SMs in ET 200M, F-module ET 200MP, F-module ET 200SP, ET 200S, ET 200pro, ET 200iSP, ET 200eco, fail-safe GSD based DP slaves and fail-safe GSD based I/O devices).

Special F-parameters

For the F-functionality there are special F-parameters that you can review and set in the "Properties" of the fail-safe components (F-CPU and F-I/O). F-parameters are marked in yellow.

F-parameters are explained in "Configuring an F-CPU (Page 44)" and "Configuring F-I/O (Page 49)".

Compiling the hardware configuration

You must compile the hardware configuration of the SIMATIC Safety F-system (shortcut menu "Compile > Hardware configuration"). A configured F-CPU with enabled F-capability is the only prerequisite for programming the safety program.

Note

Inconsistencies are possible when configuring the hardware and can also be saved. A full consistency check of the hardware configuration and possible connection data is performed only during compilation. Therefore, perform "Edit > Compile" regularly.

Changing safety-related parameters

Note

If you change a safety-related parameter (marked in yellow) for an F-I/O or an F-CPU, you must then compile the modified hardware configuration and the Compiling the safety program (Page 269) (shortcut menu "Compile > Hardware and software (only changes)") and download. This also applies for changes to the F-I/O which are not used in the safety program. F-I/O in standard operation is not affected by this.

2.3 Configuring an F-CPU

Introduction

You configure the F-CPU basically in the same way as a standard automation system.

F-CPUs are always configurable in *STEP 7*, regardless of whether or not the *STEP 7 Safety* optional package is installed. Without an installed optional package, however, the F-CPU can only be used as a standard CPU.

If the *STEP 7 Safety* optional package is installed, you can enable or disable the F-capability for the F-CPU.

If you want to use the F-I/O in safety mode or in safety-related communication, the F-capability of the F-CPU must be enabled.

F-capability is enabled by default after the *STEP 7 Safety* optional package is installed.

Enabling/disabling F-capability

If you want to modify the F-capability setting, proceed as follows:

1. Select the F-CPU in the device or network view, and select the "Properties" tab in the inspector window.
2. Select "Fail-safe" in the area navigation.
3. Use the appropriate button to enable/disable the F-capability.
4. If you want to disable F-capability, confirm the "Disable F-activation" dialog with "Yes".

Disabling F-capability for an existing safety program

If you want to disable the F-capability for an F-CPU because you intend to use the F-CPU as a standard CPU although a safety program is installed, you must note the following:

- You need the password for the safety program, if assigned.
- The Safety Administration Editor (Page 68) is deleted from the project tree.
- The F-OBs are deleted. (S7-1200, S7-1500)
- All F-blocks in the "Program blocks" folder are marked as not supported in the project tree ⊘. They can no longer be opened or compiled.

  All F-blocks within the "System blocks" folder are deleted.

  A warning is issued during the next compilation.
- From now on you cannot use F-I/O in safety mode with this F-CPU.

Configuring the F-parameters of the F-CPU

In the "Properties" tab of the F-CPU, you can change or apply the default settings for the following parameters:

- The F-destination address range
  - Low limit for F-destination addresses
  - High limit for F-destination addresses
- The default F-monitoring time for central or distributed F-I/O at the F-CPU

Note

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

Specify F-destination address for F-I/O of PROFIsafe address type 1

With the parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" you specify a range for this F-CPU in which the F-destination address of newly inserted F-I/Os of PROFIsafe address type 1 (Page 56) is assigned automatically. An F-destination address that is not within the F-destination address range yet, is also reassigned when you reassign a DP slave/IO device with the F-CPU or switch on the F-activation of the F-CPU.

The F-destination address is assigned in ascending order starting at the "Low limit for F-destination addresses". When no free F-destination address is available in the F-destination address range, the next available free F-destination address outside the F-destination address range is assigned and a warning is output during compilation.

The maximum possible F-destination address for ET 200S, ET 200eco, ET 200pro, ET 200iSP F-modules and S7-300 F-SMs is 1022.

The F-destination addresses for F-I/O of PROFIsafe address type 1 must be unique network-wide and CPU-wide.

By selecting different F-destination address ranges for different F-CPUs, you can define different ranges for the automatic assignment of the F-destination address. This is useful when you are operating multiple F-CPUs in one network. Subsequent manual address changes are possible. (see also Recommendation for PROFIsafe address assignment (Page 53))

Example:

You have configured the F-destination address range as follows:

- Low limit for F-destination addresses = 100
- High limit for F-destination addresses = 199

When inserting the first F-I/O of PROFIsafe address type 1, the F-destination address 100 is assigned. When inserting an additional F-I/O of PROFIsafe address type 1, the F-destination address 101 is assigned.

Note

The parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" have no effect on the following F-I/Os:

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 bit (article number 6ES7336-1HE00-0AB0)

Specify F-destination address for F-I/O of PROFIsafe address type 2

The F-destination address of F-I/O of PROFIsafe address type 2 (Page 58) is assigned automatically for each F-CPU in descending order starting with 65534. The low limit is the value configured with the parameter "Low limit for F-destination addresses" (for F-I/O of PROFIsafe address type 1) + 1.

When the value configured with the "High limit for F-destination addresses" parameter is reached, a warning is output during compilation. (See also Recommendation for PROFIsafe address assignment (Page 53))

Specify F-source address for F-I/O of PROFIsafe address type 2

You specify the F-source address for F-I/O of PROFIsafe address type 2 (Page 58) assigned to this F-CPU with the "Central F-source address" parameter. The F-source address must be unique throughout the network. (see also Recommendation for PROFIsafe address assignment (Page 53))

Note

A change to the "Central F-source address" parameter results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required because the F-source addresses of all F-I/Os of address type 2 are changed centrally by this step.

"Default F-monitoring time" parameter

Configure the "Default F-monitoring time" for monitoring the communication between the F-CPU and F-I/O.

You can adjust the F-monitoring time via the following parameters:

- "Default F-monitoring time for central F-I/O"
- "Default F-monitoring time for F-I/O of this interface"

The **default F-monitoring time for the central F-I/O** acts on the F-I/O that is arranged centrally, i.e. near the F-CPU. You set this parameter in the properties of the F-CPU (select F-CPU, then select "Properties > Fail-safe > F-parameters").

The **default F-monitoring time for the F-I/O of this interface** acts on the F-I/O that is assigned to this interface of the F-CPU (PROFIBUS or PROFINET). You change this parameter in the properties of the relevant interface (selection of the interface in the "Device view" tab, then "F-parameters").

The various settings available allow you to flexibly adapt the F-monitoring time to the conditions of your F-system, for example to take account of different bus cycles.

You can also change the F-monitoring time individually for each F-I/O in the F-I/O properties (see Configuring F-I/O (Page 49) or Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 65)).

Note

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

You can find additional information in Monitoring and response times (Page 530).

Automatic generation of the safety program

The safety program of an F-CPU consists of one or two F-runtime groups that contain the F-blocks (see also Defining F-Runtime Groups (Page 109)). When the F-CPU (with activated F-capability) is inserted into the work area of the device view or network view, a safety program with an F-runtime group is generated automatically.

You can define in *STEP 7 Safety* that no F-runtime group is generated while inserting the F-CPU (with activated F-capability).

Proceed as follows:

1. Select the "Options > Settings" menu command.
2. Select the "STEP 7 Safety" area.
3. If it is not already disabled, disable automatic generation of an F-runtime group by deselecting the "Generate default fail-safe program" option.

This change has no influence on any existing safety programs; it only defines whether an F-runtime group is automatically generated for each one of the subsequently inserted F-CPUs.

Configuring the protection level of the F-CPU

WARNING

(S7-300, S7-400) In safety mode, access with the CPU password must not be authorized during changes to the standard user program as this would also allow changes to the safety program. To rule out this possibility, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU. If only one person is authorized to change the standard user program and the safety program, the protection level "Write protection" or "Read/write protection" should be configured so that other persons have only limited access or no access at all to the entire user program (standard and safety programs).*(S001)*

WARNING

(S7-1200, S7-1500) In safety mode, the safety program must be password-protected. For this purpose, configure at least the protection level "Full access (no protection)" and assign a password under "Full access incl. fail-safe (no protection)". This protection level only allows full access to the standard user program, not to F-blocks.

If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".

Assign different passwords for the individual protection levels. *(S041)*

You configure the protection level following the same procedure as for standard CPUs.

For information on the password for the F-CPU, refer to Access protection (Page 80). Pay special attention to the warnings in Access protection for the F-CPU (Page 86).

2.4 Configuring F-I/O

Introduction

You configure the S7-1500/ET 200MP, ET 200SP, ET 200S, ET 200eco (S7-300, S7-400), ET 200pro and ET 200iSP F-modules, the S7-300 F-SMs and the S7-1200 F-modules as usual in *STEP 7*.

After you have inserted the F-I/O in the work area of the *device or network view*, you access the configuration dialogs by selecting the relevant F-I/O and the "Properties" tab.

Note

Changes to the parameter assignment result in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

The use of ET 200SP F-modules is possible with IM155-6PN ST as of firmware V1.1, IM155-6PN HF and IM155-6DP HF.

The distributed use of S7-1500/ET 200MP F-modules is possible with IM 155-5 PN ST as of firmware V3.0, IM 155-5 PN HF as of firmware V2.0 and IM 155-5 DP ST as of firmware V3.0.

The central use of S7-1500/ET 200MP F-modules is possible with S7-1500 F-CPUs as of firmware V1.7, distributed use as of firmware V1.5.

(S7-1200) We recommend you limit the total number of F-I/Os that are used centrally or distributed in an S7-1200 F-CPU to 12. Depending on the volume of project data, the maximum number of F-I/Os can be smaller.

⚠ WARNING

When you make changes in which the assignment of input/output addresses and wiring can change, then you must perform a wiring test.

Examples for such changes are:

- Adding F-I/O
- Changing the start address of F-I/O
- Changing the slot position of F-I/O
- Changing
  - the rack
  - the slave/device address
  - the PROFIBUS DP/PROFINET IO subnet
  - the IP address
  - the device name

(S071)

Channel-granular passivation after channel faults

You can configure how the F-I/O will respond to channel faults, such as a short-circuit, overload, discrepancy error, or wire break, provided the F-I/O supports this parameter (e.g. for ET 200S or ET 200pro F-modules). You configure this response in the properties for the relevant F-I/O ("Behavior after channel fault" parameter). This parameter is used to specify whether the entire F-I/O or just the faulty channel(s) are passivated in the event of channel faults.

Note

(S7-300, S7-400) Note that channel-granular passivation increases the runtime of the F-runtime group(s) compared to passivation of the entire F-I/O (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).

"Channel failure acknowledge" parameter (S7-1200, S7-1500)

For S7-1500/ET 200MP F-modules and S7-1200 F-modules, the "Channel failure acknowledge" parameter replaces the ACK_NEC tag of the F-I/O DB.

If an F-I/O fault is detected by the F-I/O, passivation of all channels of the relevant F-I/O occurs. If channel faults are detected, the relevant channels are passivated if "Passivate channel" is configured. If "Passivate the entire module" is configured, all channels of the relevant F-I/O are passivated. Once the F-I/O fault or channel fault has been eliminated, reintegration of the relevant F-I/O occurs in line with the "Channel failure acknowledge" parameter.

- Automatically
- Manually

⚠ WARNING

The parameter assignment "Channel failure acknowledge = Automatic" is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint.*(S045)*

Note

The default assignment for the "Channel failure acknowledge" parameter when the F-module is created is "Manually".

Organization block/Process image (S7-1200, S7-1500)

If you use F-I/O in standard mode, you can select the organization block/process image as you do for standard I/O.

If you use F-I/O in safety mode, no selection is possible. The process image is updated at the beginning or end of the F-OB (see section Program structure of the safety program (S7-1200, S7-1500) (Page 93)).

Changing the name and number of the F-I/O DB

The name and number of the F-I/O DB (Page 135) are assigned automatically when the F-I/O is configured. The name of the F-I/O DB contains the start address and the name of the F-I/O. You can change the number in the properties of the F-I/O. You can change the name of the F-I/O DB indirectly by changing the name of the F-I/O.

You can find information on the assignment of number ranges in *Safety Administration Editor*, "Settings" area (Page 75).

Customizing the F-monitoring time for F-I/O

You can customize the F-monitoring time in the properties of the F-I/O under "F-parameters". This may be necessary to prevent a timeout being triggered when no error occurs and the F-I/O requires a longer F-monitoring time or assignment with a default F-monitoring time is not possible. For this purpose, activate the corresponding check box and assign an F-monitoring time.

Note

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

You can find additional information in Monitoring and response times (Page 530).

Group diagnostics for fail-safe S7-300 signal modules

By disabling a channel of the fail-safe signal module in the module properties, you also disable the group diagnostics for this channel.

Exception for S7-300/400 F-CPUs:

For the following S7-300 fail-safe signal modules

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0) and
- SM 336; AI 6 x 13Bit (article number 6ES7336-1HE00-0AB0)

the "Group diagnostics" parameter enables and disables the monitoring of channel-specific diagnostic messages of F-SMs (such as wire break and short-circuit) to the F-CPU. You should disable group diagnostics for **unused** input or output channels.

WARNING

(S7-300, S7-400) For the following S7-300 fail-safe signal modules (F-SMs) with activated safety mode, "Group diagnostics" must be enabled for all connected channels:

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 Bit (article number 6ES7336-1HE00-0AB0)

Check to verify that you have only disabled group diagnostics for these F-SMs for input and output channels that are actually unused. *(S003)*

Diagnostic interrupts can be enabled optionally.

Additional information

For detailed description of the **parameters**, refer to the help on the properties of the respective F-I/O and in the respective *manual for the F-I/O*.

2.5 Configuring shared device

To configure shared devices follow the procedure as in the standard. The configuration is described in the STEP 7 online help under "Configuring shared devices".

F-destination addresses

Please also read the chapter "Recommendation for PROFIsafe address assignment (Page 53)“ for assigning the F-destination address.

See also

Assign PROFIsafe address to an F-module (Page 63)

2.6 Recommendation for PROFIsafe address assignment

Before inserting the F-I/O, specify an address range for each F-CPU for the F-destination addresses of the F-I/O of PROFIsafe address type 1 (Page 56) that does not overlap with the address range of any other F-CPU network-wide or CPU-wide (system-wide). You define the range for F-I/Os of PROFIsafe address type 1 with the parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" (see also section Configuring an F-CPU (Page 44)).

The F-destination addresses of F-I/O of PROFIsafe address type 2 (Page 58) must not overlap with any address range of the F-I/O of PROFIsafe address type 1. The ranges of the F-destination addresses of the F-I/O of PROFIsafe address type 2 may overlap if the F-source addresses are different. This is the case for supported configurations (Page 54) if the "Central F-source address" parameter has been set differently for each F-CPU.

Assign relatively low F-destination addresses for F-I/O of PROFIsafe address type 1 and relatively high F-destination addresses for F-I/O of PROFIsafe address type 2.

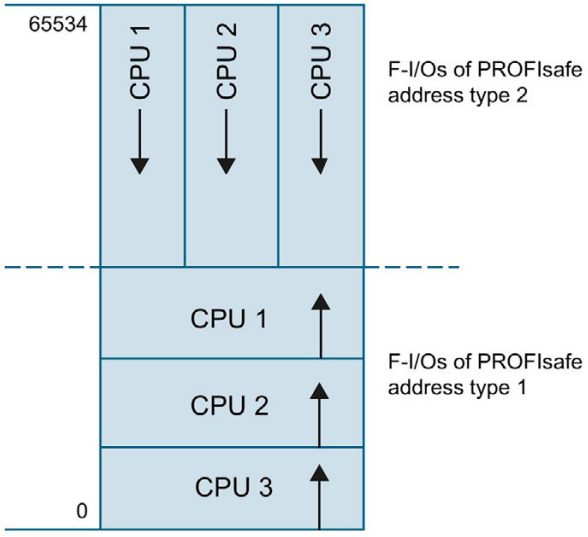


Figure 2-1 Address assignment for F-I/O of PROFIsafe address types 1 and 2

The safety summary (Page 310) lists the following information for each F-CPU:

- "Central F-source address" parameter (F-source address for F-I/O of PROFIsafe address type 2)
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 1
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 2

Any F-I/O configured using I-slave-slave communication is taken into consideration in the safety summary as part of the F-destination address range of the I-slave.

Any F-I/O configured in a shared device is taken is specified in the safety summary as part of the F-destination address range of the F-CPU to which this F-I/O is assigned.

2.7 Configurations supported by the SIMATIC Safety F-system

Supported configurations

F-I/Os (see Overview of Configuration (Page 39)) are supported in the following configurations:

central configuration (also I-slave):

- The F-I/O is in the same rack as the associated F-CPU.
- The F-I/O is located in a subrack of the rack of the associated F-CPU.

distributed configuration (at integrated DP-/PN interface of the CPU or at CP/CM):

- PROFIBUS (also after IE/PB link)
  - The F-I/O is located on a DP Slave.
  - The F-I/O is located on a DP Slave and is addressed via I-slave-slave communication. The assigned DP master (of the assigned IO controller of the IE/PB link) can be a standard CPU or an F-CPU.
- PROFINET IO
  - The F-I/O is located on an IO Device.
  - The F-I/O is located in a shared device.

For F-I/O not listed in "Overview of Configuration (Page 39)", please check the relevant documentation to see whether it is supported by the SIMATIC Safety F-system. If in doubt, treat these F-I/Os as part of a configuration that is not supported.

Checks performed by the SIMATIC Safety F-system

For supported configuration, the F-system checks:

- Whether the PROFIsafe operating mode parameter (F_Par_Version) is set to V2 mode in the PROFINET IO environment**.
- Whether the F-destination addresses have been assigned uniquely CPU-wide.
  You yourself must ensure the network-wide uniqueness of the PROFIsafe address.
- Whether the F-source address for the F-I/O of PROFIsafe address type 2 corresponds to the "Central F-source address" parameter of the F-CPU.

⚠ WARNING

Please note the following with configurations that are not included in supported configurations:

- Make sure that the F-I/O of this configuration appears in the safety summary and that an F-I/O DB has been created for it. Otherwise, you cannot use the F-I/O in this configuration. (Contact Customer Support.)
- For F-I/Os in the PROFINET IO environment**, you must check the PROFIsafe operating mode parameter (F_Par_Version) against the safety summary to make sure that it is correct. V2 mode must be set in the PROFINET IO environment. F-I/O which only support V1 mode may not be used in the PROFINET IO environment.
- You must ensure that PROFIsafe address assignment is unique CPU-wide* and network-wide***:
  - Check the correctness of the PROFIsafe addresses with the help of the safety summary.
  - Use the safety summary to check that the F-source address corresponds to the "Central F-source address" parameter of the F-CPU for F-I/O of PROFIsafe address type 2.
  - For F-I/O of PROFIsafe address type 1 or if you cannot set the F-source address in accordance with the "Central F-source address" parameter of the F-CPU, you will have to ensure the uniqueness of the PROFIsafe address solely by assigning a unique F-destination address.

  You must check the uniqueness of the F-destination address individually for each F-I/O based on the safety summary in a configuration that is not supported. (see Completeness and correctness of the hardware configuration (Page 314)) *(S050)*

* "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

** The F-I/O is located in the "PROFINET IO environment" if at least part of safety-related communication with the F-CPU takes place via PROFINET IO. If the F-I/O is connected via I-slave-slave communication, also keep in mind the communication line to the DP master/IO controller.

*** A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

2.8 PROFIsafe addresses for F-I/O of PROFIsafe address type 1

F-destination address

The uniqueness of the PROFIsafe address is ensured solely with the F-destination address. The F-source address has no effect on whether or not the PROFIsafe address is unique.

Therefore, the F-destination address must be unique network-wide and CPU-wide (see the following rules for address assignment).

To prevent incorrect parameter assignment, an F-destination address which is unique CPU-wide is automatically assigned during placement of the F-I/O in the work area of the device or network view as long as you only configure supported configurations (Page 54).

To ensure a network-wide unique F-destination address assignment when multiple DP master systems and PROFINET IO systems are operated on one network, you must set the "Low limit for F-destination addresses" and "High limit for F-destination addresses" in the properties of the F-CPU in SIMATIC Safety F-systems appropriately, before placing the F-I/O (see section "Recommendations for address assignment") so that the F-destination address ranges do not overlap.

When you change the F-destination address of an F-I/O, the CPU-wide uniqueness of the F-destination address is checked automatically for supported configurations. You yourself must ensure the network-wide uniqueness of the F-destination address.

For ET 200S, ET 200eco (S7-300, S7-400), ET 200pro, and ET 200iSP F-modules and S7-300 F-SMs:
You must set the F-destination address at the F-I/O with the DIP switch before you install the F-I/O. You can assign up to 1022 different F-destination addresses.

Note

(S7-300, S7-400) For the following fail-safe S7-300 signal modules, the F-destination address is the start address of the F-SM divided by 8:

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 Bit (article number 6ES7336-1HE00-0AB0)

You can show the columns "F-source address" and "F-destination address" in the device view of the device overview. The addresses displayed in these columns are for information purposes only. You have to check the F-destination addresses in the safety summary when you accept the system.

Rules for address assignment

⚠ WARNING

F-I/Os of PROFIsafe address type 1 are uniquely addressed by their F-destination address (e.g. with the switch setting on the address switch).

The F-destination address (and therefore also the switch setting on the address switch) of the F-I/O must be unique network-wide* and CPU-wide** (system-wide) **for the entire** F-I/O. The F-I/O of PROFIsafe address type 2 must also be considered. *(S051)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

Please also note Recommendation for PROFIsafe address assignment (Page 53).

See also

Completeness of the safety summary (Page 310)

2.9 PROFIsafe addresses for F-I/O of PROFIsafe address type 2

F-source address and F-destination address

The uniqueness of the PROFIsafe address is ensured by the combination of F-source address and F-destination address.

The PROFIsafe address must be unique network-wide and CPU-wide. This is the case if the following two conditions are met:

- The F-source address ("Central F-source address" parameter) of the F-CPU is unique network-wide. Keep this in mind for changes.
- The F-destination address of the F-module is unique CPU-wide.

You define the F-source address using the "Central F-source address" parameter in the F-CPU. Provided you only configure supported configurations (Page 54), this parameter is automatically applied as the F-source address and a CPU-wide unique F-destination address is assigned (usually in descending order starting with 65534).

When you change the F-destination address, the CPU-wide uniqueness of the F-destination address is checked automatically for supported configurations.

You must assign the F-source address and F-destination address to the F-I/O before you commission the F-I/O. You can find additional information in Assigning PROFIsafe address to fail-safe modules with SIMATIC Safety (Page 60).

You can show the columns "F-source address" and "F-destination address" in the device view of the device overview. The addresses displayed in these columns are for information purposes only. You have to check the F-source and F-destination addresses in the safety summary when you accept the system.

Rules for address assignment

⚠ WARNING

FI/O of PROFIsafe address type 2 is uniquely addressed using a combination of F-source address ("Central F-source address" parameter of the assigned F-CPU) and F-destination address.

The combination of F-source address and F-destination address for each F-I/O must be unique network-wide* and CPU-wide** (system-wide). In addition, the F-destination address may not be occupied by F-I/O of PROFIsafe address type 1.

To ensure that addresses are unique across F-CPUs for supported configurations (Page 54), you need to ensure that the "Central F-source address" parameter of all F-CPUs is unique network-wide*. This is achieved through different settings for the "Central F-source address" parameter of the F-CPUs. *(S052)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

Please also note Recommendation for PROFIsafe address assignment (Page 53).

See also

Completeness of the safety summary (Page 310)

2.10 Setting the F-destination address for F-I/O with DIP switches

Information on how to set the F-destination address for F-I/O with DIP switches is available in the documentation of the respective F-I/O.

2.11 Assigning PROFIsafe address to fail-safe modules with SIMATIC Safety

Introduction

Fail-safe ET 200SP modules, fail-safe S7-1500/ET 200MP modules and fail-safe S7-1200 modules do not have a DIP switch that allows you to set the unique F-destination address for each module. Instead, you assign the PROFIsafe address (Page 54) consisting of F-source address and F-destination address directly from *STEP 7 Safety* for fail-safe ET 200SP modules and fail-safe S7-1500/ET 200MP modules. The PROFIsafe addresses for S7-1200 F-modules are automatically assigned during download of the hardware configuration.

In the following cases it is necessary to reassign the addresses of the fail-safe ET 200SP and fail-safe S7-1500/ET 200MP modules:

- Later placement of a fail-safe module during initial commissioning
- Intentional modification of the F-destination address
- Modification of the "Central F-source address" parameter for the associated F-CPU (changes the F-source address).
- Replacement of the coding element
- Commissioning of a mass-produced machine

In the following cases it is not necessary to reassign the addresses of the fail-safe ET 200SP and fail-safe S7-1500/ET 200MP modules:

- Power On/Off
- Replacement of an F-module (repair) without PG/PC
- Replacement of the BaseUnit
- Replacement of a BaseUnit without coding element
- Changes in the design in case a new BaseUnit is inserted in front of a fail-safe module
- Repair/replacement of the interface module

Basic procedure

Note

Assigning the PROFIsafe address for S7-1200 fail-safe modules

The procedure described below for identifying and assigning the PROFIsafe addresses is not required for S7-1200 fail-safe modules.

Note that an S7-1200 F-CPU must not include an additional unconfigured F-module.

1. Configure the F-destination address (Page 58) and F-source address in the hardware configuration in *STEP 7 Safety*.
2. Identify the ET 200SP or S7-1500/ET 200MP F-modules to which you want to assign the configured F-destination addresses (together with the F-source address).
3. Assign the PROFIsafe address to the F-modules.

2.11.1 Identifying F-modules

Requirement

The following requirements must be met:

- The F-CPU and fail-safe modules are configured.
- The hardware configuration has been downloaded.
- When using an ET 200SP Open Controller, the hardware configuration of the ET 200SP Open Controller **and** of the fail-safe software controller must be downloaded.
- The F-CPU and fail-safe modules can be reached online.

⚠ WARNING

Make sure that the latest hardware configuration has been downloaded to the F-CPU before identification.

Clicking "Identification" confirms the fail-safe correctness of the PROFIsafe addresses for the fail-safe modules.

Therefore, proceed carefully when confirming the F-modules by LED flashing or the serial number of the F-CPU with central fail-safe modules or the serial number of the interface module with fail-safe modules. *(S046)*

Procedure

Proceed as follows to identify the F-modules:

1. Establish an online connection to the F-CPU with which the fail-safe modules are operated.
2. In the network view, select the F-CPU with fail-safe modules or the interface module with the fail-safe modules to which you want to assign the PROFIsafe address.
3. Select "Assign PROFIsafe address" from the shortcut menu.
4. Under "Assign PROFIsafe address by", select the method to be used for identifying the F-modules.
   - "Identification by LED flashing"

     This is the default setting. The DIAG and STATUS LEDs of the F-modules to be identified flash upon identification.
   - "Identification by serial number"

     If you cannot see the fail-safe modules directly, you can identify the fail-safe modules by the serial number of the F-CPU or interface module.

     Note

     The displayed serial number may be amended with a year number compared to the serial number printed on the interface module. The serial numbers are nevertheless identical.

     Note

     Determining the serial number of an ET 200SP Open Controller

     When you use the ET 200SP F-modules centrally on an ET 200SP Open Controller and identify them by the serial number, then read the serial number in the display of the fail-safe S7-1500 software controller in the menu "Overview > CPU".
5. In the "Assign" column, select all the F-modules to which you want to assign the PROFIsafe address.

   If you select the F-CPU or the interface module in the "Assign" column, all F-modules of the station are selected.
6. Click the "Identification" button. Check whether the DIAG and STATUS LEDs for the F-modules whose PROFIsafe address you want to assign are flashing green. If you identify using the serial number, compare the displayed serial number to the serial number of the F-CPU with central fail-safe modules or the interface module with fail-safe modules.
7. If you have configured more S7-1500/ET 200MP fail-safe modules than exist online, a dialog is displayed. Enter the number of S7-1500/ET 200MP fail-safe modules actually existing in this dialog and confirm the dialog.

   If you have configured fewer S7-1500/ET 200MP fail-safe modules than exist online, the online-offline difference is shown and the assignment of the PROFIsafe address is not possible.

2.11.2 Assign PROFIsafe address

Requirement

The F-modules have been successfully identified.

Procedure

To assign an F-destination address, proceed as follows:

1. Use the "Assign PROFIsafe address" button to assign the PROFIsafe address to the fail-safe modules. You may have to enter the password of the F-CPU.

   You must acknowledge the "Acknowledge assignment" dialog within 60 seconds to assign the PROFIsafe address.

2.11.3 Assign PROFIsafe address to an F-module

Introduction

In the "Assign PROFIsafe address" dialog only the F-modules which are assigned to an F-CPU of this project are offered, as the PROFIsafe address of an F-module in a shared device can only be assigned from a project in which the F-CPU to which the F-modules are assigned is located.

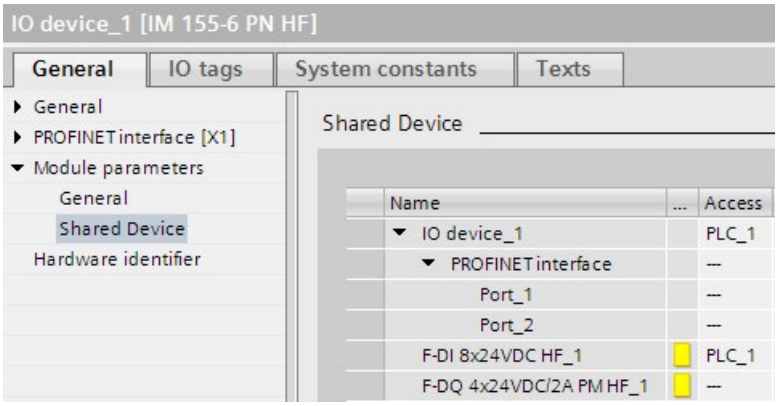
Requirement

Requirement for assignment of the PROFIsafe address is that you have downloaded the hardware configuration completely to the F-CPU. When you have assigned the F-modules in a shared device to multiple F-CPUs, you must first download the hardware configuration of all F-CPUs involved before you assign the PROFIsafe addresses.

For the assignment of the PROFIsafe addresses of the F-modules to work, the associated interface module must be assigned to the corresponding F-CPU during assignment.

Procedure for assignment of the PROFIsafe addresses with the "Shared Device" function.

1. Switch all F-CPUs in the shared device to STOP.
2. Assign the interface module to the F-CPU to which the F-modules to which you want to assign the PROFIsafe address are assigned.



3. Compile the hardware configuration.
4. Download the hardware configuration **without** starting the F-CPU.
5. Assign the PROFIsafe addresses to the F-modules assigned to the F-CPU.
6. If you want to assign additional PROFIsafe addresses to F-modules that are assigned to other F-CPUs, proceed as follows:
   - Undo the assignment you made under 2.
   - Then compile the hardware configuration.
   - Download the hardware configuration **without** starting the F-CPU.
7. Repeat steps 2 to 6 to assign the PROFIsafe addresses to the F-modules that are assigned to other F-CPUs.
8. Restore the original configuration, compile and download it.

See also

Identifying F-modules (Page 61)

Assign PROFIsafe address (Page 63)

Configuring shared device (Page 52)

2.11.4 Changing the PROFIsafe address

Changing the PROFIsafe address

Note

Keep in mind that after changing the PROFIsafe address of an F-I/O you must also conduct an acceptance (Page 314) including check of your change (Page 323) per safety summary (Page 291).

1. You change the PROFIsafe address (F-destination address, F-source address) in the hardware configuration.
2. Compile the hardware configuration.
3. Download the hardware configuration to the F-CPU.
4. Select "Assign PROFIsafe address" from the shortcut menu.
5. Proceed as described under Identifying F-modules (Page 61) and Assign PROFIsafe address (Page 63).

2.12 Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices

Requirement

In order to use fail-safe GSD based DP slaves for SIMATIC Safety, these GSD based slaves must be operated on PROFIBUS DP and support the PROFIsafe bus profile. When used in an S7-1200/1500 F-CPU, they must support the PROFIsafe bus profile in V2 mode.

Fail-safe GSD based DP slaves used in hybrid configurations on PROFIBUS DP and PROFINET IO downstream from a IE/PB link must support the PROFIsafe bus profile in V2 mode.

In order to use fail-safe GSD based I/O devices for SIMATIC Safety, the GSD based devices must be operated on PROFINET IO and support the PROFIsafe bus profile in V2 mode.

Configuration with GSD files

As is the case in a standard system, the basis for configuring fail-safe GSD based DP slaves/IO devices is the device specification in the GSD file (device master file).

A GSD file contains all of the properties of a GSD based DP slave or GSD based I/O device. For fail-safe GSD based DP slaves/GSD based I/O devices, certain parts are protected by a CRC.

The GSD files are supplied by the device manufacturers.

Protection of the data structure of the device in GSD files

The only GSD files supported are those that satisfy the requirements for protection defined as of *PROFIsafe Specification* V2.0 using a CRC stored in this file ("desired value" for F_IO_StructureDescCRC).

The data structure described in the GSD file is checked when the F-I/O is added to the hardware configuration and when the hardware configuration is compiled. When an error is detected, you should clarify whether the GSD file provided by the device manufacturer contains the desired value for F_IO_StructureDescCRC.

Assignment and setting of the PROFIsafe address

⚠ WARNING

Check the documentation for your fail-safe GSD based DP slaves / GSD based I/O devices to find out the valid PROFIsafe address type. If you do not find the necessary information, assume PROFIsafe address type 1. Proceed as described under PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 56) or PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 58).

Set the PROFIsafe source address for fail-safe GSD based DP slaves / GSD based I/O devices according to the manufacturer's specifications. If the F-source address needs to correspond to the "Central F-source address" parameter of the F-CPU (PROFIsafe address type 2), you will find the latter in the "Properties" tab of the F-CPU. In this case, also check in the safety summary that the value of the F-CPU for the "Central F-source address" parameter matches the value of the F-source address of the fail-safe GSD based DP slave / fail-safe GSD based I/O device. *(S053)*

Configuration procedure with GSD files

You import the GSD files to your project (see *Help on STEP 7 "GSD files"*).

1. Select the fail-safe GSD based DP slave / GSD based I/O device in the "Hardware catalog" task card and connect it to the relevant subnet in the network view.
2. Select the fail-safe GSD based DP slave/GSD based I/O device and insert the necessary F-modules, if this does not occur automatically.
3. Select the relevant F-module and open the "Properties" tab in the inspector window.

For fail-safe GSD based DP slaves/GSD based I/O devices (contrary to other F-I/O), the "Manual assignment of the F-monitoring time" parameter is enabled. The result is that the value specified in the GSD file for the F-monitoring time is used as default value when the slaves/devices are plugged. You can change both values (time and type of assignment) later manually.

F-parameter "F_CRC_Seed" and "F_Passivation" for fail-safe GSD based I/O devices

The F-parameters "F_CRC_Seed" and "F_Passivation" influence the behavior of a fail-safe GSD based I/O device. The combination of the F-parameters cannot be set but is specified by selecting a corresponding F-module. Up to three F-module variants can be used, depending on the S7-300/400 or S7-1200/1500 F-CPU used.

F-module variant	F_CRC_Seed	F_Passivation	Behavior of the fail-safe GSD based I/O device	Can be used with F-CPU
1	Parameter does not exist	Parameter does not exist	The GSD based I/O device works with the Basic Protocol (BP) from PROFIsafe. The "RIOforFA-Safety" profile is not supported.	S7-300/400/1200/1500*
2	CRC-Seed24/32	Device/module	The GSD based I/O device works with the Expanded Protocol (XP) from PROFIsafe. The "RIOforFA-Safety" profile is not supported.	S7-1200/1500
3	CRC-Seed24/32	Channel	The GSD based I/O device works with the Expanded Protocol (XP) from PROFIsafe. The "RIOforFA-Safety" profile is supported.	S7-1200/1500

* Only use the F-module variant 1 with S7-1200/1500 F-CPUs if neither F-module variant 2 nor 3 exists.

Additional information

You can find the description of the parameters in the Help on fail-safe GSD based DP slaves and GSD based I/O devices.

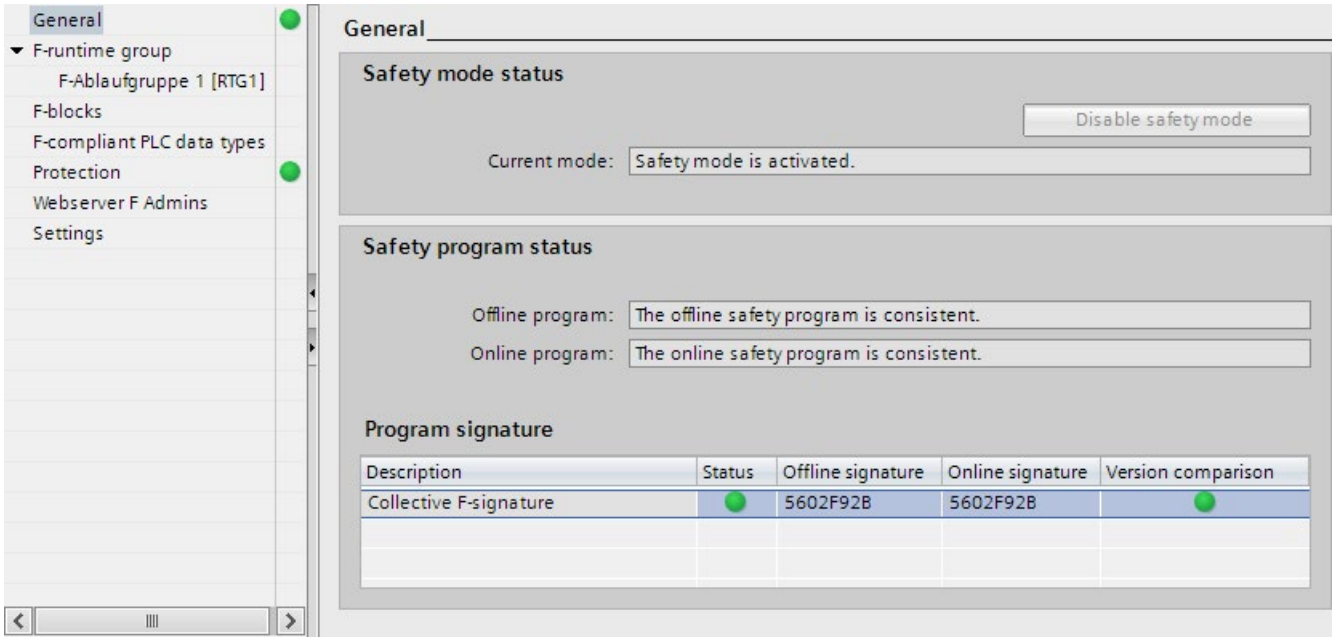
Safety Administration Editor

3

Overview

The *Safety Administration Editor* supports you as follows:

- Displaying of status of the safety program
- Displaying of collective F-signature
- Displaying of status of safety mode
- Creating and organizing of F-runtime groups
- Displaying information on the F-blocks
- Displaying information about F-compliant PLC data types (UDT)
- Information for users with F-Admin permission
- Specifying/changing access protection
- Set/modify settings for the safety program, e.g. Enable F-change history



The *Safety Administration Editor* is divided into the following areas:

- General

  Under "General", the status of safety mode, the safety program, and the collective F-signature are displayed to you. Additional information on the "General" area can be obtained in ""General" area (Page 70)".

- F-runtime groups

  A safety program consists of one or two F-runtime groups. Under "F-runtime groups", you determine the blocks and properties of an F-runtime group.

  General information on F-runtime groups can be found in "Program structure of the safety program (S7-1200, S7-1500) (Page 93)" and "Program structure of the safety program (S7-300, S7-400) (Page 91)".

  Information on the creation of F-runtime groups can be obtained under "Defining F-Runtime Groups (Page 109)".

- F-blocks

  Under "F-blocks", you can find information on the F-blocks used in your safety program and their properties . Additional information on the "F-blocks" area can be obtained in ""F-blocks" area (Page 73)".

- F-compliant PLC data types

  Under "F-compliant PLC data types", you obtain information on the created F-compliant PLC data types (UDT). There you also obtain information whether or not an F-compliant PLC data type (UDT) is used in the safety program. Additional information on "F-compliant PLC data types" can be found in ""F-compliant PLC data types" area (S7-1200, S7-1500) (Page 74)".

- Access protection

  Under "Access protection", you can set up, change, or revoke the password for the safety program. Access protection is mandatory for productive operation. Additional information on access protection can be found in "Access protection for the safety program (Page 83)".

- Web server F-Admins

  Under "Web server F-admins", you obtain information on users with the F-Admin attribute for the Web server of the F-CPU. Additional information on the "Web server F-Admins" area can be obtained in ""Web server F-Admins" area (S7-1200, S7-1500) (Page 75)".

- Settings

  Under "Settings", you set the parameters for the safety program. Information on the settings for your safety program can be found in ""Settings" area (Page 75)".

3.1 Opening the Safety Administration Editor

Requirement

The *Safety Administration Editor* is visible as an element in the project tree, if you have configured a CPU as an F-CPU in the project, which means the "F-capability activated" option must be selected (in the properties of the F-CPU).

Procedure

To open the *Safety Administration Editor*, follow these steps:

1. Open the folder for your F-CPU in the project tree.
2. Double-click on "Safety administration" or right-click and select the corresponding shortcut menu for the *Safety Administration Editor*.

Result

The *Safety Administration Editor* for your F-CPU opens in the work area.

3.2 "General" area

"Safety mode status"

The "Safety mode status" shows the current status of safety mode. The prerequisite is an existing online connection to the selected F-CPU.

The following statuses are possible:

- "Safety mode is activated"
- "The safety mode is not activated"
- "F-CPU is in STOP"
- "F-CPU is in RUN but no safety program exists"
- "No active F-CPU available"
- "Unknown"
- "F-runtime group was not called"
- "The safety program is not called"
- "Safety program status changing"
- "(No online connection)"

"Disable safety mode"

For existing online connection and active safety mode operation, you have the option of using the "Disable safety mode" button to disable safety mode for the selected F-CPU. Safety mode can be deactivated only for the entire safety program and not for individual F-runtime groups.

Requirement: "Safety mode can be disabled" is selected in the "Settings" area.

Proceed as follows:

1. Click the "Disable safety mode" button.
2. Enter the password for the safety program in the dialog window and confirm with "OK".
3. A corresponding dialog will display the collective F-signature.
4. Using the displayed collective F-signature, verify that you have selected the desired F-CPU.
5. If you have selected the correct F-CPU, confirm the dialog with "Yes".

Result: Safety mode for the F-CPU is disabled.

"Safety program status"

"Safety program status" displays the current status of your online and offline program.

The following statuses are possible:

- Consistent (with information if no password has been assigned.)
- Inconsistent
- Modified

If no connection to the online program could been established, the message "(no online connection) " will be shown.

"Program signature"

For a non-existing online connection

"Program signature" displays the collective F-signature offline and the "Time stamp" displays the time of the last compilation process.

For an existing online connection

For an existing online connection, the following is displayed under the "Program signature":

- The status of safety program

Status	Meaning
	The online and offline collective F-signatures match, and a password was assigned for the online and offline safety programs.
	The online and offline collective F-signatures do *not* match or no password was assigned for one of the safety programs.
—	The safety program status could not be determined.

- The online and offline collective F-signatures
- Information on whether the safety system versions are consistent online and offline.

Version comparison	Meaning
	The online and offline safety system versions match one another.
	The online and offline safety system versions do *not* match one another.
—	The safety system versions could not be determined.

See also

Disabling safety mode (Page 294)

Program identification (Page 286)

3.3 "F-blocks" area

Overview

The "F-Blocks" area helps you in the following tasks:

- Displaying the F-blocks used in your safety programs.
- Displaying the F-blocks used in the F-runtime groups.
- Displaying additional information about the F-blocks.

A description of the F-blocks is available in "Creating F-blocks in FBD / LAD (Page 122)".

Displayed information

The following information is displayed for F-blocks in offline mode:

- Has the F-block been compiled and used?
- Function of F-block in the safety program
- Offline signature
- Time stamp of the last change

The following information is displayed for F-blocks in online mode:

- Status (whether block has the same time stamp online and offline)
- Function of F-block in the safety program
- Offline signature
- Online signature

The F-blocks are hierarchically displayed as in the "Program blocks" folder.

The description of the symbols in the "Status" column can be found in "Comparing Safety Programs (Page 289)".

Note

During the offline-online comparison, the comparison statuses may occasionally differ between the *comparison editor* and status display in the *Safety Administration Editor*. The decisive status is the result of the comparison in the *comparison editor*, since this is the only comparison that takes into account the contents of the F-blocks.

Filter function

Using the filter function, you can select whether you want to view all F-blocks of a certain Fruntime group or the entire safety program.

- Select "All F-blocks " from the drop-down list to view all F-blocks.
- Select an F-runtime group from the drop-down list to see all F-blocks of this F-runtime group.

3.4 "F-compliant PLC data types" area (S7-1200, S7-1500)

Overview

Under "F-compliant PLC Data Types" you obtain information on the F-compliant PLC data types (UDT) you have defined.

You can delete F-compliant PLC data types (UDT) from the shortcut menu.

A description of F-compliant PLC data types (UDT) is available in "F-compliant PLC data types (UDT) (S7-1200, S7-1500) (Page 103)".

Displayed information

The following information is displayed for F-compliant PLC data types (UDT) in offline mode:

- Is the F-compliant PLC data type used in the safety program?
- Time stamp of the last change.

The following information is displayed for F-compliant PLC data types (UDT) in online mode:

- Status (whether the F-compliant PLC data types (UDT) have the same time stamp online and offline)

The F-compliant PLC data types (UDT) are displayed hierarchically as in the folder "PLC Data Types".

Double-click the F-compliant PLC data type (UDT) to open it for editing.

The description of the symbols in the "Status" column can be found in "Comparing Safety Programs (Page 289)".

Note

During offline-online comparison, the comparison statuses between the *comparison editor* and status display in the *Safety Administration Editor* can be different under certain circumstances. The comparison result in the *comparison editor* is decisive, since this is the only comparison that takes into account the contents of the F-compliant PLC data types (UDT).

3.5 "Web server F-Admins" area (S7-1200, S7-1500)

You require the "F-admin" right in order to carry out restoration of a backup (Page 285) via the Web server of your F-CPU. You assign the "F-admin" right in the hardware configuration of the F-CPU under the user management of the Web server.

In this section, you obtain information on which users have the "F-admin" right online or offline for F-CPUs that support this right. You can see from this whether a change to the "F-admin" right is active on the F-CPU. In order to make a change to the "F-admin" right effective, you have to load the configuration to the F-CPU.

See also

Completeness and correctness of the hardware configuration (Page 314)

3.6 "Settings" area

"Number ranges of the generated F-system blocks"

The number ranges assigned here are used by the F-System for new, automatically generated F-blocks.

At this point, you can select whether the number ranges are managed by the F-system or if a fixed range specified by you is used.

- "F-system managed"

  The number ranges are managed automatically by the F-system, depending on the F-CPU used. The F-system selects an available number range. The start and end ranges of the number ranges are displayed.

- "Fixed range"

  You can select the start and end ranges of the number ranges from the available range. The available range depends on the F-CPU used.

  An invalid number range selection is indicated by an error message.

  The only check performed during configuration is whether the configured low limit is less than or equal to the high limit and within the available range of the F-CPU. The check as to whether the configured range is sufficient is first made during compiling. You need to ensure a sufficiently large range. Where the available range is insufficient, a compiling error occurs. Not all blocks are generated and the safety program is not executable.

Changes will become valid only during the next compilation. The automatically created F-blocks may be moved into the new area during compilation. The F-I/O DBs are an exception. They always retain their original number that you may change in the properties of the F-I/O.

"Safety system version"

This parameter is used to specify the safety system version (including version of the F-system blocks and automatically generated F-blocks, see Overview of Programming (Page 90)).

A number of versions are available:

Version[3]	S7-300/400	S7-1200	S7-1500	Function
1.6	—	x	x	These versions have identical functions.
2.0	x	x[1]	x[2]	Depending on the set version, the result may be different runtimes of the F-runtime group(s) (see Excel file for response time calculation on the Internet (http://support.automation.siemens.com/WW/view/en/49368678/133100)).

1 supported for Firmware version V4.2 or higher

2 supported for Firmware version V2.0 or higher

3 After the migration of projects that were created with S7 Distributed Safety V5.4 SP5, version 1.0 is set automatically in order to identify migrated projects which have not yet been compiled with STEP 7 Safety Advanced.

Usually, you do not need to make any settings for this parameters.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

"Local data used in safety program" (S7-300, S7-400)

You use this parameter to specify the amount of temporary local data (in bytes) that is available for the call hierarchy below the main safety block.

The setting applies to each F-runtime group of a safety program. Additional information on F-runtime groups can be found in "Program structure of the safety program (S7-1200, S7-1500) (Page 93)" and "Program structure of the safety program (S7-300, S7-400) (Page 91)".

The **minimum possible amount** is determined by the local data requirement of the F-blocks generated automatically when the safety program is compiled.

For this reason, you must provide at least 440 bytes. However, the local data requirement for the automatically added F-blocks may be higher depending on the local data requirement of the F-blocks you created with FBD or LAD.

Therefore, provide as much local data as possible. If there is not enough local data available for the automatically added F-blocks (440 bytes or more), the safety program will be compiled nevertheless.

Data in automatically added F-DBs are then used instead of local data. However, this increases the runtime of the F-runtime group(s). You will receive a notice when the automatically added F-blocks require more local data than configured.

⚠ WARNING

The calculated maximum runtime of the F-runtime group using the Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100) is no longer correct in this case because the calculation assumes sufficient availability of F-local data.

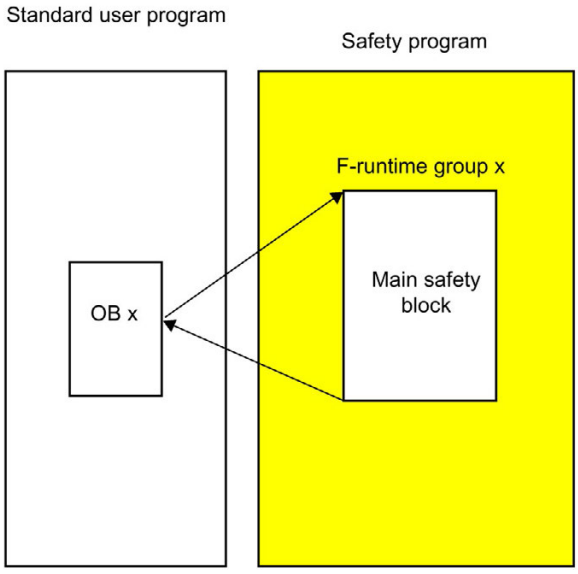
In this case, use the value you configured for the maximum cycle time of the F-runtime group (F-monitoring time) as the maximum runtime of the F-runtime group when calculating the maximum response times in the event of an error and for any runtimes of the standard system using the above-mentioned Excel file. *(S004)*

The maximum possible amount depends on:

- Local data requirement of the main safety block and the higher-level standard user program. For this reason, you should call the main safety blocks directly in OBs (cyclic interrupt OBs, whenever possible), and additional local data should not be declared in these cyclic interrupt OBs.
- Maximum volume of local data of the utilized F-CPU (see Technical Specifications in the product information for the utilized F-CPU). For S7-400 F-CPUs, you can configure the local data for each priority class. Therefore, assign the largest possible local data volume for the priority classes in which the safety program (the main safety blocks) is called (e.g., OB 35).

Maximum possible amount of local data as a function of local data requirement of main safety block and higher-level standard user program (S7-300, S7-400):

Case 1: Main safety block called directly from OBs

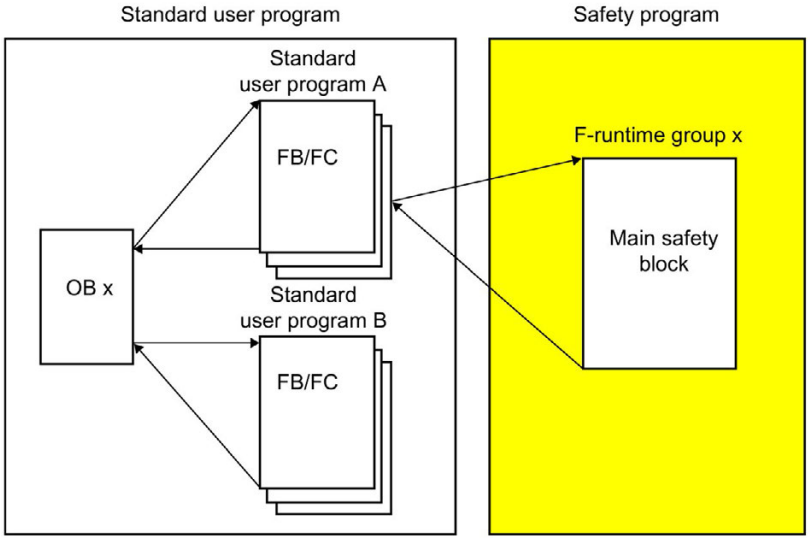


Set the "Local data used in safety program" parameter to the maximum amount of local data of the utilized F-CPU minus the local data requirement of the main safety block (if the main safety block has 2 F-runtime groups, use the largest local data requirement) and minus the local data requirement of the calling OBx (if there are 2 F-runtime groups, use the OB with the largest local data requirement).

Note: If you have not declared any temporary local data in the main safety blocks and calling OBx, the local data requirement of the main safety blocks is 6 bytes and the local data requirement of the calling OBx is 26 bytes. You can derive the local data requirement of the main safety blocks and calling OBx from the program structure.

Select the utilized F-CPU in the project tree and then "Tools > Call structure". The table gives the local data requirement in the path or for the individual blocks (see also the help on *STEP 7*).

Case 2: Main safety block not called directly from OBs



Set the "Local data settings" parameter to the value calculated for Case 1, minus the local data requirement of standard user program A (if standard user program A has 2 F-runtime groups, use the largest local data requirement).

Note: You can derive the local data requirement of the standard user program A from the program structure.

Select the utilized F-CPU in the project tree and then "Tools > Call structure". The table gives the local data requirement in the path or for the individual blocks (see also the help on *STEP 7*).

"Advanced settings"

"Safety mode can be disabled"

If you deselect the "Safety mode can be disabled" option, you can prevent the disabling of safety mode for a safety program.

When you change the setting for this option, you need to recompile the safety program and download it to the F-CPU for the change to become effective. This changes the collective F-signature of your safety program.

We recommend that you disable this option before you start production and before acceptance of the safety program to prevent an unintentional disabling of the safety mode.

"Enable F-change history"

Enable the logging of changes to the safety program by using the "Enable F-change history" option. For more information, refer to the section "F-change history (Page 307)".

"System-generated objects" (S7-1200, S7-1500)

The "Debug" button is provided for service and support purposes.

Access protection

4

Access protection is necessary for productive operation

Access protection to the SIMATIC Safety F-system is mandatory for productive operation.

No access protection is initially necessary for test purposes, commissioning, etc. This means you can execute all offline and online actions without access protection, i.e., without password prompt.

⚠ WARNING

Access to the SIMATIC Safety F-system without access protection is intended for test purposes, commissioning, etc., when the system is not in productive operation. You must guarantee the safety of the system through other organizational measures, for example, restricted access to certain areas.

Before you transition into productive operation, you must have set up and activated access protection. *(S005)*

Note

(S7-300/400) If you also want to download an F-CPU with *STEP 7 Distributed Safety*, you must specify the password for the F-CPU because assignment of a password is mandatory for the F-CPU in *STEP 7 Distributed Safety* .

4.1 Overview of access protection

Introduction

You can protect access to the SIMATIC Safety F-system by two password prompts: one for the safety program and another for the F-CPU.

Password for the safety program

The password for the safety program is available in two forms:

- The offline password is part of the safety program in the offline project on the programming device or PC.
- The online password is part of the safety program in the F-CPU.

Password for the F-CPU

The access protection is set at the F-CPU level. This password is also used to identify the F-CPU and must therefore be unique network-wide.

Overview of password assignment and prompt

The following table provides an overview of the access permissions for the F-CPU and the safety program.

The sections below show you how to assign the passwords and how to set up, change, and cancel access permissions for the F-CPU and the safety program.

	Password for F-CPU	Password for safety program
Assignment	In the *hardware and network editor*, during configuration of the F-CPU, inspector window, in "Settings" tab under "Protection", corresponding safety level, e.g., "Write protection for fail-safe blocks" (S7-300, S7-400). Select at least the access level "Full access (no protection)" for S7-1200/1500 F-CPUs and assign a password for "Full access incl. fail-safe (no protection)". If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".	In the *Safety Administration Editor* under "Access Protection".
Prompt	If you do not have access permission for the safety program (Page 83): For example • When the safety program is downloaded in its entirety • (S7-300, S7-400) When the hardware configuration is downloaded • (S7-1200, S7-1500) When a hardware configuration is downloaded that includes safety-related changes • When PROFIsafe address is assigned • When F-blocks that are used in the safety program are downloaded and deleted • When disabling safety mode • When restoring a backup of the F-CPU. Exception with S7-1200/1500 F-CPUs: If neither the safety program nor the F-CPU password is changed by the restore process, you are not prompted for the F-CPU password.	If you have assigned a password and this has not yet been entered since the project was opened, or you do not have access permission for the safety program (Page 83): **Offline password** e.g.: • When the password is changed • When modifying the safety program • When changing and deleting F-runtime groups • When changing safety-related parameters of F-I/O **Online password** e.g., when disabling safety mode (the password must always be entered, even if access permission for the safety program is still valid)

Safety program recompilation is required after changes to standard DBs to which the safety program has read or write access (Page 165). These standard DBs are not governed by the safety program access protection.

Please note that you also require the online password to download the safety-relevant changes to the hardware configuration. This is also true for changes to F-I/O not used in the safety program.
You have to also recompile and download the safety program for the download to be consistent.

4.2 Access protection for the safety program

Setting up access protection for the safety program

To set up access protection for the safety program, assign a password for the safety program. Proceed as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.

   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open. Select "Access protection" in the area navigation.
3. Under "Offline safety program protection", click "Setup" and enter the password (max. 30 characters) for the safety program in the following dialog in the "New password" and "Confirm password" fields.
4. Confirm the assigned password with "OK".

You have set up access protection for the safety program and have gained access permission for the safety program.

Note

You cannot define the online password separately; the offline password assigned during the next download is applied. After a change to the offline password, the online and offline passwords may differ until the next time the offline safety program is downloaded to the F-CPU.

Note

Use different passwords for the F-CPU and the safety program to optimize access protection.

⚠ WARNING

If access protection is not used to limit access to the programming device or PC to only those persons who are authorized to modify the safety program, the following organizational measures must be taken to ensure the effectiveness of the password protection for the F-CPU at the programming device or PC:

- Only authorized personnel may have access to the password.
- Authorized personnel must explicitly cancel the access permission for the F-CPU before leaving the programming device or PC by closing *STEP 7* or via the "Online > Delete access rights" menu. If this is not strictly implemented, a screen saver equipped with a password accessible only to authorized personnel must also be used. *(S006)*

Changing the password for the safety program

You may change the safety program password as long as you have the necessary access permissions. It takes place likewise in the "Access protection" area (via "Change" button) and is carried out as usual under Windows through entry of the old and double entry of the new password.

Deleting access protection for the safety program

To delete access protection for the safety program, delete the password for the safety program. Proceed as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.

   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open.
3. Select "Access protection" in the area navigation.
4. Click the "Change" button.
5. Under "Old password", enter the password for the safety program.
6. Click "Revoke" and then on "OK".

Gaining access permission through login to the safety program

Log in to the safety program as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.

   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open.
3. Select "Access protection" in the area navigation.
4. Enter the password for the safety program in the "Password" input field.
5. Select the "Login" button.

Validity of access permission for a safety program

If access permission for a safety program was obtained through the entry of the password, this remains until the project is closed. If *STEP 7* is closed, any project that is still open is automatically closed and any access permission granted is canceled.

Canceling access permission through logoff

The access permission for the safety program can be canceled as follows:

- By clicking the "Log off" button in the "Access protection" area in the "*Safety Administration Editor*".
- In the shortcut menu for the *Safety Administration Editor* shortcut menu (access by right-clicking).
- By using the lock symbol in the line of the *Safety Administration Editor*.

The user will then be prompted to enter the password for the safety program again the next time an action requiring a password is performed. To "cancel" access permission when using the Modify function, the connection to the F-CPU must first be terminated (e.g. with the "Online > Go offline" menu command or the corresponding icon in the toolbar).

Access permission for the safety program is canceled automatically, if the project or *STEP 7* has been closed.

Displaying the validity of access permission

The validity of the access permission is displayed in the project tree as follows:

- The access permission is valid, if the lock symbol in the line of the *Safety Administration Editor* is shown unlocked.
- The access permission is not available, if the lock symbol shows a closed lock.
- If no lock symbol is shown, no password was assigned.

4.3 Access protection for the F-CPU

Setting up access protection for the F-CPU

To set up access protection for the F-CPU, assign a password for the F-CPU in the F-CPU configuration.

You arrive there directly, if you click the link "Go to the "Protection" area of the F-CPU" in the "Access protection" area in the *Safety Administration Editor*. Proceed as described in the *STEP 7* help under "Configuring access levels".

⚠ WARNING

(S7-300, S7-400) In safety mode, access with the CPU password must not be authorized during changes to the standard user program as this would also allow changes to the safety program. To rule out this possibility, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU. If only one person is authorized to change the standard user program and the safety program, the protection level "Write protection" or "Read/write protection" should be configured so that other persons have only limited access or no access at all to the entire user program (standard and safety programs).*(S001)*

⚠ WARNING

(S7-1200, S7-1500) In safety mode, the safety program must be password-protected. For this purpose, configure at least the protection level "Full access (no protection)" and assign a password under "Full access incl. fail-safe (no protection)". This protection level only allows full access to the standard user program, not to F-blocks.

If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".

Assign different passwords for the individual protection levels. *(S041)*

You enable access protection by downloading (Page 271) the hardware configuration to the F-CPU.

⚠ WARNING

If **multiple F-CPUs** can be reached over a network (e.g. Industrial Ethernet) by **one programming device or PC**, you must take the following actions to ensure that the project data is downloaded to the correct F-CPU:

Use passwords specific to each F-CPU, such as a uniform password for the F-CPUs with attached Ethernet address for each.

Note the following:

- A point-to-point connection must be used to activate the access protection of an F-CPU when the hardware configuration is loaded for the first time (similar to assigning an MPI address to an F-CPU for the first time).
- Before downloading the safety program to an F-CPU, you must first revoke an existing access permission for any other F-CPU.
- The last download of the safety program prior to switching to productive operation must be made with enabled access protection. *(S021)*

⚠ WARNING

The use of tools for the automation/operation of user interfaces (e.g. TIA Portal, Web server) which allow access protection for the F-CPU to be bypassed (e.g. saving or automatic entry of an F-CPU password or Web server password), is not permitted. *(S078)*

Changing the password for the F-CPU

For the new password to become valid after a password change for the F-CPU, you must download the changed configuration into the F-CPU. If necessary, you must enter the "old" password for the F-CPU for this load operation. The F-CPU must be in STOP mode.

Deleting access protection for the F-CPU

To delete access protection for the F-CPU, delete the password for the F-CPU. To do this, proceed as in the standard.

Obtaining access permission for the F-CPU

You obtain access permission for the F-CPU - depending on the configured protection level - by entering the password for the F-CPU prior to performing an action requiring a password.

Obtaining access permission for the F-CPU

Access permission for the F-CPU remains valid until the project is closed in *STEP 7* or access permission is canceled.

Canceling access permission for the F-CPU

You cancel the access permission with the menu command "Online > Delete access rights" auf.

⚠ WARNING

If access protection is not used to limit access to the programming device or PC to only those persons who are authorized to modify the safety program, the following organizational measures must be taken to ensure the effectiveness of the access protection for the F-CPU at the programming device or PC:

- Only authorized personnel may have access to the password.
- Authorized personnel must explicitly cancel the access permission for the F-CPU before leaving the programming device or PC by closing *STEP 7* or via the "Online > Delete access rights" menu. If this is not strictly implemented, a screen saver equipped with a password accessible only to authorized personnel must also be used. *(S006)*

4.4 Access protection through organizational measures

To prevent that a safety program is swapped without authorization by exchanging removable media (e.g. flash card, SIMATIC Micro Memory Card or hard disk with WinAC RTX F), you must observe the following warning:

⚠ WARNING

You must limit access to the F-CPU to persons who are entitled for plugging removable media through access protection. *(S079)*

To prevent that a WinAC RTX F or an S7-1500 F Software Controller is accidentally uninstalled or installed, you must observe the following warning:

⚠ WARNING

You must limit access to a WinAC RTX F or an S7-1500 F Software Controller through access protection to persons who are authorized to uninstall or install a WinAC RTX F or an S7-1500 F Software Controller (e.g. by using Windows administrator rights (ADMIN)). *(S075)*

The "Delete Configuration" function is only offered in the panel of the PC station with an S7-1500 F Software Controller when no access protection is set up on the F-CPU. We therefore recommend that you do not set up F-access protection until after commissioning.

To prevent unauthorized restoration of the safety program, formatting of the F-CPU and deleting program folders using the display of an S7-1500 F-CPU, you must observe the following warning:

WARNING

The display password may only be given to persons who are authorized to restore safety programs, format the F-CPU and delete program folders. If a password is not set up for the display, you must protect the display through organizational measures against unauthorized operation. For example by setting up access protection for specific rooms. *(S063)*

To prevent unauthorized restoration of the safety program with the Web server in an S7-1200/1500 F-CPU, you must observe the following warning:

WARNING

The "F-admin" authorization for Web server without password protection (user "Everybody" or "Anyone") is only intended for test purposes, maintenance, etc. This means only when the system is not in productive operation. In this case you must ensure the safety of the system through other organizational measures. For example by setting up access protection for specific rooms.

Before you transition into productive operation, you must remove the "F-admin" right for the user "Everybody".

Only authorized personnel may have access to the password of the Web server user with the "F-admin" right. After downloading the hardware configuration, check whether only permitted users of the Web server have the "F-admin" right on the F-CPU. To do so, use the online view of the *Safety Administration Editor* (see also Safety Administration Editor (Page 68)).

Saving the login file and the password of the Web server in the browser is only permitted when use by unauthorized persons is prevented through other organizational measures (e.g. access protection to the PG/PC). *(S064)*

Programming

5

5.1 Overview of Programming

Introduction

A safety program consists of F-blocks that you create using the FBD or LAD programming language and F-blocks that are automatically added. Fault detection and reaction measures are automatically added to the safety program you create, and additional safety-related tests are performed. Moreover, you have the option to incorporate special ready-made safety functions in the form of instructions into your safety program.

An overview of the following is given below:

- The structure of the safety program
- The fail-safe blocks
- Differences in the programming of the safety program with FBD/LAD compared to programming of standard user programs

5.1.1 Program structure of the safety program (S7-300, S7-400)

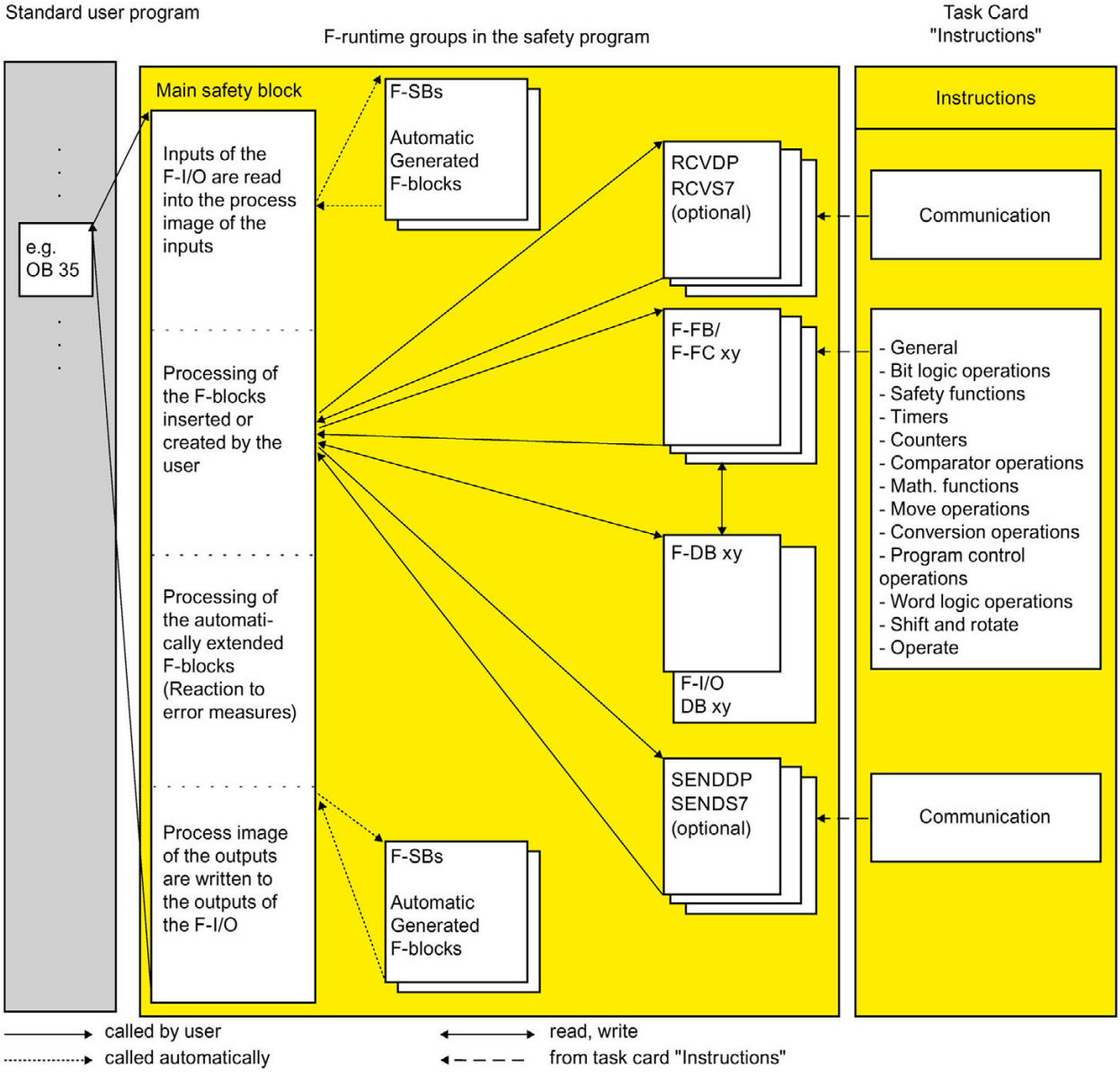
Representation of program structure

For structuring purposes, a safety program consists of one or two F-runtime groups.

Each F-runtime group contains:

- F-blocks that you create using FBD or LAD or that are inserted from the project library or global libraries
- F-blocks that are added automatically (F-system blocks, automatically generated F-blocks, and F-I/O DBs)

Below is a schematic diagram of a safety program or an F-runtime group for an S7-300/400 F-CPU.

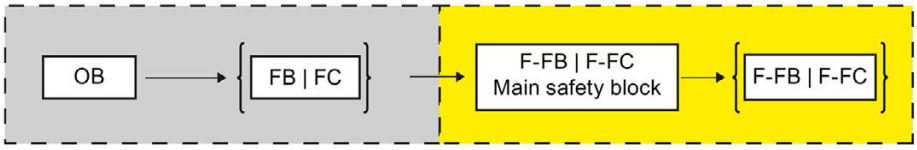


Main safety block

The main safety block is the first F-block of the safety program that you program yourself. During compiling, it is supplemented by additional invisible calls of F-system blocks.

You must assign the main safety block to an F-runtime group (Page 109).

The main safety block in an S7-300/400 F-CPU is called from any block in the standard user program. We recommend a call from an OB 3x.



F-runtime groups

To improve handling, a safety program consists of one or two "F-runtime groups". An F-runtime group is a logical construct of several related F-blocks that is formed internally by the F-system.

An F-runtime group consists of the following:

- a main safety block (an F-FB/F-FC that you assign to the OB)
- Any additional F-FBs or F-FCs that you program using FBD or LAD and call from the main safety block
- One or more F-DBs, as needed
- F-I/O DBs
- F-blocks from the project library or global libraries
- F-system blocks F-SBs
- Automatically generated F-blocks

Structuring the safety program in two F-runtime groups

You can divide your safety program into two F-runtime groups. By having parts of the safety program (one F-runtime group) run in a faster priority class, you achieve faster safety circuits with shorter response times.

5.1.2 Program structure of the safety program (S7-1200, S7-1500)

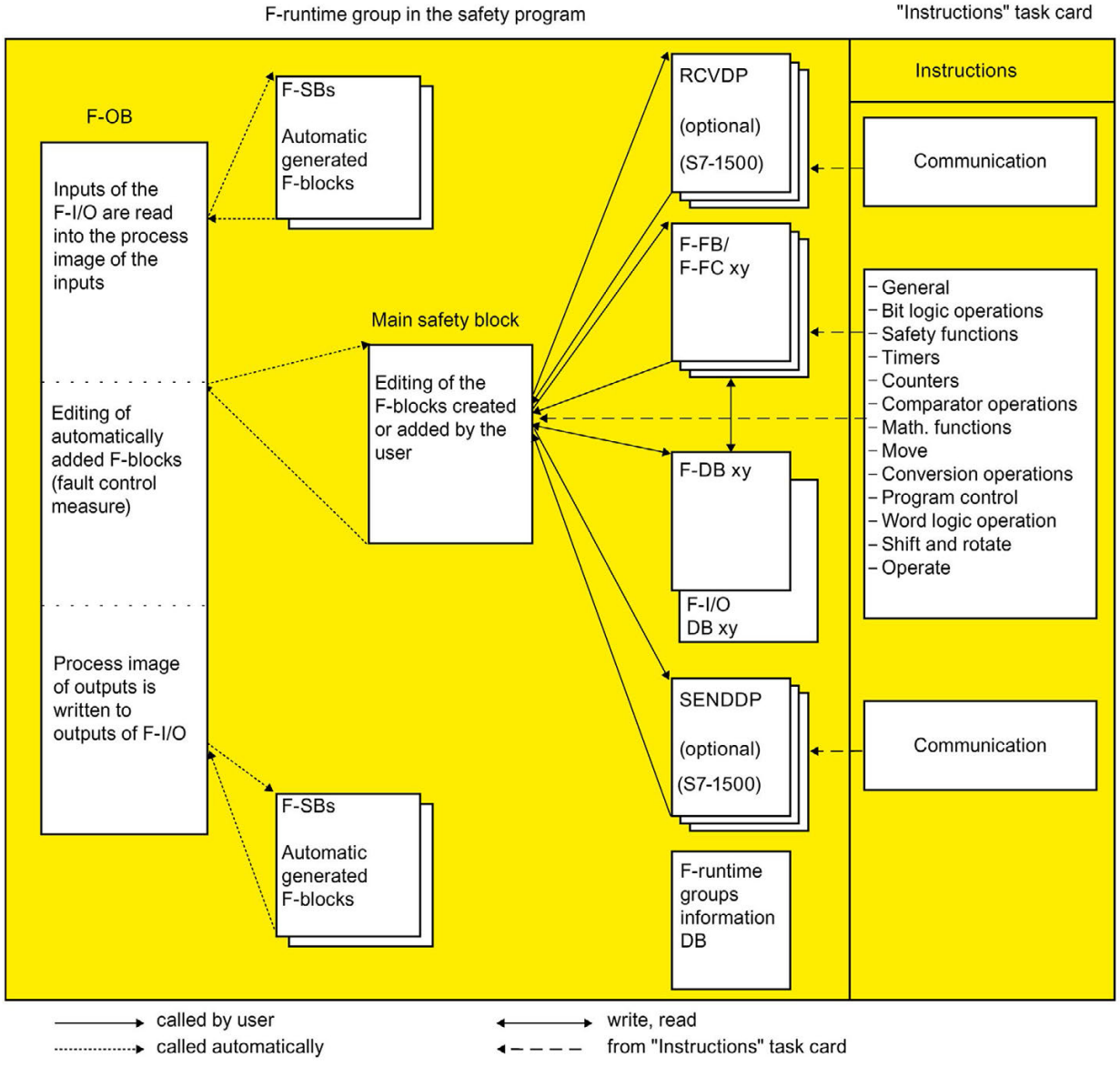
Representation of program structure

For structuring purposes, a safety program consists of one or two F-runtime groups.

Each F-runtime group contains:

- F-blocks that you create using FBD or LAD or that are inserted from the project library or global libraries
- F-blocks that are added automatically (F-system blocks F-SBs, automatically generated F-blocks, F-runtime DB, and F-I/O DBs)

Below is a schematic diagram of a safety program or an F-runtime group for an S7-1200/1500 F-CPU.

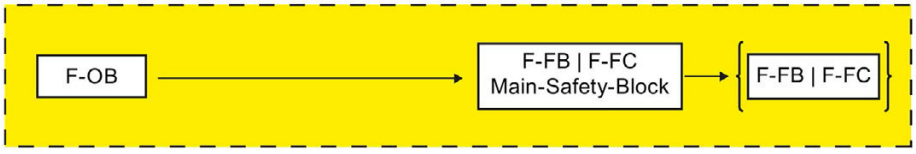


Main safety block

The main safety block is the first F-block of the safety program that you program yourself.

You must assign the main safety block to an F-runtime group (Page 109).

The main safety block in an S7-1200/1500 F-CPU is called by the F-OB assigned to the F-runtime group.



F-runtime groups

To improve handling, a safety program consists of one or two "F-runtime groups". An F-runtime group is a logical construct of several related F-blocks that is formed internally by the F-system.

An F-runtime group consists of the following:

- An F-OB which calls the main safety block
- A main safety block (an F-FB/F-FC that you assign to the F-OB)
- Any additional F-FBs or F-FCs that you program using FBD or LAD and call from the main safety block
- One or more F-DBs, as needed
- F-I/O DBs
- F-runtime group information DB
- F-blocks from the project library or global libraries
- F-system blocks F-SBs
- Automatically generated F-blocks

Structuring the safety program in two F-runtime groups

You can divide your safety program into two F-runtime groups. By having parts of the safety program (one F-runtime group) run in a faster priority class, you achieve faster safety circuits with shorter response times.

See also

F-runtime group information DB (S7-1200, S7-1500) (Page 118)

5.1.3 Fail-Safe Blocks

F-blocks of an F-runtime group

The following table shows the F-blocks that you use in an F-runtime group:

F-block	Function	S7-300/400 F-CPUs	S7-1200/1500 F-CPUs
Main safety block	The first step in programming of the safety program is the main safety block. The main safety block in S7-300/400 F-CPUs is an F-FC or F-FB (with instance DB), which is called by a standard block (recommendation: OB 35) from the standard user program. The main safety block in S7-1200/1500 F-CPUs is an F-FC or F-FB (with instance DB), which is called by the F-OB.	X	X
F-FB/F-FC	Both in the main safety block as well as additional F-FBs and F-FCs, you can perform the following: • Program the safety program with the instructions available for F-blocks in FBD or LAD • Call other created F-FBs/F-FCs for structuring the safety program • Insert F-blocks from the project library or global libraries	X	X
F-DB	Optional fail-safe data blocks that can be read- and write-accessed within the entire safety program.	X	X
F-I/O DB	An F-I/O DB is automatically generated for each F-I/O when it is configured. You can or you must access the tags of the F-I/O DB in conjunction with F-I/O accesses.	X	X
F-shared DB	The F-shared DB is a fail-safe data block that contains all of the shared data of the safety program and additional information needed by the F-system.	X	—
F-runtime group information DB	An F-runtime group information DB is created when you create an F-runtime group. The F-runtime group information DB provides information on the F-runtime group and on the safety program as a whole.	—	X

Note

You are not permitted to insert F-system blocks from the "System blocks" folder in a main safety block/F-FB/F-FC.

Instructions for the safety program

In the "Instructions" task card, you can find instructions for the F-CPU used and which you can to use program the safety program.

You can find instructions that you know from the standard user program, such as bit logic operations, mathematical functions, functions for program control, and word logic operations.

Moreover, there are instructions with safety functions, e.g., for two-hand monitoring, discrepancy analysis, muting, emergency STOP/emergency OFF, safety door monitoring, feedback monitoring and instructions for safety-related communication between F-CPUs.

Additional information

For a detailed description of the instructions for the safety program, refer to Overview of instructions (Page 335).

Using instruction versions

As with the instructions for the standard user program, there may also be different versions of the instructions for the safety program.

Additional information on instruction versions can be found in the help on STEP 7 in "Basics for instruction versions".

Further information on the differences of the individual versions of the instructions for the safety program can be found in the relevant chapter of the instructions.

Note

Note the following:

- If you change the version of an instruction used in the safety program in the task card “Instructions” to a version which does not have identical functions, the functioning of your safety program may change after recompiling the safety program. In addition to the signature of the F-block which uses the instruction, the collective F-signature of your safety program also changes. You may have to perform an acceptance test (Page 323).
- If you use a know-how protected F-block in your safety program which uses an instruction which is not the same version as that set in the task card “Instructions”, when the program is compiled without entering the password for the know-how protected F-block, it is adjusted to the version set in the task card “Instructions”. If the instruction versions do not have identical functions, the functioning of the know-how protected F-block may change and always its signature.

5.1.4 Restrictions in the programming languages FBD/LAD

LAD and FBD programming languages

The user program in the F-CPU typically consists of a standard user program and a safety program.

The standard user program is created using standard programming languages such as SCL, STL, LAD, or FBD.

For the safety program, LAD or FBD may be used with certain restrictions in the instructions and the applicable data types and operand areas. Please also note the restrictions for the individual instructions.

Supported instructions

The instructions available depend on the F-CPU used. You can find the supported instructions in the description of the instructions (starting from STEP 7 Safety V14 instructions (Page 335)).

Note

Preconnection of enable input EN or evaluation of enable output ENO is not possible.

Supported data types and parameter types

Only the following data types are supported:

- BOOL
- INT
- WORD
- DINT
- DWORD (S7-300, S7-400)
- TIME
- F-compliant PLC data type (UDT) (S7-1200, S7-1500)

Note

If the result of an instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
You must therefore ensure that the permitted range for the data type is observed when creating the program or select a matching data type.

Non-permitted data and parameter types

The following types are **not** permitted:

- All types not listed in the section "Supported data types and parameters types" (e.g. BYTE, REAL)
- Complex data types (e.g., STRING, ARRAY, STRUCT, PLC data type (UDT) (S7300/400))
- Parameter types (e.g. BLOCK_FB, BLOCK_DB, ANY)

Supported operand areas

The system memory of an F-CPU is divided into the same operand areas as the system memory of a standard CPU. You can access the operand areas listed in the table below from within the safety program.

Table 5- 1 Supported operand areas

Operand area	Access via units of the following size:	S7 Notation	Description
Process image of the inputs			
• Of F-I/O	Input (bit) Input word Input double-word	I IW ID	Only read-only access to input channels of F-I/O is possible. Transfer to IN_OUT parameters of an F-FB or F-FC is therefore not valid either. The process image of the inputs of F-I/O is updated prior to the start of the main safety block.
• Of standard I/O	Input (bit) Input word Input double-word	I IW ID	Input channels of standard I/O can only be accessed read-only. Transfer to IN_OUT parameters of an F-FB or F-FC is therefore not valid either. In addition, a process-specific validity check is required. See the *STEP 7 help* for the update times of the process image of the inputs of standard I/O.
Process image of the outputs			
• Of F-I/O	Output (bit) Output word Output double-word	Q QW QD	Only write-only access to output channels of F-I/O is possible. Transfer to IN_OUT parameters of an F-FB or F-FC is therefore not valid either. In the safety program, the values for the outputs of the F-I/O are calculated and stored in the process image of the outputs. The process image of the outputs for F-I/O is updated after the end of the main safety block.

Operand area	Access via units of the following size:	S7 Notation	Description
• Of standard I/O	Output (bit) Output word Output double-word	Q QW QD	Output channels of standard I/O are write-only channels. Transfer to IN_OUT parameters of an F-FB or F-FC is therefore not valid either. In the safety program, the values for the outputs of the standard I/O are also calculated and stored in the process image of the outputs, if needed. See the *STEP 7 help* for the update times of the process image of the outputs of standard I/O.
Bit memory	Bit memory (bit) Memory word Memory double word	M MW MD	This area is used for data exchange with the standard user program. In addition, read access requires a process-specific validity check. A particular element of the bit memory can be either read- or write-accessed in the safety program. Transfer to IN_OUT parameters of an F-FB or F-FC is therefore not valid either. Note that it is only permitted to use bit memory for connecting the standard user program and the safety program; it must not be used as a buffer for F-data.
Data blocks			
• F-DB	Data bit Data word Data double word	DBX DBW DBD	Data blocks store information for the program. They can either be defined as global data blocks such that all F-FBs, F-FCs, or main safety blocks can access them or assigned to a particular F-FB or main safety block (instance DB). A tag of a shared DB can only be accessed from one F-runtime group, and an instance DB only from the F-runtime group in which the corresponding F-FB/instruction is called.
• DB	Data bit Data word Data double word	DBX DBW DBD	This area is used for data exchange with the standard user program. In addition, read access requires a process-specific validity check. For a tag of a DB, either read access or write access is possible in the safety program. Transfer to IN_OUT parameters of an F-FB or F-FC is therefore not valid either. Please note that the tags of a DB can only be used for transferring data between the standard user program and the safety program; DBs must not be used as a buffer for F-data.
Temporary local data	Local data bit Local data word Local data double word	L LW LD	This memory area holds the temporary tags of a block (or F-block) while the (F-) block is being executed. The local data stack also provides memory for transferring block parameters and for saving intermediate results.

File type conversion

Just as with the standard user program, there are two possibilities for file type conversion in the safety program.

- Implicit conversion

  The implicit conversion is executed as in the standard user program with the following restrictions: The bit length of the source data type has to match the bit length of the destination data type.

- Explicit conversion

  You use an explicit conversion instruction (Page 478) before the actual instruction is executed.

Slice access

Slice access is not possible in the safety program.

Non-permitted operand areas

Access via units other than those listed in the table above is **not** permitted. The same applies to access to operand areas not listed, in particular:

- Data blocks that were automatically added

  Exception: Certain tags in the F-I/O DB (Page 135) and in the F-shared DB (S7-300, S7-400) (Page 118) or F-runtime group information DB (S7-1200, S7-1500) (Page 118)

- I/O area: Inputs
- I/O area: Outputs

Boolean constants "0" or "FALSE" and "1" or "TRUE" (S7-300, S7-400)

The Boolean constants "0" or "FALSE" and "1" or "TRUE" are available for S7-300/400 F-CPUs as "Tags" "RLO0" and "RLO1" in the F-shared DB. You access them through a fully qualified DB access ("F_GLOBDB".RLO0 or "F_GLOBDB".RLO1).

Boolean constants "0" or "FALSE" and "1" or "TRUE" (S7-1200, S7-1500)

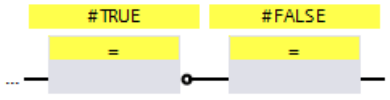
The Boolean constants "0" or "FALSE" and "1" or "TRUE" are available for S7-1200/1500 F-CPUs to assign parameters during block calls.

You can also create "1" or "TRUE" in a tag with the help of the "Assignment (Page 344)" instruction.

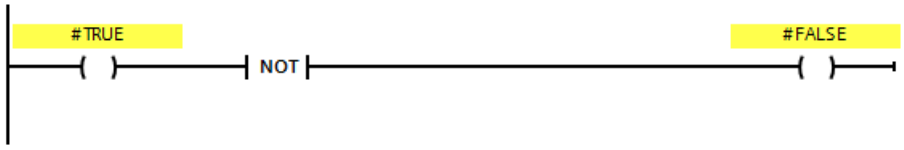
To do so, do not interconnect the box input of the "Assignment" instruction in FBD. In LAD, you interconnect the input directly with the power rail.

You obtain a tag with "0" or "FALSE" by subsequent inversion with the instruction "Invert RLO (Page 341)".

Example FBD:



Example LAD:



Operand area of temporary local data: Particularities

Note

Note when using the operand area of temporary local data that the first access of a local data element in a main safety block/F-FB/F-FC must always be a write access. This initializes the local data element.

Make sure that a temporary local data element is initialized prior to the first JMP, JMPN, or RET instruction.

The "local data bit" should be initialized with the Assign ("=") (FBD) or ("--( )") (LAD) instruction. Assign the local data bit a signal state of "0" or "1" as a Boolean constant.

Local data bits cannot be initialized with the Flip Flop (SR, RS), Set Output (S) or Reset Output (R) instructions.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

"Fully qualified DB access"

Access to tags of a data block in an F-FB/F-FC is "fully qualified DB access". This also applies to initial access to tags of a data block after a jump label.

For S7-300/400 F-CPUs, only initial access needs to be "fully qualified DB access". Alternatively, you can use the instruction "OPN".

Example of "fully qualified DB access":

Assign a name for the F-DB, e.g. "F_Data_1". Use the names assigned in the declaration of the F-DB instead of the absolute addresses.

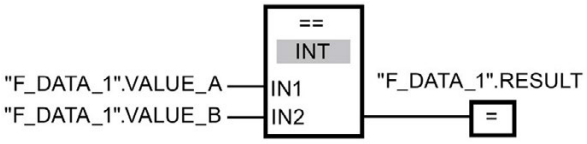


Figure 5-1 Example with fully-qualified access

Example of "non-fully qualified DB access" (S7-300, S7-400):

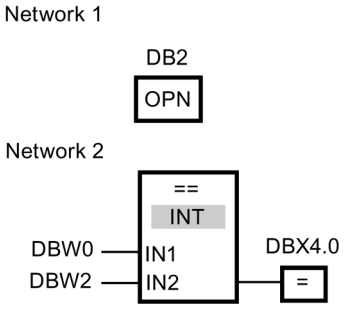


Figure 5-2 Example without fully-qualified access

Access to instance DBs

You can also access instance DBs of F-FBs with fully qualified access, e.g., for transfer of block parameters. It is not possible to access static local data in single/multi-instances of other F-FBs.

Note that accessing instance DBs of F-FBs that are not called in the safety program can cause the F-CPU to go to STOP mode.

5.1.5 F-compliant PLC data types (UDT) (S7-1200, S7-1500)

Introduction

You declare and use F-compliant PLC data types (UDT) as you would standard PLC data types (UDT). You can use F-compliant PLC data types (UDT) in the safety program as well as in the standard user program.

Differences to standard PLC data types (UDT) are described in this chapter.

Information on the use and declaration of standard PLC data types (UDT) is available in the *STEP 7 online help* under "Declaring PLC data types".

Declaring F-compliant PLC data types (UDT)

You declare F-compliant PLC data types (UDT) as you would PLC data types (UDT).

In F-compliant PLC data types (UDT), you can use all data types (Page 97) that you can also use in safety programs.

Nesting of F-compliant PLC data types (UDT) within F-compliant PLC data types (UDT) is not supported.

Proceed as follows for declaration:

1. Click on "Add new PLC data type" in the "PLC Data Types" folder in the project tree.
2. To create an F-compliant PLC data type (UDT), enable the option "Create F-compliant PLC data type" in the "Add new PLC data type" dialog.
3. Proceed as described in the *STEP 7 online help* under "Programming structure of PLC data types".

You specify default values for F-compliant PLC data types (UDT) during the declaration.

Using F-compliant PLC data types (UDT)

You use F-compliant PLC data types as you would standard PLC data types (UDT).

Changes to F-compliant PLC data types (UDT)

You need the password for the safety program to change F-compliant PLC data types (UDT). Regardless if you are using the F-compliant PLC data type (UDT) in an F-block, in a standard block or not at all.

See also

"F-compliant PLC data types" area (S7-1200, S7-1500) (Page 74)

5.1.5.1 Grouping PLC tags for inputs and outputs of F-I/O in structures (S7-1200, S7-1500)

You group PLC tags for inputs and outputs of F-I/O in structures (structured PLC tag) as you would for inputs and outputs of standard I/O.

Use F-compliant PLC data types (UDT).

Rules

When creating structured PLC tags for inputs and outputs of F-I/O, you must also observe the following rules in addition to the rules in the standard:

- You must not group inputs/outputs of standard I/O and F-I/O at the same time in a structured PLC tag.
- You may only group inputs/outputs of actually existing channels (channel value and value status) in a structured PLC tag.

  See also Addressing F-I/O (Page 128)
- You may only group inputs/outputs of channels (channel value and value status) that are enabled in the hardware configuration in a structured PLC tag.

  See also Addressing F-I/O (Page 128)
- You may only group inputs of channels (channel value and value status) that provide the result of the "1oo2 sensor evaluation" with set "1oo2 sensor evaluation".

  See also Addressing F-I/O (Page 128)
- In a structured PLC tag for an F-I/O with outputs, you must either group all outputs of this F-I/O or an output range with multiples of 16 bits.

  The F-CPU can go to STOP mode if this is disregarded. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
- A structured PLC tag that groups outputs of an F-I/O must not overlap with other PLC tags.

  The F-CPU can go to STOP mode if this is disregarded. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

To observe these rules, you must declare the F-compliant PLC data type that is used for the structured PLC tag accordingly.

You can find the addresses allocated to a structured PLC tag in the "IO tags" tab of an F-I/O configuration.

5.1.5.2 Example of structured PLC tags for inputs and outputs of F-I/O (S7-1200, S7-1500)

Introduction

This example uses the F-module 4 F-DI/3 F-DO DC24V/2A with 1oo2 evaluation to demonstrate how you use structured PLC tags for access to F-I/O.

Channel structure of the 4 F-DI/3 F-DO DC24V/2A F-module

The table below sets out the channel structure and address assignment of the F-module 4 F-DI/3 F-DO DC24V/2A with 1oo2 evaluation. You may only access existing and enabled channels (addresses I11.0 to I11.3 and I12.0 to I12.3). These channels provide the result of 1oo2 evaluation generated internally in the F-module.

Table 5- 2 Channel structure and addresses of the channel values of inputs with 1oo2 evaluation

Channel	Address
DI channel 0 channel value	I11.0
DI channel 1 channel value	I11.1
DI channel 2 channel value	I11.2
DI channel 3 channel value	I11.3
—	I11.4
—	I11.5
—	I11.6
—	I11.7

Table 5- 3 Channel structure and addresses of the value status of the inputs with 1oo2 evaluation

Channel	Address
DI channel 0 value status	I12.0
DI channel 1 value status	I12.1
DI channel 2 value status	I12.2
DI channel 3 value status	I12.3
—	I12.4
—	I12.5
—	I12.6
—	I12.7

Table 5- 4 Channel structure and addresses of the value status of outputs

Channel	Address
DO channel 0 value status	I13.0
DO channel 1 value status	I13.1
DO channel 2 value status	I13.2
DO channel 3 value status	I13.3

Table 5- 5 Channel structure and addresses of the channel values of outputs

Channel	Address
DO channel 0 channel value	Q11.0
DO channel 1 channel value	Q11.1
DO channel 2 channel value	Q11.2
DO channel 3 channel value	Q11.3

Creating F-compliant PLC data types (UDT)

Create two F-compliant PLC data types (UDT), for example, for access to all channels.

The figure below shows an F-compliant PLC data type (UDT) for access to the channel values and value status of the inputs with 1oo2 evaluation:

4 F-DI/3 F-DO DC24V/2A_DI

	Name	Data type	Comment
1	CH_DI_0	Bool	Channel 0 (DI)
2	CH_DI_1	Bool	Channel 1 (DI)
3	CH_DI_2	Bool	Channel 2 (DI)
4	CH_DI_3	Bool	Channel 3 (DI)

Figure 5-3 F-compliant PLC data type (UDT) "4 F-DI/3 F-DO DC24V/2A_DI"

The figure below shows the F-compliant PLC data type (UDT) for access to the channel values and value status of the outputs:

4 F-DI/3 F-DO DC24V/2A_DO

	Name	Data type	Comment
1	CH_DO_0	Bool	Channel 0 (DQ)
2	CH_DO_1	Bool	Channel 1 (DQ)
3	CH_DO_2	Bool	Channel 2 (DQ)

Figure 5-4 F-compliant PLC data type (UDT) "4 F-DI/3 F-DO DC24V/2A_DO"

Using F-compliant PLC data types (UDT)

As demonstrated in the figure below, you can use the two F-compliant PLC data types (UDT) that you have created in an F-FC (e.g. "Motor"):

Motor

	Name	Data type	Default value	Comment
1	Input			
2	Motor SS DI	"4 F-DI/3 F-DO DC24V/2A_DI"		Motor interface channel values DI
3	CH_DI_0	Bool		Channel 0 (DI)
4	CH_DI_1	Bool		Channel 1 (DI)
5	CH_DI_2	Bool		Channel 2 (DI)
6	CH_DI_3	Bool		Channel 3 (DI)
7	Motor SS DI VS	"4 F-DI/3 F-DO DC24V/2A_DI"		Motor interface value status DI
8	CH_DI_0	Bool		Channel 0 (DI)
9	CH_DI_1	Bool		Channel 1 (DI)
10	CH_DI_2	Bool		Channel 2 (DI)
11	CH_DI_3	Bool		Channel 3 (DI)
12	Motor SS DO VS	"4 F-DI/3 F-DO DC24V/2A_DO"		Motor interface value status DQ
13	CH_DO_0	Bool		Channel 0 (DQ)
14	CH_DO_1	Bool		Channel 1 (DQ)
15	CH_DO_2	Bool		Channel 2 (DQ)
16	Output			
17	Motor SS DO	"4 F-DI/3 F-DO DC24V/2A_DO"		Motor interface channel values DQ
18	CH_DO_0	Bool		Channel 0 (DQ)
19	CH_DO_1	Bool		Channel 1 (DQ)
20	CH_DO_2	Bool		Channel 2 (DQ)
21	InOut			

Creating structured PLC tag for the F-module 4 F-DI/3 F-DO DC24V/2A

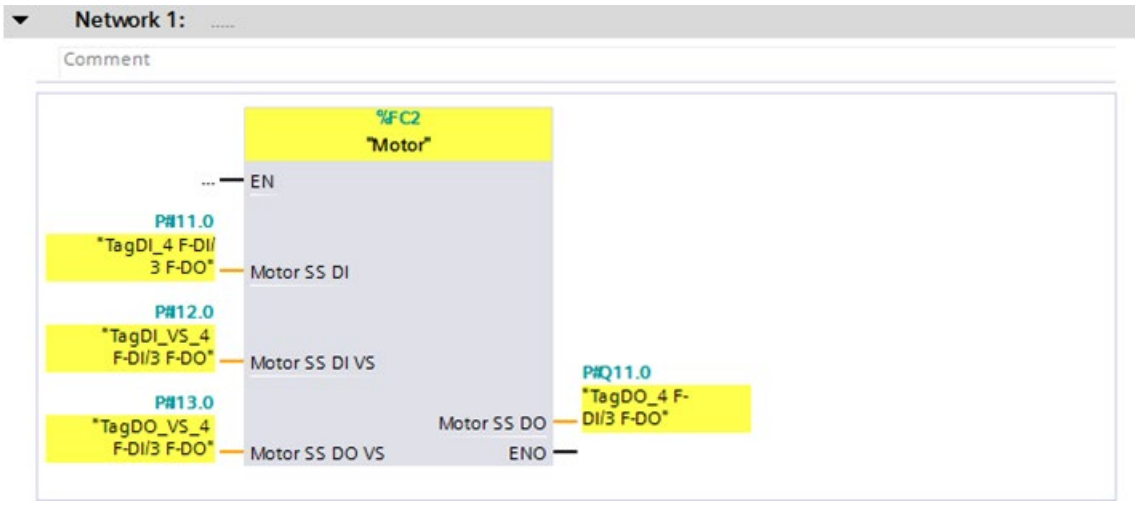
Create structured PLC tags for the F-module 4 F-DI/3 F-DO DC24V/2A:

Tag table_1

	Name	Data type	Address	Comment
1	TagDI_4 F-DI/3 F-DO(1)	"4 F-DI/3 F-DO DC24V/2A_DI"	%I11.0	Motor 1 DI
2	TagDI_VS_4 F-DI/3 F-DO(1)	"4 F-DI/3 F-DO DC24V/2A_DI"	%I12.0	Motor 1 DI VS
3	TagDO_VS_4 F-DI/3 F-DO(1)	"4 F-DI/3 F-DO DC24V/2A_DO"	%I13.0	Motor 1 DQ VS
4	TagDO_4 F-DI/3 F-DO(1)	"4 F-DI/3 F-DO DC24V/2A_DO"	%Q11.0	Motor 1 DQ

Accessing the F-FC

Transfer the structured PLC tags you have created when you call the F-FC (e.g. "Motor"):



See also

Addressing F-I/O (Page 128)

Value status (S7-1200, S7-1500) (Page 130)

5.1.6 Editing PLC tags with external editors

To edit PLC tags with external editors follow the procedure as in the standard. Additional information can be found in the *STEP 7* help in "Editing PLC tags with external editors".

Note the following:

Note

After importing a tag table which contains tags used in the safety program, the collective F-signature of the safety program is reset.

To form the collective F-signature again you have to recompile the project data. For this, with access protection set up for the safety program, you need a valid access authorization for the safety program.

If you would like to edit PLC tags with external editors, we therefore recommend that you store PLC tags to be used in the safety program in a separate tag table.

5.1.7 Using Multiuser engineering

If you want to use Multiuser engineering, proceed as described in the STEP 7 help under "Using Multiuser engineering".

5.2 Defining F-Runtime Groups

5.2.1 Rules for F-Runtime Groups of the Safety Program

Rules

Note the following:

- The channels (channel values and value status) of an F-I/O can only be accessed from a single F-runtime group.
- Tags of the F-I/O DB of an F-I/O can only be accessed from one F-runtime group and only from that F-runtime group from which the channels or value status of this F-I/O are also accessed (if access is made).
- F-FBs can be used in more than one F-runtime group but they must be called with different instance DBs.
- Instance DBs of F-FB can only be accessed from the F-runtime group in which the associated F-FB is called.
- A tag of a global F-DB (except the F-global DB) can only be accessed from one F-runtime group (however, a global F-DB can be used in more than one F-runtime group).
- (S7-300, S7-400) A DB for F-runtime group communication can be read and write accessed by the F-runtime group to which it was assigned as "DB for runtime group communication", but only read-accessed by the "receiver" F-runtime group.
- (S7-300, S7-400) An F-communication DB can only be accessed from one F-runtime group.
- (S7-1200, S7-1500) You must not call the main safety block yourself. It is automatically called by the assigned F-OB.
- (S7-1200, S7-1500). The F-OB should be created with the highest priority of all OBs.
- (S7-300, S7-400) The main safety block may only be called once from a standard block. Multiple calls can cause the F-CPU to go to STOP mode.
- (S7-300, S7-400) For optimal use of temporary local data, you must call the F-runtime group (the main safety block) directly in an OB (cyclic interrupt OB, if possible); you should not declare any additional temporary local data in this cyclic interrupt OB.
- (S7-300, S7-400) Within a cyclic interrupt OB, the F-runtime group should be executed **before** the standard user program; i.e. it should be called at the very beginning of the OB, so that the F-runtime group is always called at fixed time intervals, regardless of how long it takes to process the standard user program.

For this reason, the cyclic interrupt OB should also not be interrupted by higher priority interrupts.

- The process image of the inputs and outputs of standard I/O, bit memory, and tags of DBs in the standard user program may be accessed either as read-only or read/write from more than one F-runtime group. (see also Data exchange between standard user program and safety program (Page 165))
- F-FCs can generally be called in more than one F-runtime group.

Note

You can improve performance by writing sections of the program that are not required for the safety function in the standard user program.

When determining which elements to include in the standard user program and which to include in the safety program, you should keep in mind that the standard user program can be modified and downloaded to the F-CPU more easily. In general, changes in the standard user program do not require an acceptance.

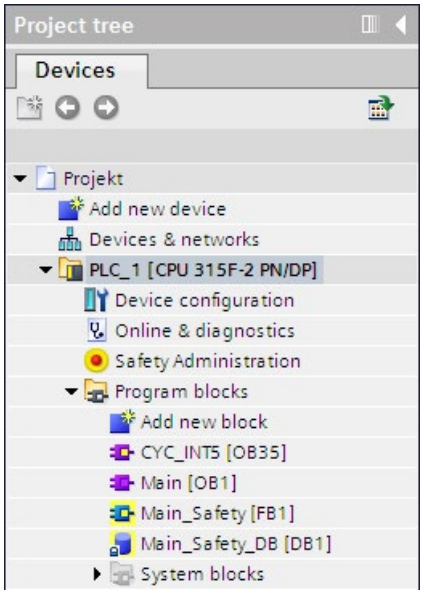
5.2.2 Procedure for defining an F-runtime group (S7-300, S7-400)

Requirements

In your project, you have selected an S7-300 or S7-400 F-CPU from the "Hardware catalog" task card and inserted it into the *hardware and network editor*. In the "Properties" tab of the F-CPU, the "F-capability activated" check box is selected (default setting).

F-runtime group created by default

STEP 7 Safety inserts F-blocks for an F-runtime group in the project tree by default. You see the (F-)blocks of the F-runtime group (CYC_INT5 [OB 35], Main_Safety [FB 1], and Main_Safety_DB [DB1]) in the project tree when you open the "Program blocks" folder.

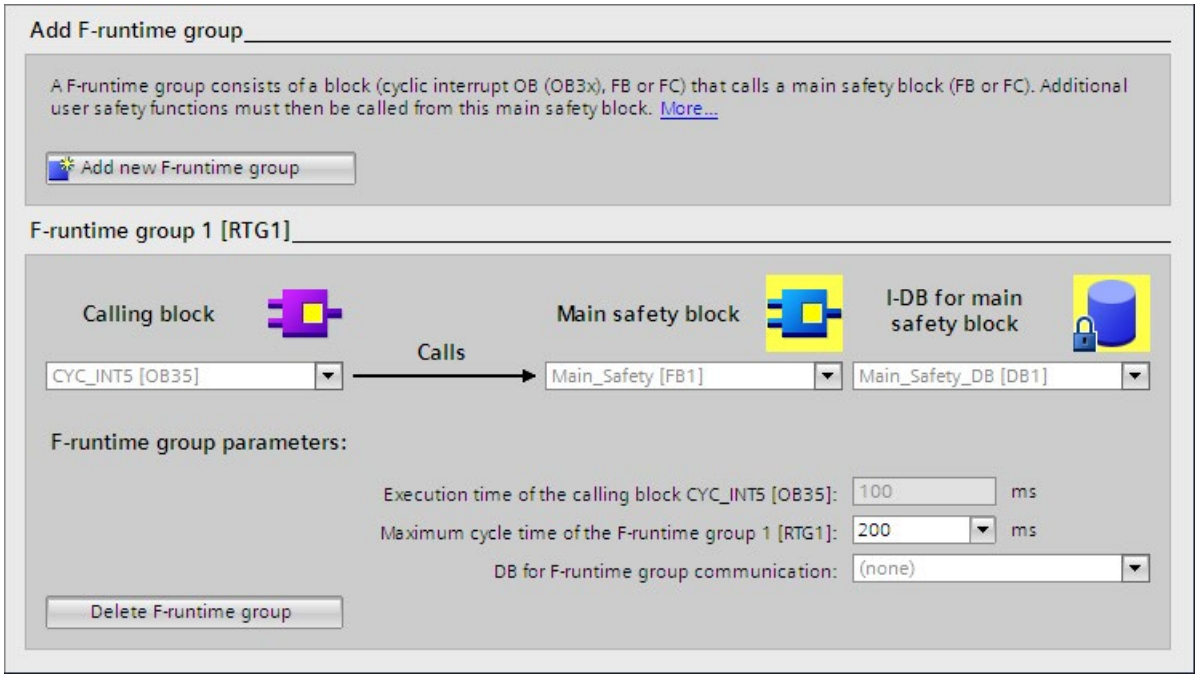


Procedure for defining an F-runtime group

Proceed as follows to define an F-runtime group:

1. Open the *Safety Administration Editor* by double-clicking in the project tree.
2. Select "F-runtime group" in the area navigation.

   Result: The work area for defining an F-runtime group with the (default) settings for F-runtime group 1 opens.



3. Specify the block in which the main safety block is to be called.

   Cyclic interrupt OB 35 is suggested here by default. The advantage of using cyclic interrupt OBs is that they interrupt the cyclic program execution in OB 1 of the standard user program at fixed time intervals; that is, the safety program is called and executed at fixed time intervals in a cyclic interrupt OB.

   In this input field, you can select only those blocks that were created in the LAD, FBD, or STL programming language. If you select a block here, the call is inserted automatically into the selected block and, if necessary, removed from a previously selected block.

   If you want to call the main safety block in a block that was created in another programming language, you must program this call itself. The input field is then not editable (grayed out), and you can change the call only in the calling block and not the *Safety Administration Editor*.

4. Assign the desired main safety block to the F-runtime group. If the main safety block is an FB, you must also assign an instance DB.

   Main_Safety [FB1] and Main_Safety_DB [DB1]) are suggested by default.

5. The F-CPU monitors the F-cycle time in the F-runtime group. For "Maximum cycle time of F-runtime group", enter the maximum permitted time between two calls of this F-runtime group.

> **⚠ WARNING**
>
> The F-runtime group call interval is monitored for the maximum value; i.e. monitoring is performed to determine whether the call is executed often enough, but not whether it is executed too often. Fail-safe timers must therefore be implemented using the TP, TON, or TOF instructions (Page 434) from the "Instructions" task card and not using counters (OB calls). *(S007)*

6. If one F-runtime group is to provide tags for evaluation to another F-runtime group of the safety program, assign a DB for F-runtime group communication. Select an F-DB for "DB for F-runtime group communication". (See also Safety-related communication between the F-runtime groups of a safety program (S7-300, S7-400) (Page 115))
7. **Create an additional F-runtime group** by clicking the "Add new F-runtime group" button.
8. Assign an F-FB or F-FC as the main safety block to a calling block. This F-FB or F-FC is automatically generated in the project tree, if not already present.
9. If the main safety block is an F-FB, assign an instance DB to the main safety block. The instance DB is generated automatically in the project tree.
10. Follow steps 3 and 4 above to complete generation of the second F-runtime group.

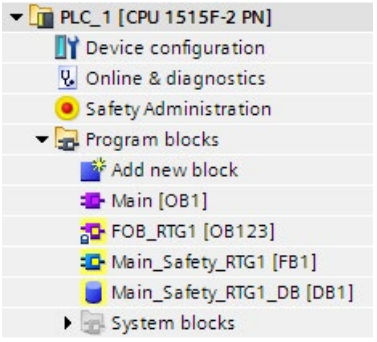
5.2.3 Procedure for defining an F-runtime group (S7-1200, S7-1500)

Requirements

In your project, you have selected an S7-1200/1500 F-CPU from the "Hardware catalog" task card and inserted it into the *hardware and network editor*. In the "Properties" tab of the F-CPU, the "F-capability activated" check box is selected (default setting).

F-runtime group created by default

STEP 7 Safety inserts F-blocks for an F-runtime group in the project tree by default. The (F-)blocks of the F-runtime group (FOB_RTG1 [OB123], Main_Safety_RTG1 [FB1] and Main_Safety_RTG1_DB [DB1]) are shown in the project tree when you open the "Program blocks" folder.

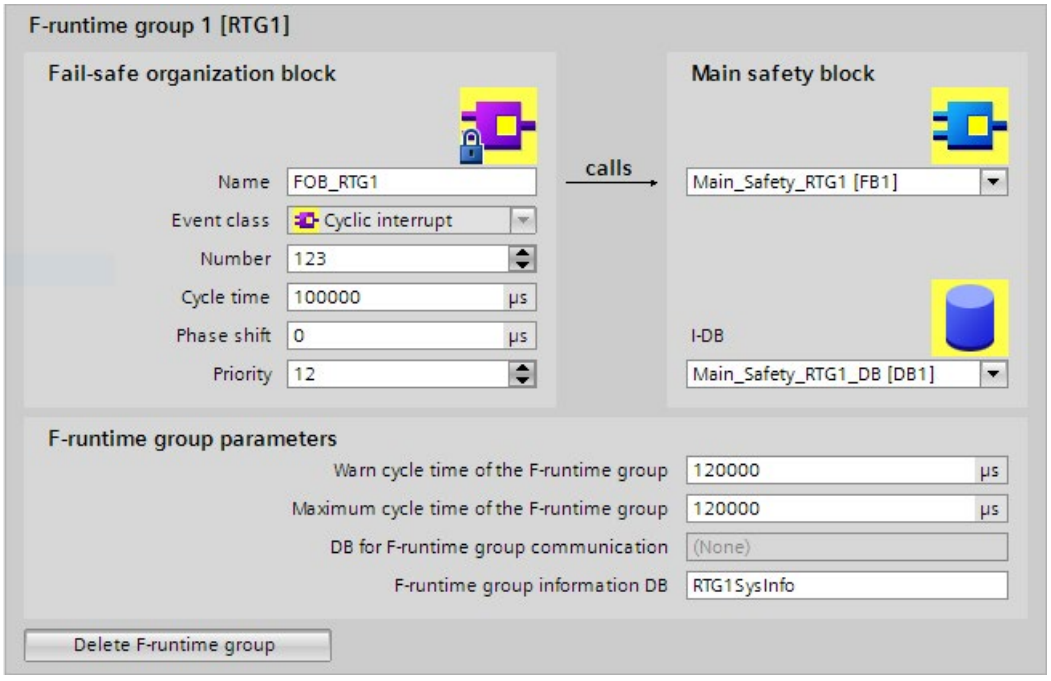


Procedure for defining an F-runtime group

Proceed as follows to define an F-runtime group:

1. Open the *Safety Administration Editor* by double-clicking in the project tree.
2. Select "F-runtime group" in the area navigation.

   Result: The work area for defining an F-runtime group with the (default) settings for F-runtime group 1 opens.



3. Assign a name for the F-OB under "F-OB". The F-OB calls the main safety block.

   By default, the F-OB is created with the event class "cyclic interrupt OB". The advantage of the event class "cyclic interrupt OB" is that the F-OB calls the main safety block, and therefore the safety program, at set intervals.

4. Assign the F-OB a number.

5. Assign parameters for the cycle time, phase shifting and priority of the F-OB.

   Select a cycle time which is less than the "Maximum cycle time of F-runtime group" and less than the "Warn cycle time of the F-runtime group".

   Select a phase shift which is less than the cycle time.

   Note

   You can also specify the event class "cyclic" for the F-OB. Keep in mind that the F-OB has the lowest priority in this case and that the runtime as well as the reaction time of the safety program are also influenced by the standard user program.

   Note

   We recommend creating the F-OB with the highest priority of all OBs. This will ensure:
   - Defined response times
   - Guaranteed data consistency during data communication between the standard and safety program. See also Data exchange between standard user program and safety program (Page 165).

6. Assign the calling main safety block to the F-OB. If the main safety block is an FB, you must also assign an instance DB.

   Main_Safety_RTG1 [FB1] and Main_Safety_RTG1_DB [DB1] are suggested by default.

7. The F-CPU monitors the F-cycle time in the F-runtime group. Two parameters are available:
   – If "Warn cycle time of the F-runtime group" is exceeded, an entry is written to the diagnostics buffer of the F-CPU. This parameter can, for example, be used to determine whether the cycle time exceeds a required value without the F-CPU switching to STOP mode.
   – If "Maximum cycle time of F-runtime group" is exceeded, the F-CPU switches to STOP mode. For "Maximum cycle time of F-runtime group", select the maximum permitted time between two calls of this F-runtime group (maximum of 20000000 µs).

   ⚠ WARNING

   The F-runtime group call interval is monitored for the maximum value; i.e. monitoring is performed to determine whether the call is executed often enough, but not whether it is executed too often. Fail-safe timers must therefore be implemented using the TP, TON, or TOF instructions (Page 434) from the "Instructions" task card and not using counters (OB calls). *(S007)*

   "Warn cycle time of the F-runtime group" must be configured as less than or equal to the "Maximum cycle time of F-runtime group".

8. Assign a name for the F-runtime group information DB (Page 118) under "F-runtime group DB".
9. **Create an additional F-runtime group** by clicking the "Add new F-runtime group" button.
10. If the main safety block is an F-FB, assign an instance DB to the main safety block. The instance DB is generated automatically in the project tree.
11. Follow steps 3 to 6 above to complete generation of the second F-runtime group.

5.2.4 Safety-related communication between the F-runtime groups of a safety program (S7-300, S7-400)

Safety-related communication between F-runtime groups

Safety-related communication can take place between the two F-runtime groups of a safety program. This means fail-safe tags can be provided by one F-runtime group in an F-DB and read in another F-runtime group.

Note

A DB for F-runtime group communication can be read and write accessed by the F-runtime group to which it was assigned as "DB for runtime group communication", while it can only be read-accessed by the "receiver" F-runtime group.

Tip: You can improve performance by structuring your safety program in such a way that as few tags as possible are exchanged between the F-runtime groups.

Procedure for defining a DB for F-runtime group communication

You define the DB for F-runtime group communication in the work area "F-runtime groups". Proceed as follows:

1. Click "F-runtime groups" in "*Safety Administration Editor*".
2. Select an existing F-DB in the "DB for F-runtime group communication" field or assign a new one.
3. Assign a name to the F-DB.

Up-to-dateness of tags read from another F-runtime group

Note

Tags read are up-to-date as at the time of the last completed processing cycle of the F-runtime group providing the tags prior to start-up of the F-runtime group reading the tags.

If the tags supplied undergo multiple changes during runtime of the F-runtime group supplying the tags, the F-runtime group reading the tags only receives the last change (see figure below).

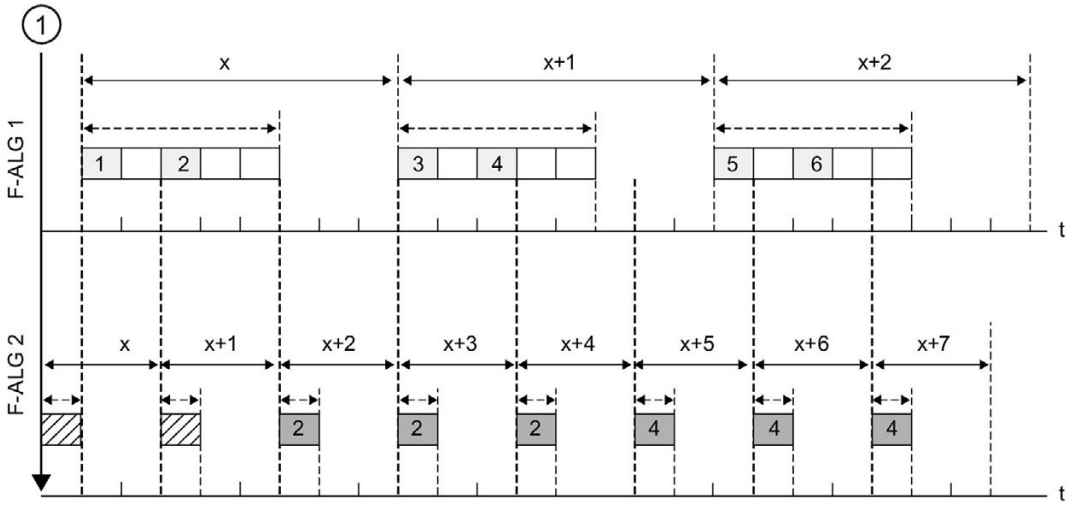
Assignment of fail-safe values

After F-system start-up, fail-safe values are supplied to the F-runtime group which has read access to tags in the DB for F-runtime group communication of another F-runtime group (for example, F-runtime group 2). These are the values you specified as initial values in the DB for F-runtime group communication of F-runtime group 1.

F-runtime group 2 reads the fail-safe values the first time it is called. The second time the F-runtime group 2 is called, it reads the latest tags if F-runtime group 1 has been processed completely between the two calls of F-runtime group 2. If F-runtime group 1 has not been processed completely, F-runtime group 2 continues to read the fail-safe values until F-runtime group 1 is completely processed.

The behavior is illustrated in the two figures below.

Reading tags from F-runtime group 1, which has a longer OB cycle and lower priority than F-runtime group 2



① Startup of F-system

Cycle time of the (F-)OB in which the F-runtime group is called.

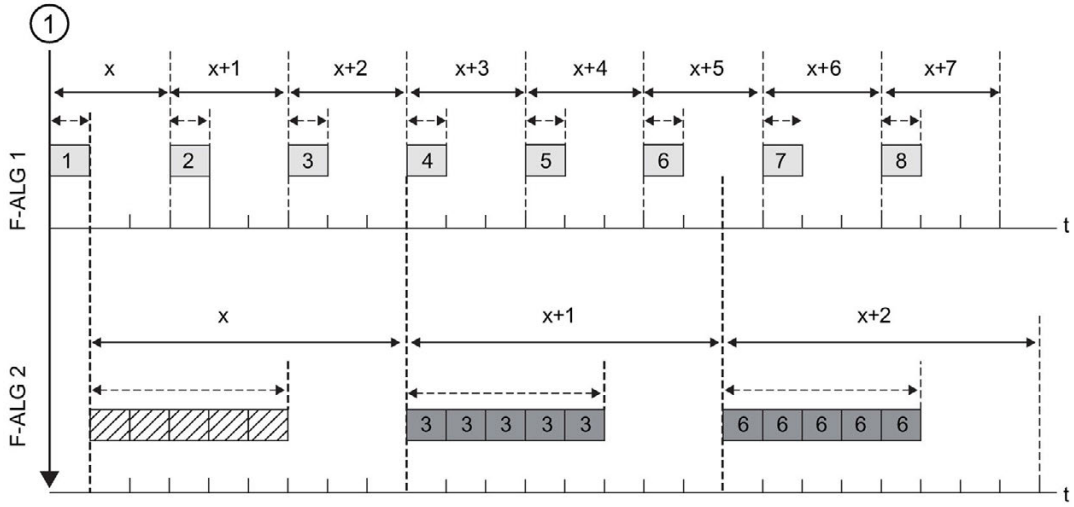
Runtime of the F-runtime group

1 ... Tag of F-runtime group 1, written to DB for F-runtime group communication of F-runtime group 1

2 ...Tag of F-runtime group 2, read in DB for F-runtime group communication of F-runtime group 1

Initial value in the DB for F-runtime group communication

Reading tags from F-runtime group 1, which has a shorter OB cycle and higher priority than F-runtime group 2



① Startup of F-system

Cycle time of the (F-)OB in which the F-runtime group is called.

Runtime of the F-runtime group

1 ... Tag of F-runtime group 1, written to DB for F-runtime group communication of F-runtime group 1

2 ... Tag of F-runtime group 2, read in DB for F-runtime group communication of F-runtime group 1

Initial value in the DB for F-runtime group communication

F-runtime group supplying tags is not processed

Note

If the F-runtime group whose DB for F-runtime group communication is to supply the tags is not processed (the main safety block of the F-runtime group is not called), the F-CPU goes to STOP mode. One of the following diagnostics events is then entered in the diagnostics buffer of the F-CPU:

- Error in safety program: cycle time exceeded
- Number of the relevant main safety block (of F-runtime group that is not processed)
- Current cycle time in ms: "0"

5.2.5 F-shared DB (S7-300, S7-400)

Function

The F-shared DB is a fail-safe data block that contains all of the shared data of the safety program and additional information needed by the F-system. The F-shared DB is automatically inserted when the hardware configuration is compiled.

Using its name F_GLOBDB, you can evaluate certain data elements of the safety program in the standard user program.

Reading an F-shared DB in the standard user program

You can read out the following information in the F-shared DB in the standard user program or on an operator control and monitoring system:

- Operating mode: safety mode or disabled safety mode ("MODE" tag)
- Error information "Error occurred when executing safety program" ("ERROR" tag)
- Collective F-signature ("F_PROG_SIG" tag)
- Compilation date of the safety program ("F_PROG_DAT" tag, DATE_AND_TIME data type)

You use fully qualified access to access these tags (e.g. ""F_GLOBDB".MODE").

5.2.6 F-runtime group information DB (S7-1200, S7-1500)

Introduction

The F-runtime group information DB provides key information on the corresponding F-runtime group and on the safety program as a whole.

The F-runtime group information DB is generated automatically when an F-runtime group is created. A symbol, for example, "RTG1SysInfo", is assigned for the F-runtime group information DB. You can change the name in the *Safety Administration Editor*.

Information in the F-runtime group information DB

The F-runtime group information DB provides the following information:

Name		Data type	For processing in the safety program	For processing in the standard user program	Description
MODE		BOOL	x	x	1 = Disabled safety mode
F_SYSINFO					
	MODE	BOOL	—	x	1 = Disabled safety mode
	TCYC_CURR	DINT	—	x	Current cycle time of the F-runtime group, in ms
	TCYC_LONG	DINT	—	x	Longest cycle time of the F-runtime group, in ms
	TRTG_CURR	DINT	—	x	Current runtime of the F-runtime group, in ms
	TRTG_LONG	DINT	—	x	Longest runtime of the F-runtime group, in ms
	T1RTG_CURR	DINT	—	x	Not supported by STEP 7 Safety V14.
	T1RTG_LONG	DINT	—	x	Not supported by STEP 7 Safety V14.
	F_PROG_SIG	DWORD	—	x	Collective F-signature of the safety program
	F_PROG_DAT	DTL	—	x	Compilation date of the safety program
	F_RTG_SIG	DWORD	—	x	Collective F-signature of the F-runtime group
	F_RTG_DAT	DTL	—	x	Compilation date of the F-runtime group
	VERS_S7SAF	DWORD	—	x	Version identifier for *STEP 7 Safety*

You access the content of the F-runtime group information DB with fully qualified addressing. Either collectively with the F_SYSINFO PLC data type (UDT), for example, "RTG1SysInfo.F_SYSINFO", provided by the F-system or individual information, for example, "RTG1SysInfo.F_SYSINFO.MODE".

See also

Program identification (Page 286)

5.2.7 Deleting an F-runtime group

Deleting an F-runtime group

To delete an F-runtime group, proceed as follows:

1. In the area navigation of the *Safety Administration Editor*, click on the F-runtime group to be deleted.
2. Select the "Delete F-runtime group" button in the work area.
3. Confirm the dialog with "Yes".
4. Compile the safety program (Page 269) (menu command "Edit > Compile") to put your changes into effect.

The assignment of the F-blocks to an F-runtime group (to the calling block of the main safety block) is deleted. However, the F-blocks continue to exist.

Note

If you want to delete your safety program, delete all F-blocks outside the System blocks folder in the project tree.

F-blocks that do not allow deletion are deleted by recompiling the safety program or deactivating F-capability for the F-CPU (see Configuring an F-CPU (Page 44)).

5.2.8 Changing the F-runtime group (S7-300, S7-400)

Changing an F-runtime group

You can make the following changes for each F-runtime group in your safety program in the corresponding "F-runtime group" work area:

- Specify another block as the calling block of the main safety block.
- Specify another F-FB or F-FC as main safety block.
- Enter a different or new I-DB for the main safety block.
- Change the value for the maximum cycle time of the F-runtime group
- Specify another DB as a data block for F-runtime group communication.

5.2.9 Changing the F-runtime group (S7-1200, S7-1500)

Changing an F-runtime group

You can make the following changes for each F-runtime group in your safety program in the corresponding "F-runtime group" work area:

- Change the name, number, cycle time, phase shift and priority of the F-OB.
- Specify another F-FB or F-FC as main safety block.
- Enter a different or new I-DB for the main safety block.
- Change the value for the maximum cycle time and the cycle time warning limit of the F-runtime group.
- Assign another name for the F-runtime group information DB.

Copying F-OB

You may not copy an F-OB.

5.3 Creating F-blocks in FBD / LAD

5.3.1 Creating F-blocks

Introduction

In order to create F-FBs, F-FCs, and F-DBs for the safety program, you should follow the same basic procedure as for standard blocks. In the following, only the deviations from the procedure for standard blocks are presented.

Creating F-FBs, F-FCs, and F-DBs

You create F-blocks in the same way as for standard blocks. Proceed as follows:

1. Double-click on "Add new block" under "Program blocks" in the project tree.
2. In the dialog that appears, specify the type, name, and language and select the "Create F-block" check box. (If you do not select the check box, a standard block is created.)
3. After the dialog is confirmed, the F-block is opened in the *Program editor*.

Note the following

Note the following important instructions:

Note

You may not declare block parameters in the block interface of the main safety block because they cannot be supplied.

Note

You may not edit initial values in instance DBs of F-FBs online and offline. Editing can cause the F-CPU to go to STOP mode.

Note

You may not access static local data in single instances or multi-instances of other F-FBs.

Note

You must always initialize outputs of F-FCs.

The F-CPU can go to STOP mode if the information above is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

If you wish to assign an address from the data area (data block) to a formal parameter of an F-FC as an actual parameter, you have to use fully qualified DB access. (S7-300, S7-400)

Note

Access to the inputs in an F-FB/F-FC is read-only, while access to the outputs is write-only.

Use an in/out if you wish to have both read and write access.

Note

For greater clarity, assign meaningful names to the F-blocks you have created.

Copying/pasting F-blocks

You can copy F-FBs, F-FCs, and F-DBs in exactly the same was as blocks of the standard user program.

(S7-1200, S7-1500) Information on copying an F-OB is provided in Changing the F-runtime group (S7-1200, S7-1500) (Page 121).

Exception:

You cannot copy blocks from the folder "Program blocks > System blocks".

5.3.2 Know-how protection

For know-how protection of F-blocks, proceed as described in the *STEP 7* help under "Protecting blocks".

Requirements

Note the following with regard to know-how protection of F-blocks:

- An F-block to which you wish to assign know-how protection must be called in the safety program.
- Before you can set up the know-how protection for an F-block, the safety program must be consistent. For this purpose, compile (Page 269) the safety program.

Note

No source code is output for know-how protected F-blocks in the safety summary. Therefore, create the safety summary (for example to carry out a code review or accept the F-block) before you set up the know-how protection.

Note

If you want to edit the program code and/or the block interface of a know-how protected F-block, we recommend that you do not open the F-block by entering a password, but rather remove the know-how protection completely and set it up again after compiling.

Note

(S7-1200, S7-1500) When a know-how protected F-block or F-blocks called by it are renamed, the signature of the know-how protected F-block is not changed until the password is entered when opening or removing the know-how protection.

Note

When know-how protected F-blocks are used, warnings and error messages whose cause can lie in the know-how protected F-blocks can be displayed during compilation of the safety program. The warnings and error messages contain corresponding information. Example: In a know-how protected F-block, you perform read access to a tag of the standard user program to which write access is taking place in a different (know-how protected) F-block.

For S7-1200/1500 F-CPUs, you can obtain additional information from the safety summary in the section "Know-how protected F-blocks in the safety program".

See also

Reuse of F-blocks (Page 125)

5.3.3 Reuse of F-blocks

Introduction

You can reuse F-blocks that you have already tested and, if applicable, approved, in other safety programs – without having to test and approve them again.

You can protect the content of the F-block by setting up the know-how protection.

Like standard blocks, you can store F-blocks as master copies or types in global libraries or in the project library.

Additional information can be found in the *STEP 7 help* under "Using libraries".

Creating safety documentation for the F-block to be reused

Create safety documentation with the following information for F-blocks that you want to reuse.

S7-300/400 F-CPUs

- Signature and initial value signature of the know-how protected F-block
- Versions of all the used versioned LAD/FBD instructions
- Signatures and initial value signatures of all called F-blocks

S7-1200/1500 F-CPUs

- Signature of the know-how protected F-block
- Safety system version when setting up the know-how protection
- Versions of all the used versioned LAD/FBD instructions
- Signatures of all called F-blocks

The safety documentation should also contain a description of the functionality of the F-block, in particular if it is know-how protected.

The required information is obtained by creating a safety summary of the safety program in which you originally created, tested and approved the F-block to be reused.

This safety summary can also serve directly as the safety documentation for the F-block to be reused.

Checks when using the F-block to be reused

When reusing the F-block, ensure the following:

- The signature and initial value signature (S7-300/400) of the F-block are unchanged.
- (SIMATIC S7-1200, S7-1500) The documented safety system version is set.
- The documented (or functionally identical) versions of the versioned LAD/FBD instructions are set. You will find information on the instruction versions in the online help for the instructions.
- The called F-blocks with the documented signatures and initial value signatures (S7-300/400) are used.

If the version conflicts cannot be eliminated due to other dependencies, please contact the author of the know-how protected block in order to obtain a compatible approved version.

See also

Compliance of the know-how protected F-blocks used in the safety program with their safety documentation. (Page 312)

5.4 Programming startup protection

Introduction

⚠ WARNING

STOP, for example, via programming device/PC, mode switch, communication function or "STP" instruction

Initiating STOP, for example by means of programming device/PC operation, mode switch, communication function or "STP" instruction as well as maintaining the STOP state are not safety-oriented. This STOP state can be easily (and unintentionally) be revoked, for example, by programming device/PC operation.

When an F-CPU is switched from STOP to RUN mode, the standard user program starts up in the usual way. When the safety program is started up, all F-DBs are initialized with the values from the load memory - as is the case with a cold restart. This means that saved error information is lost. The F-system automatically reintegrates the F-I/O.

If your process does not allow such a startup, you must program a restart/startup protection in the safety program: The output of process data must be blocked until manually enabled. This enable must not occur until it is safe to output process data and faults have been corrected. *(S031)*

Example of restart/startup prevention

In order to implement a restart/startup prevention, it must be possible to detect a startup. To detect a startup, you declare a tag of data type BOOL with initial value "TRUE" in an F-DB.

Block the output of process data when this tag has the value "1," for example, by passivating F-I/O using the PASS_ON tag in the F-I/O DB.

To manually enable the output of process data, you reset this tag by means of a user acknowledgment.

See also

Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 156)

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 162)

F-I/O DB (Page 135)

F-I/O access

6

6.1 Addressing F-I/O

Overview

Below you will find a description of how to address the F-I/O in the safety program and which rules must be observed in the process.

Addressing via the process image

As with standard I/O, you access F-I/O (e.g., S7-1500/ET 200MP fail-safe modules) via the **process image** (PII and PIQ).

Direct reading (with I/O identification ":P") of inputs or writing of outputs is not possible in the safety program.

Updating the process image

The process image of the inputs of F-I/O is updated at the start of the F-runtime group. The process image of the outputs of F-I/O is updated at the end of the F-runtime group (see Program structure of the safety program (S7-300, S7-400) (Page 91) or Program structure of the safety program (S7-1200, S7-1500) (Page 93)). For additional information on updating the process image, refer to the note in Data Transfer from the Safety Program to the Standard User Program (Page 166).

The communication required between the F-CPU (process image) and the F-I/O to update the process image uses a special safety protocol in accordance with PROFIsafe.

Rules

- You may only address a channel (channel value and value status) of an F-I/O in **one** F-runtime group. The first programmed addressing defines the assignment for the F-runtime group.
- You may only address a channel (channel value and value status) of an F-I/O with a unit that matches the data type of the channel.
  Example: To access input channels of data type BOOL, you must use the "input (bit)" (I x.y) unit. Access to the 16 consecutive input channels of the data type BOOL via the unit "input word" (IW x) is not possible.
- Address only inputs and outputs that reference an actually existing channel (channel value and value status) (e.g. for an F-DO 10xDC24V with start address 10 only the outputs Q10.0 to Q11.1 for the channel values and the inputs I10.0 to I11.1 for the value status). Keep in mind that due to the special safety protocol, the F-I/O occupies a larger area of the process image than is required for the existing and enabled channels on the F-I/O (channel values and value status). To find the area of the process image where the channels (channel values and value status) are stored (channel structure), refer to the relevant manuals for the F-I/O.
- Channels can be disabled for certain F-I/O (such as ET 200SP fail-safe modules or S7-1500/ET 200MP fail-safe modules). Address only channels (channel value and value status) that are enabled in the hardware configuration. When you address channels that are disabled in the hardware configuration, a warning may be output when compiling the safety program.
- For certain F-I/O (such as ET 200SP fail-safe modules or S7-1500/ET 200MP fail-safe modules), a "1oo2 (2v2) sensor evaluation" can be specified. Two channels are grouped into one channel pair in this case, and the result of the "1oo2 sensor evaluation" is usually provided under the address of the channel with the lower channel number (see relevant manuals of the F-I/O). Address only this channel (channel value and value status) of the channel pair. When you address a different channel, a warning may be output when compiling the safety program.

⚠ WARNING

If you use an additional component between the F-CPU (S7-300/400) and the F-I/O that copies the safety message frame in accordance with PROFIsafe between the F-CPU (S7-300/400) and F-I/O per user program, you must test all safety functions affected by the copy function whenever you change the user-programmed copy function. *(S049)*

See also

Safety-Related I-Slave-Slave Communication - F-I/O Access (Page 214)

Value status (S7-1200, S7-1500) (Page 130)

6.2 Value status (S7-1200, S7-1500)

Properties

The value status is additional binary information for the channel value of an F-I/O. The value status is entered in the process image input (PII).

The value status is supported by S7-1500/ET 200MP, ET 200SP, ET 200S, ET 200iSP, ET 200pro, S7-1200 fail-safe modules or S7-300 F-SMs fail-safe GSD based I/O devices as well as fail-safe GSD based DP slaves which support the "RIOforFA-Safety" profile.

We recommend you amend the name of the channel value with "_VS" for the value status, for example, "TagIn_1_VS".

The value status provides information on the validity of the corresponding channel value:

- 1: A valid process value is output for the channel.
- 0: A fail-safe value is output for the channel.

The channel value and value status of an F-I/O can only be accessed from the same F-runtime group.

Location of value status bits in the PII for F-I/O with digital inputs

The value status bits come straight after the channel values in the PII.

Table 6- 1 Example: Address assignment in PII for F-I/O with 16 digital input channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	DI_7	DI_6	DI_5	DI_4	DI_3	DI_2	DI_1	DI_0
x + 1	DI_{15}	DI_{14}	DI_{13}	DI_{12}	DI_{11}	DI_{10}	DI_9	DI_8
x + 2	Value status DI_7	Value status DI_6	Value status DI_5	Value status DI_4	Value status DI_3	Value status DI_2	Value status DI_1	Value status DI_0
x + 3	Value status DI_{15}	Value status DI_{14}	Value status DI_{13}	Value status DI_{12}	Value status DI_{11}	Value status DI_{10}	Value status DI_9	Value status DI_8

x = Module start address

The location of the channel values in the PII can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with digital outputs

The value status bits in the PII are mapped with the same structure as the channel values in the PIQ.

Table 6- 2 Example: Address assignment in PIQ for F-I/O with 4 digital output channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

Table 6- 3 Example: Address assignment in PII for F-I/O with 4 digital output channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0

x = Module start address

The location of the channel values in the PIQ can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with digital outputs and digital inputs

The value status bits come directly after the channel values in the PII in the following order:

- Value status bits for the digital inputs
- Value status bits for the digital outputs

Table 6- 4 Example: Address assignment in PIQ for F-I/O with 2 digital input channels and 1 digital output channel

Byte in the F-CPU	Assigned bit in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	—	DQ_0

x = Module start address

Table 6- 5 Example: Address assignment in PII for F-I/O with 2 digital input channels and 1 digital output channel

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	DI_1	DI_0
x + 1	—	—	—	—	—	—	Value status DI_1	Value status DI_0
x + 2	—	—	—	—	—	—	—	Value status DQ_0

x = Module start address

The location of the channel values in the PII and PIQ can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with analog inputs

The value status bits come directly after the channel values in the PII.

Table 6- 6 Example: Address assignment in PII for F-I/O with 6 analog input channels (data type INT)

Byte in the F-CPU	Assigned bytes/bits in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	Channel value AI_0							
...	...							
x + 10	Channel value AI_5							
x + 12	—	—	Value status AI_5	Value status AI_4	Value status AI_3	Value status AI_2	Value status AI_1	Value status AI_0

x = Module start address

The location of the channel values in the PII can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with analog outputs

The value status bits are mapped in the PII.

Table 6- 7 Example: Address assignment in PIQ for F-I/O with 6 analog output channels (data type INT)

Byte in the F-CPU	Assigned bytes in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	Channel value AO_0							
...	...							
x + 10	Channel value AO_5							

x = Module start address

Table 6- 8 Example: Address assignment in PII for F-I/O with 6 analog output channels (data type INT)

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	Value status AO_5	Value status AO_4	Value status AO_3	Value status AO_2	Value status AO_1	Value status AO_0

x = Module start address

The location of the channel values in the PIQ can be found in the device manual for the F-I/O.

6.3 Process Data or Fail-Safe Values

When are fail-safe values used?

The safety function requires that fail-safe values (0) be used instead of process data for passivation of the entire F-I/O or individual channels of an F-I/O in the following cases. This applies both to digital channels (data type BOOL) as well as for analog channels (data type INT or DINT):

- When the F-system starts up
- When errors occur during safety-related communication (communication errors) between the F-CPU and F-I/O using the safety protocol in accordance with PROFIsafe
- When F-I/O faults and channel faults occur (such as wire break, short circuit, and discrepancy errors)
- As long as you enable passivation of the F-I/O with PASS_ON = 1 in the F-I/O DB (see below)

Fail-safe value output for F-I/O/channels of an F-I/O

When **passivation** occurs for an **F-I/O with inputs**, the F-system provides the safety program with fail-safe values (0) in the PII instead of the process data pending at the fail-safe inputs of the F-I/O.

The overflow or underflow of a channel of the **SM 336; AI 6 x 13Bit** or **SM 336; F-AI 6 x 0/4 ... 20 mA HART** is recognized by the F-system as an F-I/O/channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

If you want to process fail-safe values other than "0" in the safety program for an F-I/O with inputs **for analog channels of data type INT or DINT**, you can assign individual fail-safe values for QBAD = 1 and value status = 0 or QBAD_I_xx/QBAD_O_xx = 1 (instructions JMP/JMPN, LABEL and MOVE). For details about the characteristics go to PASS_OUT/QBAD/QBAD_I_xx/QBAD_O_xx and value status (Page 141).

⚠ WARNING

For an F-I/O with digital input channels (data type BOOL), the value provided in the PII must always be processed in the safety program, regardless of the value status or QBAD/QBAD_I_xx. *(S009)*

When **passivation** occurs in an **F-I/O with outputs**, the F-system outputs fail-safe values (0) at the fail-safe outputs instead of the output values provided by the safety program in the PIQ.

State of associated PAA/PIQ by ...	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPUs	F-I/O without "RIOforFA-Safety" profile with S7-1200/1500 F-CPUs	F-I/O with S7-300/400 F-CPUs
Startup of F-system	The F-system overwrites the PII/PIQ with fail-safe values (0).		
Communication errors			
F-I/O faults	The F-system overwrites the PII with fail-safe values (0). In the PII the values formed in the safety program are retained.	The F-system overwrites the PII/PIQ with fail-safe values (0).	
Channel faults in configuration of passivation for complete F-I/O			
Channel faults during configuration of channel-granular passivation		For the affected channels: The F-system overwrites the PII/PIQ with fail-safe values (0).	
As long as passivation of the F-I/O is activated in the F-I/O DB with PASS_ON = 1	The F-system overwrites the PII/PIQ with fail-safe values (0).		

Reintegration of F-I/O/channels of an F-I/O

The switchover from fail-safe values (0) to process data (**reintegration of an F-I/O**) takes place **automatically** or following **user acknowledgment** in the F-I/O DB. The reintegration method depends on the following:

- The reason for passivation of the F-I/O or channels of the F-I/O
- The parameter assignment to be implemented by you in the F-I/O DB (Page 135) or the parameter assignment for the S7-1500/ET 200MP/F-Module S7-1200 and possibly fail-safe GSD based DP slaves/GSD based I/O devices in accordance with "RIOforFA-Safety" profile

Note

Note that for channel faults in the F-I/O, channel-granular passivation takes place if configured accordingly in the *hardware and network editor*. For the concerned channels, fail-safe values (0) are output.

Reintegration after channel faults reintegrates all channels whose faults were eliminated; faulty channels remain passivated.

See also

Configuring F-I/O (Page 49)

6.4 F-I/O DB

Introduction

An F-I/O DB is automatically generated for each F-I/O (in safety mode) when the F-I/O is configured in the *hardware and network editor*. The F-I/O DB contains tags that you can evaluate or can/must write to in the safety program. It is not permitted to change the initial values of the tags directly in the F-I/O DB. When an F-I/O is deleted, the associated F-I/O DB is also deleted.

Access to an F-I/O DB

You access tags of the F-I/O DB for the following reasons:

- For reintegration of F-I/O after communication errors, F-I/O faults, or channel faults
- If you want to passivate the F-I/O depending on particular states of your safety program (for example, group passivation)
- For changing parameters for fail-safe GSD based DP slaves/GSD based I/O devices
- If you want to evaluate whether fail-safe values or process data are output

6.4.1 Tags of the F-I/O DB

The following table presents the variables of an F-I/O DB:

	Tag	Data type	Function	Initial value
Tags that you can or must write	PASS_ON	BOOL	1=enable passivation	0
	ACK_NEC	BOOL	1=acknowledgment for reintegration required in the event of F-I/O or channel faults	1
	ACK_REI	BOOL	1=acknowledgment for reintegration	0
	IPAR_EN	BOOL	Tag for parameter reassignment of fail-safe GSD based DP slaves/GSD based I/O devices or, in the case of SM 336; F-AI 6 x 0/4 ... 20 mA HART, for enabling HART communication	0
Tags that you can evaluate	PASS_OUT	BOOL	Passivation output	1
	QBAD	BOOL	1=Fail-safe values are output	1
	ACK_REQ	BOOL	1=Acknowledgment request for reintegration	0
	IPAR_OK	BOOL	Tag for parameter reassignment of fail-safe GSD based DP slaves/GSD based I/O devices or, in the case of SM 336; F-AI 6 x 0/4 ... 20 mA HART, for enabling HART communication	0
	DIAG	BYTE	Non-fail safe service information	
	QBAD_I_xx	BOOL	1=fail-safe values are output to input channel xx (S7-300/400)	1
	QBAD_O_xx	BOOL	1=fail-safe values are output to output channel xx (S7-300/400)	1

Differences in evaluation in S7-1200/1500 F-CPUs and S7-300/400

The following table describes the differences in the evaluation of tags of the F-I/O DB and the value status depending on the F-I/O and F-CPU used.

Tag in the F-I/O DB or value status	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	F-I/O with S7-300/400 F-CPU
ACK_NEC	—[2]	x	x
QBAD	x[3]	x	x
PASS_OUT	x[3]	x	x
QBAD_I_xx[1]	—	—	x
QBAD_O_xx[1]	—	—	x
Wertstatus[1]	x	x	—

1 QBAD_I_xx and QBAD_O_xx display the validity of the channel value channel-granular and thus correspond to the inverted value status with S7-1200/1500. Value status or QBAD_I_xx and QBAD_O_xx are not available with fail-safe DP GSD based slaves or fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

2 Via F-I/O configuration; for S7-1500/ET 200MP or S7-1200 F-modules using the "Channel failure acknowledge" parameter.

3 For details about the characteristics, see "PASS_OUT/QBAD/QBAD_I_xx/QBAD_O_xx and value status"

6.4.1.1 PASS_ON

The PASS_ON tag allows you to enable passivation of an F-I/O, for example, depending on particular states in your safety program.

Using the PASS_ON tag in the F-I/O DB, you can passivate F-I/O; channel-granular passivation is not possible.

As long as PASS_ON = 1, **passivation** of the associated F-I/O occurs.

6.4.1.2 ACK_NEC

If an F-I/O fault is detected by the F-I/O, **passivation** of the relevant F-I/O occurs. If channel faults are detected and channel granular passivation is configured, the relevant channels are passivated. If passivation of the entire F-I/O is configured, all channels of the relevant F-I/O are passivated. Once the F-I/O fault or channel fault has been eliminated, **reintegration** of the relevant F-I/O occurs, depending on ACK_NEC:

- With ACK_NEC = 0, you can assign an **automatic reintegration**.
- With ACK_NEC = 1, you can assign a **reintegration** by **user acknowledgment**.

⚠ WARNING

The parameter assignment of the ACK_NEC = 0 tag is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint. *(S010)*

Note

The initial value for ACK_NEC is 1 after creation of the F-I/O DB. If you do not require automatic reintegration, you do not have to write ACK_NEC.

See also

After F-I/O or channel faults (Page 150)

6.4.1.3 ACK_REI

When the F-system detects a communication error or an F-I/O fault for an F-I/O, the relevant F-I/O is passivated. If channel faults are detected and channel granular passivation is configured, the relevant channels are passivated. If passivation of the entire F-I/O is configured, all channels of the relevant F-I/O are passivated. **Reintegration** of the F-I/O/channels of the F-I/O after the fault has been eliminated requires a **user acknowledgment** with a positive edge at variable ACK_REI of the F-I/O DB:

- After every communication error
- After F-I/O or channel faults only with parameter assignment "Channel failure acknowledgement = manual" or ACK_NEC = 1

Reintegration after channel faults reintegrates all channels whose faults were eliminated.

Acknowledgment is not possible until tag ACK_REQ = 1.

In your safety program, you must provide a user acknowledgment by means of the ACK_REI tag for each F-I/O.

⚠ WARNING

For the user acknowledgement, you must interconnect the ACK_REI tag of the F--I/O DB with a signal generated by an operator input. An interconnection with an automatically generated signal is not permitted. *(S011)*

Note

Alternatively, you can use the "ACK_GL" instruction to carry out reintegration of the F-I/O following communication errors or F-I/O/channel faults (ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V14) (Page 432)).

6.4.1.4 IPAR_EN

The IPAR_EN tag corresponds to the iPar_EN_C tag in the PROFIsafe bus profile as of PROFIsafe Specification V1.20 and higher.

Fail-safe GSD based DP slaves/GSD based I/O devices

To find out when this tag must be set or reset when parameters of fail-safe GSD based DP slaves/GSD based I/O devices are reassigned, consult the PROFIsafe Specification V1.20 or higher or the documentation for the fail-safe GSD based DP slave/GSD based I/O device.

Note that IPAR_EN = 1 does not trigger passivation of the relevant F-I/O.

If passivation is to occur when IPAR_EN = 1, you must also set tag PASS_ON = 1.

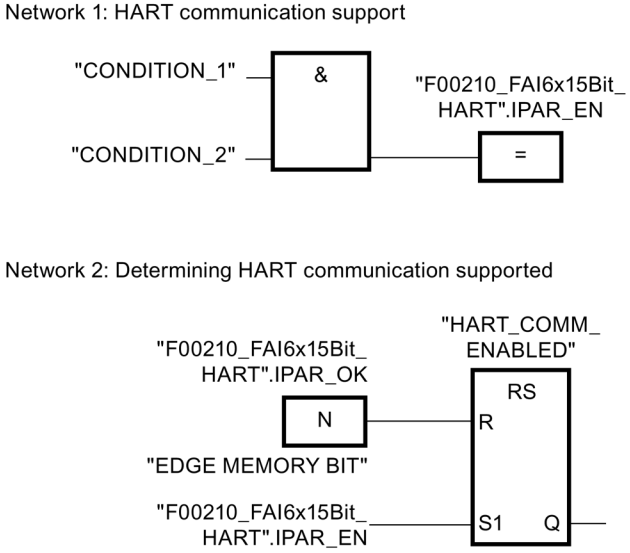
HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART

If you set the IPAR_EN tag to "1" while parameter "HART_Tor" = "switchable" is assigned, the HART communication for the SM 336; F-AI 6 x 0/4 ... 20 mA HART is enabled. Setting this tag to "0" disables the HART communication. The F-SM acknowledges the enabled or disabled HART communication with tag IPAR_OK = 1 or 0.

Enable HART communication only when your system is in a status, in which any reassignment of parameters for an associated HART device can be done without any risk.

If you want to evaluate the "HART communication enabled" status in your safety program, e.g., for the purpose of programming interlocks, you must build up the information as shown in the following example. This is necessary to ensure that the information is properly available even if communication errors occur while the HART communication is enabled with IPAR_EN = 1. Only change the status of the IPAR_EN tag during this evaluation if there is no passivation due to a communication error or F-I/O or channel fault.

Example of enabling HART communication



Additional information on HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART can be found in the Automation System S7-300, ET 200M Distributed I/O System manual, Fail-Safe Signal Modules (http://support.automation.siemens.com/WW/view/en/19026151) manual and in the online help on the module.

6.4.1.5 PASS_OUT/QBAD/QBAD_I_xx/QBAD_O_xx and value status

The following table set outs differences in the reaction of the channel values and PASS_OUT, QBAD, QBAD_I_xx/QBAD_O_xx tags and of the value status depending on the F-I/O and F-CPU used.

Fail-safe value output after...	**F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU**	**F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPUs**	**F-I/O with S7-300/400 F-CPU**
Startup of F-system Communication errors F-I/O faults Channel faults in configuration of passivation for complete F-I/O	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*
Channel faults during configuration of channel-granular passivation	QBAD and PASS_OUT **unchanged** For the **affected** channels: Channel value = fail-safe value (0) Value status = 0	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) Value status = 0*	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*
As long as passivation of the F-I/O is activated in the F-I/O DB with PASS_ON = 1	QBAD = 1, PASS_OUT **unchanged** For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD = 1, PASS_OUT **unchanged** For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

6.4.1.6 ACK_REQ

When the F-system detects a communication error or an F-I/O fault or channel fault for an F-I/O, the relevant F-I/O or individual channels of the F-I/O are passivated. ACK_REQ = 1 signals that **user acknowledgment** is required for reintegration of the relevant F-I/O or channels of the F-I/O.

The F-system sets ACK_REQ = 1 as soon as the fault has been eliminated and user acknowledgment is possible. For channel-granular passivation, the F-system sets ACK_REQ = 1 as soon as the channel fault is corrected. User acknowledgment is possible for this fault. Once acknowledgment has occurred, the F-system resets ACK_REQ to 0.

Note

For F-I/O with outputs, acknowledgment after F-I/O or channel faults may only be possible some minutes after the fault has been eliminated, until the necessary test signal is applied (see *F-I/O manuals*).

6.4.1.7 IPAR_OK

The IPAR_OK tag corresponds to the iPar_OK_S tag in the PROFIsafe bus profile, PROFIsafe Specification V1.20 and higher.

Fail-safe GSD based DP slaves/GSD based I/O devices

To find out how to evaluate this tag when parameters of fail-safe GSD based DP slaves or GSD based I/O devices are reassigned, consult the PROFIsafe Specification V1.20 or higher or the documentation for the fail-safe GSD based DP slave/GSD based I/O device.

For HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART see Chapter IPAR_EN (Page 139).

6.4.1.8 DIAG

The DIAG tag provides non-fail-safe information (1 byte) about errors or faults that have occurred for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until you perform an acknowledgment with the ACK_REI tag or until automatic reintegration takes place.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Timeout detected by F-I/O	The PROFIBUS/PROFINET connection between F-CPU and F-I/O is faulty. The value of the F-monitoring time for the F-I/O is set too low. The F-I/O are receiving invalid parameter assignment data or	• Check the PROFIBUS/PROFINET connection and ensure that there are no external sources of interference. • Check the parameter assignment of the F-I/O. If necessary, set a higher value for the monitoring time. Recompile the hardware configuration, and download it to the F-CPU. Recompile the safety program. • Check the diagnostics buffer of the F-I/O. • Turn the power of the F-I/O off and back on.
		Internal F-I/O fault or	Replace F-I/O
		Internal F-CPU fault	Replace F-CPU
Bit 1	F-I/O fault or channel fault detected by F-I/O[1]	See *F-I/O manuals*	See *F-I/O manuals*
Bit 2	CRC error or sequence number error detected by F-I/O	See description for bit 0	See description for bit 0
Bit 3	Reserved	—	—
Bit 4	Timeout detected by F-system	See description for bit 0	See description for bit 0
Bit 5	Sequence number error detected by F-system[2]	See description for bit 0	See description for bit 0
Bit 6	CRC-error detected by F-system	See description for bit 0	See description for bit 0
Bit 7	Addressing error[3]	—	Contact Service & Support

[1] Not for F-I/O that support the "RIOforFA-Safety" profile.

[2] For S7-300/400 F-CPUs only

[3] For S7-1200/1500 F-CPUs only

6.4.2 Accessing tags of the F-I/O DB

Name of the F-I/O DB

An F-I/O DB is automatically generated for each F-I/O when the F-I/O is configured in the *hardware and network editor* and a name is generated at the same time.

The name is formed by combining the fixed prefix "F", the start address of the F-I/O, and the names entered in the properties for the F-I/O in the *hardware and network editor* (example: F00005_4_8_F_DI_DC24V_1).

Changing the name and number of the F-I/O DB

The name and number of the F-I/O DB are assigned automatically when the F-I/O are configured. You change the number in the "Properties" tab of the associated F-I/O. You change the name by renaming the F-I/O.

Rule for accessing tags of the F-I/O DB

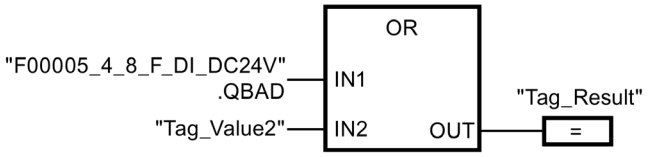
Tags of the F-I/O DB of an F-I/O can only be accessed from the F-runtime group from which the channels of this F-I/O are accessed (if access is made).

"Fully qualified DB access"

You can access the tags of the F-I/O DB via a "fully qualified DB access" (that is, by specifying the name of the F-I/O DB and by specifying the name of the tag).

Example of evaluating the QBAD tag

Network 4: fully qualified access to the QBAD tag



6.5 Passivation and reintegration of F-I/O

Overview

In the following you can find information on passivation and reintegration of F-I/O.

Signal sequence charts

The signal sequences presented below represent typical signal sequences for the indicated behavior.

Actual signal sequences and, in particular, the relative position of the status change of individual signals can deviate from the given signal sequences within the scope of known "fuzzy" cyclic program execution factors, depending on the following:

- The F-I/O used
- The F-CPU used
- The cycle time of the (F-)OB in which the associated F-runtime group is called
- The target rotation time of the PROFIBUS DP or the update time of the PROFINET IO

Note

The signal sequences shown refer to the status of signals in the user's safety program.

6.5.1 After startup of F-system

Behavior after a startup

Fail-safe value output after startup of the F-system	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
Passivation of the entire F-I/O occurs during startup.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Reintegration of F-I/O

Reintegration of the F-I/O, i.e. the provision of process values in the PII or the output of process values provided in the PIQ at the fail-safe outputs, takes place **automatically**, regardless of the setting at the ACK_NEC tag or the configuration "Channel failure acknowledge", no sooner than the second cycle of the F-runtime group after startup of the F-system.

You can find additional information on pending F-communication, F-I/O or channel errors during startup of the F-system in the sections After communication errors (Page 148) and After F-I/O or channel faults (Page 150).

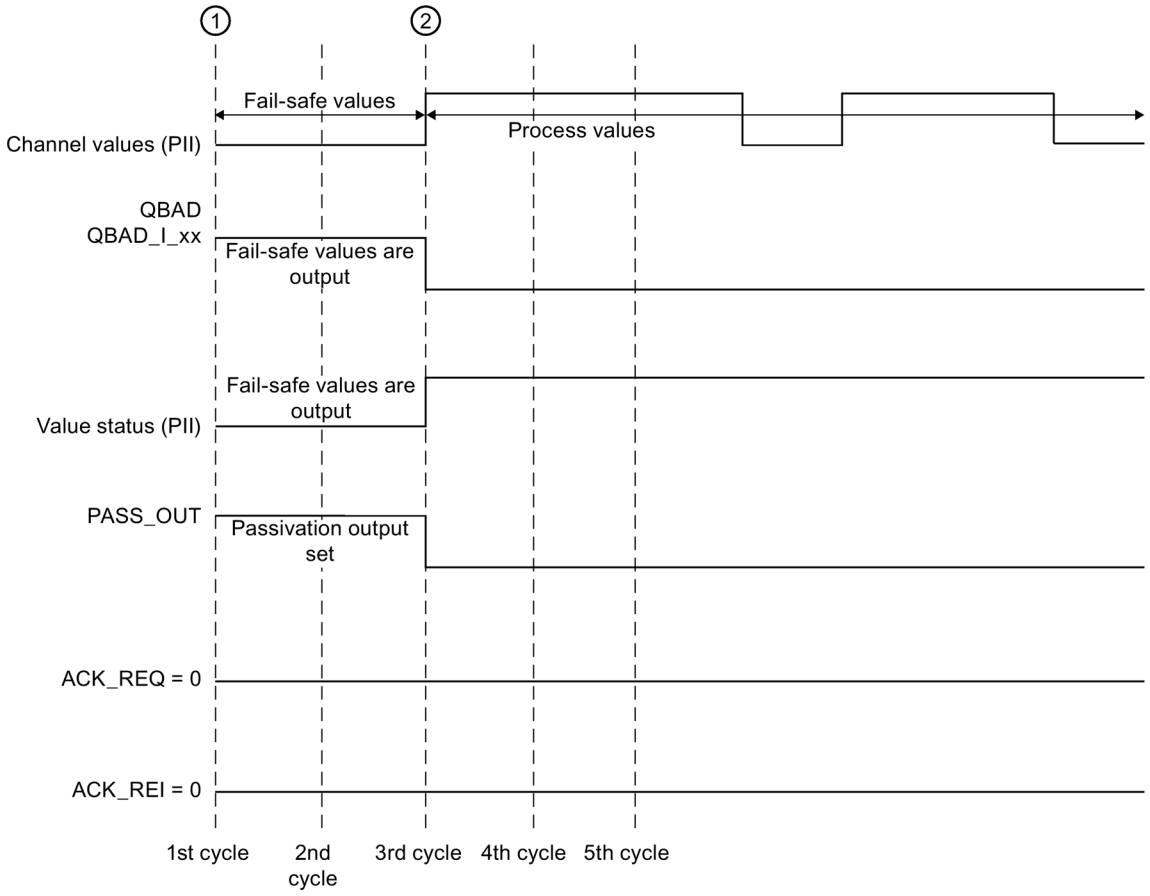
For fail-safe GSD based DP slaves/GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation for the fail-safe GSD based DP slave/GSD based I/O device.

Depending on the F-I/O you are using and the cycle time of the F-runtime group and PROFIBUS DP/PROFINET IO, several cycles of the F-runtime group can elapse before reintegration occurs.

If communication between the F-CPU and F-I/O takes longer to establish than the F-monitoring time set in the properties for the F-I/O, automatic reintegration does not take place.

Signal sequence for passivation and reintegration of F-I/O after F-system startup

Example for an F-I/O with inputs:



① Startup of F-system/passivation

② Automatic reintegration (e.g. third cycle)

⚠ WARNING

When an F-CPU is switched from STOP to RUN mode, the standard user program starts up in the usual way. When the safety program is started up, all F-DBs are initialized with the values from the load memory - as is the case with a cold restart. This means that saved error information is lost.

The F-system automatically reintegrates the F-I/O, as described above.

An operating error or an internal error can also trigger a startup of the safety program with the values from the load memory. If your process does not allow such a startup, you must program a restart/startup protection in the safety program: The output of process data must be blocked until manually enabled. This enable must not occur until it is safe to output process data and faults have been corrected. *(S008)*

6.5.2 After communication errors

Behavior after communication errors

Fail-safe value output after communication errors	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
If a communication error between the F-CPU and the F-I/O is detected, all channels of the entire F-I/O are passivated.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

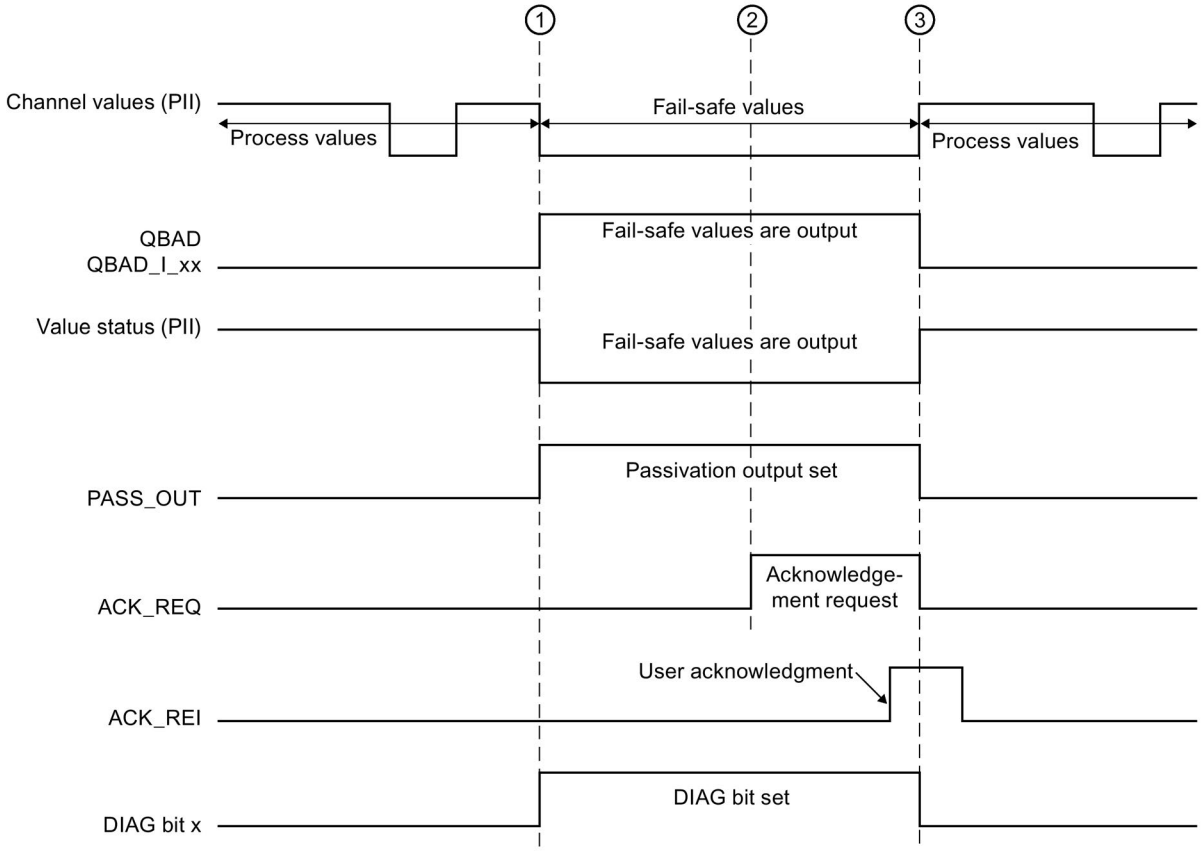
Reintegration of F-I/O

Reintegration of the relevant F-I/O, that is, provision of process data in the PII or output of process data provided in the PIQ at the failsafe outputs, takes place only when the following occurs:

- All communication errors have been eliminated and the F-system has set tag ACK_REQ = 1
- A **user acknowledgment** with a positive edge has occurred:
  - At the ACK_REI tag of the F-I/O DB (Page 138) or
  - At the ACK_REI_GLOB input of the "ACK_GL" instruction (ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V14) (Page 432))

Signal sequence for passivation and reintegration of F-I/O after communication errors

Example for an F-I/O with inputs:



① Communication error/passivation
② All communication errors have been eliminated
③ Reintegration

See also

Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 156)

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 162)

6.5.3 After F-I/O or channel faults

Behavior after F-I/O faults

Fail-safe value output after F-I/O faults	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
If an F-I/O fault is detected by the F-system, passivation of all channels of the entire F-I/O occurs.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Behavior after channel fault

Fail-safe value output after channel faults	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
When passivation for **complete** F-I/O is configured: If a channel fault is detected by the F-system, passivation of all channels of the entire F-I/O occurs.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*
With configuration of **channel-granular** passivation: If a channel fault is detected by the F-system, passivation of all the affected channels of the entire F-I/O occurs.	QBAD and PASS_OUT **unchanged** For the **affected** channels: Channel value = fail-safe value (0) Value status = 0	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) Value status = 0*	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Reintegration of F-I/O

Reintegration of the relevant F-I/O or the relevant channels of the F-I/O, that is, provision of process data in the PII or output of process data provided in the PIQ at the failsafe outputs, takes place only when the following occurs:

- All F-I/O or channel faults have been eliminated.

If you have configured channel-granular passivation for the F-I/O, the relevant channels are reintegrated once the fault is corrected; any faulty channels remain passivated.

Reintegration is performed depending on your setting for the ACK_NEC tag or the "Channel failure acknowledge" parameter (configuration of the S7-1500/ET 200MP F-module and S7-1200 F-module)

- With ACK_NEC = 0 or the configuration "Channel failure acknowledge = automatic", **automatic reintegration** is performed as soon as the F-system detects that the fault has been corrected. For F-I/O with inputs, reintegration takes place right away. For F-I/O with outputs or F-I/O with inputs and outputs, depending on the F-I/O you are using, reintegration can take several minutes, first after the necessary test signals have been applied, which are used by the F-I/O to determine that the fault has been eliminated.
- With ACK_NEC = 1 or the configuration "Channel failure acknowledge = manual", reintegration is performed only as a result of user acknowledgment with a positive edge at the ACK_REI tag of the F-I/O DB or at the ACK_REI_GLOB input of the "ACK_GL" instruction. Acknowledgment can be made as soon as the F-system detects that the fault has been eliminated and tag ACK_REQ = 1 has been set.

  For fail-safe GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation for the fail-safe GSD based I/O device .

⚠ WARNING

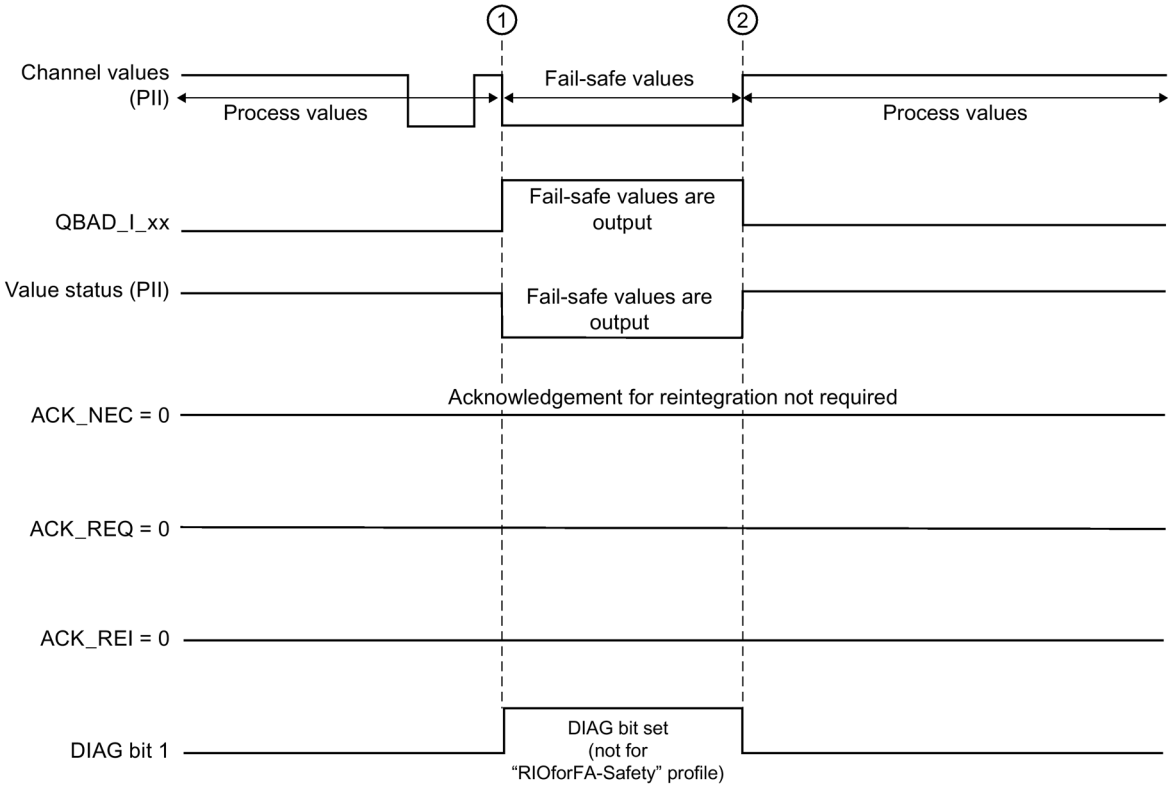
Following a power failure of the F-I/O lasting less than the assigned F-monitoring time for the F-I/O, automatic reintegration can occur regardless of your setting for the ACK_NEC tag, as described for the case when ACK_NEC = 0 or configuration "Channel failure acknowledge = automatic".

If automatic reintegration is not permitted for the relevant process in this case, you must program startup protection by evaluating tags QBAD or QBAD_I_xx and QBAD_O_xx or value status or PASS_OUT.

In the event of a power failure of the F-I/O lasting longer than the specified F-monitoring time for the F-I/O, the F-system detects a communication error. *(S012)*

Signal sequence for passivation and reintegration of F-I/O after F-I/O faults or channel faults when ACK_NEC = 0 or configuration "Channel failure acknowledge = automatic" (for passivation of entire F-I/O after channel faults)

Example for an F-I/O with inputs:



① F-I/O or channel faults
Passivation

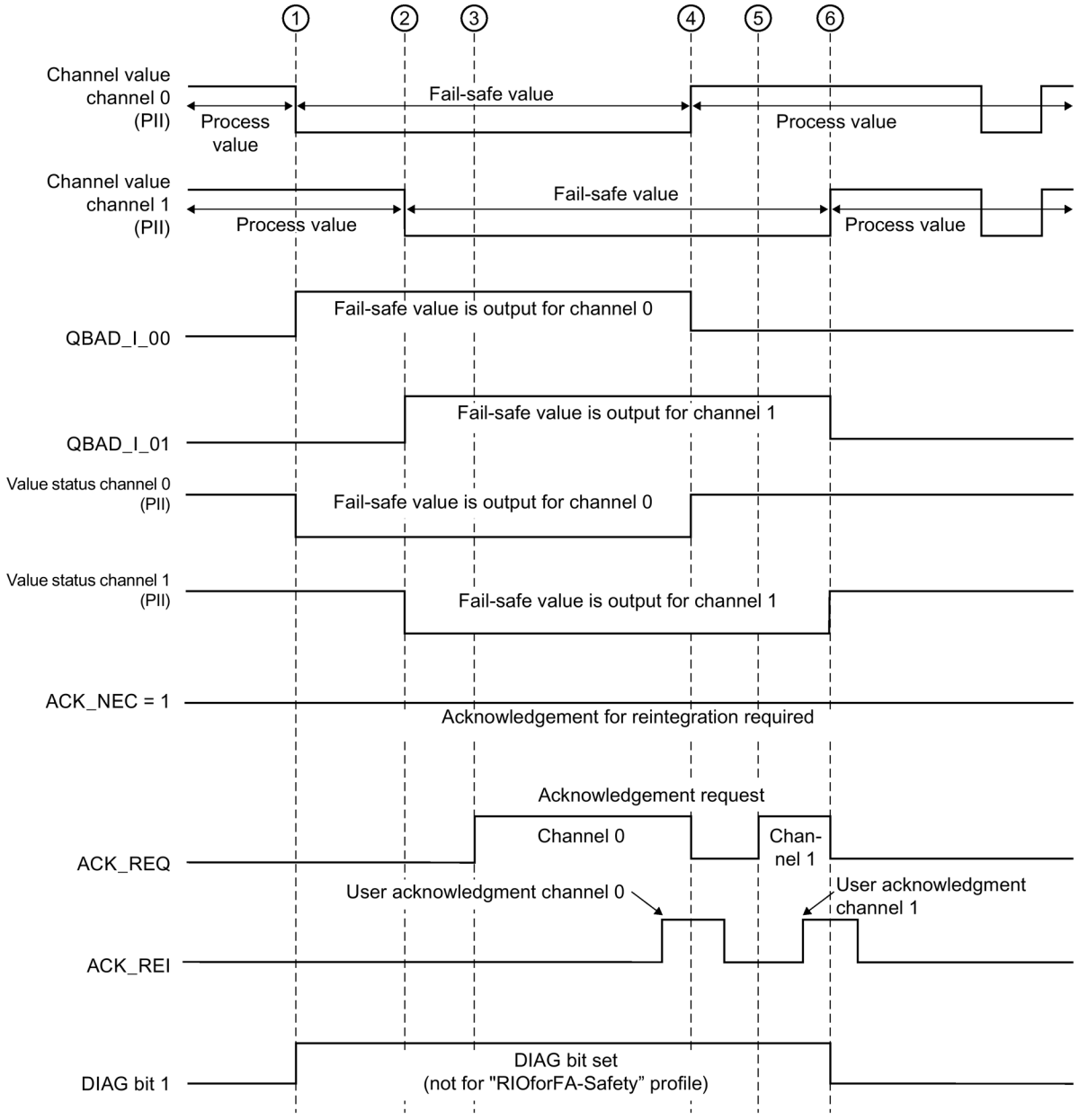
② F-I/O or channel faults corrected
Automatic reintegration

Signal sequence for passivation and reintegration of F-I/O after F-I/O faults or channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (for passivation of entire F-I/O after channel faults)

For the signal sequence for passivation and reintegration of F-I/O after F-I/O or channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (initial value), see After communication errors (Page 148).

Signal sequence for passivation and reintegration of F-I/O after channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (for channel-granular passivation)

Example for an F-I/O with inputs:



① Channel fault for channel 0/passivation of channel 0
② Channel fault for channel 1/passivation of channel 1
③ Channel fault eliminated for channel 0
④ Reintegration of channel 0
⑤ Channel fault eliminated for channel 1
⑥ Reintegration of channel 1

6.5.4 Group passivation

Programming a group passivation

If you want to enable passivation of additional F-I/O when an F-I/O or a channel of an F-I/O is passivated by the F-system, you can use the PASS_OUT/PASS_ON tags to perform **group passivation** of the associated F-I/O.

Group passivation by means of PASS_OUT/PASS_ON can, for example, be used to force simultaneous reintegration of all F-I/O after startup of the F-system.

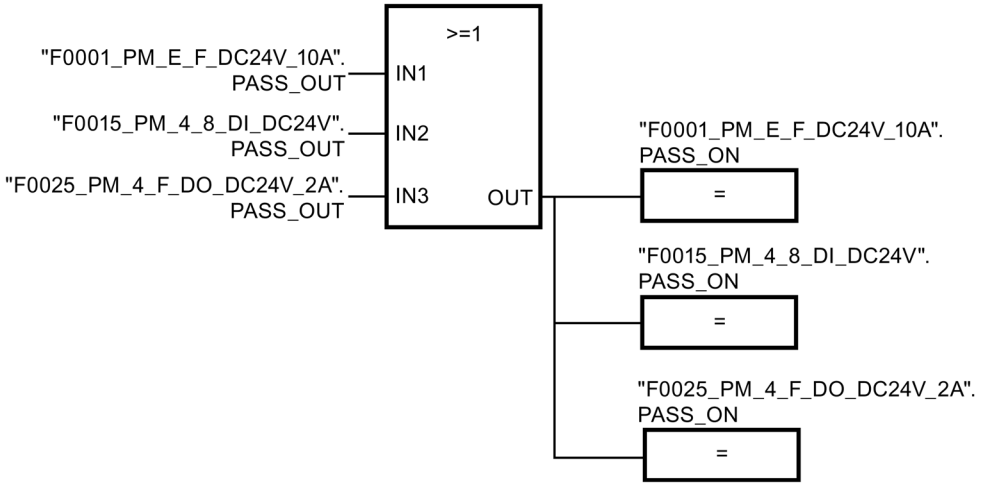
For group passivation, you must OR all PASS_OUT tags of the F-I/O in the group and assign the result to all PASS_ON tags of the F-I/O in the group.

During use of fail-safe values (0) due to group passivation by means of PASS_ON = 1, the QBAD tag of the F-I/O of this group = 1.

Note

Note the different behavior of PASS_OUT for F-I/O with/without "RIOforFA-Safety" profile (see table in section PASS_OUT/QBAD/QBAD_I_xx/QBAD_O_xx and value status (Page 141)).

Example of group passivation

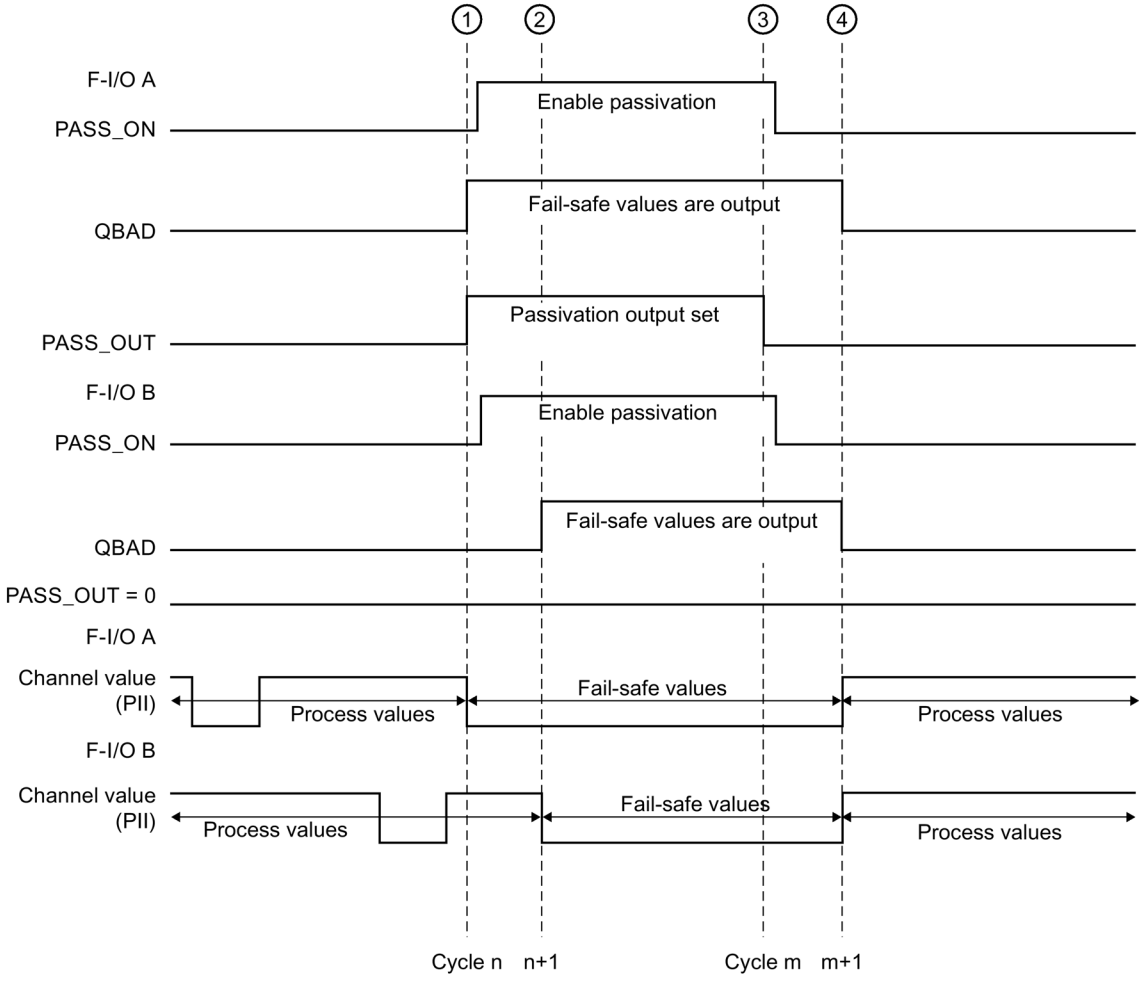


Reintegration of F-I/O

Reintegration of F-I/O passivated by group passivation occurs **automatically**, if a reintegration (**automatic** or **through user acknowledgment**) occurs for the F-I/O that triggered the group passivation (PASS_OUT = 0).

Signal sequence for group passivation following communication error

Example for two F-I/O with inputs:



① Communication error in F-I/O A
Passivation of F-I/O A
② Passivation of F-I/O B
③ Communication error in F-I/O A corrected and acknowledged
④ Reintegration F-I/O A and B

Implementation of user acknowledgment 7

7.1 Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller

Options for user acknowledgment

You have the following options for implementing a user acknowledgment:

- An acknowledgment key that you connect to an F-I/O with inputs
- An HMI system

User acknowledgment by means of acknowledgment key

Note

When you implement user acknowledgment by means of acknowledgment key, and a communication error, an F-I/O fault, or a channel fault occurs in the F-I/O to which the acknowledgment key is connected, then it will not be possible to acknowledge the reintegration of this F-I/O.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system, in order to acknowledge reintegration of an F-I/O to which an acknowledgment key is connected.

A user acknowledgment may be issued using an acknowledgment key connected to a standard I/O with inputs if this risk analysis allows this.

User acknowledgment by means of an HMI system

For implementation of a user acknowledgment by means of an HMI system, the ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V14) (Page 503) instruction is required.

Procedure for programming user acknowledgment by means of an HMI system (S7-300, S7-400)

1. Select the "ACK_OP" instruction in the "Instructions" task card and place it in your safety program. The acknowledgment signal for evaluating user acknowledgments is provided at output OUT of ACK_OP.
2. On your HMI system, set up a field for manual entry of an "acknowledgment value" of "6" (1st step in acknowledgment) and an "acknowledgment value" of "9" (2nd step in acknowledgment).

   or

   Assign function key 1 to transfer an "acknowledgment value" of "6" (1st step in acknowledgment) once, and function key 2 to transfer an "acknowledgment value" of "9" (2nd step in acknowledgment) once. You need to assign the in/out IN (in the data area of the ACK_OP instruction) to the field or the function keys.
3. Optional: In your HMI system, evaluate output Q in the instance DB of ACK_OP to see the time frame within which the 2nd step in acknowledgment must occur or to indicate that the 1st step in acknowledgment has already occurred.

If you want to perform a user acknowledgment exclusively from a programming device or PC using the watch table (monitor/modify tag) without having to disable safety mode, then you must transfer an operand (memory word or DBW of a DB of the standard user program) at in/out IN when calling ACK_OP. You can then transfer "acknowledgment values" "6" and "9" on the programming device or PC by modifying the memory word or DBW of a DB once. The memory word or DBW of a DB must not be written by the program.

Note

If you connect the in/out IN to a memory word or DBW of a DB, you have use a separate memory word or DBW of a DB of the standard user program for each instance of the ACK_OP instruction at the in/out IN.

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example by automatically storing them along with the time conditions in a program and using a function key to trigger them.
Having two separate acknowledgment steps also prevents erroneous triggering of an acknowledgment by your non-fail-safe HMI system. *(S013)*

WARNING

If you have HMI systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

- To do this, store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your HMI system, set up a field from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:

  in your HMI system, set up a field to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored name. *(S014)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

Note

The configuration of your operator control and monitoring system does not have any effect on the collective F-signature.

Changes to the configuration of your operator control and monitoring system therefore do not result in a changed collective F-signature.

Procedure for programming user acknowledgment by means of an HMI system (S7-1200, S7-1500)

1. Select the "ACK_OP" instruction in the "Instructions" task card and place it in your safety program. The acknowledgment signal for evaluating user acknowledgments is provided at output OUT of ACK_OP.
2. Assign the ACK_ID input an identifier between 9 and 30000 for the acknowledgment.
3. Assign the in/out IN a memory word or DBW of a DB of the standard user program.

   Note

   You need to provide the in/out parameter IN with a separate memory word or DBW of a DB of the standard user program for each instance of the ACK_OP instruction.

4. On your HMI system, set up a field for manual entry of an "acknowledgment value" of "6" (1st step in acknowledgment) and the "Identifier" configured at the ACK_ID input (2nd step in acknowledgment).

   or

   Allocate a function key 1 for a one-time transfer of the "acknowledgment value" of "6" (1st step in acknowledgment) and a function key 2 for a one-time transfer of the "Identifier" set at the ACK_ID input (2nd step in acknowledgment).
   You need to assign memory word or the DBW of the DB of the standard user program assigned to the in/out IN to the field or the function keys.
5. Optional: In your HMI system, evaluate output Q in the instance DB of ACK_OP to see the time frame within which the 2nd step in acknowledgment must occur or to indicate that the 1st step in acknowledgment has already occurred.

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example by automatically storing them along with the time conditions in a program and using a function key to trigger them.
Having two separate acknowledgment steps also prevents erroneous triggering of an acknowledgment by your non-fail-safe HMI system. *(S013)*

⚠ WARNING

If you have HMI systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

Alternative 1:

- The value for each identifier of the acknowledgment (ACK_ID input; data type: INT) can be freely selected in the range from 9 to 30000, but must be unique network-wide* for all instances of the ACK_OP instruction.
  You must supply the ACK_ID input with constant values when calling the instruction. Direct read or write access in the associated instance DB is not permitted in the safety program!

Alternative 2:

- To do this, store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your HMI system, set up a field from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:

  in your HMI system, set up a field to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S047)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

Note

The supply of the IN input/output of the ACK_OP instruction as well as the configuration of your operator control and monitoring system do not have any effect on the collective F-signature or of the signature of the block that calls the ACK_OP instruction.

Changes to the supply of the IN input/output or to the configuration of your operator control and monitoring system therefore do not result in a changed collective F-signature/signature of the calling block.

Example of procedure for programming a user acknowledgment for reintegrating an F-I/O

1. Optional: set the ACK_NEC tag in the respective F-I/O DB (Page 138) to "0" if automatic reintegration (without user acknowledgment) is to take place after an F-I/O fault or a channel fault.

   ⚠ WARNING

   The parameter assignment of the ACK_NEC = 0 tag is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint. *(S010)*

2. Optional: Evaluate the QBAD or QBAD_I_xx/QBAD_O_xx (S7-300/400) tags or value status (S7-1200, S7-1500) or DIAG in the respective F-I/O DB to trigger an indicator light in the event of an error, and/or generate error messages on the HMI system in your standard user program by evaluating the above tags or the value status. These messages can be evaluated before performing the acknowledgment operation. Alternatively, you can evaluate the diagnostic buffer of the F-CPU.
3. Optional: Evaluate the ACK_REQ tag in the respective F-I/O DB, for example, in the standard user program or on the HMI system, to query or to indicate whether user acknowledgment is required.
4. Assign the input of the acknowledgment key or the OUT output of the ACK_OP instruction to the ACK_REI tag in the respective F-I/O DB or the ACK_REI_GLOB input of the ACK_GL instruction (see above).

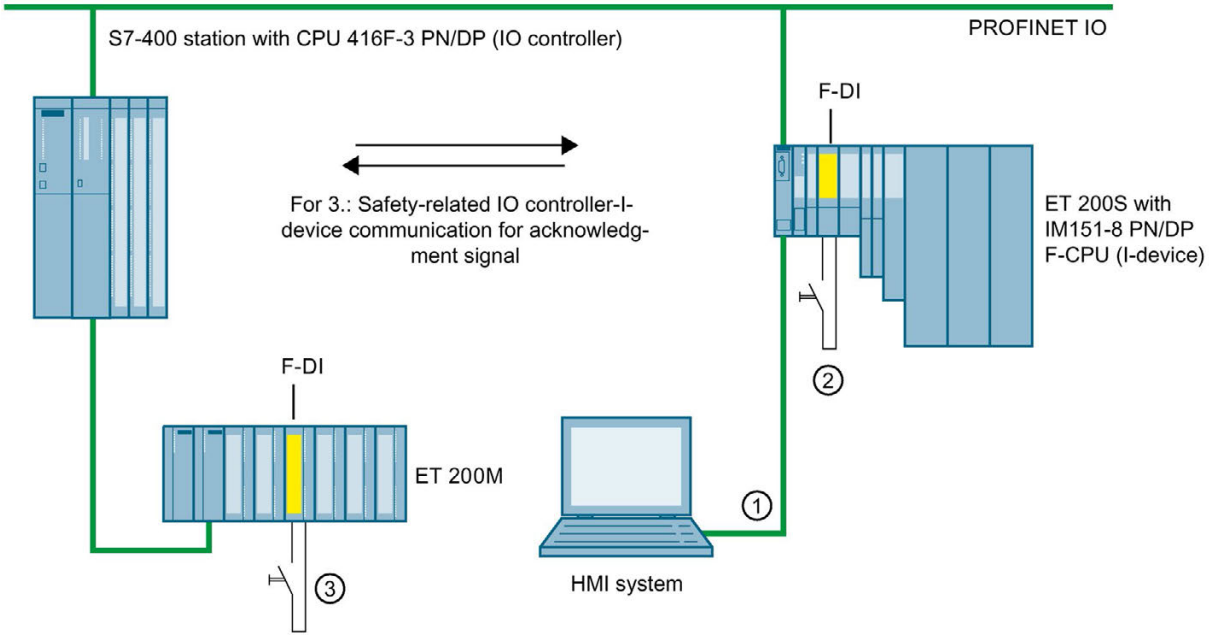
7.2 Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device

Options for user acknowledgment

You can implement a user acknowledgment by means of:

- An HMI system that you can use to access the F-CPU of the I-slave/I-Device
- An acknowledgment key that you connect to an F-I/O with inputs that is assigned to the F-CPU of the I-slave/I-Device
- An acknowledgment key that you connect to an F-I/O with inputs that is assigned to the F-CPU of the DP master/IO controller

These three options are illustrated in the figure below.



1. User acknowledgment by means of an HMI system with which you can access the F-CPU of the I-slave/I-device

The ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V14) (Page 503) instruction is required to implement user acknowledgment with an HMI system that you can use to access the F-CPU of the I-slave/I-device.

Programming procedure

Follow the procedure described in "Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 156)" under "Programming procedure ...".

From your HMI system, you can then directly access the instance DB of ACK_OP in the I-slave/I-Device.

2. User acknowledgment by means of an acknowledgment key at an F-I/O with inputs that are assigned to the F-CPU of the I-slave/I-device

Note

In the event of a communication error, F-I/O fault, or channel fault in the F-I/O to which the acknowledgment key is connected, an acknowledgment for reintegration of this F-I/O is no longer possible.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the I-slave/I-Device.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the I-slave/I-Device, in order to acknowledge reintegration of an F-I/O to which an acknowledgment key is connected (see 1).

3. User acknowledgment by means of an acknowledgment key at an F-I/O with inputs that are assigned to the F-CPU of the DP master/IO controller

If you want to use the acknowledgment key that is assigned to the F-CPU at the DP master/IO controller to perform user acknowledgment in the safety program of the F-CPU of an I-slave/I-device as well, you must transmit the acknowledgment signal from the safety program in the F-CPU of the DP master/IO controller to the safety program in the F-CPU of the I-slave/I-device using safety-related master-I-slave/IO controller-I-device communication.

Programming procedure

1. Place the SENDDP (Page 515) instruction in the safety program in the F-CPU of the DP master/IO controller.
2. Place the RCVDP (Page 515) instruction in the safety program in the F-CPU of the I-slave/I-Device.
3. Supply an input SD_BO_xx of SENDDP with the input of the acknowledgment key.
4. The acknowledgment signal for evaluating user acknowledgments is now available at the corresponding RD_BO_xx output of RCVDP.

   The acknowledgment signal can now be read in the program sections in which further processing is to take place with fully qualified access directly in the associated instance DB (for example, "RCVDP_DB".RD_BO_02).

5. Supply the corresponding input SUBBO_xx of RCVDP with FALSE (fail-safe value 0) to ensure that user acknowledgment is not accidentally triggered before communication is established for the first time after startup of the sending and receiving F-systems, or in the event of a safety-related communication error.

Note

If a communication error, an F-I/O error, or a channel fault occurs at the F-I/O to which the acknowledgment key is connected, then an acknowledgment for reintegration of this F-I/O will no longer be possible.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the DP master/IO controller.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the DP master/IO controller, in order to acknowledge reintegration of the F-I/O to which an acknowledgment key is connected.

If a safety-related master-I-slave/IO controller-I-Device communication error occurs, the acknowledgment signal cannot be transmitted, and an acknowledgment for reintegration of safety-related communication is no longer possible.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the I-slave/I-Device.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the I-slave/I-Device, in order to acknowledge reintegration of the safety-related communication for transmission of the acknowledgment signal (see 1).

Data exchange between standard user program and safety program

8

You have the option of transferring data between the safety program and the standard user program. Tags can be transferred using DBs, F-DBs and bit memory:

	From the standard user program		From the safety program	
	Read access	Write access	Read access	Write access
Tag from DB	Permitted	Permitted	A tag from the DB can be read-accessed *or* write-accessed	
Tag from F-DB	Permitted	**Not permitted**	Permitted	Permitted
Bit memory	Permitted	Permitted	Bit memory can be read-accessed *or* write-accessed	

You can also access the process image of the standard I/O and F-I/O:

		From the standard user program		From the safety program	
		Read access	Write access	Read access	Write access
Process image of standard I/O	PII	Permitted	Permitted	Permitted	**Not permitted**
	PIQ	Permitted	Permitted	**Not permitted**	Permitted
Process image of F-I/O	PII	Permitted	**Not permitted**	Permitted	**Not permitted**
	PIQ	Permitted	**Not permitted**	**Not permitted**	Permitted

Decoupling of the safety program from the standard program

For data exchange between standard user program and safety program, we recommend that you define special data blocks (transfer data blocks) in which the data to be exchanged is stored. This action allows you to decouple the blocks of the standard and the safety program. The changes in the standard program do not affect the safety program (and vice versa) provided these data blocks are not modified.

8.1 Data Transfer from the Safety Program to the Standard User Program

Data transfer from the safety program to the standard user program

The standard user program can read all data of the safety program, for example using symbolic (fully qualified) accesses to the following:

- The instance DBs of the F-FBs ("Name of instance DB".Signal_x)
- F-DBs (for example "Name of F_DB".Signal_1)
- The process image input and output of F-I/O (for example "Emergency_Stop_Button_1" (I 5.0))

Note

For S7-300/400 F-CPUs

The process image input of F-I/O is updated not only at the start of the main safety block, but also by the standard operating system.

To find the standard operating system update times, refer to the *Help on STEP 7* under "Process image input and output". For F-CPUs that support process image partitions, also bear in mind the update times when process image partitions are used. For this reason, when the process image input of F-I/O is accessed in the standard user program, it is possible to obtain different values than in the safety program. The differing values can occur due to:

- Different update times
- Use of fail-safe values in the safety program

To obtain the same values in the standard user program as in the safety program, you must not access the process image input in the standard program until after execution of an F-runtime group. In this case, you can also evaluate the QBAD or QBAD_I_xx tag in the associated F-I/O DB in the standard user program, in order to find out whether the process image input is receiving fail-safe values (0) or process data. When using process image partitions, also make sure that the process image is not updated by the standard operating system or by the UPDAT_PI instruction between execution of an F-runtime group and evaluation of the process image input in the standard user program.

Note

For S7-1200/1500 F-CPUs

The process image input of F-I/O is updated prior to processing the main safety block.

You can also write safety program data directly to the standard user program (see also the table of supported operand areas in: Restrictions in the programming languages FBD/LAD (Page 97)):

Data block/bit memory

In order to write safety program data directly to the standard user program (e.g., DIAG output of the SENDDP instruction), you can write to data blocks of the standard user program from the safety program. However, a written tag must not be read in the safety program itself.

You can also write to bit memory in the safety program. However, written bit memory must not be read in the safety program itself.

Process image output

You can write to the process image output (PIQ) of standard I/O in the safety program, for example for display purposes. The PIQ must not be read in the safety program.

8.2 Data Transfer from Standard User Program to Safety Program

Data transfer from standard user program to safety program

As a basic principle, only fail-safe data or fail-safe signals from F-I/O and other safety programs (in other F-CPUs) can be processed in the safety program, as standard tags are unsafe.

If you have to process tags from the standard user program in the safety program, however, you can evaluate either bit memory from the standard user program, tags from a standard DB, or the process image input (PII) of standard I/O in the safety program (see table of supported operand areas in: Restrictions in the programming languages FBD/LAD (Page 97)).

Note that structural changes to standard data blocks which are used in the safety program lead to inconsistencies of the safety program and possibly to the password being requested. In this case the collective F-signature is the same as the original again after compilation. To prevent this effect, use “interprocess communication blocks” between the standard user program and the safety program.

⚠ WARNING

Because these tags are not generated safely, you must carry out additional process-specific validity checks in the safety program to ensure that no dangerous states can arise. If bit memory, a tag of a standard DB, or an input of standard I/O is used in both F-runtime groups, you must perform the validity check separately in each F-runtime group. *(S015)*

To facilitate checks, all PLC tags from the standard user program that are evaluated in the safety program are included in the safety summary (Page 291).

Bit memory

In order to process tags of the standard user program in the safety program, you can also read bit memory in the safety program. However, read bit memory must not be written in the safety program itself.

Data block

In order to process tags of the standard user program in the safety program, you can read tags from data blocks of the standard user program in the safety program. However, a read tag must not be written in the safety program itself.

Note

It is not possible to access static local data in single/multi-instances of FBs of the standard user program.

Process image input

You can read the process image input (PII) of standard I/O in the safety program. The PII must not be written in the safety program.

Examples: Programming validity checks

- Use Comparison (Page 456) instructions to check whether tags from the standard user program exceed or fall below permitted high and low limits. You can then influence your safety function with the result of the comparison.
- Use the ---(S)---: Set output (STEP 7 Safety V14) (Page 346), ---(R)---: Reset output (STEP 7 Safety V14) (Page 345) or SR: Set/reset flip-flop (STEP 7 Safety V14) (Page 348) instructions, for example, with tags from the standard user program to allow a motor to be switched off, but not switched on.
- For switch-on sequences, use the AND logic operation instruction, for example, to logically combine tags from the standard user program with switch-on conditions that you derive from fail-safe tags.

If you want to process tags from the standard user program in the safety program, please bear in mind that there is not a sufficiently simple method of checking validity for all tags.

Reading tags from the standard user program that can change during the runtime of an F-runtime group

If you want to read tags from the standard user program (bit memory, tags of a standard DB, or PII of standard I/O) in the safety program, and these tags can be changed - either by the standard user program or an operator control and monitoring system - during runtime of the F-runtime group in which they are read (for example because your standard user program is being processed by a higher-priority cyclic interrupt), you must use bit memory or tags of a standard DB for this purpose. You must write the bit memory or tags of a standard DB with the tags from the standard user program immediately before calling the F-runtime group. You are then permitted to access only this bit memory or these tags of a standard DB in the safety program.

Also note that **clock memory** that you defined when configuring your F-CPU in the "Properties" tab can change during runtime of the F-runtime group, since clock memory runs asynchronously to the F-CPU cycle.

Note

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Safety-related communication

9

9.1 Configuring and programming communication (S7-300, S7-400)

9.1.1 Overview of communication

Introduction

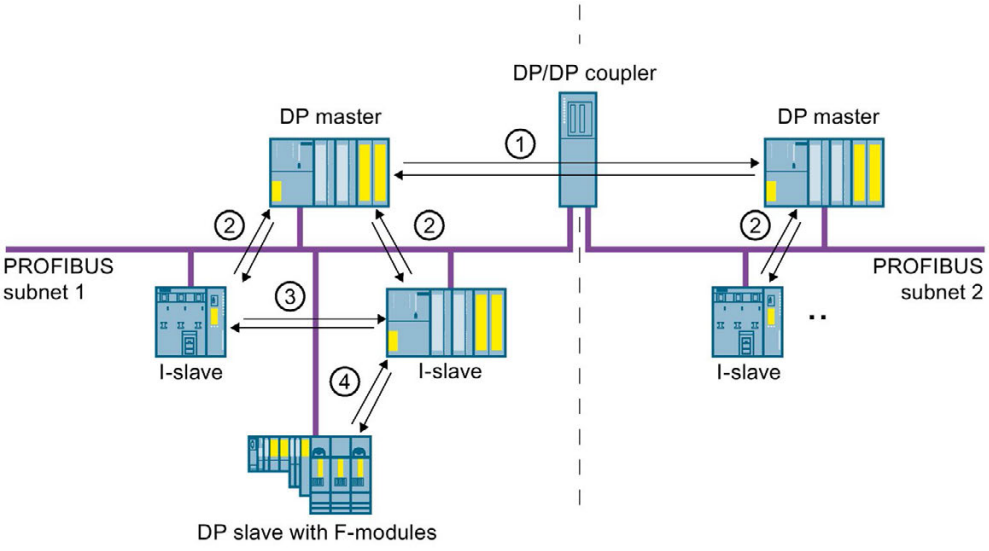
This section gives an overview of the safety-related communication options in SIMATIC Safety F-systems.

Options for safety-related communication

Safety-related communication	On subnet	Additional hardware required
I-slave-slave communication	PROFIBUS DP	—
Safety-related CPU-CPU communication:		
IO controller-IO controller communication	PROFINET IO	PN/PN coupler
Master-master communication	PROFIBUS DP	DP/DP coupler
IO controller-I-device communication	PROFINET IO	—
Master-I-slave communication	PROFIBUS DP	—
I-slave-I-slave communication	PROFIBUS DP	—
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link
Safety-related communication via S7 connections	Industrial Ethernet	—
IO controller-IO controller communication for S7 Distributed Safety	PROFINET IO	PN/PN coupler
Master-master communication for S7 Distributed Safety	PROFIBUS DP	DP/DP coupler
Safety-related communication to S7 Distributed Safety or S7 F Systems via S7 connections	Industrial Ethernet	—

Overview of safety-related communication via PROFIBUS DP

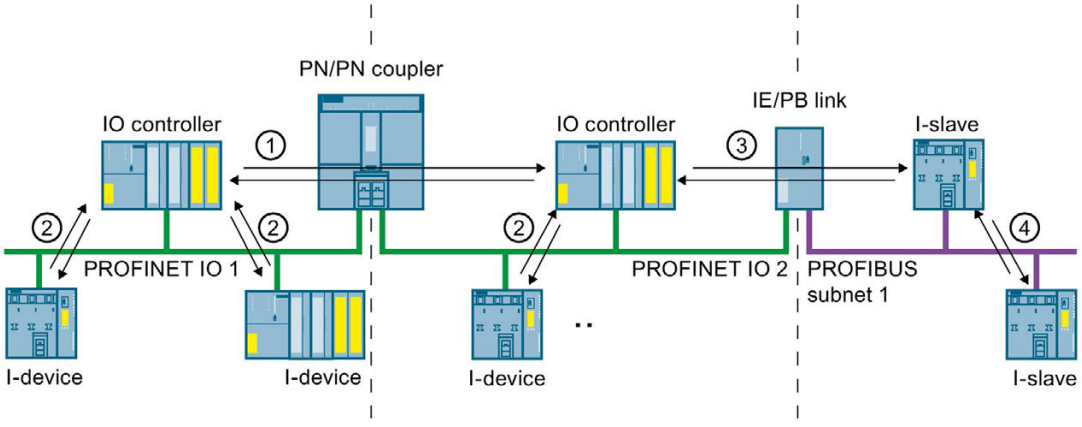
The figure below presents an overview of the 4 options for safety-related communication via PROFIBUS DP in SIMATIC Safety F-systems with S7-300/400 F-CPUs.



① Safety-related master-master communication
② Safety-related master-I-slave communication
③ Safety-related I-slave-I-slave communication
④ Safety-related I-slave-slave communication

Overview of safety-related communication via PROFINET IO

The figure below presents an overview of the four options for safety-related communication via PROFINET IO in SIMATIC Safety F-systems with S7-300/400 F-CPUs. If an IE/PB-link is used, safety-related communication is possible between assigned I-slaves.



① Safety-related IO controller-IO controller communication
② Safety-related IO controller-I-device communication
③ Safety-related IO controller-I-slave communication
④ Safety-related I-slave-I-slave communication integrating an IO controller

Safety-related CPU-CPU communication via PROFIBUS DP or PROFINET IO

In safety-related CPU-CPU communication, a fixed amount of fail-safe data of the data type INT or BOOL is transmitted fail-safe between the safety programs in F-CPUs of DP masters/I-slaves or IO controllers/I-devices.

The data are transferred using the SENDDP instruction for sending and the RCVDP instruction for receiving. The data are stored in configured transfer areas of the devices. Each transfer area consists of one input and one output address area.

Safety-related I-slave-slave communication via PROFIBUS DP

Safety-related I-slave-slave communication with F-I/O is possible in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware version > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware version > V4.0.0.

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O of a DP slave takes place using direct data exchange, as in the standard program. The process image is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave.

Safety-related CPU-CPU communication via Industrial Ethernet

Safety-related CPU-CPU communication via Industrial Ethernet is possible using S7 connections, both from and to the following:

- S7-300 F-CPUs via the integrated PROFINET interface
- S7-400 F-CPUs via the integrated PROFINET interface or a CP 443-1 or CP 443-1 Advanced-IT

In safety-related communication via S7 connections, a specified amount of fail-safe data of data type BOOL, INT, WORD, DINT, DWORD, or TIME is transferred fail-safe between the safety programs of the F-CPUs linked by the S7 connection.

The data transfer makes use of the SENDS7 instruction for sending and the RCVS7 instruction for receiving. Data are exchanged using one F-DB ("F-communication DB") each at the sender and receiver ends.

Safety-related CPU-CPU communication to *S7 Distributed Safety* or *F-systems*

Safety-related communication is possible from F-CPUs in *SIMATIC Safety* to F-CPUs in *S7 Distributed Safety* or *S7 F-systems*.

9.1.2 Safety-related IO controller-IO controller communication

9.1.2.1 Configure safety-related IO controller-IO controller communication

Introduction

Safety-related communication between safety programs of the F-CPUs of IO controllers takes place over a PN/PN coupler that you set up between the F-CPUs.

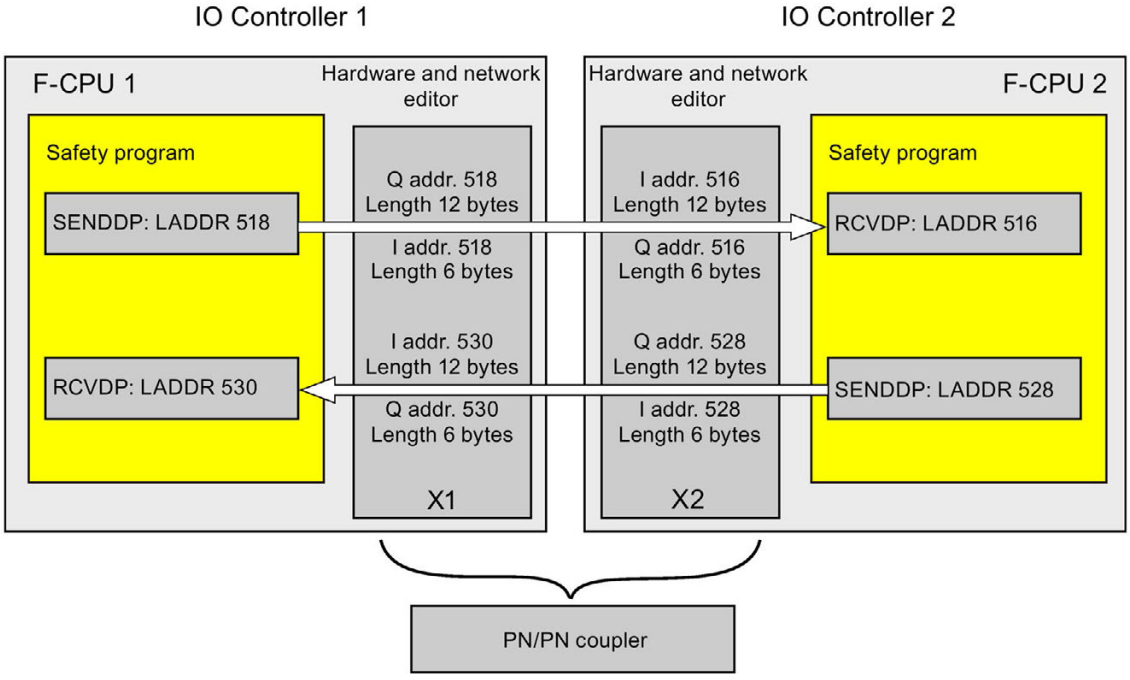
For 416F-2 DP CPUs without an integrated PROFINET interface, use a CP 443-1 or CP 443-1 Advanced-IT.

Note

Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler in the *hardware and network editor*. This is the default setting. Otherwise, safety-related IO controller-IO controller communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the PN/PN coupler. The figure below shows how both of the F-CPUs are able to send **and** receive data (bidirectional communication). One transfer area for output data and one transfer area for input data must be configured in the PN/PN coupler for each of the two communication connections.



Rules for defining transfer areas

The transfer area for output data and the transfer area for input data for the **data to be sent** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

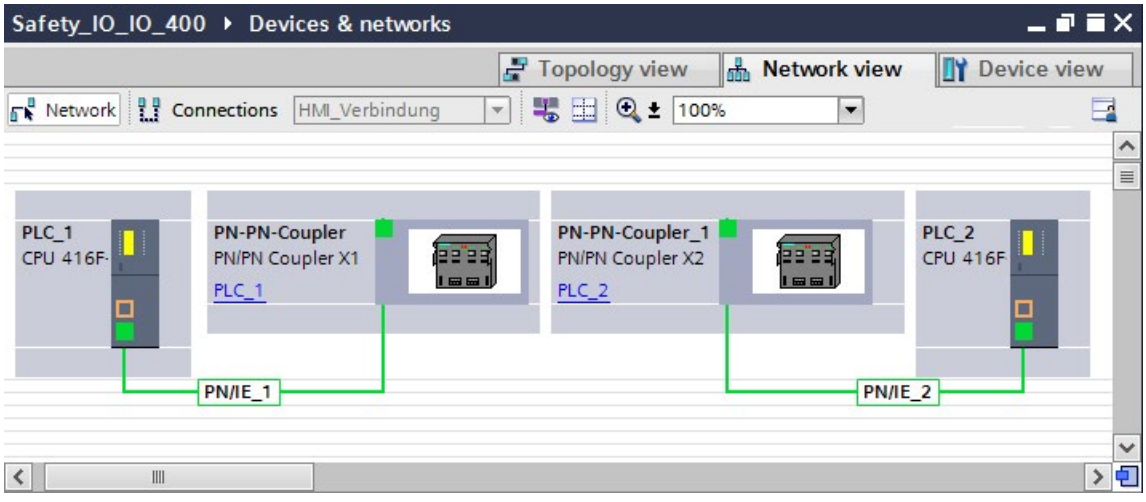
The transfer area for input data and the transfer area for output data for the **data to be received** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

Procedure for configuration

The procedure for configuring safety-related IO controller-IO controller communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a PN/PN Coupler X1 and a PN/PN Coupler X2 from "Other field devices\PROFINET IO\Gateway\Siemens AG\PN/PN Coupler" in the "Hardware catalog" task card and insert them into the network view of the hardware and network editor.
4. Connect the PN interface of the F-CPU 1 with the PN interface of the PN/PN Coupler X1 and the PN interface of the F-CPU 2 with the PN interface of PN/PN Coupler X2.



5. Switch to the device view of PN/PN Coupler X1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from "IN/OUT" in the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "IN/OUT 6 bytes / 12 bytes" module and
   - One "IN/OUT 12 bytes / 6 bytes" module

6. In the properties of the modules, assign the addresses outside the process image as follows:

   For the "IN/OUT 6 bytes / 12 bytes" module for sending data for example:

   – Input addresses: Start address 518

   – Output addresses: Start address 518

   For the "IN/OUT 12 bytes / 6 bytes" module for receiving data for example:

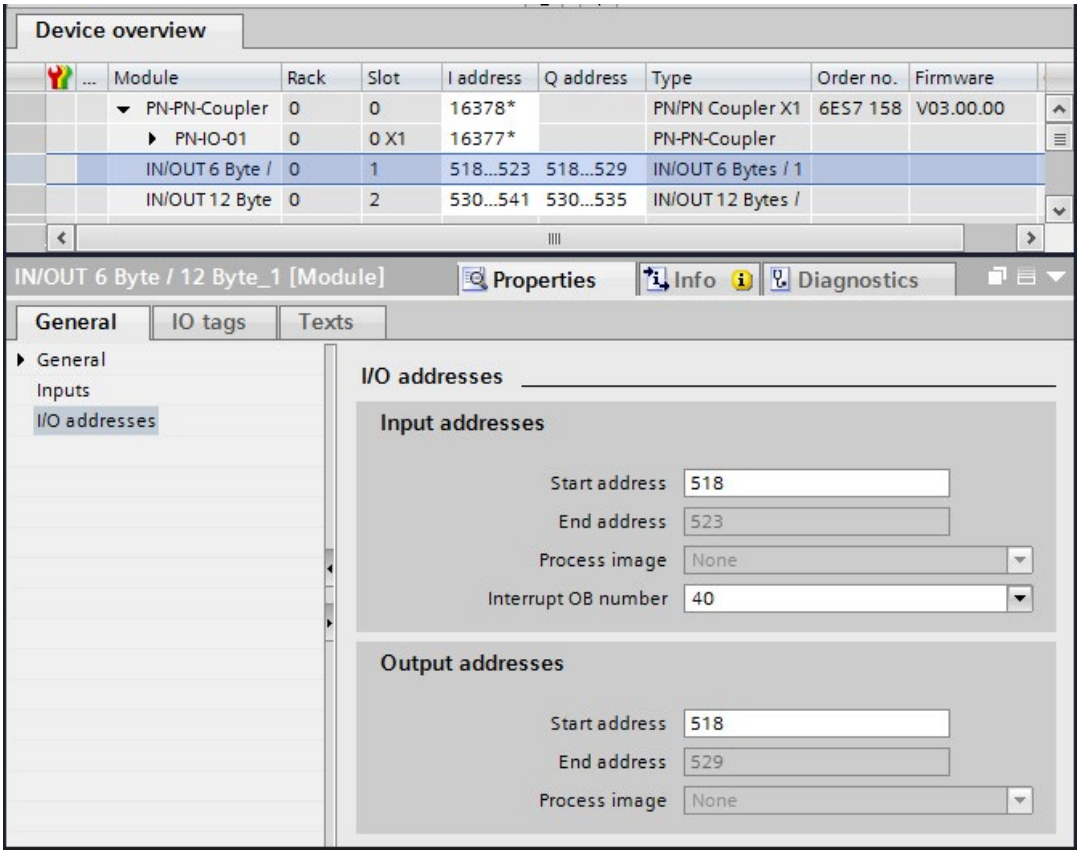
   – Input addresses: Start address 530

   – Output addresses: Start address 530

Note

Make sure that you assign identical start addresses for the address areas of the output and input data.

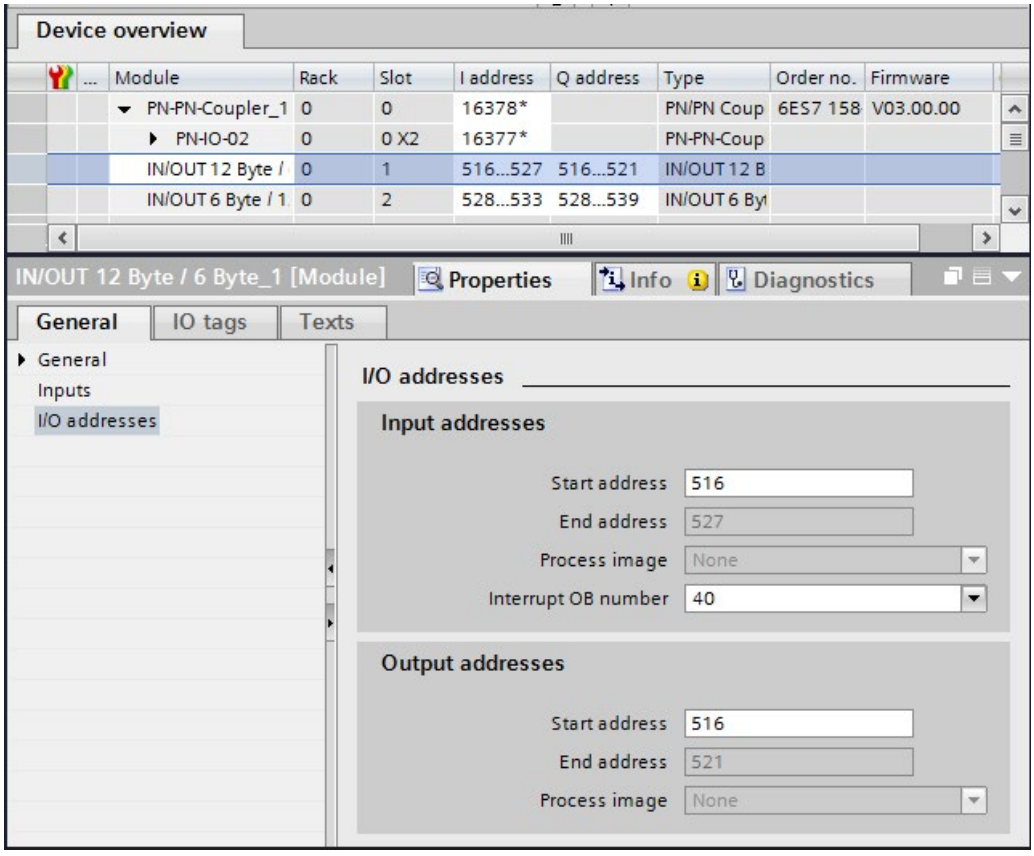
Tip: Make a note of the start addresses of the transfer areas. You need these to program the SENDDP and RCVDP blocks (LADDR input).



7. Select the following modules from "IN/OUT" in the device view of PN/PN coupler X2 and insert them in the "Device overview" tab:
   - One "IN/OUT 12 bytes / 6 bytes" module and
   - One "IN/OUT 6 bytes / 12 bytes" module
8. In the properties of the modules, assign the addresses outside the process image as follows:

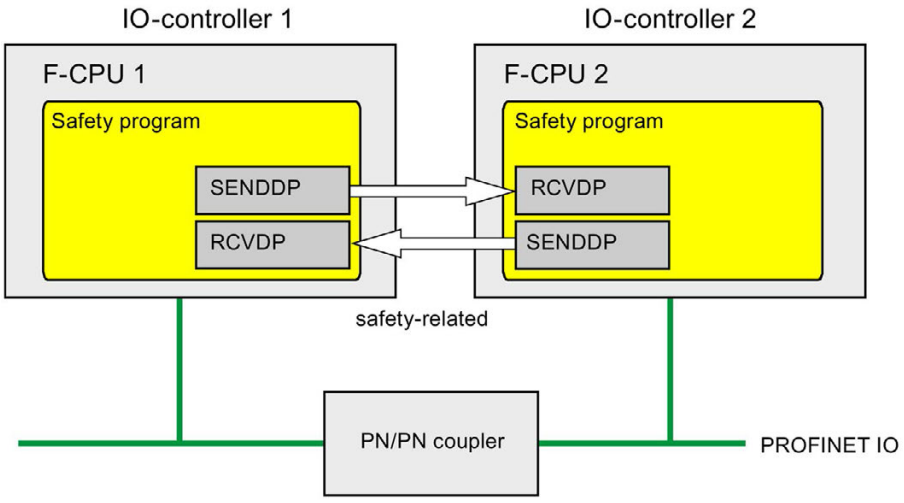
   For the "IN/OUT 12 bytes / 6 bytes" module for receiving data for example:
   - Input addresses: Start address 516
   - Output addresses: Start address 516

   For the "IN/OUT 6 bytes / 12 bytes" module for sending data for example:
   - Input addresses: Start address 528
   - Output addresses: Start address 528



9.1.2.2 Safety-related IO controller-IO controller communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controllers uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.1.2.3 Program safety-related IO controller-IO controller communication

Requirement for programming

The transfer areas for input and output data for the PN/PN coupler must be configured.

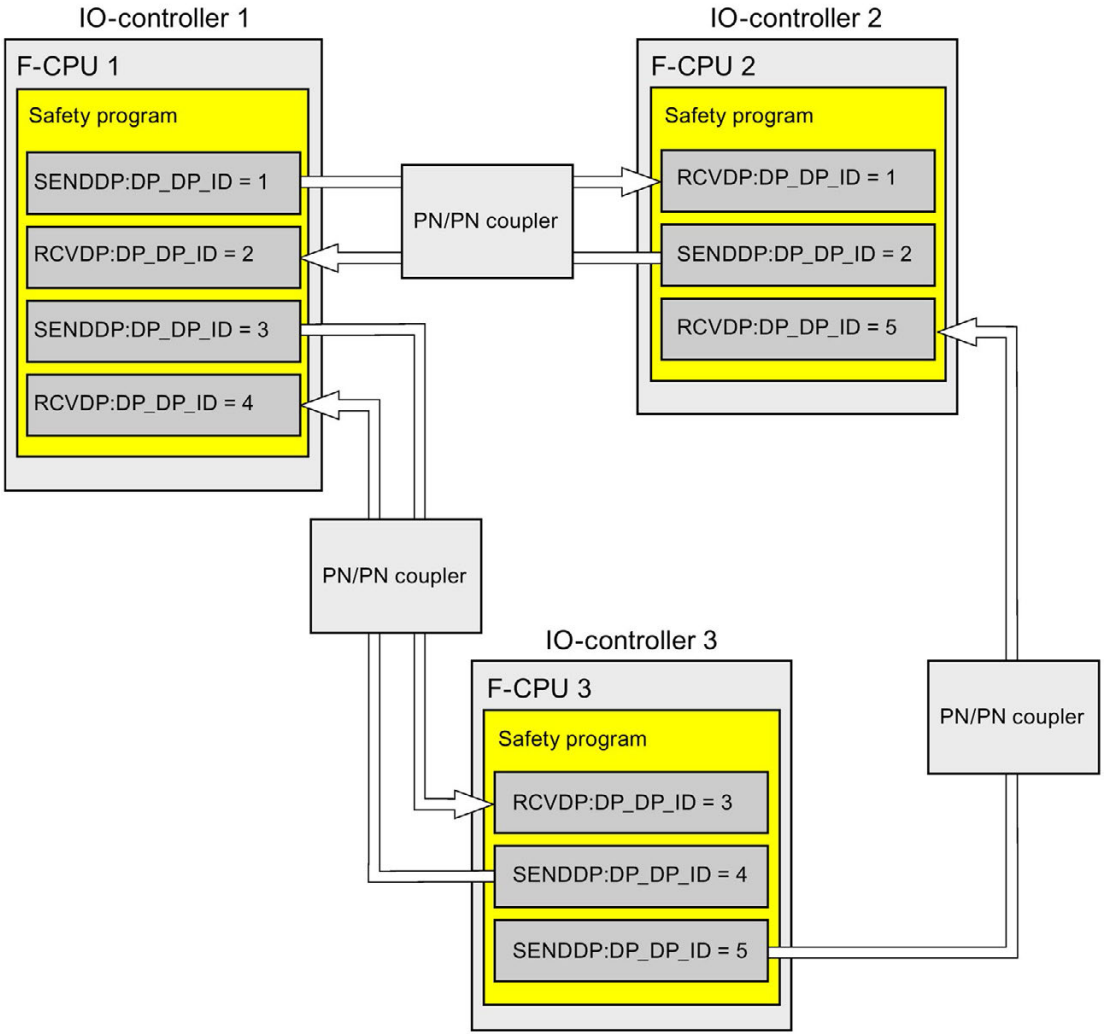
Programming procedure

You program safety-related IO controller-IO controller communication as follows:

1. In the safety program from which data are to be sent, call the SENDDP instruction (Page 515) for sending at the end of the main safety block.
2. In the safety program in which data are to be received, call the RCVDP instruction (Page 515) for receiving at the start of the main safety block.
3. Assign the start addresses of the output and input data transfer areas of the PN/PN coupler configured in the *hardware and network editor* to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.
4. Assign the value for the respective address relationship to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

The figure below contains an example of how to specify the address relationships for the inputs of the SENDDP and RCVDP instructions for five safety-related IO controller-IO-controller communication relationships.



WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. Supply the SUBBO_xx and SUBI_xx inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT, you can enter constant fail-safe values directly as constants in the SUBI_xx input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, provide the tag "F_GOBDB".VKE1 for the SUBBO_xx input (initial value = "FALSE").
   - Specification of dynamic fail-safe values:

     If you want to specify dynamic fail-safe values, define a tag that you change dynamically through your safety program in an F-DB and specify this tag (fully qualified) in the SUBI_xx or SUBBO_xx input.

     ⚠ WARNING

     Note that your safety program for dynamically changing the tag for a dynamic fail-safe value can only be processed after the call of the RCVDP, because prior to the RCVDP call, there must not be any network and no more than one other RCVDP instruction in the main safety block. You must therefore assign appropriate start values for these tags to be output by RCVDP in the first cycle after a startup of the F-system. *(S017)*
8. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   ⚠ WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).
9. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether user acknowledgment is required.
10. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.

11. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx inputs.
12. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether a communication error has occurred.
13. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 294).

9.1.2.4 Safety-related IO controller-IO controller communication - Limits for data transfer

Note

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the PN/PN coupler. Whether or not this is possible with one single PN/PN coupler depends on the capacity restrictions of the PN/PN coupler.

9.1.3 Safety-related master-master communication

9.1.3.1 Configure safety-related master-master communication

Introduction

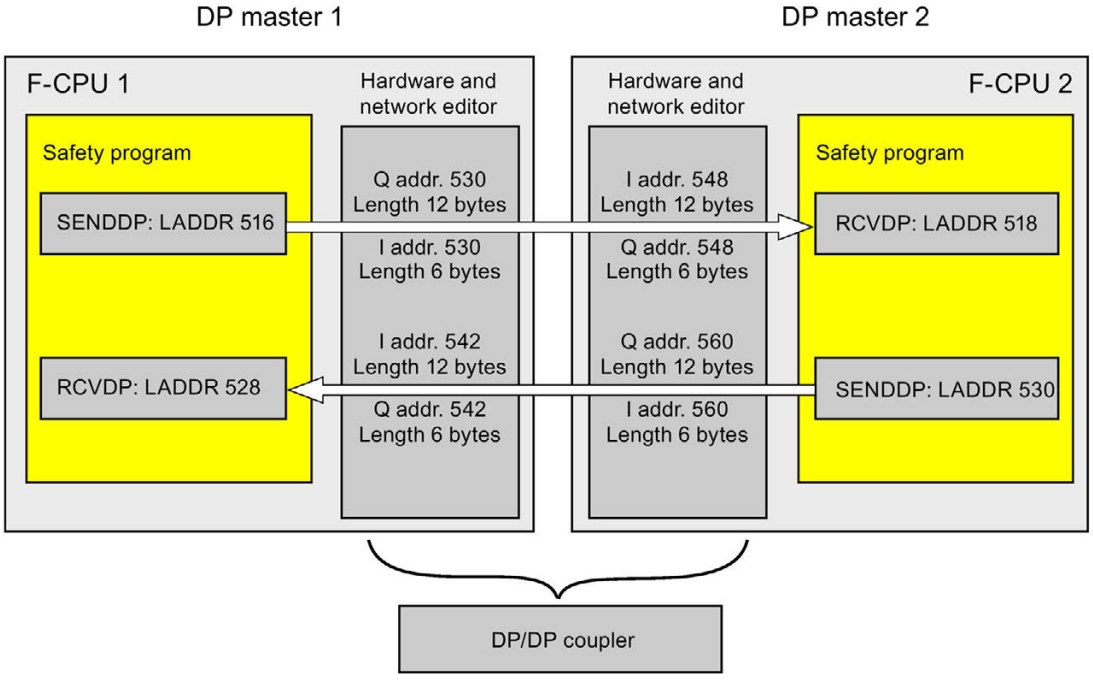
Safety-related communication between safety programs of the F-CPUs of DP masters takes place via a DP/DP coupler.

Note

Switch the data validity indicator "DIA" on the DIP switch of the DP/DP coupler to "OFF". Otherwise, safety-related CPU-CPU communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the DP/DP coupler. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication). One transfer area for output data and one transfer area for input data must be configured in the DP/DP coupler for each of the two communication connections.



Rules for defining transfer areas

The transfer area for input data and the transfer area for output data for the **data to be sent** must begin with the same start address. A total of 6 bytes (consistent) is required for the transfer area for input data; 12 bytes (consistent) are required for the transfer area for output data.

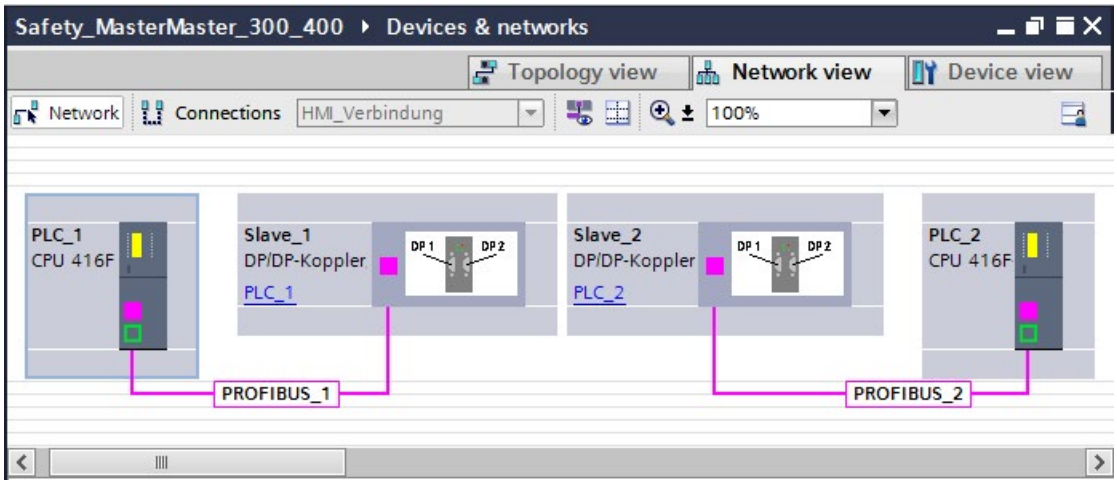
The transfer area for input data and the transfer area for output data for the **data to be received** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

Procedure for configuration

The procedure for configuring safety-related master-master communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a DP/DP coupler from "Other field devices\PROFIBUS DP\Gateways\Siemens AG\DP/DP Coupler" in the "Hardware catalog" task card and insert it into the network view of the hardware and network editor.
4. Insert a second DP/DP coupler.
5. Connect a DP interface of F-CPU 1 to the DP interface of a DP/DP coupler and a DP interface of F-CPU 2 to the DP interface of the other DP/DP coupler.



6. A free PROFIBUS address is assigned automatically in the properties of the DP/DP-coupler in the device view. You must set this address on the DP/DP coupler of PLC 1, either using the DIP switch on the device or in the configuration of the DP/DP coupler (see DP/DP Coupler (http://support.automation.siemens.com/WW/view/en/1179382) manual).
7. Switch to the device view of the DP/DP coupler for PLC1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "6 bytes I/12 bytes Q consistent" module, and
   - One "12 bytes I/6 bytes Q consistent" module

8. In the properties of the modules, assign the addresses outside the process image as follows:

   For "6 bytes I/12 bytes Q consistent" module for sending data for example:

   – Input addresses: Start address 530

   – Output addresses: Start address 530

   For "12 bytes I/6 bytes Q consistent" module for receiving data for example:

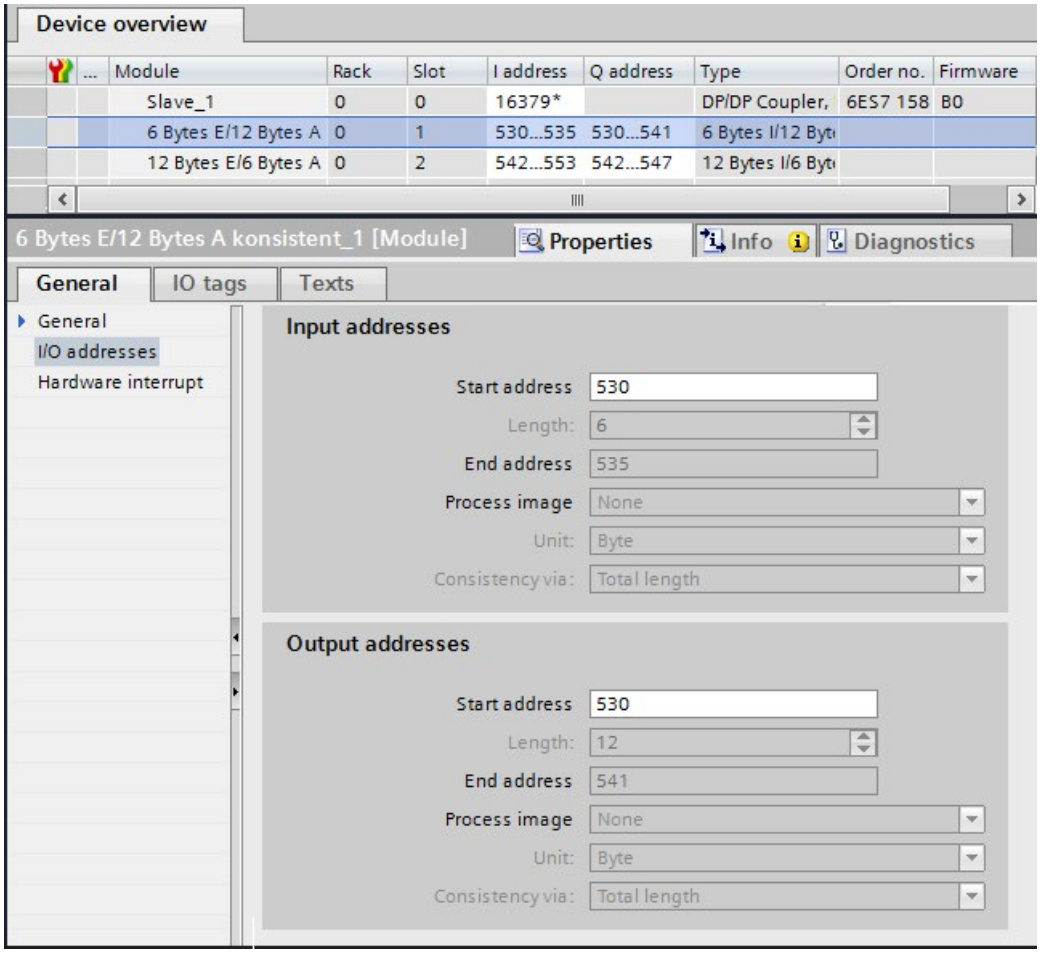
   – Input addresses: Start address 542

   – Output addresses: Start address 542

   Note

   Make sure that you assign identical start addresses for the address areas of the output and input data.

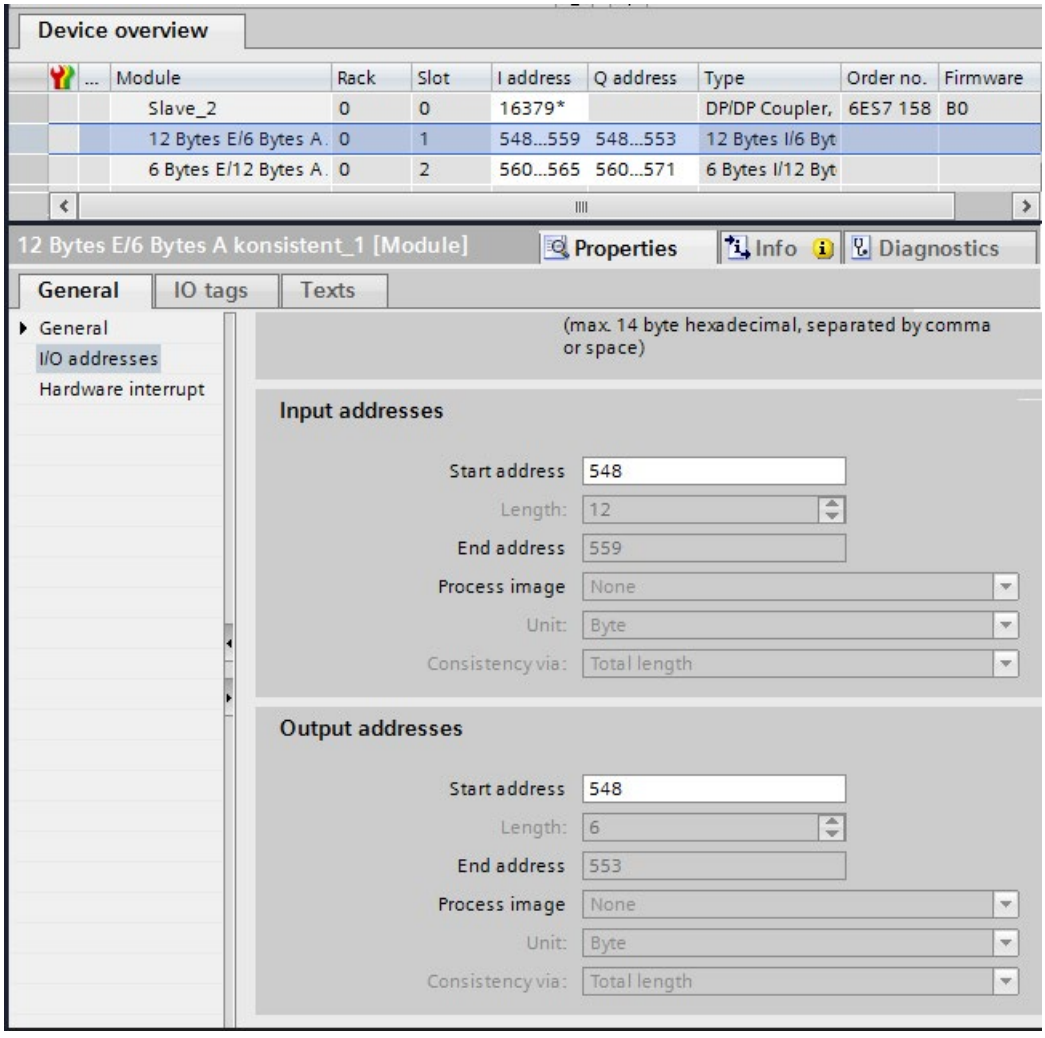
   Tip: Make a note of the start addresses of the transfer areas. You need these to program the SENDDP and RCVDP blocks (LADDR input).



9. Select the following modules from the "Hardware catalog" task card (with filter activated) in the device view of DP/DP coupler PLC2, and insert them in the "Device overview" tab:
   - One "12 bytes I/6 bytes Q consistent" module, and
   - One "6 bytes I/12 bytes Q consistent" module
10. In the properties of the modules, assign the addresses outside the process image as follows:

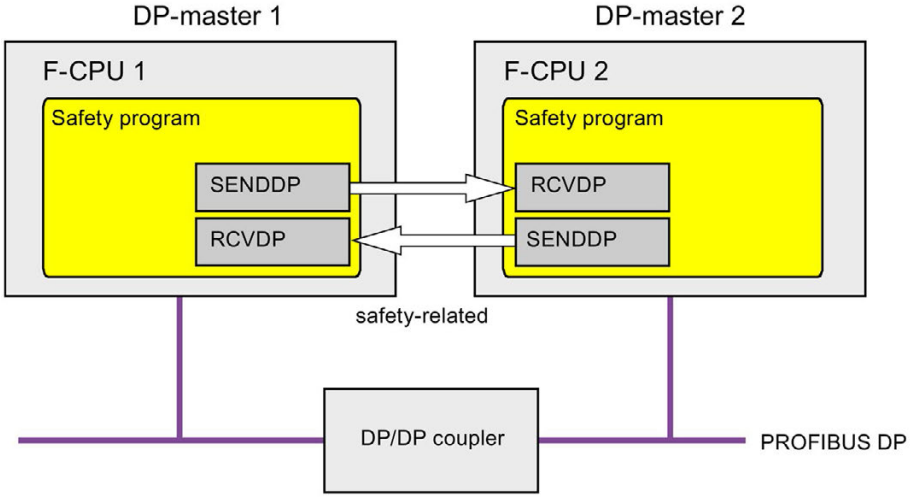
    For "12 bytes I/6 bytes Q consistent" module for receiving data for example:
    - Input addresses: Start address 548
    - Output addresses: Start address 548

    For "6 bytes I/12 bytes Q consistent" module for sending data for example:
    - Input addresses: Start address 560
    - Output addresses: Start address 560



9.1.3.2 Safety-related master-master communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.1.3.3 Program safety-related master-master communication

Requirement for programming

The transfer areas for input and output data for the DP/DP coupler must be configured.

Programming procedure

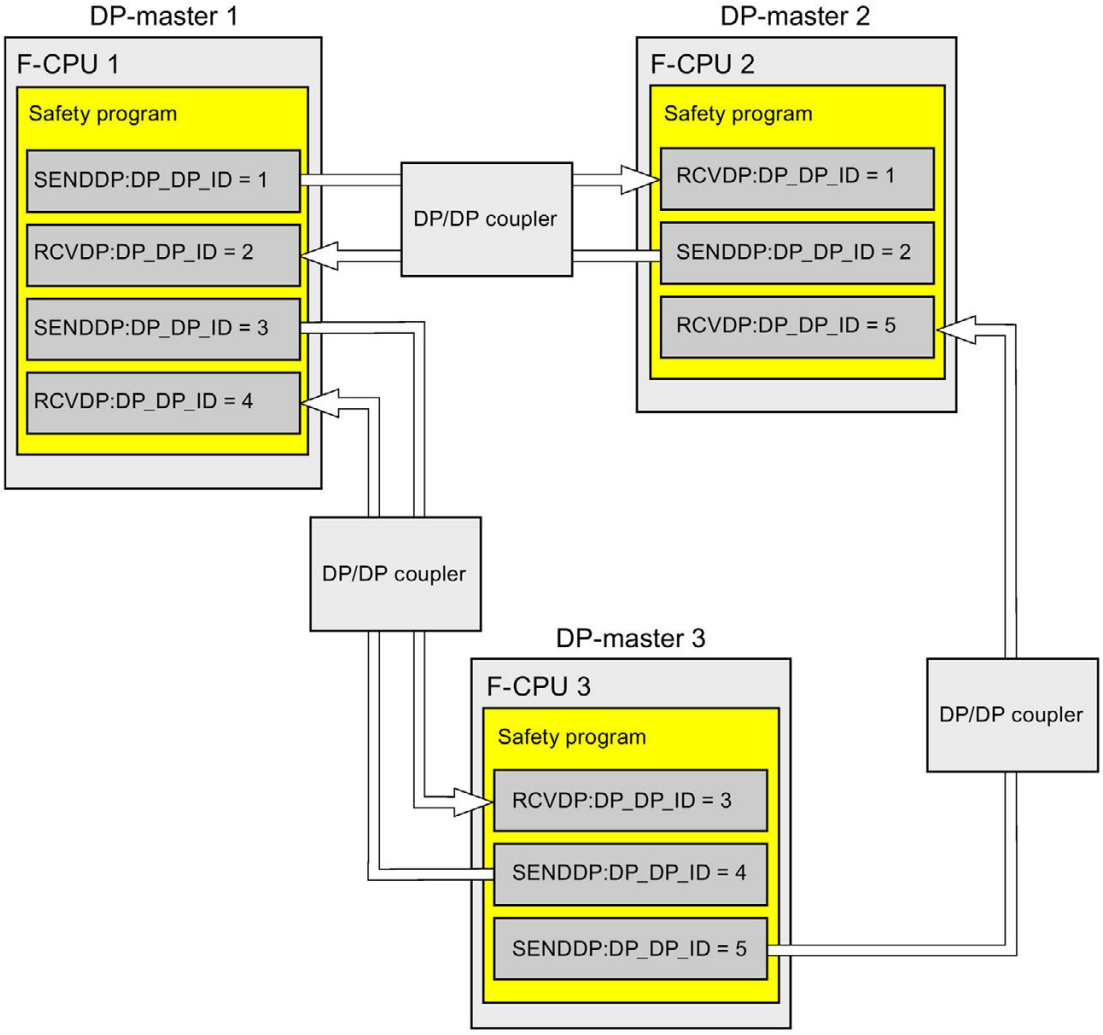
You program safety-related master-master communication as follows:

1. In the safety program from which data are to be sent, call the SENDDP instruction (Page 515) for sending at the end of the main safety block.
2. In the safety program in which data are to be received, call the RCVDP instruction (Page 515) for receiving at the start of the main safety block.
3. Assign the start addresses of the transfer areas for output and input data of the DP/DP coupler configured in the *hardware and network editor* to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective address relationship to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the address relationships at the inputs of SENDDP and RCVDP instructions for five safety-related master-master communications relationships.



⚠ WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g. "Name RCVDP_1".RD_BO_02).
7. Supply the SUBBO_xx and SUBI_xx inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT, you can enter constant fail-safe values directly as constants in the SUBI_xx input (initial value = "0"). If you want to specify a constant fail-safe value for data of the data type BOOL, provide the tag "F_GLOBDB".VKE1 for the SUBBO_xx input (initial value = "FALSE").
   - Specification of dynamic fail-safe values:

     If you want to specify dynamic fail-safe values, define a tag that you change dynamically through your safety program in an F-DB and specify this tag (fully qualified) in the SUBI_xx or SUBBO_xx input.

     ⚠ WARNING

     Note that your safety program for dynamically changing the tag for a dynamic fail-safe value can only be processed after the call of the RCVDP, because prior to the RCVDP call, there must not be any network and no more than one other RCVDP instruction in the main safety block. You must therefore assign appropriate start values for these tags to be output by RCVDP in the first cycle after a startup of the F-system. *(S017)*

8. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   ⚠ WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

9. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether user acknowledgment is required.
10. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
11. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx inputs.
12. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether a communication error has occurred.
13. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 294).

9.1.3.4 Safety-related master-master communication:Limits for data transfer

Note

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the DP/DP coupler. Whether or not this is possible with one single DP/DP coupler depends on the capacity restrictions of the DP/DP coupler.

9.1.4 Safety-related IO controller-I-device communication

9.1.4.1 Configuring safety-related communication between IO controller and I-device

Introduction

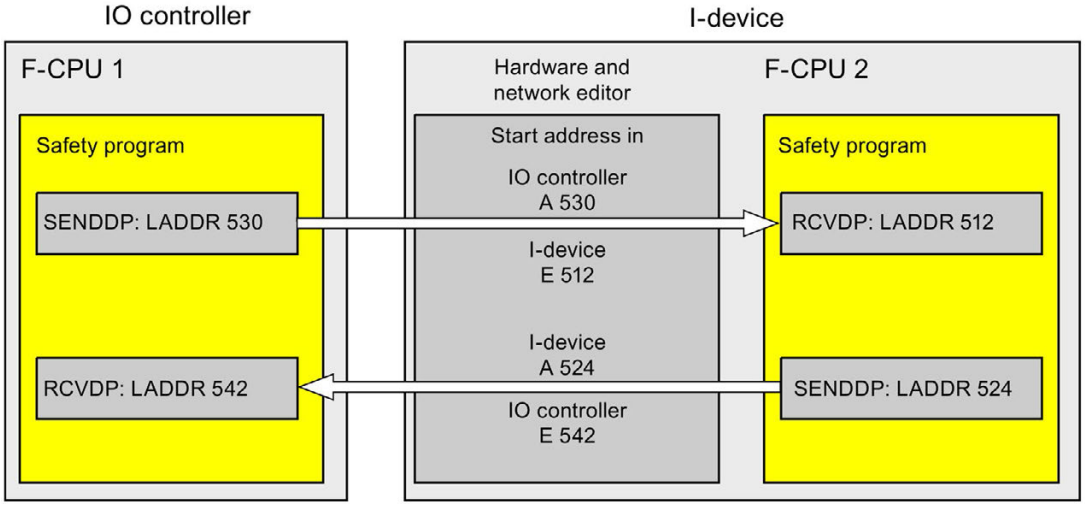
Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device connections (**F**-CD) in PROFINET IO, in the same way as in standard systems.

You do not need any additional hardware for IO controller-I-device communication.

The F-CPU to be used as an I-device must support the "IO-device" operating mode.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-CD_PLC_2 PLC_1_1" for the first F-CD connection between IO controller F-CPU 1 and I-device F-CPU 2.

You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

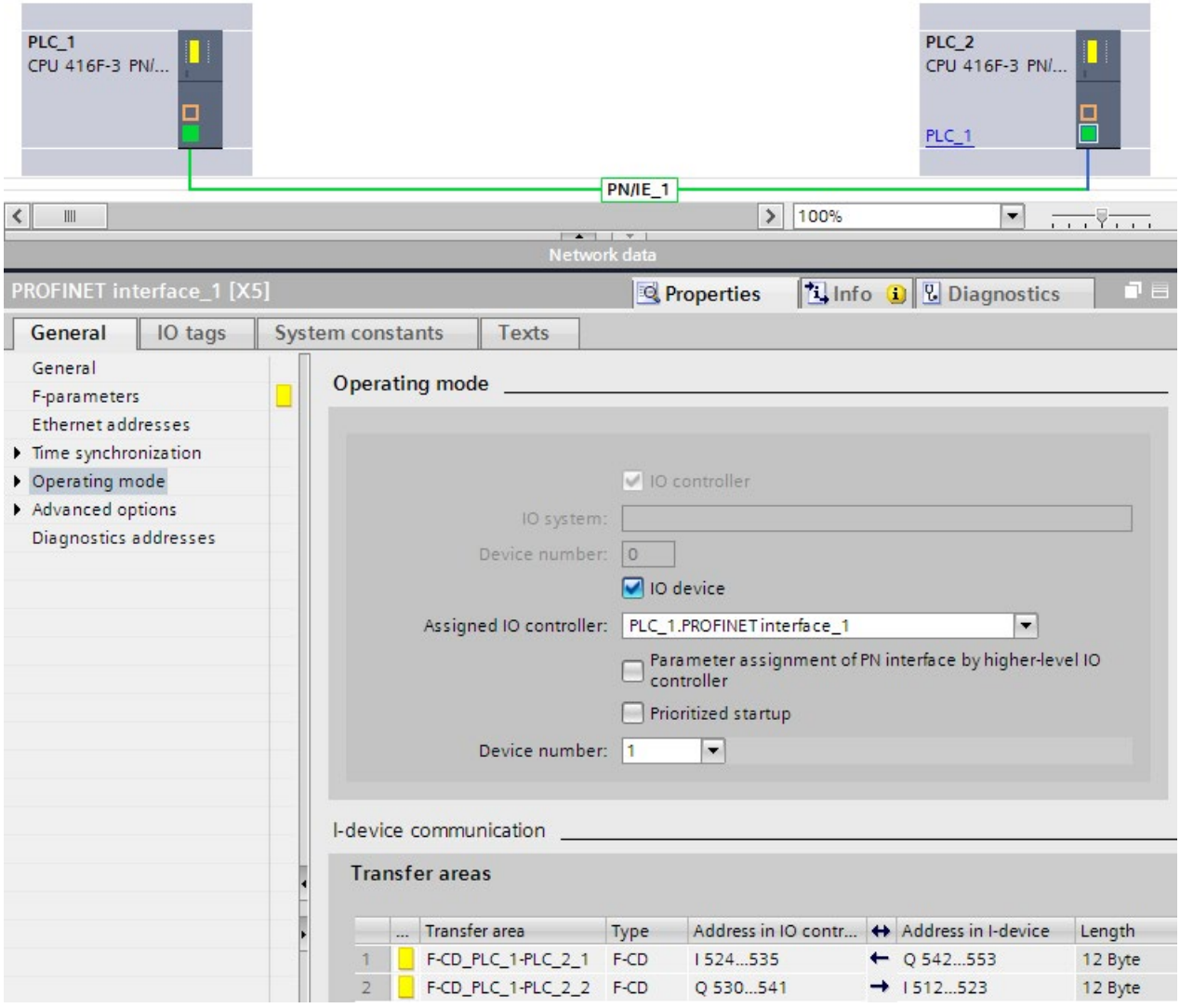
The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.
3. Select the PROFINET interface of F-CPU 2. Under "Transfer areas", you create an F-CD connection (type "F-CD") for sending to the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned outside of the process image are displayed.

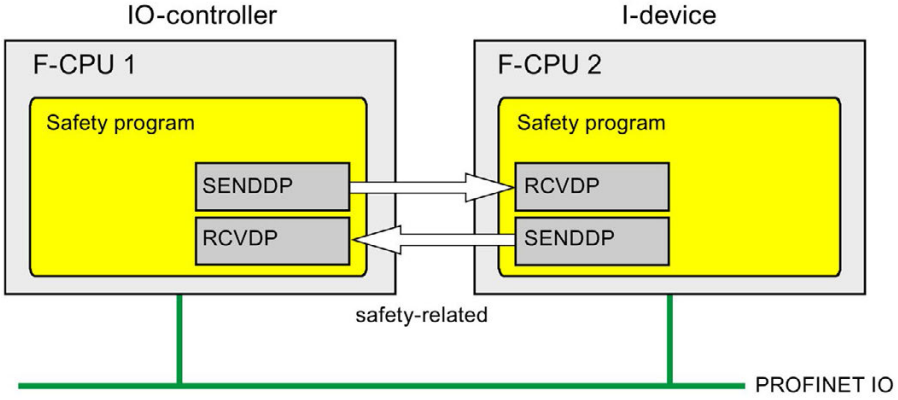
   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").
4. Create an additional F-CD connection for receiving from the IO controller.

5. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from IO controller (→).



9.1.4.2 Safety-related IO controller-I-device communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controller and an I-device makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.1.4.3 Programming safety-related IO controller I-device communication

Requirement for programming

The transfer areas must be configured.

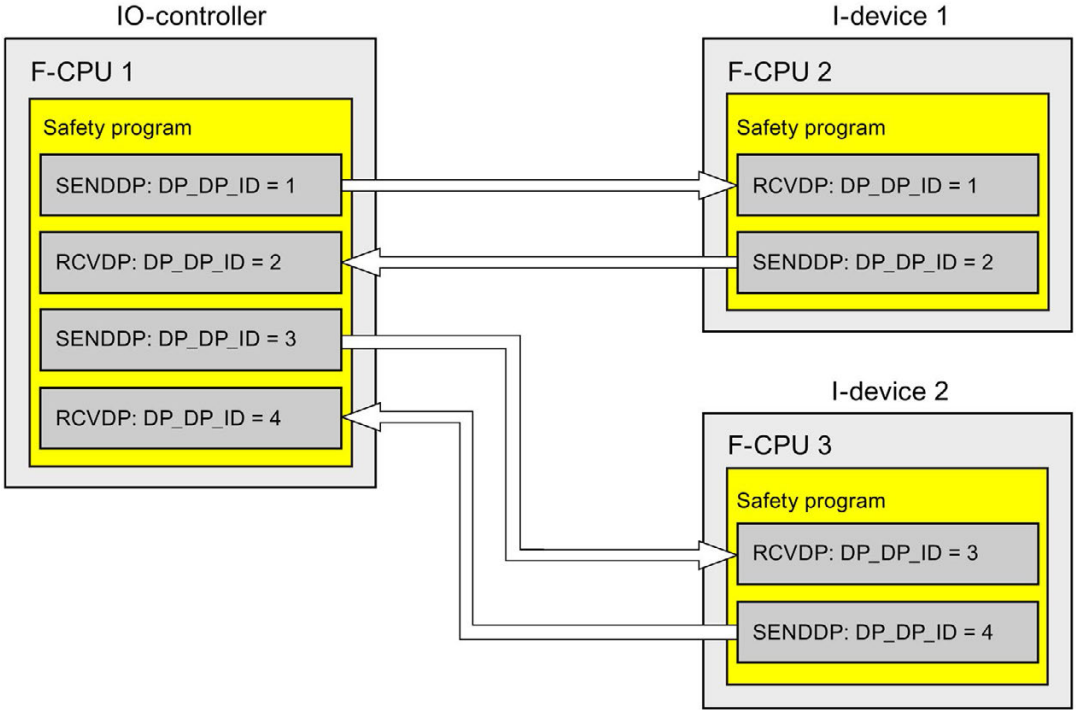
Programming procedure

The procedure for programming safety-related IO controller-I-device communication is the same as that for programming safety-related IO controller-IO controller communication (see Program safety-related IO controller-IO controller communication (Page 178)).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the IO controller	→	Address in the IO controller
RCVDP in the IO controller	←	Address in the IO controller
SENDDP in the I-device	←	Address in the IO device
RCVDP in the I-device	→	Address in the IO device

The figure below contains an example of how to specify the address relationships for the inputs of the SENDDP and RCVDP instructions for four safety-related IO controller-I-device communication relationships.



⚠ WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

9.1.4.4 Safety-related IO-Controller-IO-Device communication - Limits for data transfer

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Remember the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and a IO controller.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		In the IO controller		In the I-device	
		Output data	Input data	Output data	Input data
IO controller-I-Device	**Sending:** I-Device 1 to IO controller	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-Device 1 from IO controller	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-CD and CD) for the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and an IO controller. In addition, data are assigned for internal purposes such that the maximum limit may be reached sooner.

When the limit is exceeded, a corresponding error message is displayed.

9.1.5 Safety-related master-I-slave communication

9.1.5.1 Configuring safety-related master-I-slave communication

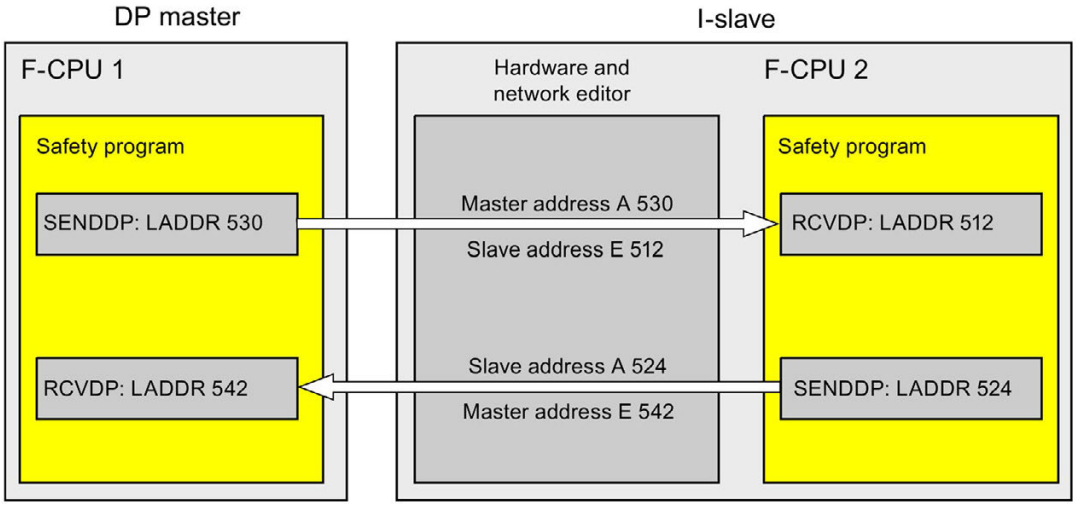
Introduction

Safety-related communication between the safety program of the F-CPU of a DP master and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place over master-I-slave connections (**F-**MS), as in standard systems.

You do not need a DP/DP coupler for master-I-slave communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-MS_PLC_2-PLC_1_1" for the first F-MS connection between DP master F-CPU 1 and I-slave F-CPU 2.

You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

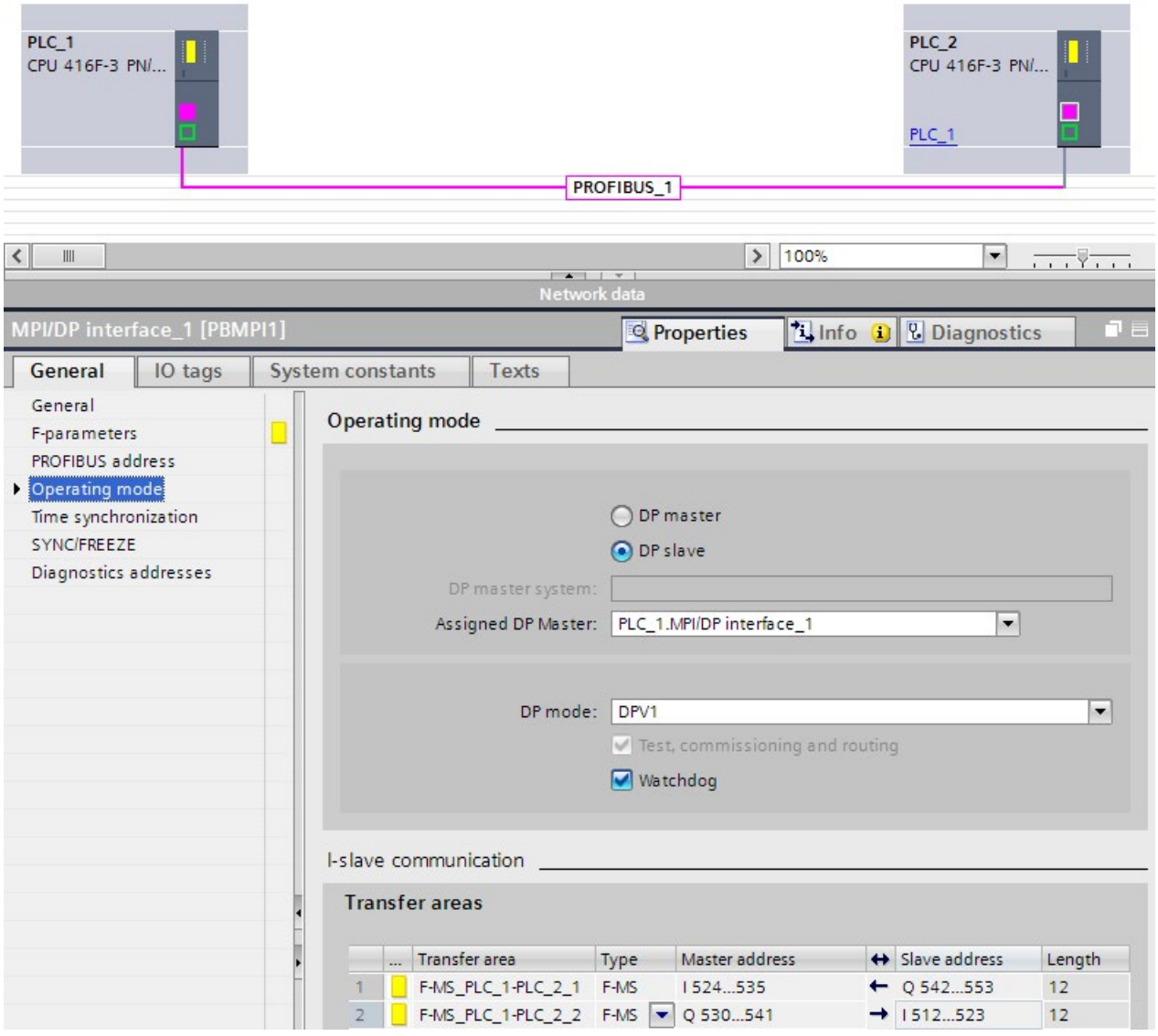
The procedure for configuring safety-related master-I-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Activate the "DP slave" mode (I-slave) for F-CPU 2 in the properties of its DP interface and assign this DP interface to a DP interface of F-CPU 1.
3. Select the PROFIBUS interface of F-CPU 2. Under "Transfer areas", you create an F-MS connection (type "F-MS") for sending to the DP master (←). The F-MS connection is shown in yellow in the table and the transfer areas in the I-slave and DP master assigned outside of the process image are displayed.

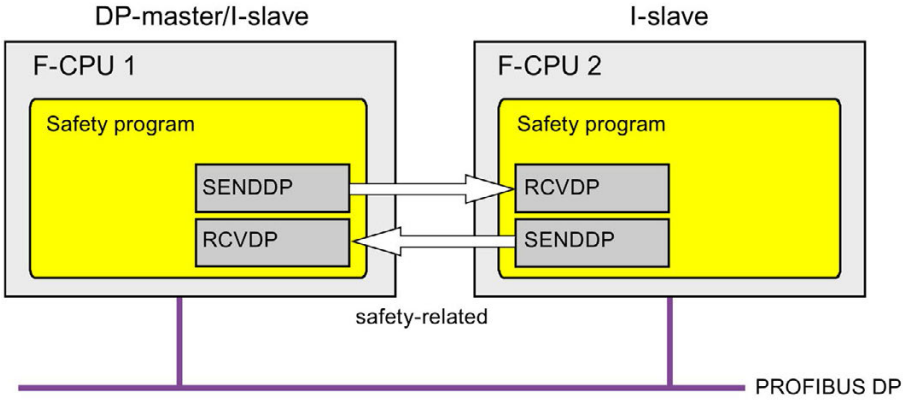
   In addition, an acknowledgment connection is created automatically for each F-MS connection. (see "Transfer area details").

4. Create an additional F-MS connection for receiving from the DP master.
5. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from DP master (→).



9.1.5.2 Safety-related master-I-slave or I-slave-I-slave communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master and an I-slave or between the F-CPUs of multiple I-slaves makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.1.5.3 Program the safety-related master-I-slave or I-slave-I-slave communication

Requirements

The transfer areas must be configured.

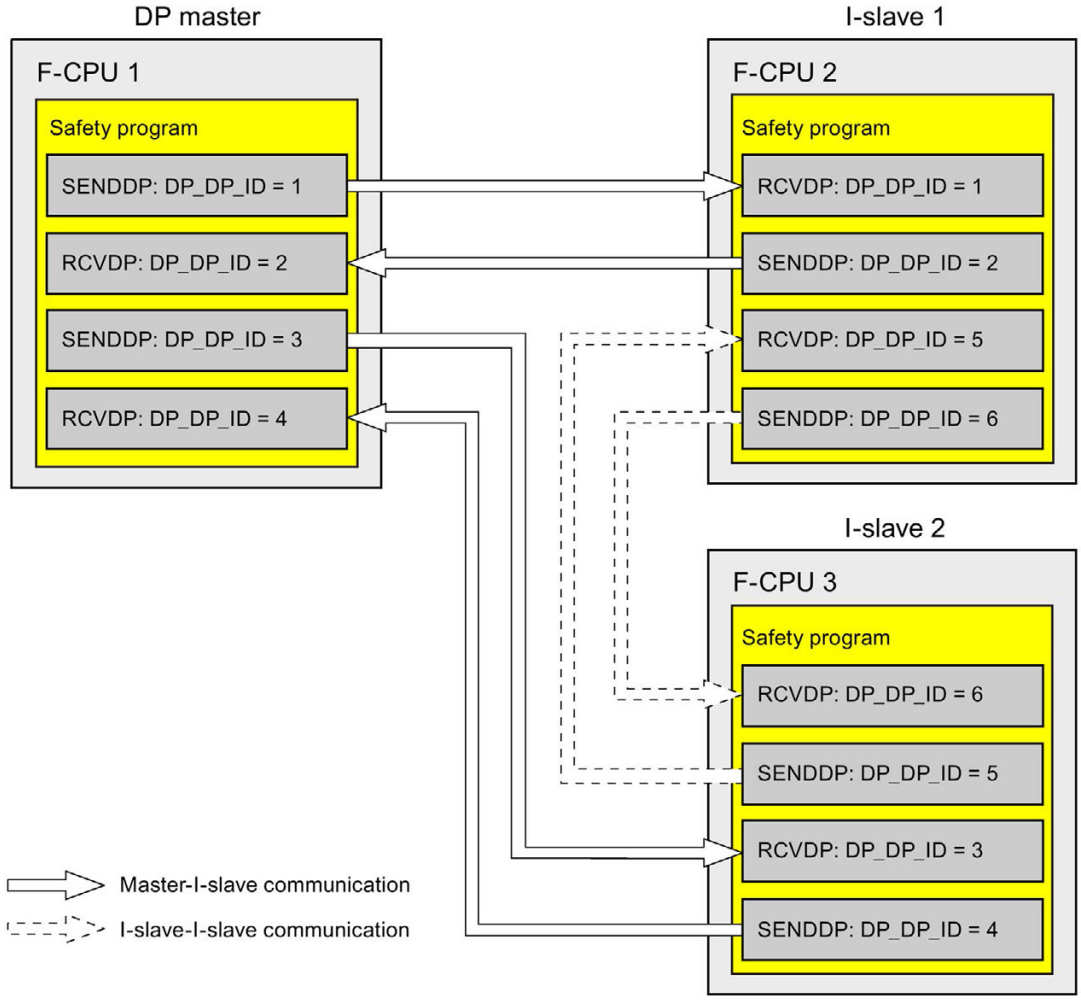
Programming procedure

The procedure for programming safety-related master-I-slave communication or I-slave-I-slave communication is the same as that for programming safety-related master-master communication (see Program safety-related master-master communication (Page 187)).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the DP master	→	Master address
RCVDP in the DP master	←	Master address
SENDDP in the I-slave	←	Slave address
RCVDP in the I-slave	→	Slave address

The figure below contains an example of how to specify the address relationships at the inputs of SENDDP and RCVDP instructions for four safety-related master-I-slave and two I-slave-I-slave communications relationships.



WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

9.1.5.4 Limits for data transfer of safety-related master-I-slave or I-slave-I-slave communication

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data					
		DP master		I-slave 1		I-slave 2	
		Output data	Input data	Output data	Input data	Output data	Input data
Master-I-slave	**Sending:** I-slave 1 to DP master	6 bytes	12 bytes	12 bytes	6 bytes	—	—
	Receiving: I-slave 1 from DP master	12 bytes	6 bytes	6 bytes	12 bytes	—	—
I-slave-I-slave	**Sending:** I-slave 1 to I-slave 2	—	18 bytes	12 bytes	6 bytes	6 bytes	12 bytes
	Receiving: I-slave 1 from I-slave 2	—	18 bytes	6 bytes	12 bytes	12 bytes	6 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-MS-, F-DX-, F-DX-Mod., MS-, DX- and DX-Mod) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-device and a DP master F-MS, F-DX, F-DX-Mod., MS, DX). If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

9.1.6 Safety-related I-slave-I-slave communication

9.1.6.1 Configure safety-related I-slave-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPUs of I-slaves takes place using direct data exchange (**F-**DX) – same as in standard programs.

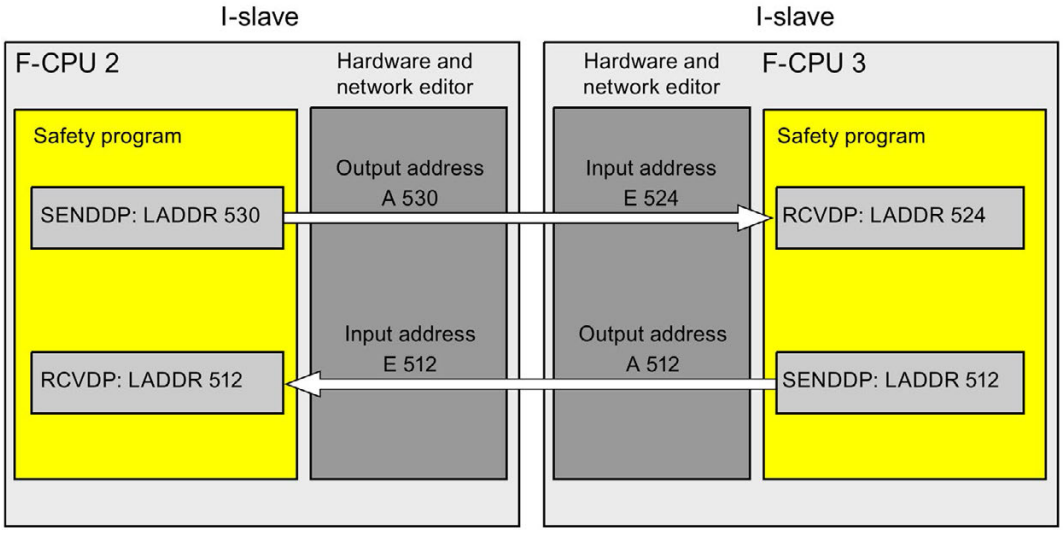
You do not need any additional hardware for I-slave-I-slave communication.

I-slave-I-slave communication is also possible:

- If the assigned DP master is a standard CPU that supports direct data exchange
- when instead of a DP master, an IO controller is networked with the I-slaves via an IE/PB link

Configuring transfer areas

For every safety-related communication connection between two I-slaves, you must configure transfer areas in the *hardware and network editor*. In the figure below, both of the I-slaves are to be able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-DX_PLC_2-PLC_1_1" for the first F-DX connection between F-CPU 1 and F-CPU 2.

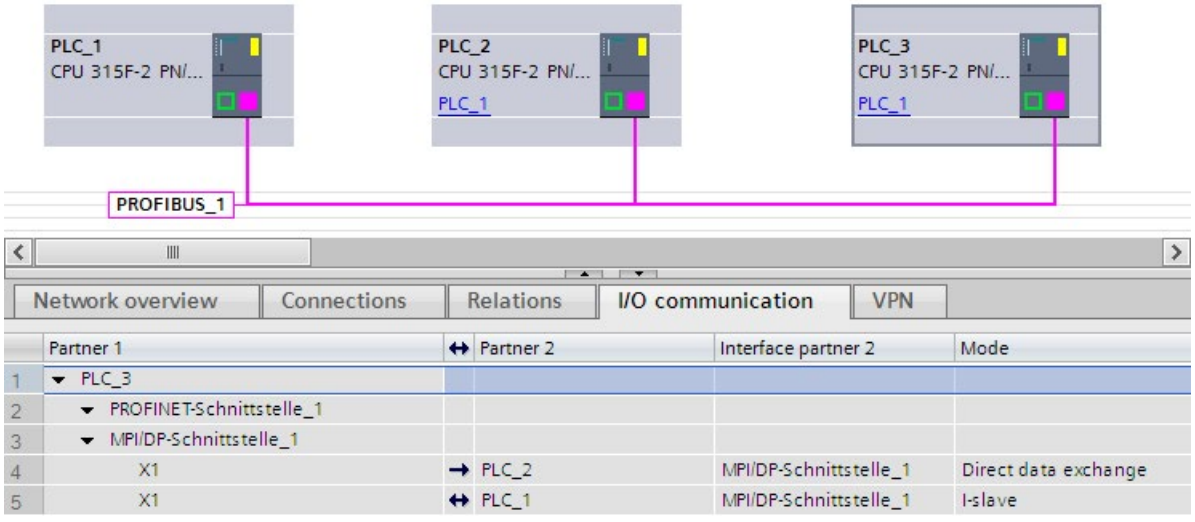
You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related I-slave-I-slave communication is identical to that in the standard system. Proceed as follows:

1. Insert three F-CPUS from the "Hardware catalog" task card in the project.
2. Activate "DP slaves" mode (I-slave) for F-CPU 2 and F-CPU 3 in the properties of their DP interfaces and assign these DP interfaces to a DP interface of F-CPU 1.
3. Select the DP interface of F-CPU 3 in the network view.
4. Select the "I/O communication" tab.
5. Use a drag-and-drop operation in the network view to move F-CPU 2 to the "Partner 2" column on the "I/O-communication" tab.

   This creates a line with "Direct data exchange" mode for sending to the I-slave (F-CPU 2) (→).



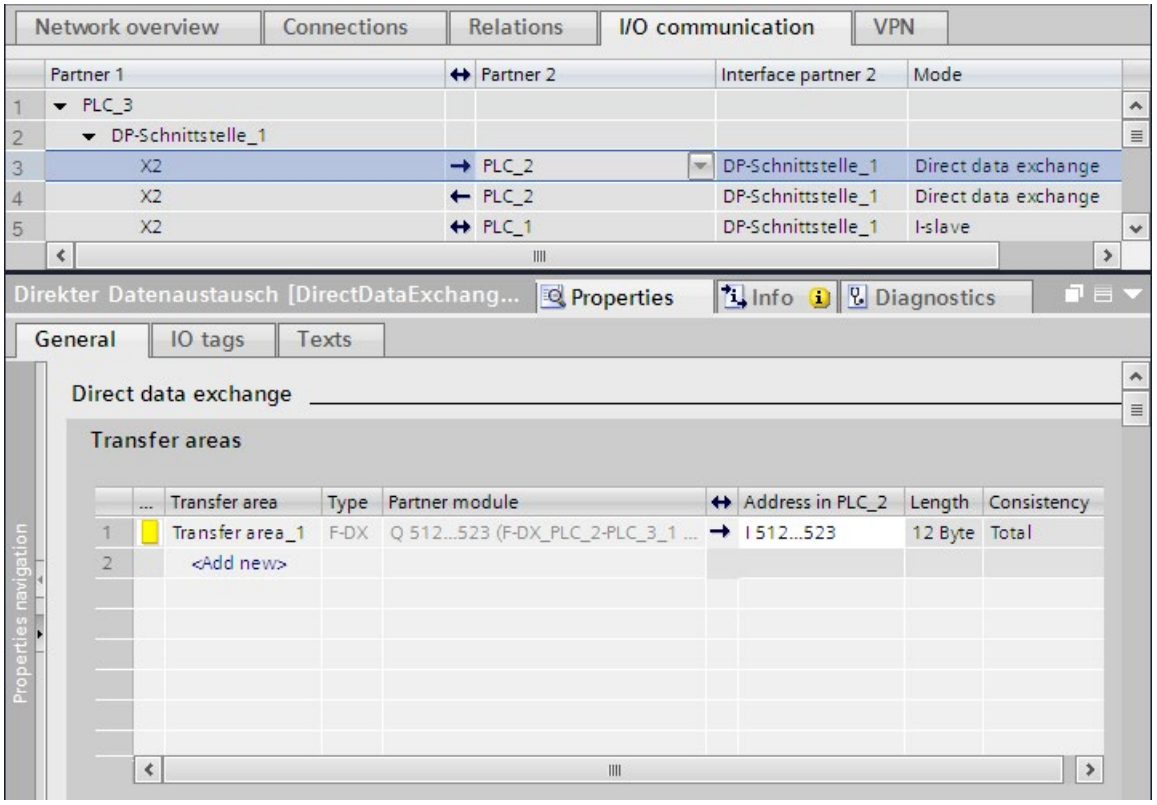
6. Click in the newly created line (→).

7. In "Transfer areas" ("Direct data exchange" table), create an F-DX connection (type "F-DX") for sending to the I-slave (F-CPU 2) (→). The F-DX connection is shown in yellow in the table and the transfer areas in the I-slaves assigned outside of the process image (PLC_2 and PLC_3) are displayed.

   In addition, a line with "Direct data exchange" mode for receiving from the I-slave (F-CPU 2) (→) is created automatically in the "I/O communication" tab, and an acknowledgment connection (←, transfer area x_Ack) is created automatically in the associated "Direct data exchange" table.

   One transfer area (type F-MS) for the master CPU (disabled in display) is created for in the "I-slave communication table" of each I-slave.

   This completes the configuration for sending to F-CPU 2.

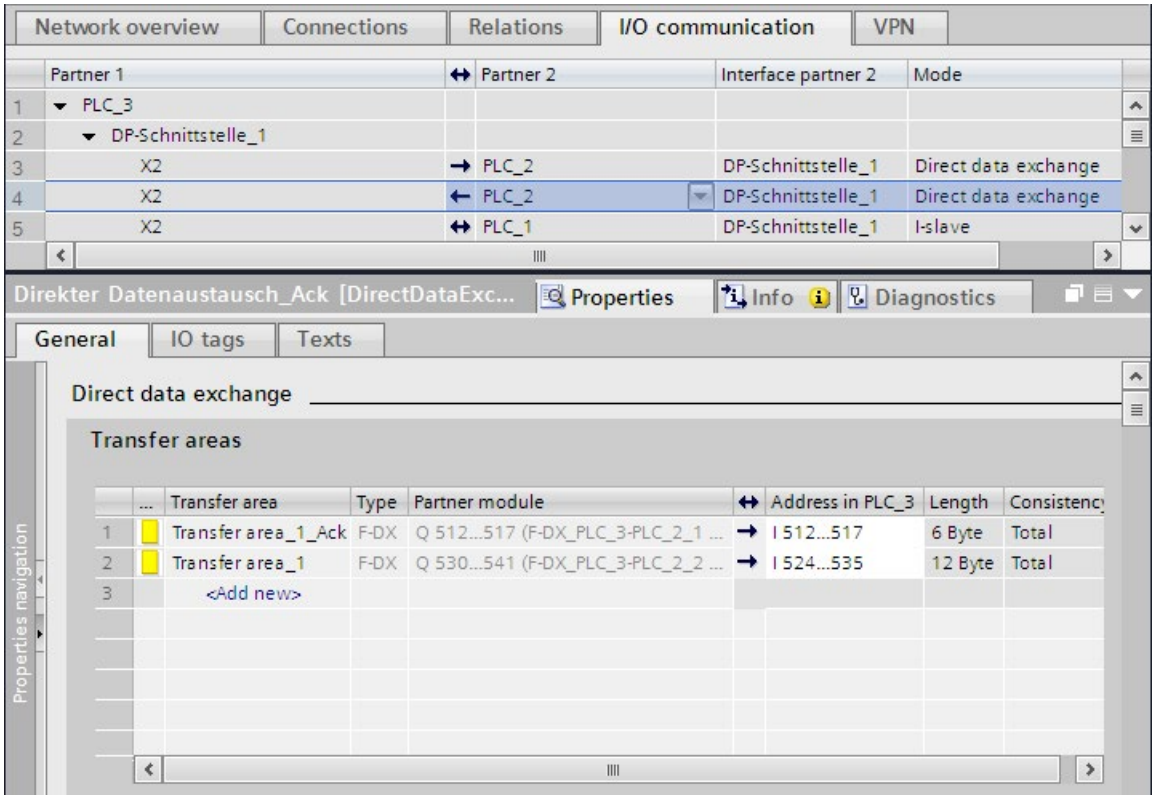


8. In the "I/O communication" tab, select the automatically created line with "Direct data exchange" mode for receiving from the I-slave (F-CPU 3) (←).

9. In "Transfer areas" ("Direct data exchange" table), create another F-DX connection for receiving from the I-slave (F-CPU 3).

   In this case, as well, an acknowledgment connection (←, transfer area x_Ack) is created automatically in the "Direct data exchange table" and two transfer areas (type F-MS) for the master CPU (disabled in display) are created in the "I-slave communication" table of both I-slaves.

   This completes the configuration for receiving from F-CPU 2.



Changing disabled local address areas of the transfer areas

In order to change the disabled local address area of "Transfer area x", you must change the address area of the corresponding acknowledgment connection "Transfer area x_Ack".

1. In "I/O communication", select the line with the arrow pointing in the same direction as the arrow of "Transfer area x" in the "Direct data exchange" table.
2. Then select the line with "Transfer area x_Ack" in the "Direct data exchange" table.
3. Change the address area there.

9.1.6.2 Safety-related I-slave-I-slave communication via SENDDP and RCVDP

Reference

The description of the communication via SENDDP and RCVDP for safety-related I-slave-I-slave communication can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.1.6.3 Programming safety-related I-slave-I-slave communication

Reference

The description of the programming of safety-related I-slave-I-slave communication can be found in Program the safety-related master-I-slave or I-slave-I-slave communication (Page 201).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the 1st I-slave	→	Address in the <1st I-slave> (in example column "Address in PLC_2")
RCVDP in the 1st I-slave	←	Address in the <1st I-slave> (in example column "Address in PLC_2")
SENDDP in the 2nd I-slave	←	Address in the <2nd I-slave> (in example column "Address in PLC_3")
RCVDP in the 2nd I-slave	→	Address in the <2nd I-slave> (in example column "Address in PLC_3")

9.1.6.4 Limits for data transfer of safety-related I-slave-I-slave communication

Limits for data transfer

The description of the limits for the data transfer of safety-related I-slave-I-slave communication can be found in Limits for data transfer of safety-related master-I-slave or I-slave-I-slave communication (Page 203).

9.1.7 Safety-Related I-Slave-Slave Communication

9.1.7.1 Configuring Safety-Related I-Slave-Slave Communication

Introduction

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O in a DP slave takes place using direct data exchange (**F-**DX-Mod), same as in standard programs.

You do not need any additional hardware for I-slave-slave communication.

I-slave-slave communication is also possible:

- when the assigned DP master is a standard CPU, if the standard CPU supports direct data exchange
- when instead of a DP master, an IO controller is networked with the I-slaves via an IE/PB link

An F-I/O DB is automatically generated for each F-I/O when it is configured in the *hardware and network editor*; this is required for the F-I/O access via safety-related I-slave-slave communication. The F-I/O DB is initially created in the safety program of the DP master, provided it is an F-CPU with F-activation. Only with the setup of the F-DX-Mod connection is the F-I/O DB created in the safety program of the I-slave and deleted in the safety program of the DP master.

The process image input is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave (see description in Safety-Related I-Slave-Slave Communication - F-I/O Access (Page 214)).

Restrictions

Note

Safety-related I-slave-slave communication with F-I/O is possible in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware version > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware version > V4.0.0.

Note

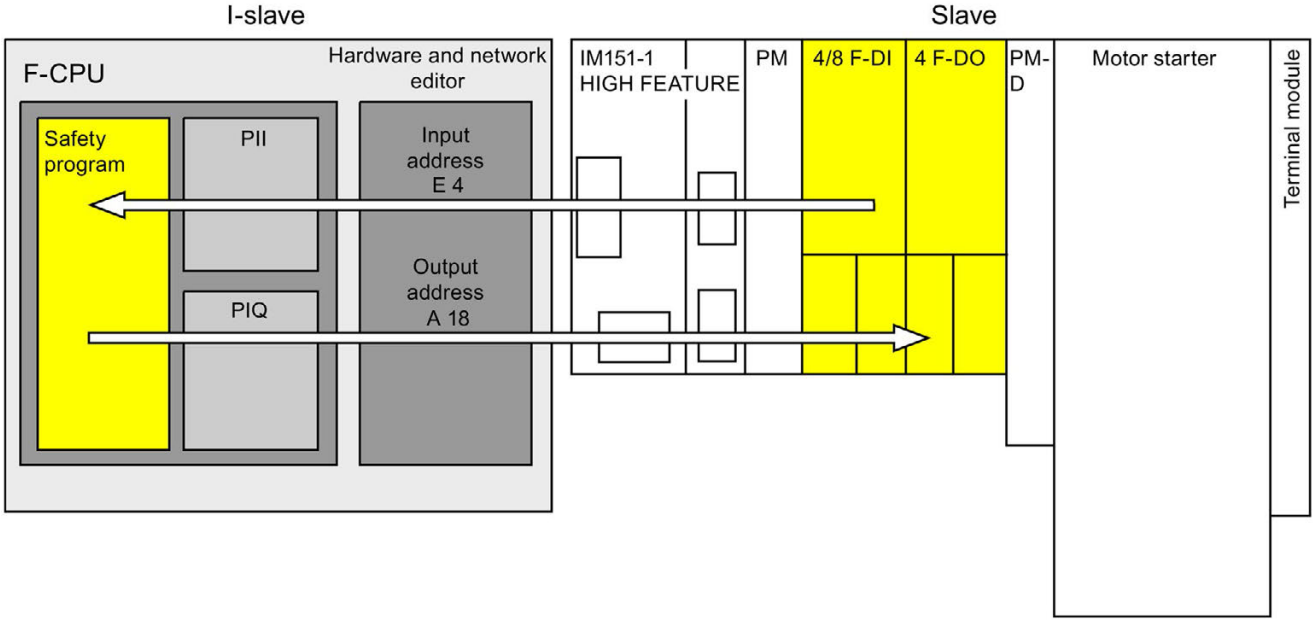
With safety-related I-slave-slave communication, make sure that the CPU of the DP master is powered up before the F-CPU of the I-slave.

Otherwise, depending on the F-monitoring time specified for the F-I/O, the F-system can detect an error in safety-related communication (communication error) between the F-CPU and the F-I/O assigned to the I-slave. This means that the F-I/O are not reintegrated automatically after F-system startup. They are instead only reintegrated after a user acknowledgment with a positive edge in the ACK_REI tag of the F-I/O DB (see also After communication errors (Page 148) and After startup of F-system (Page 145)).

Configuring transfer areas

For every safety-related communication connection between an I-slave and slave, you must configure transfer areas in the *hardware and network editor*.

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-DX-Mod_PLC_2-PLC_1_1" for the first F-DX-Mod connection between F-CPU 1 and F-CPU 2.



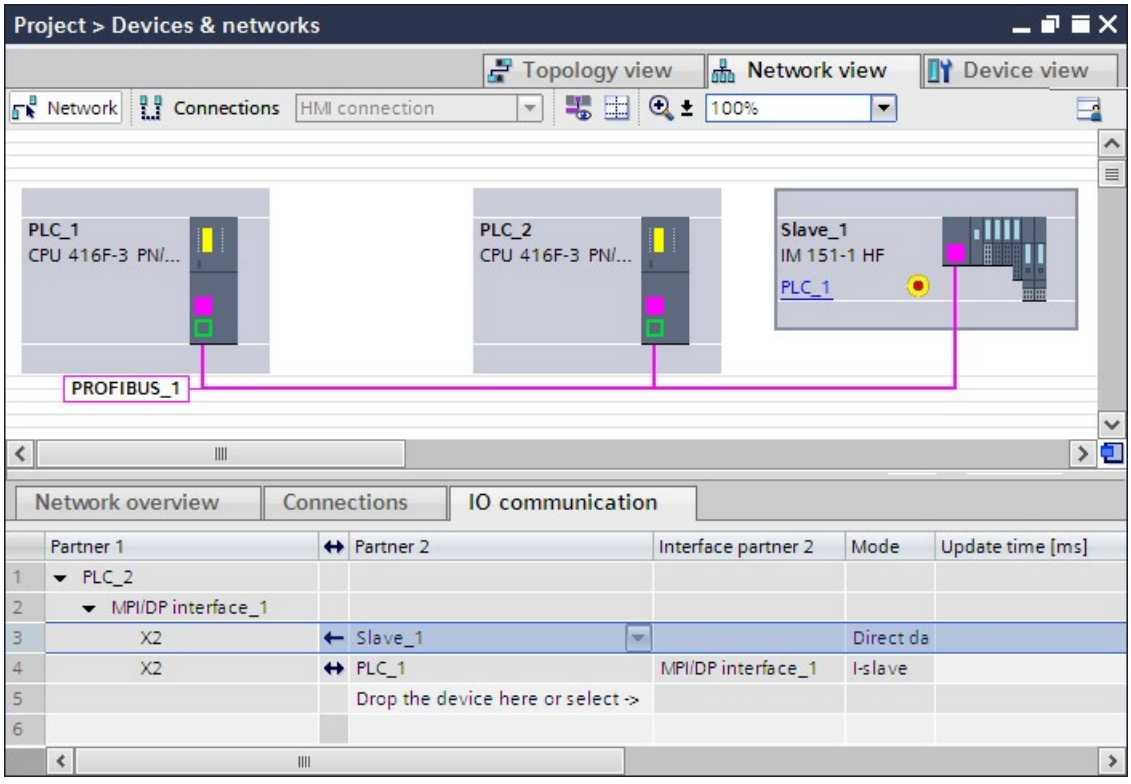
Configuration procedure using the example of an ET 200S with F-modules in the slave

The procedure for configuring safety-related I-slave-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Insert a suitable DP slave, e.g. IM 151-1 HF, article no. 6ES7151-1BA0... from the "Hardware catalog" task card into the network view of the *hardware and network editor*.
3. Insert a power module, a 4/8 F-DI module and a 4 F-DQ module in the device view of the ET 200S.
4. Activate "DP slave" mode (I-slave) for F-CPU 2 in the properties of its DP interface and assign this to F-CPU 1.
5. Assign the DP interface of the IM 151-1 HF to the DP master (F-CPU 1).
6. Select the DP interface of F-CPU 2 (I-slave) in the network view.
7. Select the "I/O communication" tab.

8. Use a drag-and-drop operation in the network view to move the ET 200S to the "Partner 2" column in the "I/O-communication" tab.

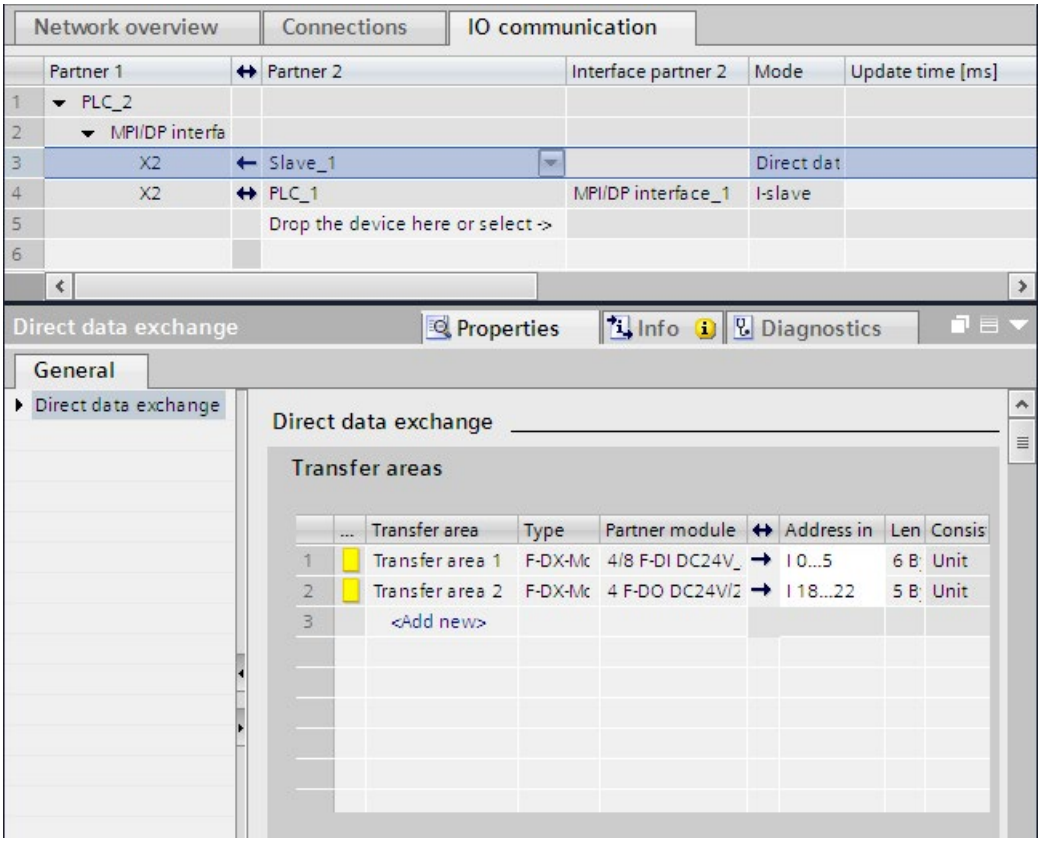


9. Click in the newly created line (←).
10. In "Transfer areas", create an F-DX-Mod connection (type "F-DX-Mod"). The F-DX-Mod connection is marked in yellow in the table. The addresses for the "partner module" 4/8 F-DI in the I-Slave (PLC_2) are displayed. You can change the addresses directly in the table, if required.

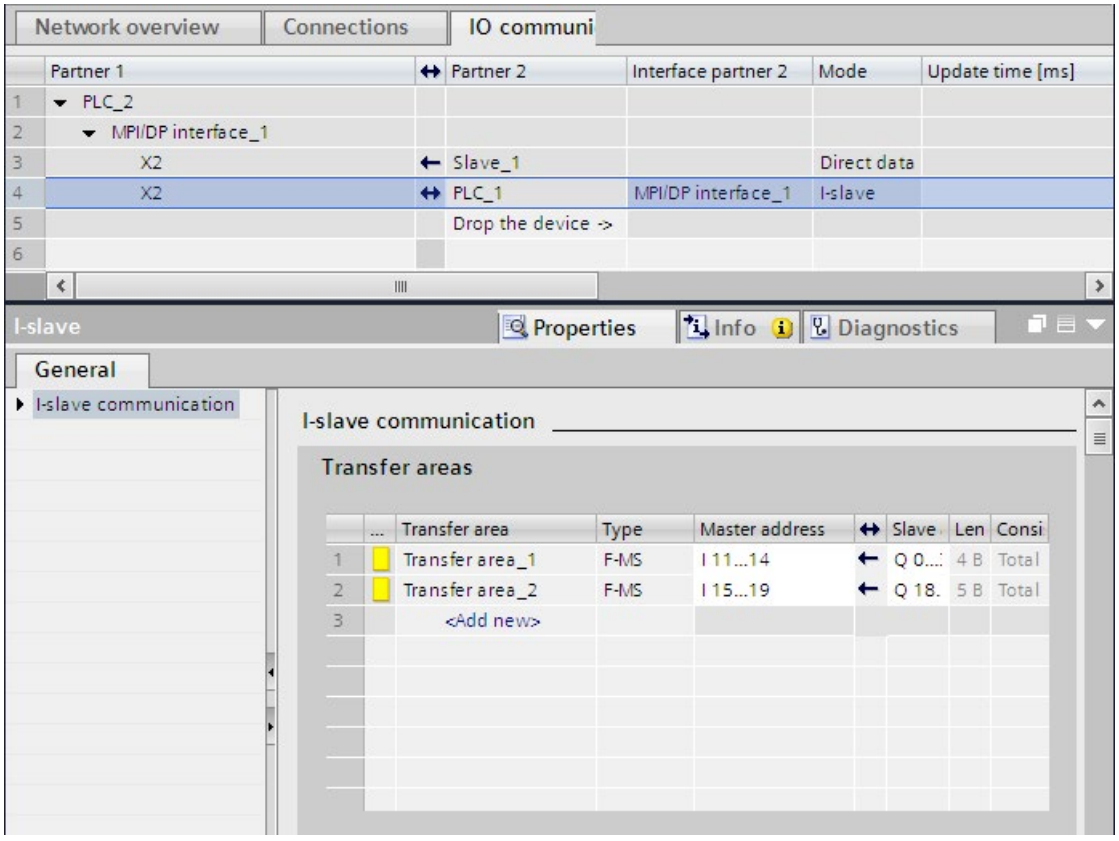
    This completes the configuration for the 4/8 F-DI module.

11. In "Transfer areas", create another F-DX-Mod connection.
12. Change the partner module to the 4 F-DO module, either directly in the "Transfer areas" table or in the details of transfer area 2, if the 4 F-DO module was not already selected.

    This completes the configuration for the 4 F-DO module.



In the "I-slave communication table" of the I-slave, a transfer area (type F-MS) for the master CPU (disabled in display) is created for each F-DX-Mod connection:



Change in configuration of I-slave-slave communication

⚠ WARNING

If you have reconfigured I-slave-slave communication for an F-I/O or have deleted an existing I-slave-slave communication, you must compile the hardware configuration of the DP master as well as the hardware configuration of the I-slave and download them to the DP master and I-slave, respectively.

The collective F-signature in the F-CPU of the I-slave and the collective F-signature in the F-CPU of the DP master (if a safety program exists there, too) are set to "0". You must then recompile the safety program(s). *(S019)*

9.1.7.2 Safety-Related I-Slave-Slave Communication - F-I/O Access

Access via the process image

In safety-related I-slave-slave communication, you use the process image (PII or PIQ) to access the F-I/O in the safety program of the F-CPU of the I-slave. This is the same as F-I/O access to F-I/O that are directly assigned to an I-slave or DP master. In the I-slave you access the F-I/O with the addresses that were assigned for the F-DX-Mod connection in "Transfer areas" ("Direct data exchange" table).

In this case, ignore the displayed operand area. Access F-I/O with inputs using the PII and F-I/O with outputs using PIQ.

Information on I/O access can be found in F-I/O access (Page 128).

9.1.7.3 Limits for data transfer of safety-related I-slave-I-slave communication

Limits for data transfer

Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

An example of the amount of output data and input data that are assigned for safety-related communication is shown in the table below for an ET 200S 4/8 F-DI and an ET 200S 4 F-DO:

Safety-related communication	Communication connection	Assigned input and output data*	
		Between I-slave and DP master	
		Output Data in the I-slave	Input data in the I-slave
I-slave-slave	I-slave-slave communication with 4/8 F-DI	4 bytes	6 bytes
	I-slave-slave communication with 4 F-DO	5 bytes	5 bytes

* Example for 4/8 F-DI and 4 F-DO of ET 200S

Consider all additional configured safety-related and standard communication connections (F-MS, F-DX, F-DX-Mod., MS and DX connections) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master. If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

9.1.8 Safety-related IO controller-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of an IO-controller and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place over master-I-slave connections (**F-**MS), as in standard systems.

IE/PB link

For the safety-related IO-controller-I-slave communication, the IE/PB link is mandatory. Each of the two F-CPUs is linked to the IE/PB link by means of its PROFIBUS DP or PROFINET-interface.

Note

If you are using an IE/PB link, you must take this into account when configuring the F-specific monitoring times and when calculating the maximum response time of your F-system (see also Monitoring and response times (Page 530)).

Note that the Excel file for calculating response times (http://support.automation.siemens.com/WW/view/en/49368678/133100) for S7-300/400 F-CPUs does not support all conceivable configurations.

Reference

The information on safety-related master-I-slave communication in Safety-related master-I-slave communication (Page 197) also applies.

9.1.9 Safety-related communication via S7 connections

9.1.9.1 Configuring safety-related communication via S7 connections

Introduction

Safety-related communication between the safety programs of F-CPUs via S7 connections takes place by means of established S7 connections that you create in the network view of the *hardware and network editor* - same as in standard programs.

Restrictions

Note

In SIMATIC Safety, S7 connections are generally permitted only via Industrial Ethernet.

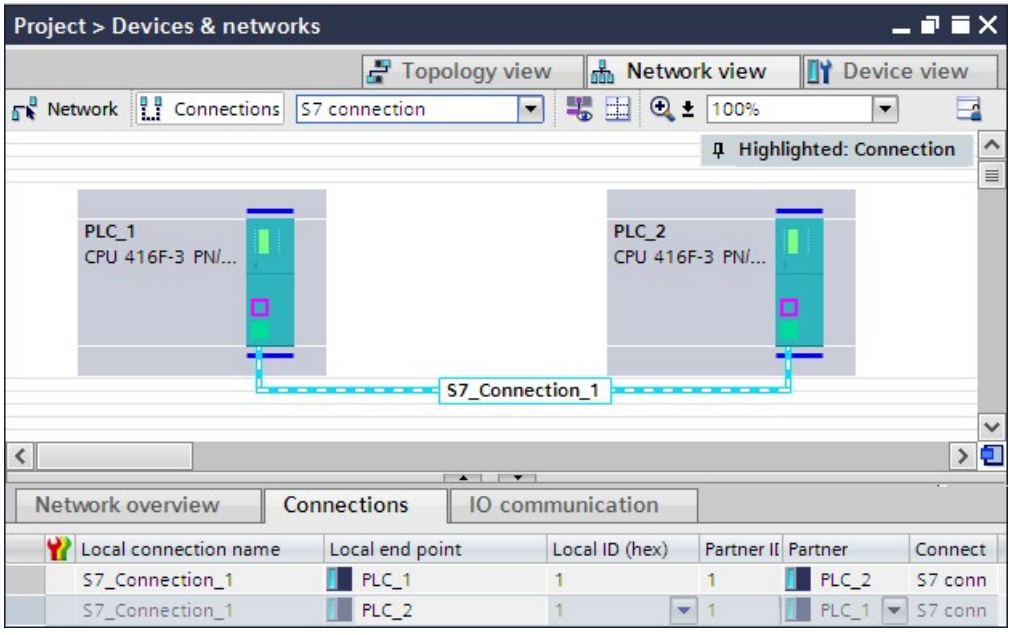
Safety-related communication via S7 connections is possible from and to the following CPUs:

- S7-300 F-CPUs via the integrated PROFINET interface
- S7-400 F-CPUs via the integrated PROFINET interface or a CP 443-1 or CP 443-1 Advanced-IT

Creating S7 connections

For each connection between two F-CPUs, you must create an S7 connection in the network view of the *hardware and network editor*.

For every end-point of a connection, a local and a partner ID is automatically assigned from the perspective of the end-point (the F-CPU). If necessary, you can change both IDs in the "Connections" tab. You assign the local ID to the "ID" input of the SENDS7 and RCVS7 instructions in the safety programs.

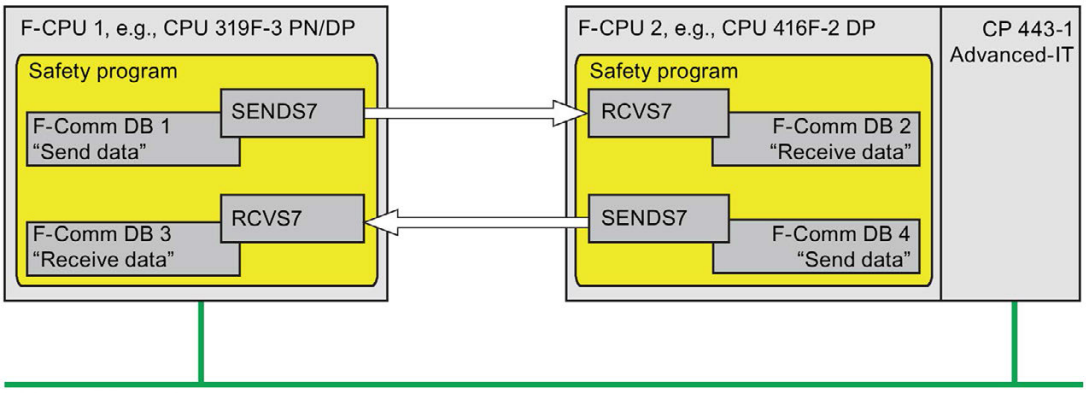


Procedure for configuring S7 connections

You configure the S7 connections for safety-related CPU-to-CPU communication in the same way as in *STEP 7 Professional* (see *Help on STEP 7 Professional* "S7 connections").

9.1.9.2 Communication via SENDS7, RCVS7, and F-Communication DB

Communication via the SENDS7 and RCVS7 instructions



You use the **SENDS7 and RCVS7** instructions for fail-safe sending and receiving of data via S7 connections.

These instructions can be used to transmit a specified amount of fail-safe data of data types BOOL, INT, WORD, DINT, DWORD, and TIME in a fail-safe manner. The fail-safe data are stored in F-DBs (F-communication DBs) that you have created.

You can find these instructions in the "Instructions" task card under "Communication". The RCVS7 instruction **must** be called at the start of the main safety block. The SENDS7 instruction **must** be called at the end of the main safety block.

Note that the send signals are sent only after calling the SENDS7 instruction at the end of the relevant F-runtime group execution.

A detailed description of the SENDS7 and RCVS7 instructions is found in SENDS7 and RCVS7: Communication via S7 connections (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 523).

F-communication DB

For each connection, send data are stored in an F-DB (F-communication DBx) and receive data are stored in an F-DB (F-communication DBy).

You can assign the F-communication DB numbers in the SENDS7 and RCVS7 instructions.

9.1.9.3 Programming safety-related communication via S7 connections

Introduction

The programming of safety-related CPU-CPU communication via S7 connections is described below. You must set up the following in the safety programs of the relevant F-CPUs:

- Create F-DBs (F-Communication-DBs) in which send/receive data for communication are stored.
- Call and assign parameters for instructions for communication from the "Instructions" Task Card in the safety program.

Requirement for programming

The S7 connections between the relevant F-CPUs must be configured in the network view in the "Connections" tab of the *hardware and network editor*.

Creating and Editing an F-Communication DB

F-communication DBs are F-DBs that you create and edit in the same way as other F-DBs in the project tree. You can assign the F-communication DB numbers in the SENDS7 and RCVS7 instructions.

Note

The length and structure of the F-communication DB on the receiver side must match the length and structure of the associated F-communication DB on the sender side.

If the F-communication DBs do not match, the F-CPU can go to STOP mode. A diagnostics event is entered in the diagnostics buffer of the F-CPU.

For this reason, we recommend that you use the following procedure:

1. Create an F-communication DB in the project tree in or below the "Program blocks" folder of the F-CPU at the sender end.
2. Specify the appropriate structure of the F-communication DB, taking into account the data to be transferred.
3. Copy this F-communication DB to the project tree in or below the "Program blocks" folder of the F-CPU at the receiver end, and change the name, if necessary.

Other requirements for F-communication DBs

F-communication DBs must also conform to the following properties:

- They are not permitted to be instance DBs.
- Their length is not permitted to exceed 100 bytes.
- In F-communication DBs, only the following data types may be declared: BOOL, INT, WORD, DINT, DWORD, and TIME.
- The data types must be arranged block-wise and in the following order: BOOL, data types with bit length of 16 bits (INT, WORD), and data types with bit length of 32 bits (DINT, DWORD, and TIME). Within the data blocks with lengths of 16 bits and 32 bits, the data types can be arranged in any order.
- No more than 128 data elements of data type BOOL are permitted to be declared.
- The amount of data of data type BOOL must always be an integer multiple of 16 (word limit). Reserve data must be added, if necessary.

If these criteria are not fulfilled, *STEP 7 Safety Advanced* outputs an error message during compilation.

Assignment of fail-safe values

Fail-safe values are made available at the receiver end:

- While the connection between the communication partners is being established the first time after startup of the F-systems
- Whenever a communication error occurs

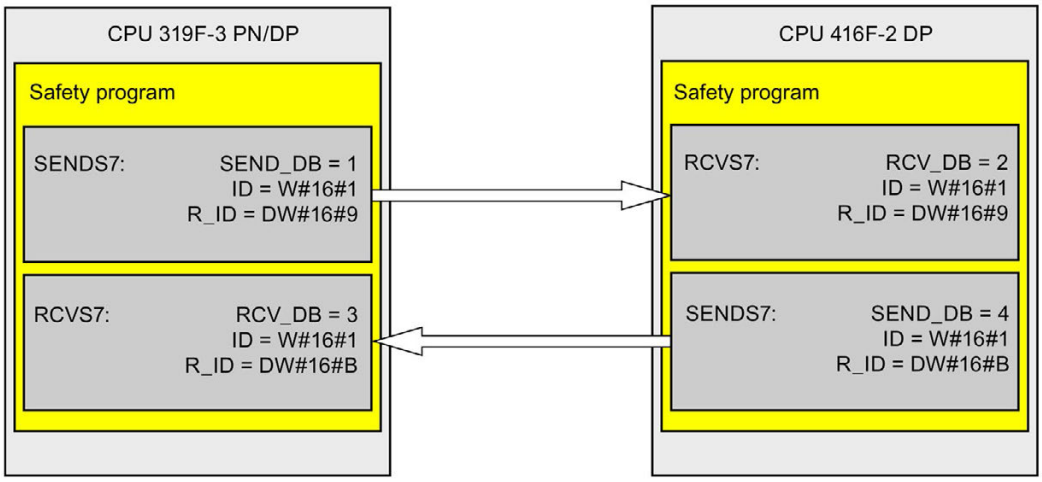
The values you specified as initial values in the F-communication DB at the receiver end are made available as initial values.

Programming procedure

You program safety-related communication via S7 connections as follows:

1. Supply the tags in the F-communication DB at the sender end with send signals using fully qualified access (e.g., "Name of F-communication DB".tag name).
2. Read the tags in the F-communication DB at the receiver end (receive signals) that you want to process further in other sections of the program using fully qualified access (e.g., "Name of F-communication DB".tag name).
3. In the safety program from which data are to be sent, call the SENDS7 instruction for sending at the end of the main safety block.
4. In the safety program in which data are to be received, call the instruction RCVS7 for receiving at the start of the main safety block.
5. Assign F-communication DB numbers to the SEND_DB input of SENDS7 and the RCV_DB input of RCVS7.
6. Assign the local ID of the S7 connection (data type: WORD) from the perspective of the F-CPU that was configured in the "Connections" tab of the network view to the ID input of SENDS7.

7. Assign the local ID of the S7 connection (data type: WORD) that was configured in the "Connections" tab of the network view to the ID input of RCVS7.
8. Assign an odd number (data type: DWORD) to the R_ID inputs of SENDS7 and RCVS7. This serves to specify that a SENDS7 instruction belongs to an RCVS7 instruction. The associated instructions receive the same value for R_ID.



WARNING

The value for each address association (R_ID input; data type: DWORD) is user-defined; however, it must be odd for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.

You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to the associated instance DB is not permitted in the safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

9. Assign the TIMEOUT inputs of the SENDS7 and RCVS7 instructions with the required monitoring time.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

10. To reduce the bus load, you can temporarily shut down communication between the F-CPUs at input EN_SEND of the SENDS7 instruction. To do so, supply input EN_SEND (initial value = "TRUE") with 0. In this case, send data are no longer sent to the F-communication DB of the associated RCVS7 instruction and the receiver RCVS7 provides fail-safe values for this period (initial values in its F-communication DB). If communication was already established between the partners, a communication error is detected.
11. Optional: Evaluate the ACK_REQ output of RCVS7, for example, in the standard user program or on the HMI system in order to query or to indicate whether user acknowledgment is required.
12. Supply the ACK_REI input of RCVS7 with the signal for the acknowledgment for reintegration.
13. Optional: evaluate the SUBS_ON output of RCVS7 or SENDS7 in order to query whether the RCVS7 instruction is outputting the fail-safe values you specified as initial values in the F-communication DB.
14. Optional: Evaluate the ERROR output of RCVS7 or SENDS7, for example, in the standard user program or on the HMI system in order to query or to indicate whether a communication error has occurred.
15. Optional: evaluate the SENDMODE output of RCVS7 in order to query whether the F-CPU with the associated SENDS7 instruction is in disabled safety mode (Page 294).

Particularities for migrated projects

If you have migrated a project from *S7 Distributed Safety V5.4 SP5* to *STEP 7 Safety Advanced* in which safety-related communication via S7 connections is programmed, you must note the following:

- Do not delete migrated instance DBs for the SENDS7 and RCVS7 instructions in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks".

Otherwise, communication errors may occur in the relevant communication connections.

A migrated instance DB for the SENDS7 and RCVS7 instructions has been deleted if, after compiling the safety program, the "User-defined ID" in the newly generated is not identical to "FRCVS7CL" or "FSNDS7CL".

You can find the "User-defined ID" of a block in its properties in the "Information" area.

9.1.9.4 Safety-related communication via S7 connections - Limits of data transfer

Note

If the amount of data to be transmitted exceeds the permitted length for the F-communication DB (100 bytes), you can create another F-communication DB that you transfer to additional SENDS7/RCVS7 instructions with modified R_ID.

Note that USEND and URCV instructions are called internally at each SENDS7 or RCVS7 call and use connection resources in the F-CPU. This affects the maximum number of communication connections available (*see manuals for F-CPUs*).

Additional information on the data transfer limits for S7 connections of individual F-CPUs is available on the Internet (http://support.automation.siemens.com/WW/view/en/38549114).

9.1.10 Safety-related communication with S7 F-systems

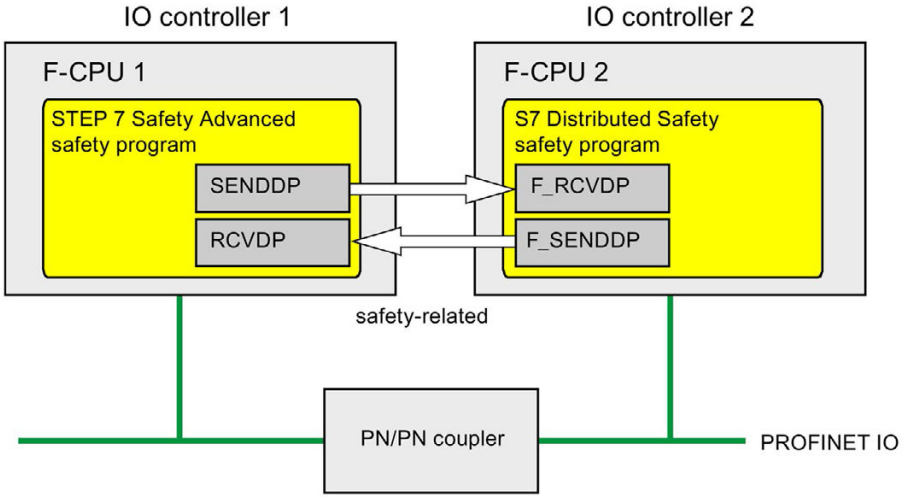
9.1.10.1 Introduction

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 Distributed Safety F-systems is possible via a PN/PN coupler or DP/DP coupler that you use between the two F-CPUs as IO controller-IO controller communication, master-master communication or communication via established S7 connections.

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 F/FH Systems F-systems is possible via established S7 connections.

9.1.10.2 Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety Advanced* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

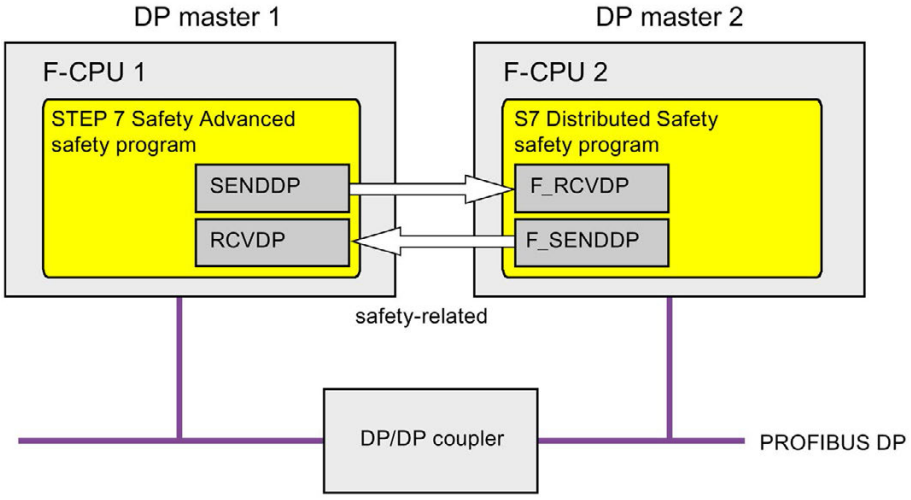
At the *S7 Distributed Safety* end, proceed as described in "Safety-related IO controller-IO controller communication" in the S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) manual.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related IO controller-IO controller communication (Page 173).

9.1.10.3 Communication with S7 Distributed Safety via DP/DP coupler (master-master communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety Advanced* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

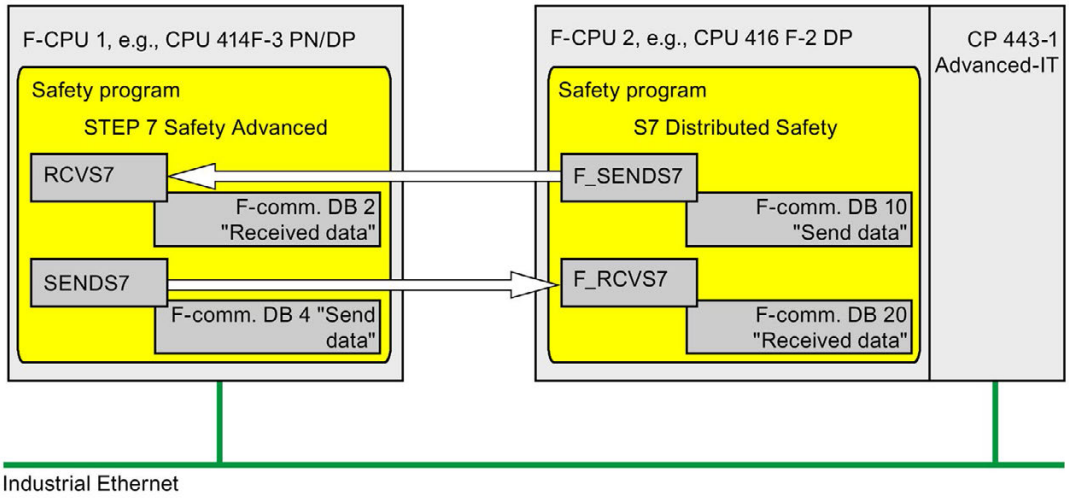
At the *S7 Distributed Safety* end, proceed as described in "Safety-related master-master communication" in the S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) manual.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related master-master communication (Page 182).

9.1.10.4 Communication with S7 Distributed Safety via S7 connections

Communication functions between SENDS7/RCVS7 instructions at the *STEP 7 Safety Advanced* end and F_SENDS7/F_RCVS7 F-application blocks at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

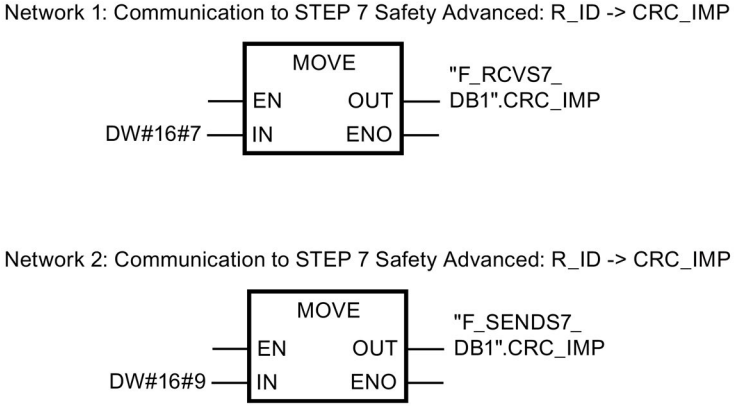
At the *S7 Distributed Safety* end, proceed as described in section "Safety-related communication via S7 communications" in the S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) manual.

Because safety-related communication via S7 connections is not possible with unspecified partners in S7 Distributed Safety, you must first create a "virtual" SIMATIC station in *S7 Distributed Safety* in which you configure an F-CPU as a proxy for the F-CPU in *STEP 7 Safety Advanced* with its IP address.

You then insert an S7 connection to this F-CPU in the connection table. Both the local connection and partner connection resources (hex) are thereby fixed. You must then set these in the associated, unspecified S7 connection that you created in *STEP 7 Professional*.

In addition, for all communication connections to this F-CPU, you must transfer the address relationship that you assigned in the R_ID input of the associated calls of the F_SENDS7 and F_RCVS7 F-application blocks additionally to the CRC_IMP tag in the instance DB of F_SENDS7 and F_RCVS7, respectively, in the standard user program immediately before calling the F-CALL.

Program example:



Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related communication via S7 connections (Page 215).

For the F-CPU in *S7 Distributed Safety*, you must create and specify an unspecified S7 connection (see also standard online help under: Creating an unspecified connection and Specifying and unspecified connection).

For these you must set the local and partner connection resources (hex) that are fixed as a result of the associated S7 connection that you have created in *S7 Distributed Safety*.

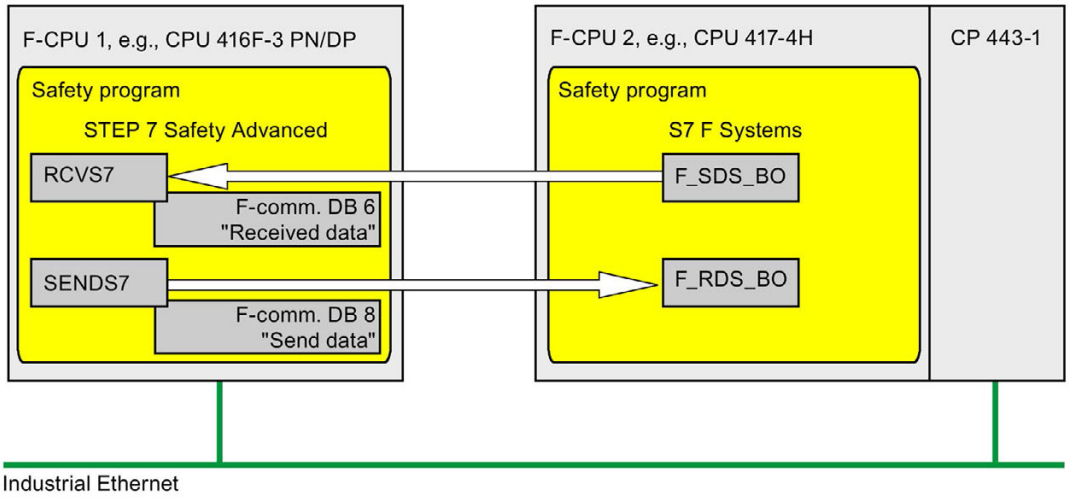
If the local connection resource (hex) is already occupied by an existing connection, you must change the connection resource (hex) for it.

If the instance DBs of the SENDS7 and RCVS7, instructions that you want to use for communication with *S7 Distributed Safety* were migrated from *S7 Distributed Safety*, you must delete them in the project tree in the "STEP 7 Safety" folder, under "Program blocks > System blocks" (contrary to the information in Programming safety-related communication via S7 connections (Page 218), section "Particularities for migrated projects").

9.1.10.5 Communication with S7 F/FH Systems via S7 connections

Communication functions between SENDS7/RCVS7 instructions at the *STEP 7 Safety Advanced* end and F_SDS_BO/F_RDS_BO F-blocks at the *S7 F Systems* end.

A maximum of 32 data elements of data type BOOL can be exchanged.



Procedure at the *S7 F Systems* end

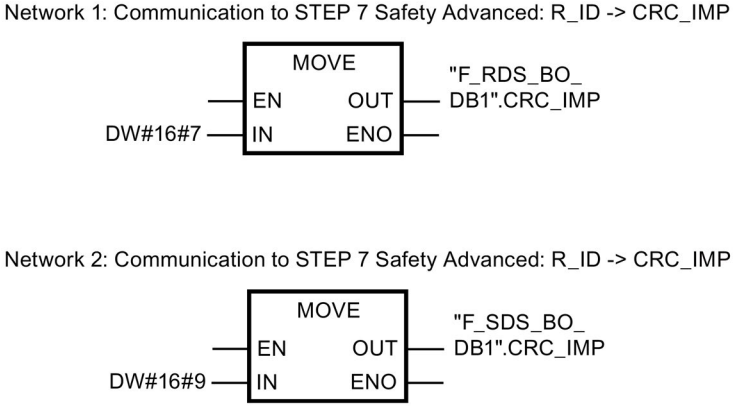
At the *S7 F-systems* end, proceed as described in section "Safety-related communication between F-CPUs" in the S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/16537972) manual.

Because safety-related communication via S7 connections is not possible with unspecified partners in *S7 F/FH Systems*, you must first create a "virtual" SIMATIC station in *S7 F/FH Systems* in which you configure an F-CPU as a proxy for the F-CPU in *STEP 7 Safety Advanced* with its IP address.

You then insert an S7 connection to this F-CPU in the connection table. Both the local connection and partner connection resources (hex) are thereby fixed. You must then set these in the associated, unspecified S7 connection that you created in *STEP 7 Safety Advanced*.

In addition, you must insert a function in your S7 program (in the area reserved in CFC for other applications), in which, for all communication connections for this F-CPU, you transfer the address relationship that you assigned in the R_ID input of the associated calls of the F_SDS_BO and F_RDS_BO F-blocks additionally to the CRC_IMP tag in the instance DB of the F_SDS_BO and F_RDS_BO, respectively. You obtain the number of the instance DB from the object properties of the block in CFC. Assign descriptive names for these instance DBs. If you perform a compress operation in CFC, you must check whether the numbers of these instance DBs have changed.

Program example:



You must then import the function in CFC as block type and insert your standard user program in a chart. In the run sequence, make sure that the associated standard runtime group is processed before the F-runtime group.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in "Safety-related communication via S7 connections" (Page 215).

Particularity: In *STEP 7 Safety Advanced*, you must create the F-communication DB with exactly 32 data elements of data type BOOL.

For the F-CPU in *S7 F/FH Systems*, you must create and specify an unspecified S7 connection (see online help for *STEP 7* under "Creating an unspecified connection" and "Specifying an unspecified connection").

For these you must set the local and partner connection resources (hex) that are fixed as a result of the associated S7 connection that you have created in *S7 F Systems*.

If the local connection resource (hex) is already occupied by an existing connection, you must change the connection resource (hex) for it.

9.2 Configuring and programming communication (S7-1200, S7-1500)

9.2.1 Overview of communication

Introduction

This section gives an overview of the safety-related communication options in SIMATIC Safety F-systems.

Options for safety-related communication

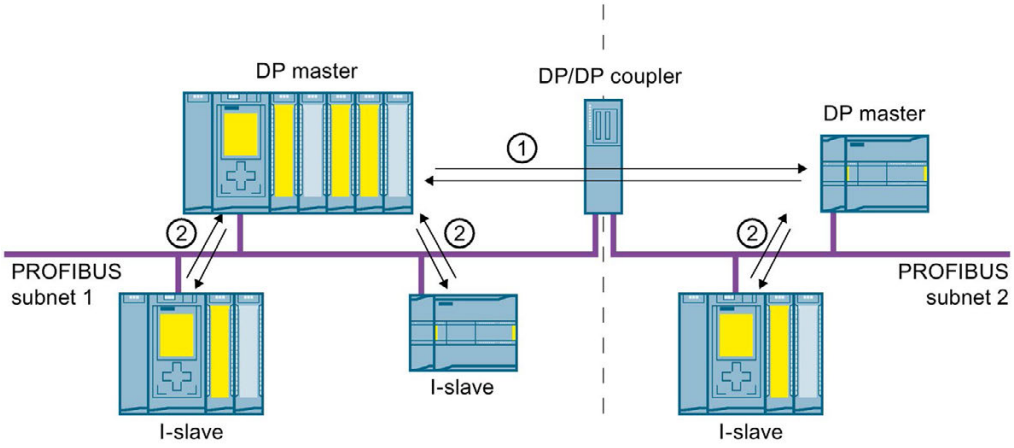
Safety-related communication	On subnet	Additional hardware required
Safety-related CPU-CPU communication:		
IO controller-IO controller communication	PROFINET IO	PN/PN coupler
Master-master communication	PROFIBUS DP	DP/DP coupler
IO controller-I-device communication	PROFINET IO	—
Master-I-slave communication	PROFIBUS DP	—
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link
IO controller-IO controller communication for *S7 Distributed Safety*	PROFINET IO	PN/PN coupler
Master-master communication for *S7 Distributed Safety*	PROFIBUS DP	DP/DP coupler

Note

Safety-related communication with S7-1200 F-CPUs is only permitted as of firmware version V4.1.2.

Overview of safety-related communication via PROFIBUS DP

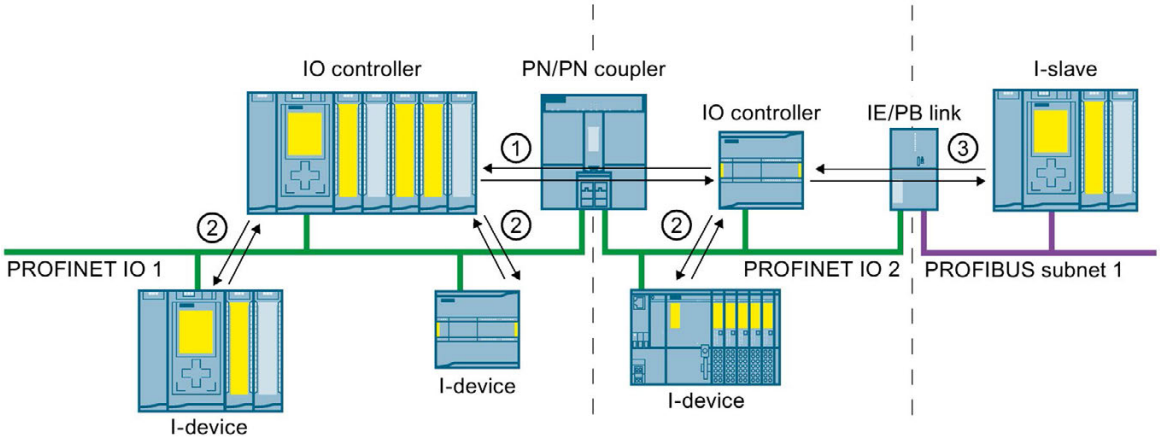
The figure below provides an overview of the options for safety-related communication via PROFIBUS DP in SIMATIC Safety F-systems with S7-1200/1500 F-CPUs.



① Safety-related master-master communication
② Safety-related master-I-slave communication

Overview of safety-related communication via PROFINET IO

The figure below provides an overview of the options for safety-related communication via PROFINET IO in SIMATIC Safety F-systems with S7-1200/1500 F-CPUs.



① Safety-related IO controller-IO controller communication
② Safety-related IO controller-I-device communication
③ Safety-related IO controller-I-slave communication

Safety-related CPU-CPU communication via PROFIBUS DP or PROFINET IO

In safety-related CPU-CPU communication, a fixed amount of data of the data type BOOL or INT (DINT as alternative) is transmitted fail-safe between the safety programs in F-CPUs of DP masters/I-slaves or IO controllers/I-devices.

The data are transferred using the SENDDP instruction for sending and the RCVDP instruction for receiving. The data are stored in configured transfer areas of the devices. The hardware identifier (HW identifier) defines the transfer areas configured.

Safety-related CPU-CPU communication for *S7 Distributed Safety*

Safety-related communication is possible from F-CPUs in *SIMATIC Safety* to F-CPUs in *S7 Distributed Safety*.

9.2.2 Safety-related IO controller-IO controller communication

9.2.2.1 Configure safety-related IO controller-IO controller communication

Introduction

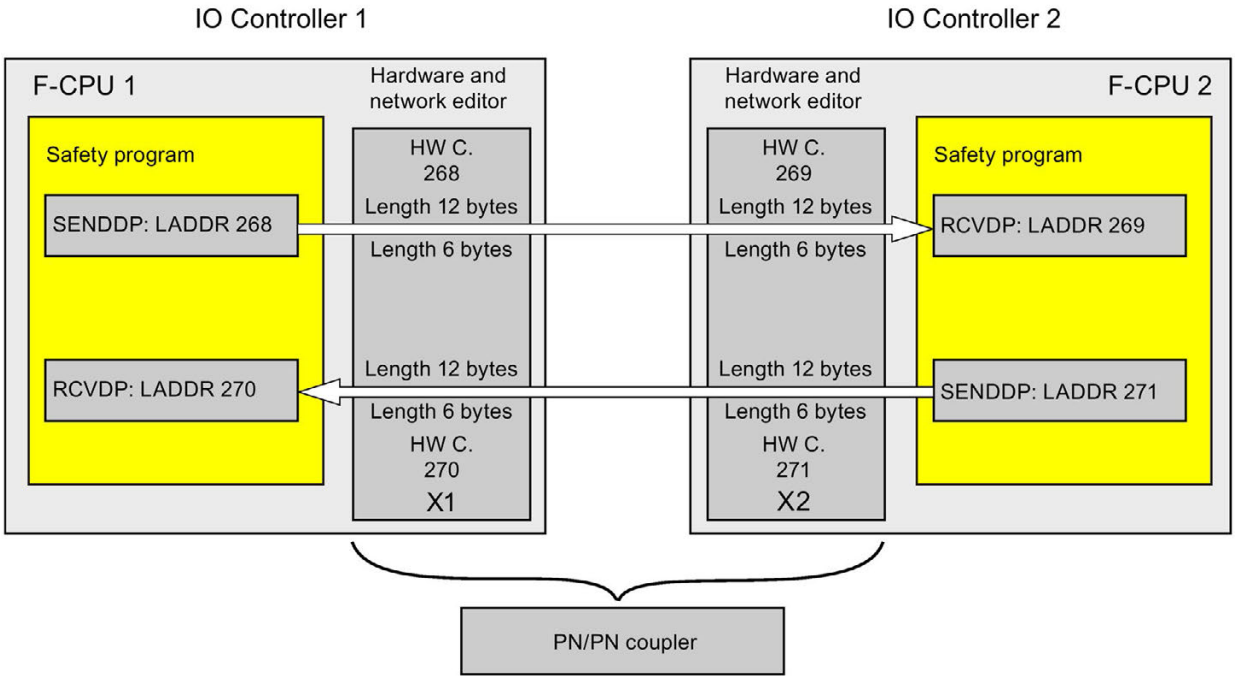
Safety-related communication between safety programs of the F-CPUs of IO controllers takes place over a PN/PN coupler that you set up between the F-CPUs.

Note

Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler in the *hardware and network editor*. This is the default setting. Otherwise, safety-related IO controller-IO controller communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the PN/PN coupler. The figure below shows how both of the F-CPUs are able to send **and** receive data (bidirectional communication).



Rules for defining transfer areas

Data to be sent:

A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

Data to be received:

A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

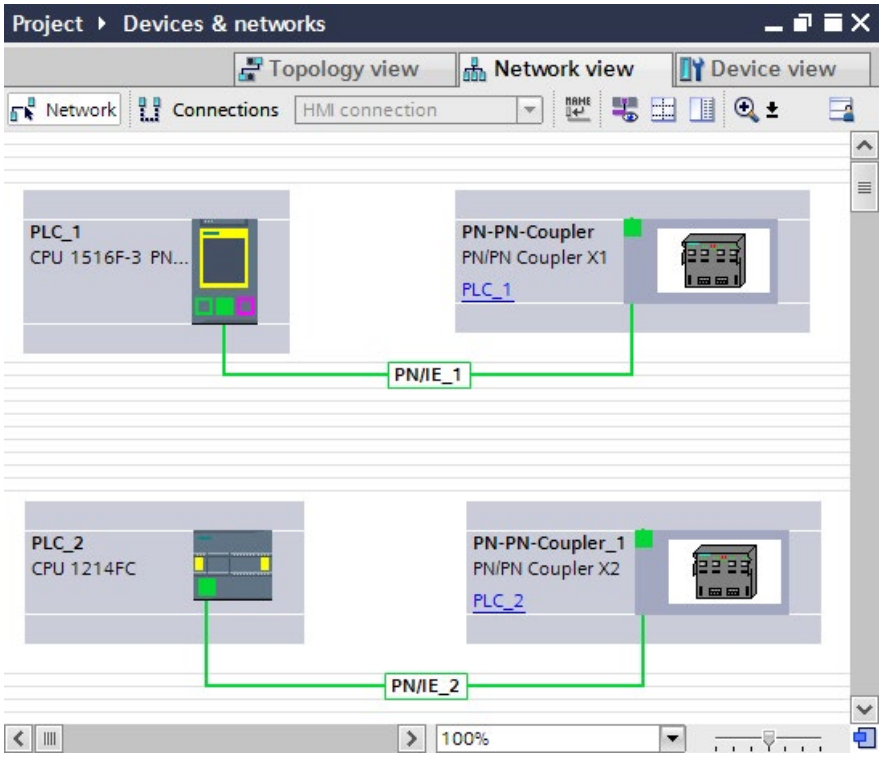
Procedure for configuration

The procedure for configuring safety-related IO controller-IO controller communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a PN/PN Coupler X1 and a PN/PN Coupler X2 from "Other field devices\PROFINET IO\Gateway\Siemens AG\PN/PN Coupler" in the "Hardware catalog" task card and insert them into the network view of the hardware and network editor.

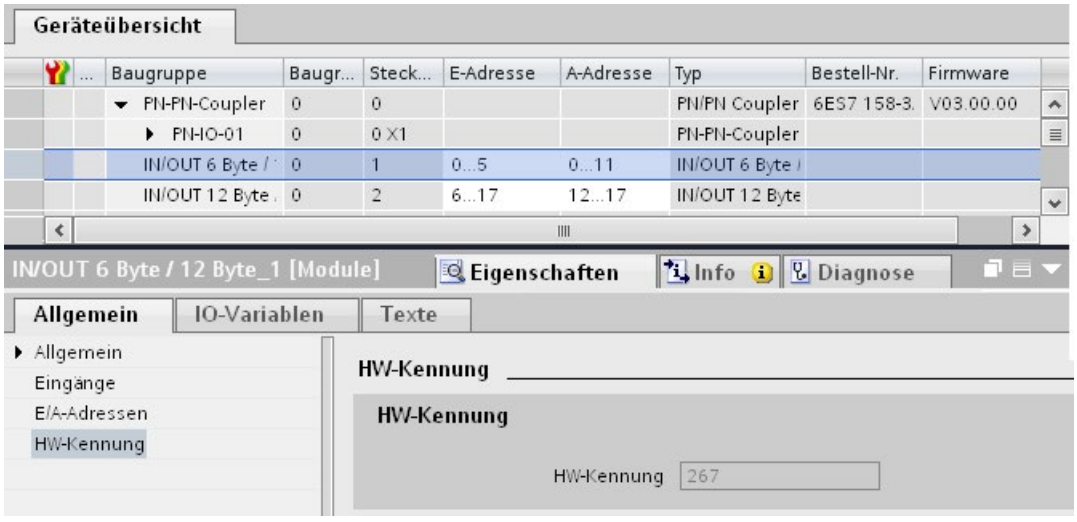
4. Connect the PN interface of the F-CPU 1 with the PN interface of the PN/PN Coupler X1 and the PN interface of the F-CPU 2 with the PN interface of PN/PN Coupler X2.



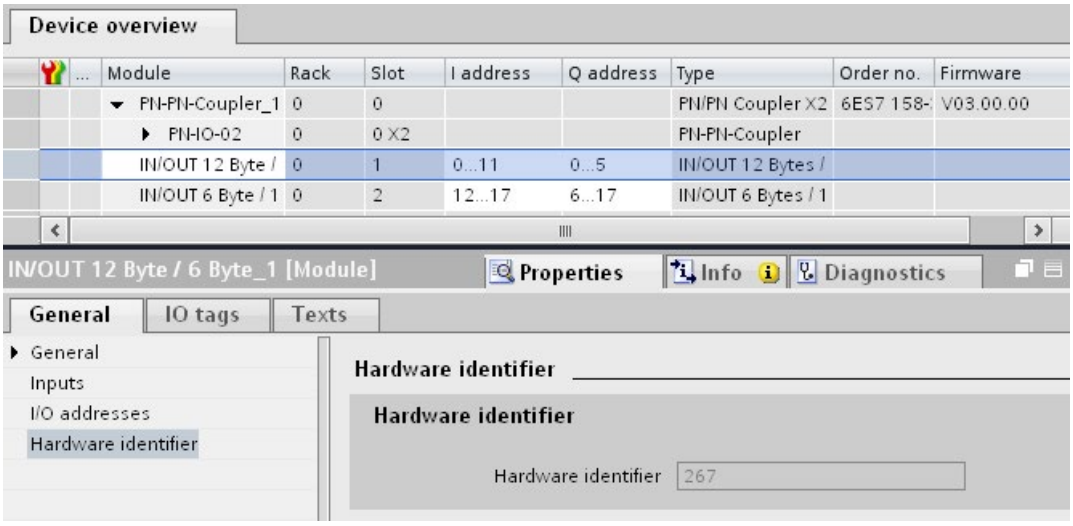
5. Switch to the device view of PN/PN Coupler X1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from "IN/OUT" in the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "IN/OUT 6 bytes / 12 bytes" module and
   - One "IN/OUT 12 bytes / 6 bytes" module

Note

The transfer areas are assigned on the basis of the hardware identifier which is automatically assigned to the modules and devices. You need the HW identifier to program the SENDDP and RCVDP blocks (LADDR input). A system constant is created in the corresponding F-CPU for each hardware identifier of the transfer area. You can assign these system constants symbolically to the SENDDP and RCVDP blocks.

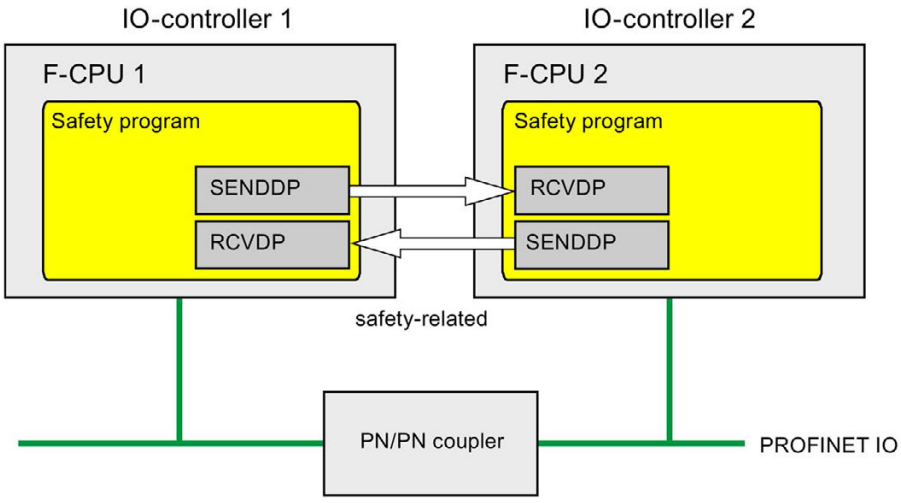


6. Select the following modules from "IN/OUT" in the device view of PN/PN coupler X2 and insert them in the "Device overview" tab:
   - One "IN/OUT 12 bytes / 6 bytes" module and
   - One "IN/OUT 6 bytes / 12 bytes" module



9.2.2.2 Safety-related IO controller-IO controller communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controllers uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.2.2.3 Program safety-related IO controller-IO controller communication

Requirement for programming

The transfer areas for input and output data for the PN/PN coupler must be configured.

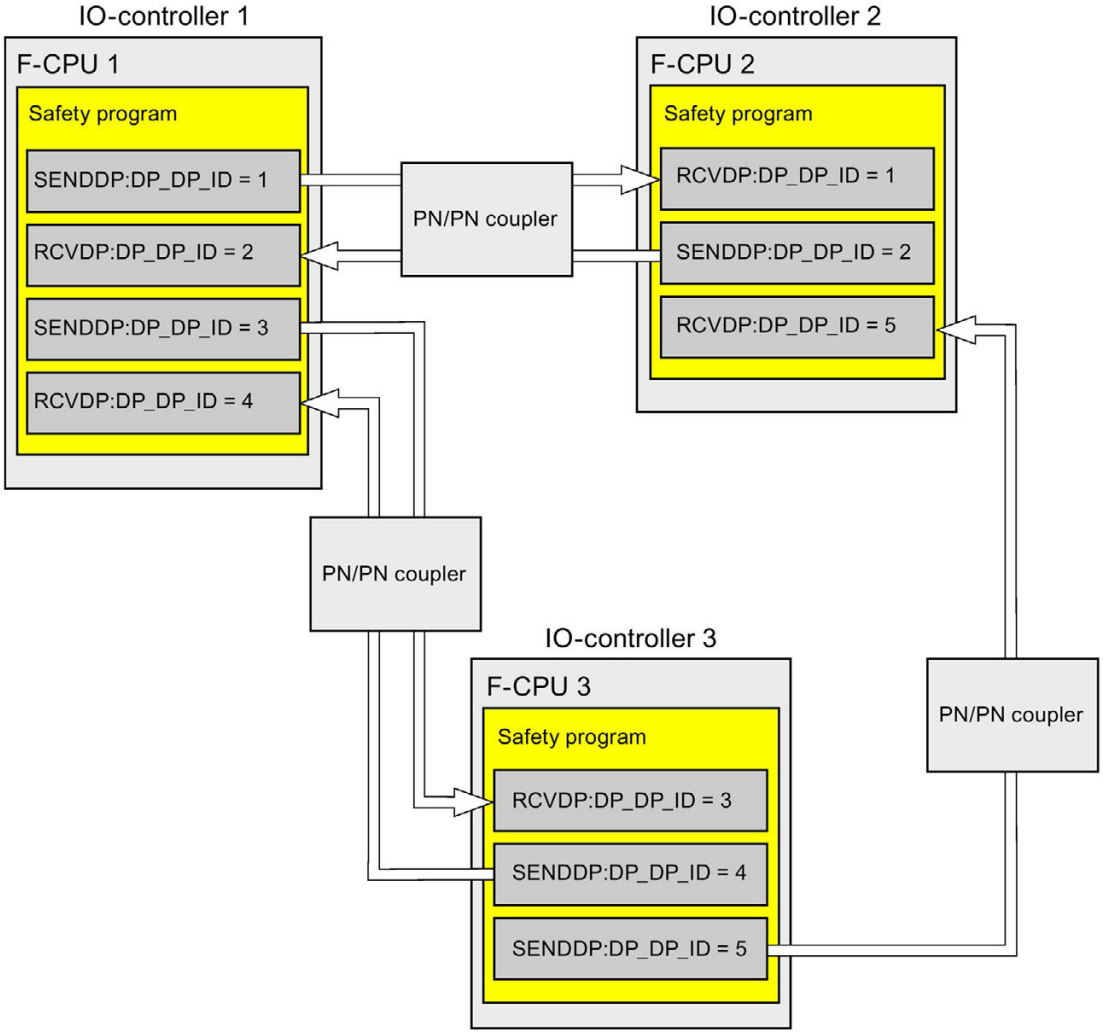
Programming procedure

You program safety-related IO controller-IO controller communication as follows:

1. In the safety program from which data are to be sent, call the SENDDP instruction (Page 515) for sending at the end of the main safety block.
2. In the safety program in which data are to be received, call the RCVDP instruction (Page 515) for receiving at the start of the main safety block.
3. Assign the respective LADDR inputs HW identifiers (system constants in the default tag table) for the transfer areas for output and input data of the PN/PN coupler that are configured in the hardware and network editor.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.
4. Assign the value for the respective address relationship to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

The figure below contains an example of how to specify the address relationships for the inputs of the SENDDP and RCVDP instructions for five safety-related IO controller-IO-controller communication relationships.



⚠ WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs (SD_DI_00 as alternative) of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs (RD_DI_00 as alternative) of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. If you want to send the data at the SD_DI_00 input instead of the data at the SD_I_00 and SD_I_01 inputs, supply the DINTMODE input (initial value = "FALSE") of SENDDP with TRUE.

8. Supply the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT/DINT, you can enter constant fail-safe values directly as constants in the SUBI_xx or alternatively SUBDI_00 input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, set TRUE for the SUBBO_xx input (initial value = "FALSE").
   - Specification of dynamic fail-safe values:

     If you want to specify dynamic fail-safe values, define a tag that you change dynamically through your safety program in an F-DB and specify this tag (fully qualified) in the SUBBO_xx or SUBI_xx or alternatively SUBDI_00 input.

     ⚠ WARNING

     Note that your safety program for dynamically changing the tag for a dynamic fail-safe value can only be processed after the call of the RCVDP, because prior to the RCVDP call, there must not be any network and no more than one other RCVDP instruction in the main safety block. You must therefore assign appropriate start values for these tags to be output by RCVDP in the first cycle after a startup of the F-system. *(S017)*

9. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   ⚠ WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

10. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether user acknowledgment is required.
11. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
12. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs.

13. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether a communication error has occurred.
14. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 294).

9.2.2.4 Safety-related IO controller-IO controller communication - Limits for data transfer

Note

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the PN/PN coupler. Whether or not this is possible with one single PN/PN coupler depends on the capacity restrictions of the PN/PN coupler.

9.2.3 Safety-related master-master communication

9.2.3.1 Configure safety-related master-master communication

Introduction

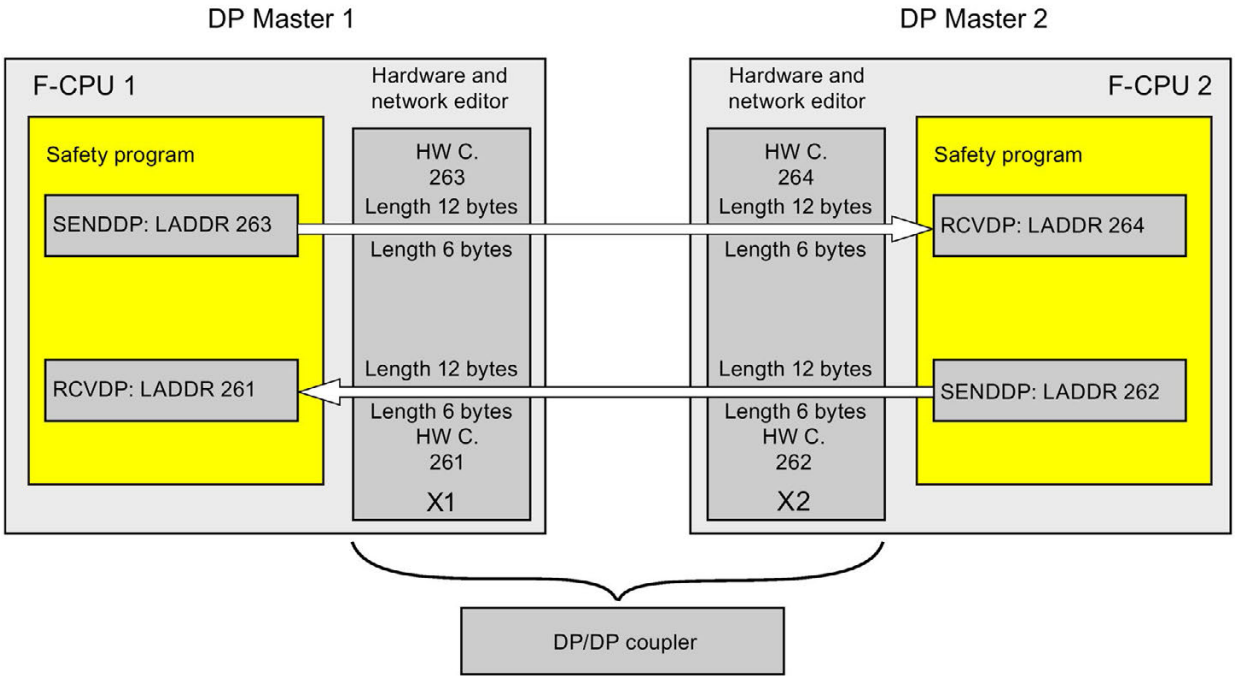
Safety-related communication between safety programs of the F-CPUs of DP masters takes place via a DP/DP coupler.

Note

Switch the data validity indicator "DIA" on the DIP switch of the DP/DP coupler to "OFF". Otherwise, safety-related CPU-CPU communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the DP/DP coupler. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



Rules for defining transfer areas

Data to be sent:

A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

Data to be received:

A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

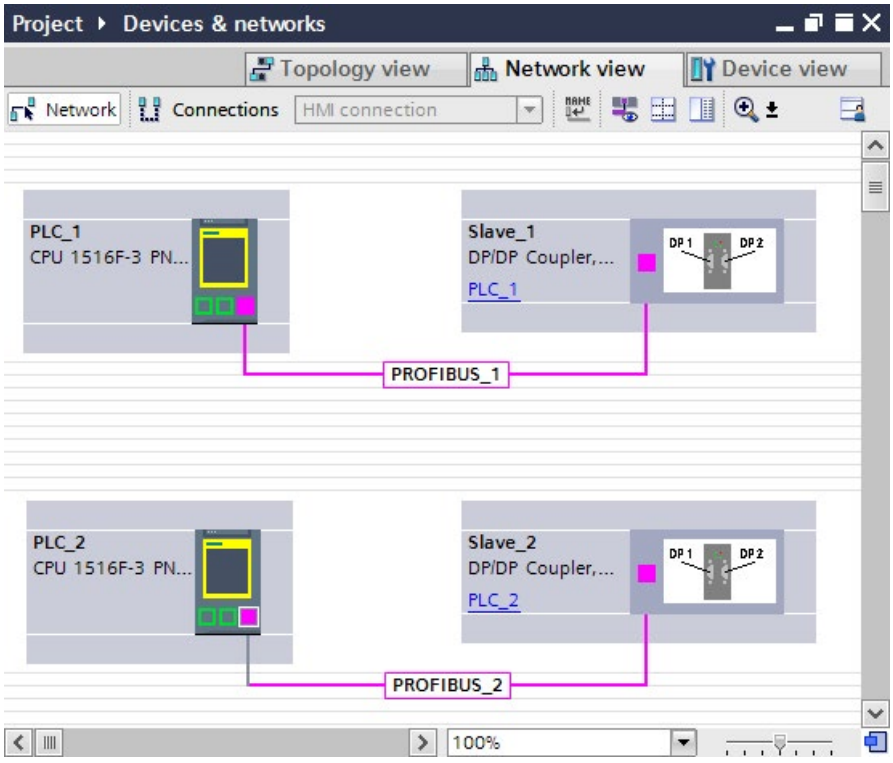
Procedure for configuration

The procedure for configuring safety-related master-master communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a DP/DP coupler from "Other field devices\PROFIBUS DP\Gateways\Siemens AG\DP/DP Coupler" in the "Hardware catalog" task card and insert it into the network view of the hardware and network editor.

4. Insert a second DP/DP coupler.
5. Connect a DP interface of F-CPU 1 to the DP interface of a DP/DP coupler and a DP interface of F-CPU 2 to the DP interface of the other DP/DP coupler.

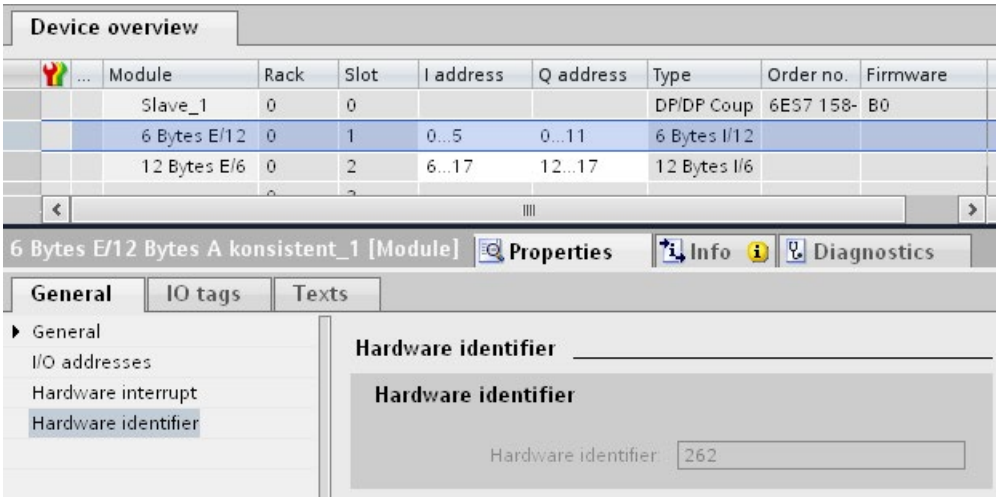


6. A free PROFIBUS address is assigned automatically in the properties of the DP/DP-coupler in the device view. You must set this address on the DP/DP coupler, either via the DIP switch on the device or in the configuration of the DP/DP coupler (see DP/DP Coupler (http://support.automation.siemens.com/WW/view/en/1179382) manual).

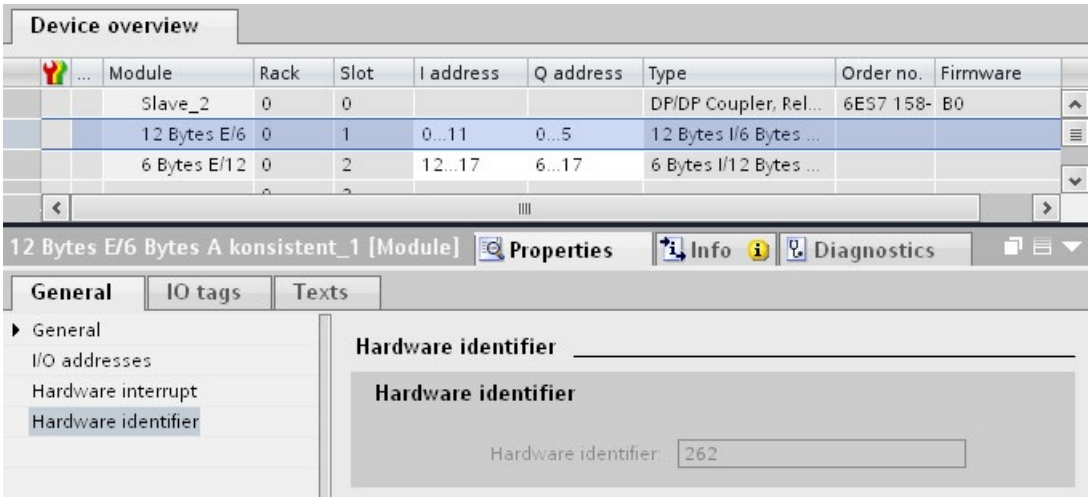
7. Switch to the device view of the DP/DP coupler PLC1 for bidirectional communication connections i.e. where each F-CPU should both send and receive data. Select the following modules from the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab of the DP/DP coupler:
   - One "6 bytes I/12 bytes Q consistent" module, and
   - One "12 bytes I/6 bytes Q consistent" module

Note

The transfer areas are assigned on the basis of the hardware identifier which is automatically assigned to the modules and devices. You need the HW identifier to program the SENDDP and RCVDP blocks (LADDR input). A system constant is created in the corresponding F-CPU for each hardware identifier of the transfer area. You can assign these system constants symbolically to the SENDDP and RCVDP blocks.

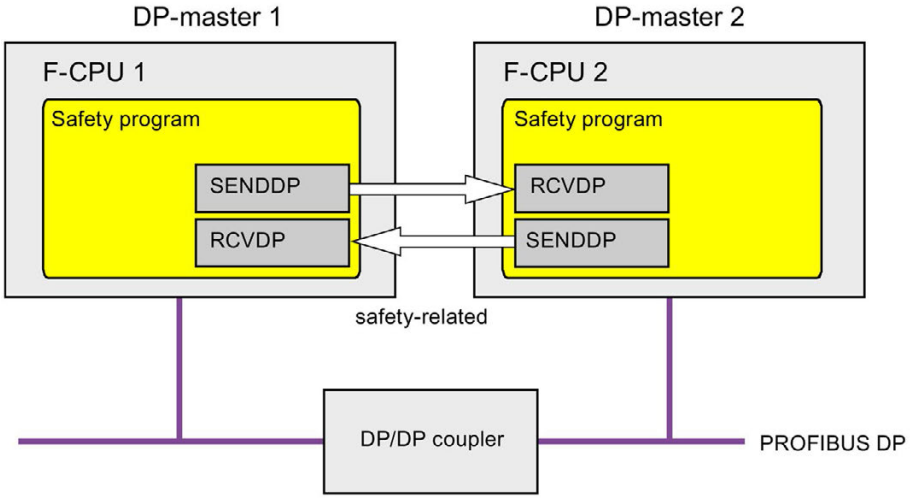


8. Select the following modules from the "Hardware catalog" task card (with filter activated) in the device view of DP/DP coupler PLC2, and insert them in the "Device overview" tab:
   - One "12 bytes I/6 bytes Q consistent" module, and
   - One "6 bytes I/12 bytes Q consistent" module



9.2.3.2 Safety-related master-master communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.2.3.3 Program safety-related master-master communication

Requirement for programming

The address areas for input and output data for the DP/DP coupler must be configured.

Programming procedure

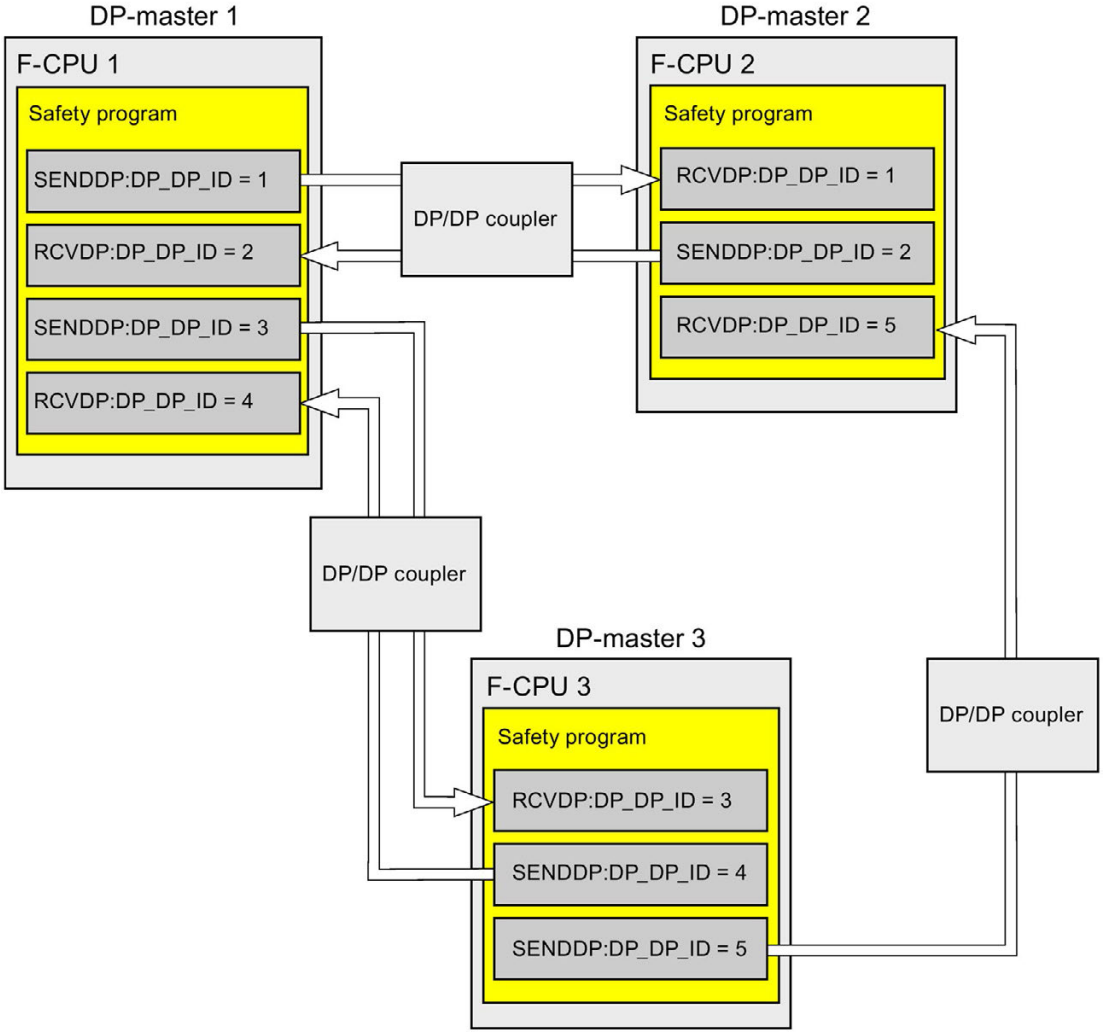
You program safety-related master-master communication as follows:

1. In the safety program from which data are to be sent, call the SENDDP instruction (Page 515) for sending at the end of the main safety block.
2. In the safety program in which data are to be received, call the RCVDP instruction (Page 515) for receiving at the start of the main safety block.
3. Assign the HW identifiers for the output and input data of the DP/DP coupler configured in the *hardware and network editor* (constant in the tag table) to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective address relationship to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the address relationships at the inputs of SENDDP and RCVDP instructions for five safety-related master-master communications relationships.



⚠ WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs (SD_DI_00 as alternative) of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs (RD_DI_00 as alternative) of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. If you want to send the data at the SD_DI_00 input instead of the data at the SD_I_00 and SD_I_01 inputs, supply the DINTMODE input (initial value = "FALSE") of SENDDP with TRUE.

8. Supply the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT/DINT, you can enter constant fail-safe values directly as constants in the SUBI_xx or alternatively SUBDI_00 input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, set TRUE for the SUBBO_xx input (initial value = "FALSE").
   - Specification of dynamic fail-safe values:

     If you want to specify dynamic fail-safe values, define a tag that you change dynamically through your safety program in an F-DB and specify this tag (fully qualified) in the SUBBO_xx or SUBI_xx or alternatively SUBDI_00 input.

     ⚠ WARNING

     Note that your safety program for dynamically changing the tag for a dynamic fail-safe value can only be processed after the call of the RCVDP, because prior to the RCVDP call, there must not be any network and no more than one other RCVDP instruction in the main safety block. You must therefore assign appropriate start values for these tags to be output by RCVDP in the first cycle after a startup of the F-system. *(S017)*

9. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   ⚠ WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

10. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether user acknowledgment is required.
11. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
12. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs.

13. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the HMI system in order to query or to indicate whether a communication error has occurred.
14. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 294).

9.2.3.4 Safety-related master-master communication:Limits for data transfer

Note

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the DP/DP coupler. Whether or not this is possible with one single DP/DP coupler depends on the capacity restrictions of the DP/DP coupler.

9.2.4 Safety-related IO controller-I-device communication

9.2.4.1 Configuring safety-related communication between IO controller and I-device

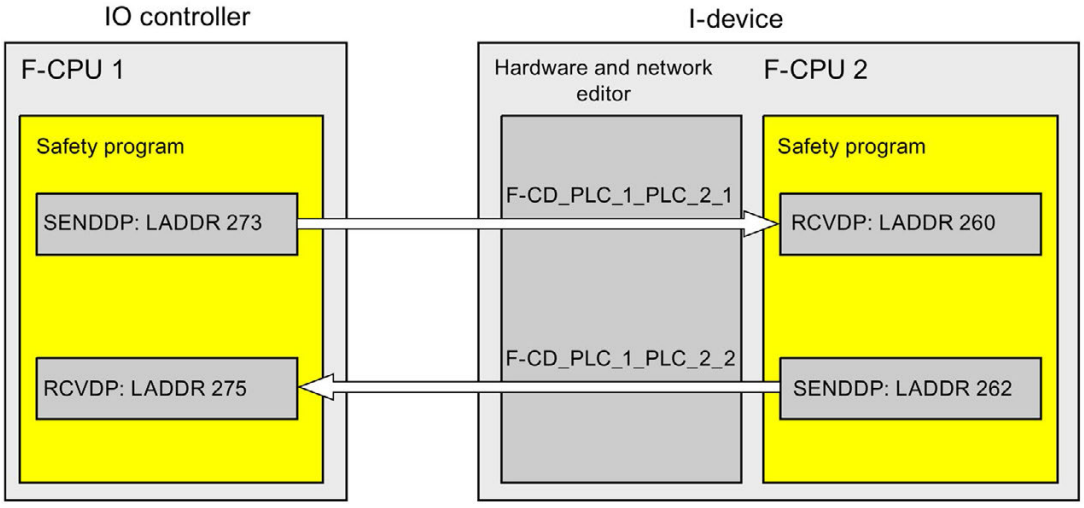
Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device connections (F-CD) in PROFINET IO, in the same way as in standard systems.

You do not need any additional hardware for IO controller-I-device communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-CD_PLC_2 PLC_1_1" for the first F-CD connection between IO controller F-CPU 1 and I-device F-CPU 2.

When you create a transfer area, a system constant with the name of the transfer area is created in the F-CPU of the IO controller and in the F-CPU of the I-device. The system constant contains the hardware identifier of the transfer area for the corresponding F-CPU.

You assign the hardware identifier (system constant from the default tag table) of the transfer areas symbolically to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

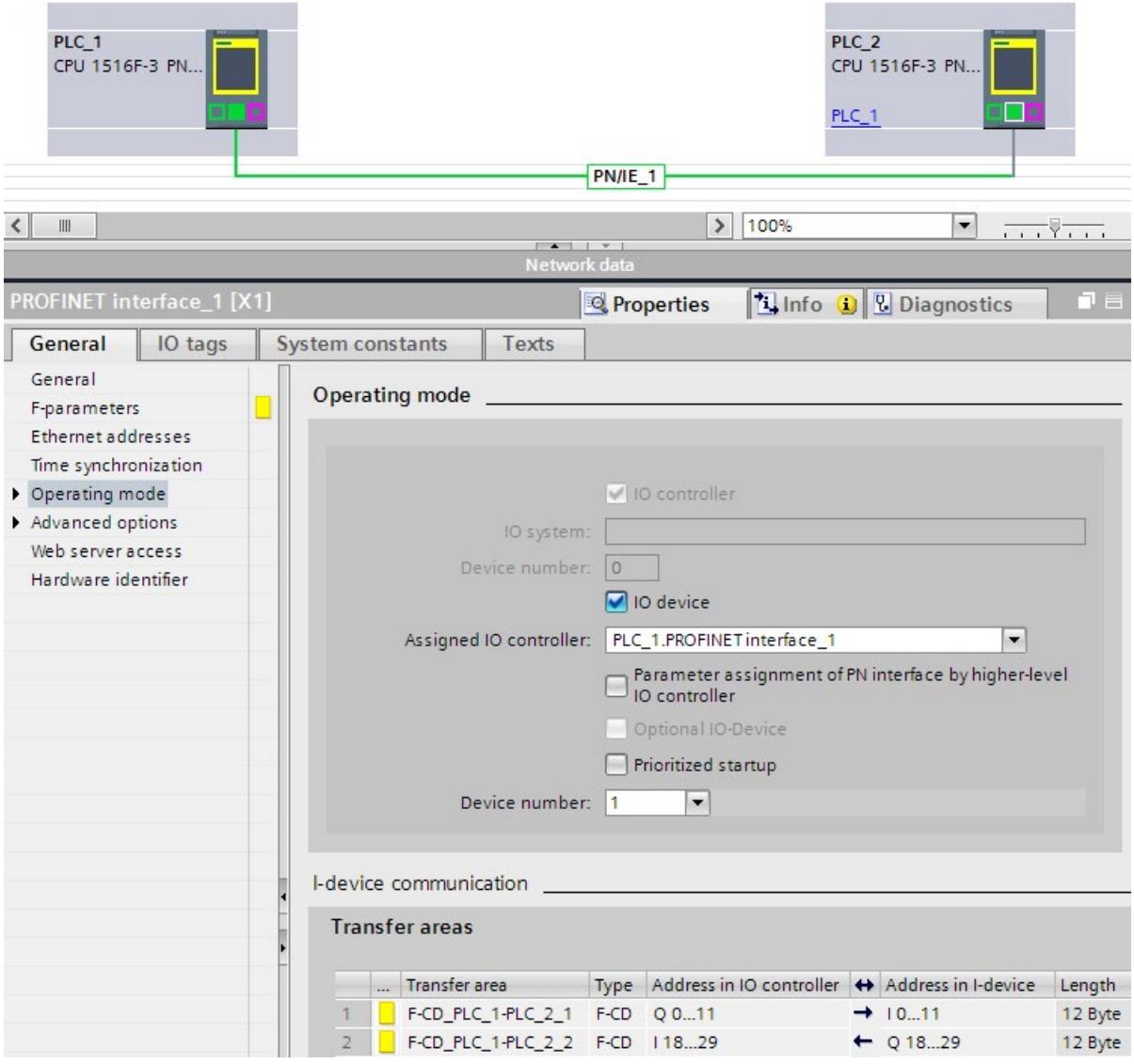
Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.

3. Select the PROFINET interface of F-CPU 2. Under "Transfer areas", you create an F-CD connection (type "F-CD") for receiving from the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned are displayed.

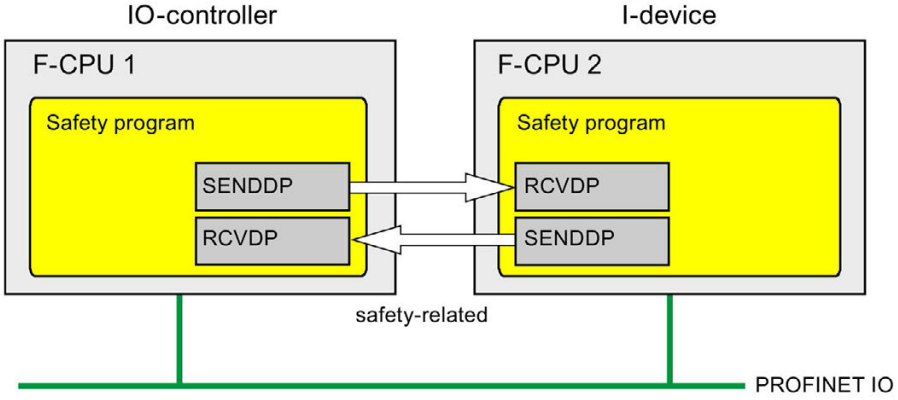
   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").

4. Create an additional F-CD connection for sending to the IO controller.
5. In the transfer area you just created, click on the arrow to change the transfer direction to sending to the IO controller (←).



9.2.4.2 Safety-related IO controller-I-device communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controller and an I-device makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.2.4.3 Programming safety-related IO controller I-device communication

Requirement for programming

The transfer areas must be configured.

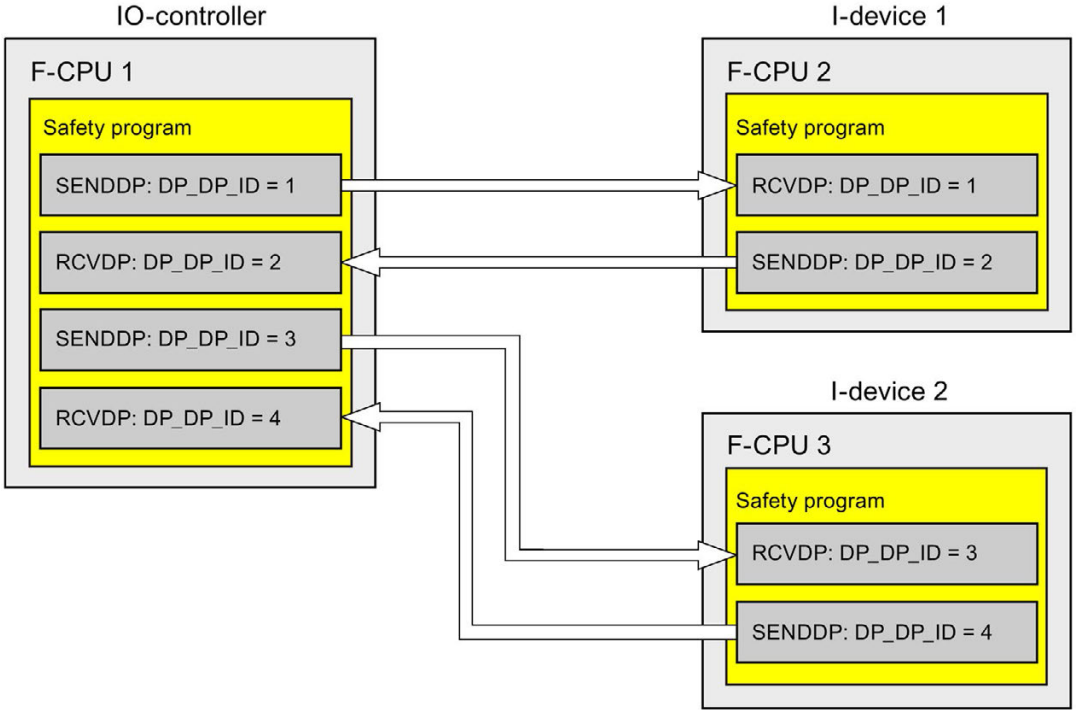
Programming procedure

The procedure for programming safety-related IO controller-I-device communication is the same as that for programming safety-related IO controller-IO controller communication (see Program safety-related IO controller-IO controller communication (Page 237)).

The assignment of the HW identifiers (system constants in the standard tag table) of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table:

Instruction	HW identifier
SENDDP in the IO controller	Hardware identifier of the transfer area in the IO controller
RCVDP in the IO controller	Hardware identifier of the transfer area in the IO controller
SENDDP in the I-device	Hardware identifier of the transfer area in the I-device
RCVDP in the I-device	Hardware identifier of the transfer area in the I-device

The figure below contains an example of how to specify the address relationships for the inputs of the SENDDP and RCVDP instructions for four safety-related IO controller-I-device communication relationships.



WARNING

The value for each address association (DP_DP_ID input; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

9.2.4.4 Safety-related IO-Controller-IO-Device communication - Limits for data transfer

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Remember the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and a IO controller.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		In the IO controller		In the I-device	
		Output data	Input data	Output data	Input data
IO controller-I-Device	**Sending:** I-Device 1 to IO controller	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-Device 1 from IO controller	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-CD and CD) for the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and an IO controller. In addition, data are assigned for internal purposes such that the maximum limit may be reached sooner.

When the limit is exceeded, a corresponding error message is displayed.

9.2.5 Safety-related master-I-slave communication

9.2.5.1 Configuring safety-related master-I-slave communication

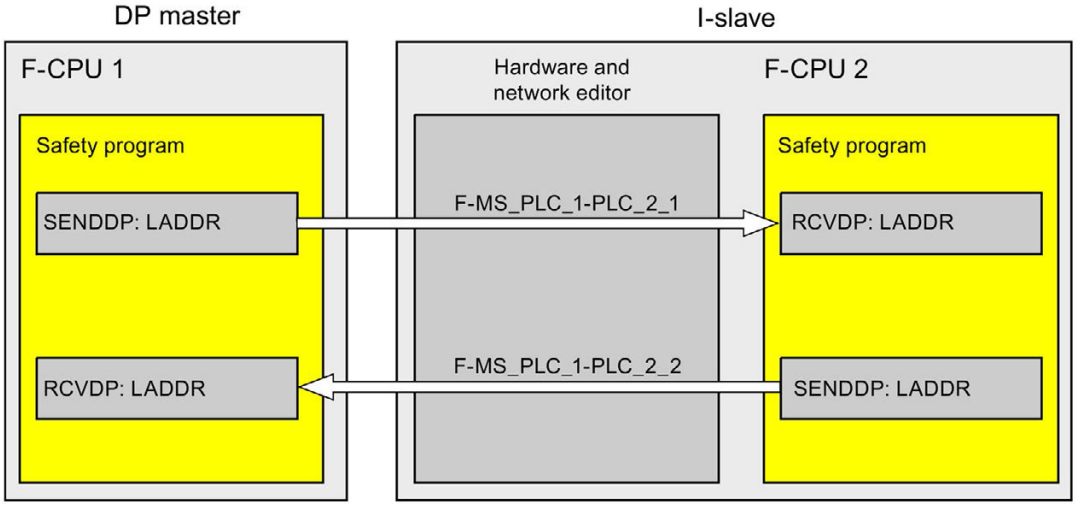
Introduction

Safety-related communication between the safety program of the F-CPU of a DP master and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place over master-I-slave connections (**F-**MS), as in standard systems.

You do not need a DP/DP coupler for master-I-slave communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-MS_PLC_2-PLC_1_1" for the first F-MS connection between DP master F-CPU 1 and I-slave F-CPU 2.

When you create a transfer area, a system constant with the name of the transfer area is created in the F-CPU of the DP master and in the F-CPU of the I-slave. The system constant contains the hardware identifier of the transfer area for the corresponding F-CPU.

You assign the hardware identifier (system constant from the default tag table) of the transfer areas symbolically to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

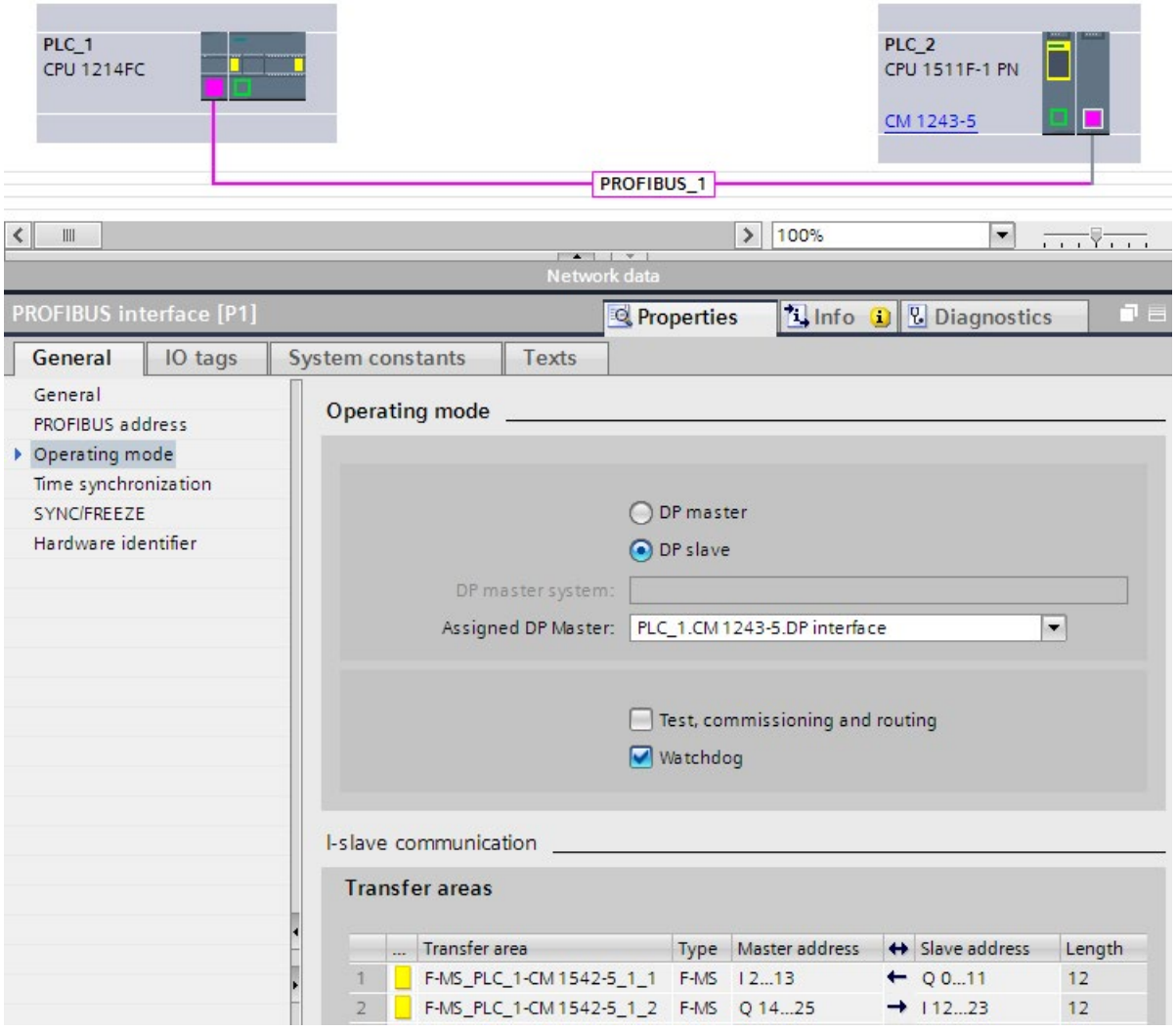
The procedure for configuring safety-related master-I-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. If the F-CPU which is to be operated as DP master (F-CPU 1) does not have an integrated PROFIBUS DP interface, insert an PROFIBUS-CM, for example.
3. From the device view of the F-CPUs which are to be operated as I-slaves (F-CPU 2), insert a suitable CM DP module or CP DP module.
4. If necessary, enable "DP-slave" (I-slave) mode in the properties for the CM/CP DP module.
5. Assign the DP interface of the CM/CP to a DP interface of F-CPU 1.
6. Select the PROFIBUS interface of F-CPU 2 or of the CM. Under "Transfer areas", you create an F-MS connection (type "F-MS") for sending to the DP master (←). The F-MS connection is shown in yellow in the table and the assigned transfer areas in the I-slave and DP master are displayed.

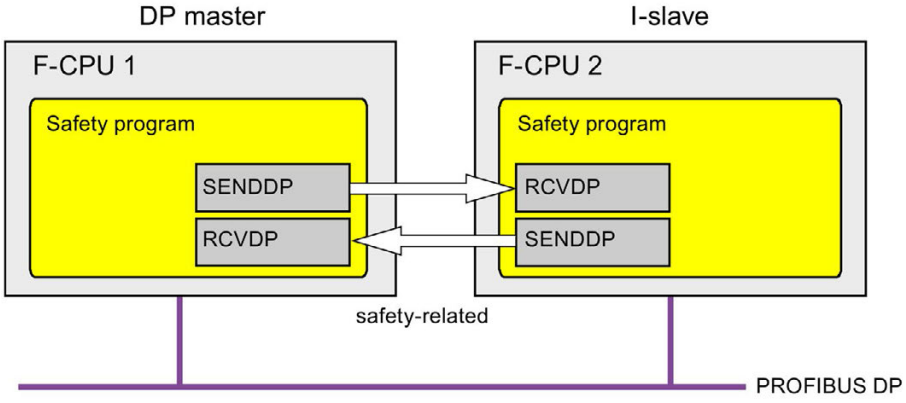
   In addition, an acknowledgment connection is created automatically for each F-MS connection. (see "Transfer area details").

7. Create an additional F-MS connection for receiving from the DP master.
8. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from DP master (→).



9.2.5.2 Safety-related master-I-slave communication via SENDDP and RCVDP

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master and an I-slave makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

A detailed description of the SENDDP and RCVDP instructions can be found in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14) (Page 515).

9.2.5.3 Programming safety-related master-I-slave communication

Requirements

The transfer areas must be configured.

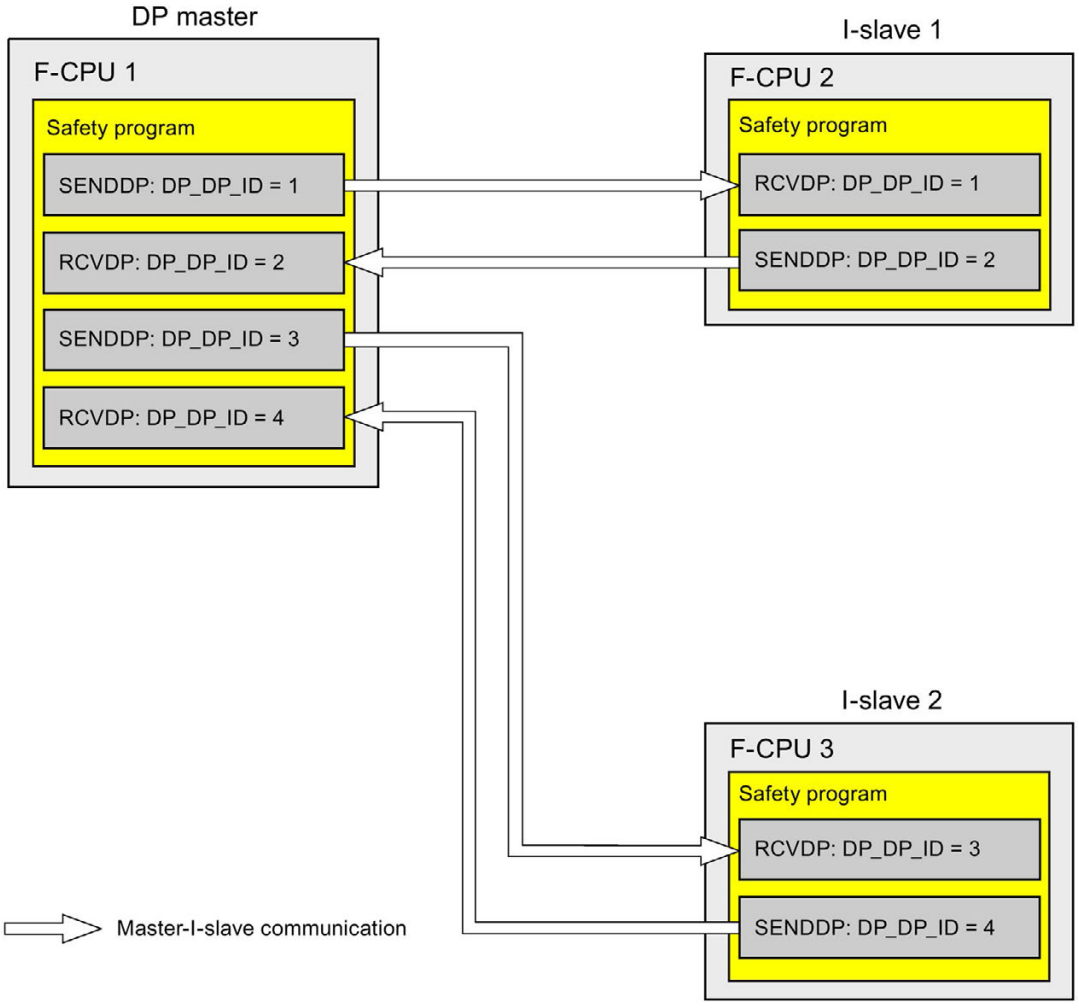
Programming procedure

The procedure for programming safety-related master-I-slave communication is the same as that for programming safety-related master-master communication (see Safety-related master-master communication (Page 241)).

The assignment of the HW identifiers of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	HW identifier
SENDDP in the DP master	Hardware identifier of the respective transfer area in the DP master
RCVDP in the DP master	Hardware identifier of the respective transfer area in the DP master
SENDDP in the I-slave	Hardware identifier of the transfer area in the I-slave
RCVDP in the I-slave	Hardware identifier of the transfer area in the I-slave

The figure below contains an example of how to specify the address relationships at the inputs of SENDDP and RCVDP instructions for four safety-related master-I-slave communication relationships.



⚠ WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 530).

9.2.5.4 Limits for data transfer of safety-related master-I-slave communication

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		DP master		I-slave	
		Output data	Input data	Output data	Input data
Master-I-slave	**Sending:** I-slave 1 to DP master	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-slave 1 from DP master	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-MS-, F-DX-, F-DX-Mod., MS-, DX- and DX-Mod) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-device and a DP master F-MS and MS). If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

9.2.6 Safety-related IO controller-I-slave communication

9.2.6.1 Safety-related IO controller-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of an IO-controller and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place over master-I-slave connections (**F-**MS), as in standard systems.

IE/PB link

For the safety-related IO-controller-I-slave communication, the IE/PB link is mandatory. Each of the two F-CPUs is linked to the IE/PB link by means of its PROFIBUS DP or PROFINET-interface.

Note

If you are using an IE/PB link, you must take this into account when configuring the F-specific monitoring times and when calculating the maximum response time of your F-system (see also Monitoring and response times (Page 530)).

Note that the Excel file for calculating response times (http://support.automation.siemens.com/WW/view/en/49368678/133100) for S7-300/400 F-CPUs does not support all conceivable configurations.

Reference

The information on safety-related master-I-slave communication in Safety-related master-I-slave communication (Page 258) also applies.

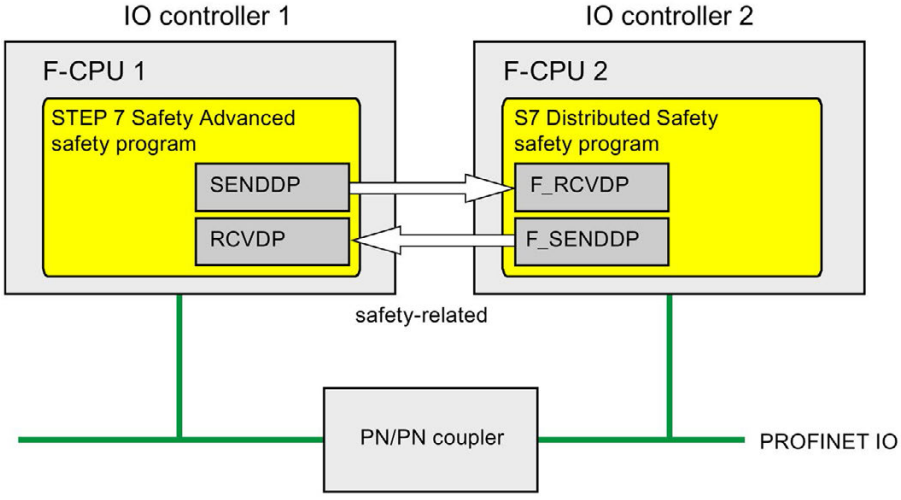
9.2.7 Safety-related communication with S7 F-systems

9.2.7.1 Introduction

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 Distributed Safety F-systems is possible, via a PN/PN coupler or DP/DP coupler that you use between the two F-CPUs, as IO controller-IO controller communication or master-master communication.

9.2.7.2 Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

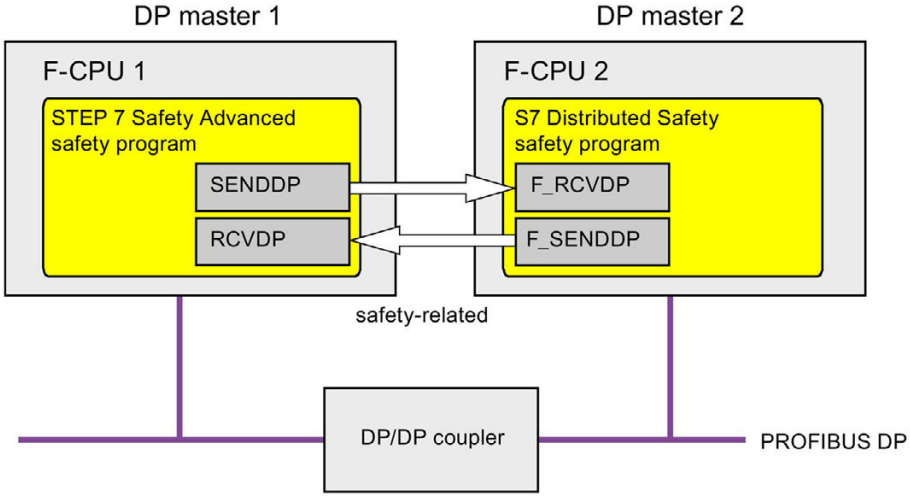
At the *S7 Distributed Safety* end, proceed as described in "Safety-related IO controller-IO controller communication" in the S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) manual.

Procedure at the *STEP 7 Safety* end

At the *STEP 7 Safety* end, proceed as described in Safety-related IO controller-IO controller communication (Page 231).

9.2.7.3 Communication with S7 Distributed Safety via DP/DP coupler (master-master communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in "Safety-related master-master communication" in the S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) manual.

Procedure at the *STEP 7 Safety* end

At the *STEP 7 Safety* end, proceed as described in Safety-related master-master communication (Page 241).

9.3 Configuring and programming communication between S7-300/400 and S7-1200/1500 F-CPUs

9.3.1 Overview of communication

Introduction

This section provides an overview of the options for safety-related communication between S7-300/400 and S7-1200/1500 F-CPUs in SIMATIC Safety F-systems.

Options for safety-related communication

Safety-related communication	On subnet	Additional hardware required
Safety-related CPU-CPU communication:		
Master-master communication	PROFIBUS DP	DP/DP coupler
Master-I-slave communication	PROFIBUS DP	—
IO controller-IO controller communication	PROFINET IO	PN/PN coupler
IO controller-I-device communication	PROFINET IO	—
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link

Basic procedure for configuring and programming

Configure and program safety-related communication between S7-300/400 F-CPUs and S7-1200/1500 F-CPUs as described in Configuring and programming communication (S7-300, S7-400) (Page 170) and Configuring and programming communication (S7-1200, S7-1500) (Page 229) for your application.

To program an S7-300/400 F-CPU, use the start addresses of the transfer areas. To program an S7-1200/1500 F-CPU, use the HW identifiers of the transfer areas.

Compiling and commissioning a safety program 10

10.1 Compiling the safety program

To compile a safety program, follow the same basic procedure as for compiling a standard user program. You can start at various points to accomplish this in *STEP 7*. The basics for compiling user programs can be found in the *Help on STEP 7*.

Note

Please note that following a safety-related change to the hardware configuration that not only this, but also the safety program has to be recompiled and downloaded. This also applies for changes to the F-I/O which are not used in the safety program.

Note

The safety program is not compiled consistently with the menu command "Edit > Compile" or the "Compile" icon under the following conditions:

- When you select a user-created folder in the project tree.
- When you select one or more (F-)blocks in the "Program blocks" folder in the project tree.

Use this procedure to test if modified F-blocks can be compiled.

Note

The following applies for S7-300/400 F-CPUs:

If you want to compile an F-FB with know-how protection after a modification, you must remove the know-how protection for this F-FB before compiling.

Reporting compiling errors

You can recognize whether or not the compilation was successful based on the message in the inspector window under "Info > Compile", error messages and warnings are output.

For information on the procedure you must follow to eliminate compiling errors, see "Eliminating compiling errors" in the *Help on STEP 7*.

See also

Safety Administration Editor (Page 68)

10.2 Safety program work memory requirements (S7-300, S7-400)

Estimation

You can estimate the work memory requirement for the safety program as follows:

Work memory required for the safety program

32 KB for F-system blocks

+ 4.4 KB for safety-related communication between F-runtime groups
+ 4.5 x work memory requirement for all F-FB/F-FCs/main safety blocks
+ 4.5 x work memory requirement of all utilized instructions, which are shown in the "Instructions" task card with the block icon.
  (except SENDDP, RCVDP, SENDS7, and RCVS7)
+ Work memory requirement of the utilized SENDDP and RCVDP instructions
  (4.3 KB each)
+ Work memory requirement of the utilized SENDS7 and RCVS7 instructions
  (8.5 KB each)

Work memory required for data

5 x work memory requirement for all F-DBs (including F-communication DB, but excluding DB for F-runtime group communication) and I-DBs for main safety block/F-FB

+ 24 x work memory requirement for all DBs for F-runtime group communication
+ 2.3 x work memory requirement for all I-DBs of instructions (except SENDDP, RCVDP, SENDS7 and RCVS7)
+ Work memory requirement of all I-DBs of instructions SENDDP (0.2 KB), RCVDP(0.3 KB), SENDS7 (0.6 KB), and RCVS7 (1.0 KB)
+ 0.7 KB per F-FC
+ 0.7 KB per F-I/O (for F-I/O DBs, etc.)
+ 4.5 KB

Block size of automatically generated F-blocks

Do not utilize the entire maximum size of an F-block, because the automatically generated F-blocks are larger and as a result, the maximum possible size may be exceeded in the F-CPU. If the block size is exceeded, this triggers a corresponding error message with information on which F-blocks are too large. These must be divided up, if necessary.

10.3 Downloading project data

10.3.1 Downloading project data to an F-CPU

Introduction

Once you have successfully compiled your safety program, you can download it to the F-CPU. To download a safety program, you follow essentially the same approach as for downloading a standard user program, via different starting points in *STEP 7*.

- In the "Load preview" dialog, enter data (e.g. password for the F-CPU) and set the requirements for downloading (e.g. that the F-CPU is switched to STOP mode before downloading).
- The "Load results" dialog shows the results after downloading.

We will show you the options for downloading the safety program later. For basic information on downloading, refer to the *Help on STEP 7*.

Rules for downloading the safety program to an F-CPU

⚠ WARNING

If **multiple F-CPUs** can be reached over a network (e.g. Industrial Ethernet) by **one programming device or PC**, you must take the following actions to ensure that the project data is downloaded to the correct F-CPU:

Use passwords specific to each F-CPU, such as a uniform password for the F-CPUs with attached Ethernet address for each.

Note the following:

- A point-to-point connection must be used to activate the access protection of an F-CPU when the hardware configuration is loaded for the first time (similar to assigning an MPI address to an F-CPU for the first time).
- Before downloading the safety program to an F-CPU, you must first revoke an existing access permission for any other F-CPU.
- The last download of the safety program prior to switching to productive operation must be made with enabled access protection. *(S021)*

Note

You can perform the downloading of a consistent safety program only in STOP mode.

Note

If *STEP 7 Safety* detects an inconsistent safety program during startup of the F-CPU, the F-CPU cannot be started, provided the F-CPU supports this detection function (see product information for the particular S7-300/400 F-CPU). This is always supported with S7-1200/1500 F-CPUs). A corresponding diagnostics event is entered in the diagnostics buffer of the F-CPU.

If the F-CPU does not support this detection function, the F-CPU can go to STOP mode if an inconsistent safety program is executed in activated safety mode.

The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

When downloading the safety program, ensure that the "Consistent download" action is set for the "Safety program" selection in the "Load preview" dialog.

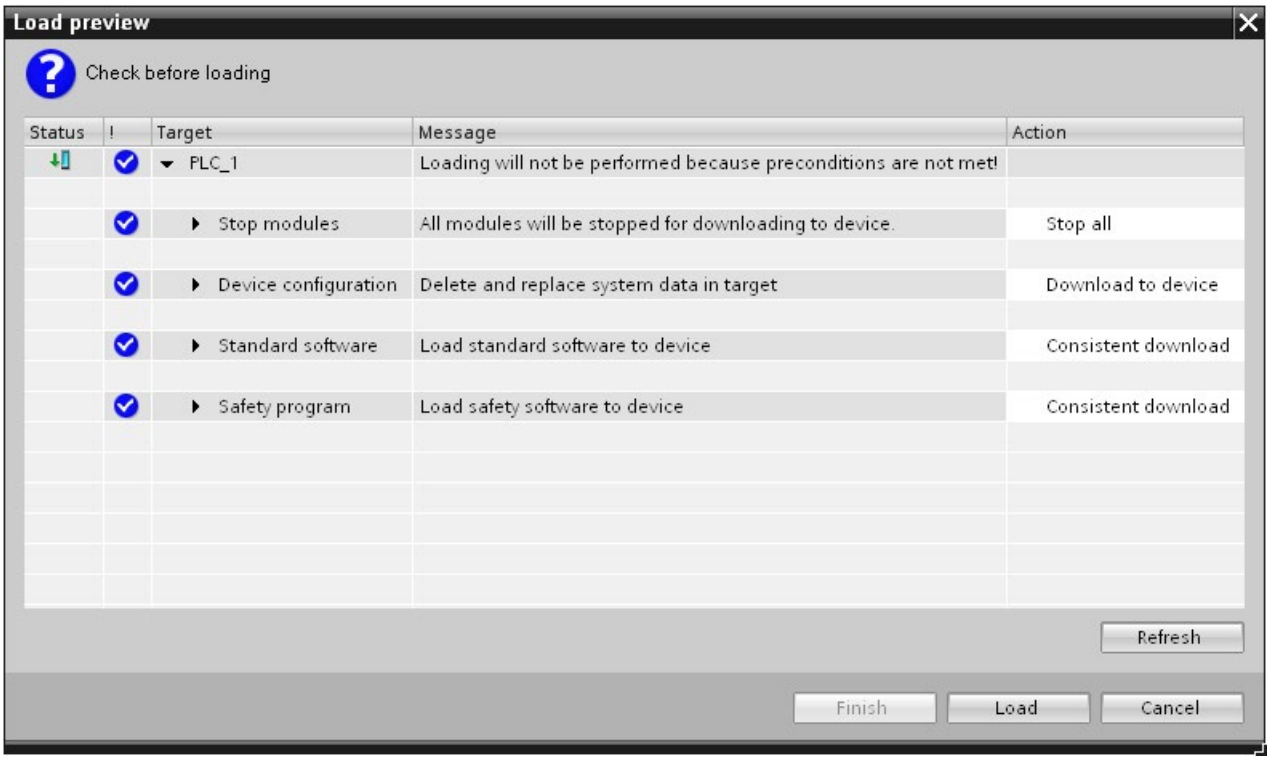
Inconsistent downloading is only possible in disabled safety mode.

Password prompt before downloading to an F-CPU

If you have assigned a protection level for the F-CPU (Page 86) (in the properties of the F-CPU in the "Protection" tab), the corresponding password is prompted in "Load preview" dialog. Without entry of password, only actions that are allowed without password are possible. As soon as the conditions for downloading are met, the "Load" button becomes active.

"Load preview" dialog

For an F-CPU, the "Load preview" dialog also contains the section "Safety program".



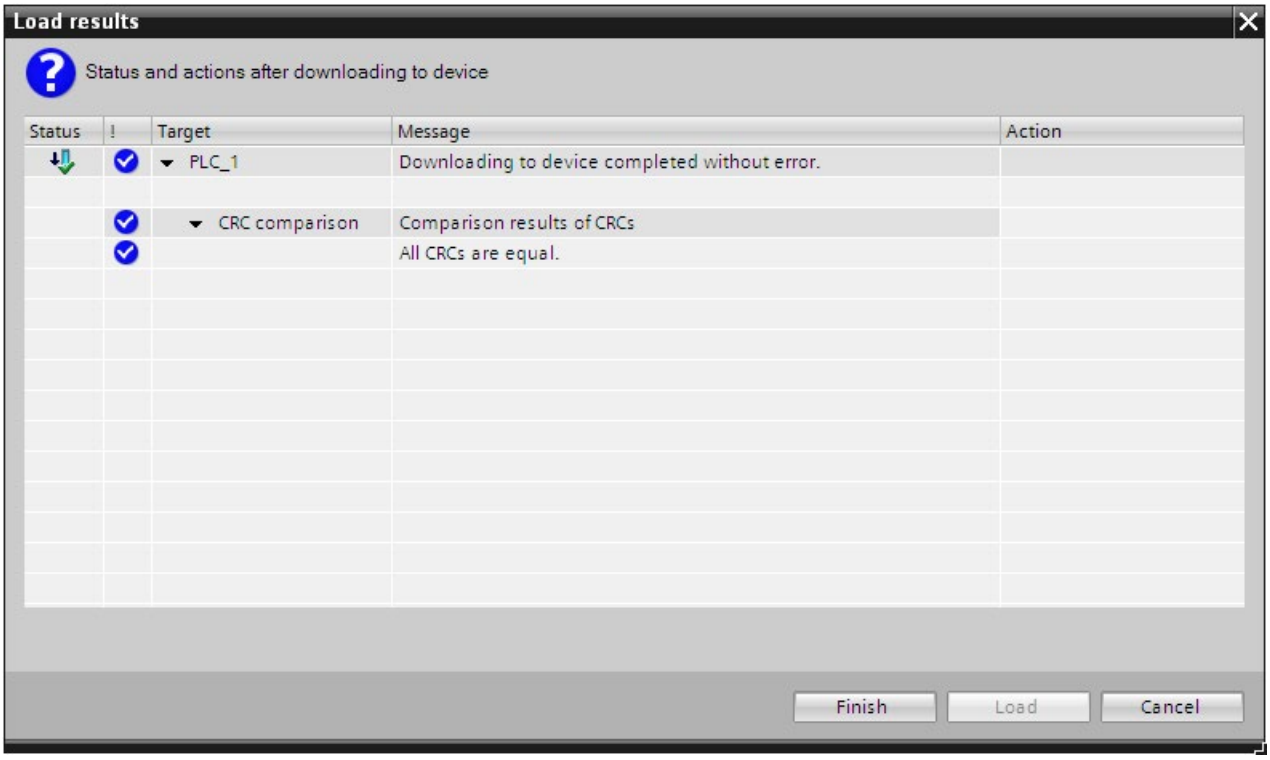
Make the following selection:

- In order to download a consistent safety program, select the "Consistent download" action under target "Safety program".
- (S7-300, S7-400) To download individual F-blocks selectively (Page 276), select the "Download selection" action under the target "Safety program", and then select the required F-blocks. If necessary, you will be prompted to disable safety mode under "Disable safety mode". This setting is only suitable for the online test of individual F-blocks.
- (S7-300, S7-400) In order to download the safety program only, select the "Consistent download" action under target "Safety program" and the "Download selection" action under target" Standard software", and then select only the standard blocks that call the main safety block.
- (S7-300, S7-400) To download no safety program, for example, because you do not know the password of the F-CPU, select the "No action" action under target "Safety program".

For S7-1200/1500 F-CPUs, only the "Consistent download" value is possible as an action in the "Load preview" dialog. It is not possible to select separate loading of standard program or safety program. The complete user program is automatically consistently downloaded as soon as changes have been made in both the standard program and in the safety program. Refer also to the section entitled Data exchange between standard user program and safety program (Page 165).

"Load results" Dialog

After downloading into the F-CPU, the dialog "Load results" is opened. This dialog shows you the status and the necessary actions after downloading.



Verify that the "Downloading of safety program completed without errors." message appears in the "Load results" dialog. If not, repeat the download operation.

10.3.1.1 Downloading project data to an S7-300/400 F-CPU with memory card inserted (SIMATIC Micro memory card or flash card)

When you download project data to an S7-300/400 F-CPU with memory card inserted (SIMATIC Micro memory card for S7-300 or flash card for S7-400), you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety program to the F-CPU with a **programming device/PC** to ensure that the F-CPU does not contain an "old" safety program:

- Download the safety program to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline).
- Perform a memory reset of the F-CPU using the mode switch or via the programming device/PC. Once the work memory has been deleted, the safety program is again transferred from the load memory (memory card, SIMATIC Micro memory card for S7-300 F-CPUs,flash card for S7-400 F-CPUs) to the work memory. *(S022)*

10.3.1.2 Downloading project data to an S7-400 F-CPU without flash card inserted

When you download project data to an S7-400 F-CPU without flash card inserted, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety program to the F-CPU with a **programming device/PC** to ensure that the F-CPU does not contain an "old" safety program:

- Perform a memory reset of the F-CPU using the **mode switch** or via the **programming device/PC**.
- Download the configuration and the safety program to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline). *(S023)*

10.3.1.3 Downloading project data to a WinAC RTX F

When you download project data to a WinAC RTX F, you must observe the following warning:

⚠ WARNING

You must adhere to the following procedure when downloading the safety program to the WinAC RTX F with a programming device/PC to ensure that the WinAC RTX F does not contain an "old" safety program:

1. Perform a memory reset of the WinAC RTX F (see Windows Automation Center RTX WinAC RTX (F) 2010 (http://support.automation.siemens.com/WW/view/en/43715176) manual).
2. Download the project data (Page 271) to the WinAC RTX F.

   If the function test of the safety program does not take place in the destination WinAC RTX F, you must also follow points 3. and 4:
3. Perform a program identification. This means you check whether the collective F-signatures match online and offline.
4. Perform the F-system startup.

Between the online program identification and the startup of the F-system, the WinAC RTX F must not be closed (for example, as a result of POWER OFF/POWER ON or booting). *(S024)*

10.3.1.4 Downloading individual F-blocks to an S7-300/400 F-CPU

Download F-blocks in disabled safety mode.

You can download F-blocks and standard blocks simultaneously to the F-CPU via the project tree. However, as soon as F-blocks are to be downloaded, a check is carried out to determine whether or not the F-CPU is in STOP mode or disabled safety mode. If not, you have the option of switching to disabled safety mode or placing the F-CPU in STOP mode.

If you want to download individual F-blocks to the F-CPU, for example, to test changes, make sure that you have not selected the folder "Program blocks" or the F-CPU in the project tree but only the blocks you want to download.

Only then will you be prompted in the "Load preview" dialog to disable safety mode once you have changed the option from "Consistent download" to "Download selection" and have changed the option “Stop modules” to “No action”.

If you fail to observe this prompt, the blocks are downloaded without deactivation of the safety mode which will STOP the F-CPU.

You can also deactivate the safety mode explicitly in the *Safety Administration Editor* before you start the download.

Be aware that the consistency of the safety program in the F-CPU cannot be guaranteed when individual F-blocks are downloaded. For a consistent safety program, always download the entire safety program to the F-CPU.

Rules for downloading individual F-blocks

The following rules apply to downloading of individual F-blocks:

- Downloading is only possible in disabled safety mode or when the F-CPU is in STOP mode.
- F-blocks can only be downloaded to an F-CPU to which a safety program has already been downloaded.
- Only an offline safety program is permitted to be used as a source program.

Consequently, you have to download the entire safety program when initially downloading the safety program and after changing the password for the safety program.

Note

If you are downloading F-blocks only, the blocks in which the main safety blocks are called (e.g., cyclic interrupt OB 35) are not downloaded. To do so, select the "Selection" option under "Standard software" in the preview dialog, and select the necessary blocks.

Note

Downloading of individual F-blocks is only suitable for testing F-blocks. Prior to the transition to productive mode, you must download the safety program consistently to the F-CPU.

10.3.1.5 Downloading project data to an S7-1200 F-CPU without program card inserted

When you download project data to an S7-1200 F-CPU without program card inserted, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety program to the F-CPU with a **programming device/PC** to ensure that the F-CPU does not contain an "old" safety program:

- Download the safety program to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline). *(S042)*

10.3.1.6 Downloading project data to an S7-1200 F-CPU with program card inserted

When you download project data to an S7-1200 F-CPU with program card inserted, you must observe the following warning:

⚠ WARNING

You must observe the following procedure to ensure that there is no "old" safety program in the internal load memory of the F-CPU when you insert a program card into an S7-1200 F-CPU:

1. Check to see whether **the STOP/RUN LED (orange) and the maintenance LED flash during startup for 3 seconds on an F-CPU without memory card**.
   If this is the case, the internal load memory of the F-CPU has already been deleted (for example, when the F-CPU has already been operated with a program card as external load memory) and you can skip step 3.
2. Insert the program card into the F-CPU.
   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the program card is being evaluated or that the internal load memory must be deleted.
3. Use one of the following methods to delete the internal load memory:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   After restart and deletion of the internal load memory, **the STOP/RUN LED (orange) and the maintenance LED must be flashing**. The internal load memory of the F-CPU has been deleted in this case and does no longer store an "old" safety program.
4. Use one of the following methods to evaluate the program card:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S061)*

For an S7-1200 F-CPU without inserted SIMATIC Memory Card and deleted internal load memory, the status LEDs have the status described in the table below.

Description	STOP/RUN Orange/Green	ERROR Red	MAINT Orange
Internal load memory deleted and SIMATIC Memory Card **not** inserted.	Flashing (orange) (for 3 seconds during startup)	Off	Flashing (for 3 seconds during startup)

WARNING

If you use a programming device/PC to download F-blocks to an S7-1200 F-CPU with inserted program card (external load memory), you must ensure that the transfer takes place to the external load memory. This can be accomplished by the following measures:

- Check to see if the program card is inserted correctly.
- Insert a program card whose memory size is different than the size of the internal load memory. Check in the project tree under "Online & Diagnostics > Diagnostics > Memory" if the memory size displayed for the load memory matches the memory size of the program card. *(S058)*

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety program to the F-CPU with a **programming device/PC** to ensure that the F-CPU does not contain an "old" safety program:

- Download the safety program to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline). *(S042)*

10.3.1.7 Downloading project data to an S7-1500 F-CPU

When you download project data to an S7-1500 F-CPU, you must observe the following warning:

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety program to the F-CPU with a **programming device/PC** to ensure that the F-CPU does not contain an "old" safety program:

- Download the safety program to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline). *(S042)*

10.3.1.8 Downloading project data to an S7-1500 F Software Controller

When you download project data to an S7-1500 F Software Controller, you must observe the following warnings:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety program to the F-CPU with a **programming device/PC** to ensure that the F-CPU does not contain an "old" safety program:

- Download the safety program to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline). *(S042)*

⚠ WARNING

For security reasons, the password of an S7-1500 F Software Controller is also stored in a separate memory in addition to the load memory.

Unlike the load memory, this separate memory is not deleted. This means the previous passwords are once again active after deleting the S7-1500 F Software Controller followed by a run-up.

For this reason, note the following:

- The S7-1500 F Software Controller is deleted in case of the following download scenarios of the PC station:
  - Downloading a PC station with revised interface assignment.
  - Downloading a PC station with revised storage location for retentive data.
- We recommend that you do not set up F-access protection until after commissioning. If you still have to change the interface assignment of the PC station or the storage location for retentive data, you do not have to enter the F-password during the subsequent mandatory download of the S7-1500 F Software Controller.
- We recommend that you remove the F-access protection from an S7-1500 F Software Controller that is no longer in use. If you forget the F-password when you want to operate the S7-1500 F Software Controller later, you can remove it by uninstalling/installing or loading a new image. *(S076)*

See also

Downloading project data to an F-CPU (Page 271)

Software Controller (http://support.automation.siemens.com/WW/view/en/109249299)

10.3.2 Downloading project data to a memory card and inserting a memory card

Proceed as you would with standard blocks to download project data from an F-CPU to a memory card (flash card for S7-400, SIMATIC Micro Memory Card for S7-300 or SIMATIC Memory Card for S7-1200/1500). You must also observe the following warning:

⚠ WARNING

If the function test of the project data is not performed in the destination F-CPU, you must ensure that the correct project data are on the memory card after downloading the project data to the memory card.

Follow these steps:

1. Make sure that you are using an empty memory card.
2. Download the project data to the memory card.
3. If necessary, clearly label the memory card (e.g. with the collective F-signature).

The procedure outlined must be ensured through organizational measures. *(S043)*

When inserting a memory card (flash card for S7-400, SIMATIC Micro Memory Card for S7-300 or SIMATIC Memory Card for S7-1200/1500) with project data from an F-CPU, you observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must ensure through online program identification or other suitable measures (e.g. by checking the labeling of the memory card) that the memory card inserted has the correct safety program. *(S025)*

10.3.2.1 Inserting a SIMATIC Micro Memory Card or flash card into an S7-300/400 F-CPU

When you insert a memory card (flash card for S7-400 or SIMATIC Micro memory card for S7-300) into an S7-300/400 F-CPU , you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must adhere to the following procedure when inserting the memory card to ensure that the F-CPU does not contain an "old" safety program:

- Switch off the power to the F-CPU. For F-CPUs with battery backup (e.g. CPU 416F-2), remove any battery. (To ensure that the F-CPU is de-energized, wait for the buffer time of the power supply you are using or, if this is not known, remove the F-CPU.)
- Remove the memory card with the old safety program from the F-CPU.
- Insert the memory card with the new safety program into the F-CPU.
- Switch on the F-CPU again. For F-CPUs with battery backup (e.g. CPU 416F-2), reinsert the battery, if one was removed.

(S026)

10.3.2.2 Inserting a transfer card into an S7-1200 F-CPU

When you insert a transfer card into an S7-1200 F-CPU, you must observe the following warning:

⚠ WARNING

You must observe the following procedure to ensure that there is no "old" safety program in the internal load memory when you copy the project data to an S7-1200 F-CPU using a transfer card:

1. Check to see whether **the STOP/RUN LED (orange) and the maintenance LED flash during startup for 3 seconds on an F-CPU without memory card**.
   If this is the case, the internal load memory of the F-CPU has already been deleted and you can skip step 3.
2. Insert the transfer card into the F-CPU.
   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the transfer card is being evaluated or that the internal load memory must be deleted.
3. Use one of the following methods to delete the internal load memory:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   After restart and deletion of the internal load memory, **the STOP/RUN LED (orange) and the maintenance LED must be flashing**. The internal load memory of the F-CPU has been deleted in this case and does no longer store an "old" safety program.
4. Use one of the following methods to evaluate the transfer card (transfer from the transfer card to the internal load memory):
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   After restart and evaluation of the SIMATIC Memory Card, the F-CPU copies the project data to the internal load memory of the F-CPU. Once the copy process is complete, the maintenance LED on the F-CPU is flashing to indicate that you can remove the transfer card.
5. Remove the transfer card from the F-CPU.
6. Use one of the following methods to evaluate the internal load memory:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S059)*

For an S7-1200 F-CPU without inserted SIMATIC Memory Card and deleted internal load memory, the status LEDs have the status described in the table below.

Description	STOP/RUN Orange/Green	ERROR Red	MAINT Orange
Internal load memory deleted and SIMATIC Memory Card **not** inserted.	Flashing (orange) (for 3 seconds during startup)	Off	Flashing (for 3 seconds during startup)

10.3.3 Downloading project data of an S7-1200 F-CPU from the internal load memory to an empty SIMATIC Memory Card

When you download project data from the internal load memory of an S7-1200 F-CPU to an empty SIMATIC Memory Card, you must observe the following warning:

⚠ WARNING

To ensure that the safety program is downloaded from the internal load memory of the F-CPU to the SIMATIC Memory Card when plugging an empty SIMATIC Memory Card into an S7-1200 F-CPU and that the internal load memory of the F-CPU is deleted afterward, you must observe the following procedure:

1. Make sure that you are using an empty SIMATIC Memory Card, for example, by checking in the Windows Explorer that the "SIMATIC.S7S" folder and the "S7_JOB.S7S" file are deleted.
2. Insert the empty SIMATIC Memory Card into the F-CPU.

   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the program can be copied from the internal load memory to the SIMATIC Memory Card and that the internal load memory is deleted afterward.
3. Use one of these methods to trigger copying from the internal load memory to the SIMATIC Memory Card and subsequent deletion of the internal load memory:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   After restart and copying of the program from the internal load memory to the SIMATIC Memory Card and subsequent deletion of the internal load memory, **the STOP/RUN LED (orange) and the maintenance LED must be flashing**. The internal load memory of the F-CPU has been deleted in this case and does no longer store the safety program. The SIMATIC Memory Card is now a program card.
4. Use one of the following methods to evaluate the program card:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S057)*

Note

Also observe the setting "Disable copying from internal load memory to external load memory" in the hardware configuration of your F-CPU.

10.3.4 Updating project data on an S7-1200 F-CPU using a transfer card

When you want to update the project data on an S7-1200 F-CPU using a transfer card, you must observe the following warning:

⚠ WARNING

If you run an update of the safety program on an S7-1200 F-CPU with the help of a transfer card, you must ensure that the transfer to the internal load memory took place correctly by means of a subsequent program identification. *(S060)*

10.3.5 Restoring a backup of the safety program to an S7-300/1200/1500 F-CPU

You have the option of backing up an F-CPU in the same way as a standard CPU and then restoring it. You can find information on backing up a CPU in the *online help on STEP 7* under "Creating a backup of an S7 CPU".

Note the following warnings when restoring the software and hardware configuration of an F-CPU:

⚠ WARNING

Once you have restored a backup of an F-CPU, you must perform a program identification. *(S055)*

Note

We recommend that you use the collective F-signature that is included in the name of the backup file for program identification. You must not change the collective F-signature in the name in this case.

⚠ WARNING

(S7-1200/1500) If multiple F-CPUs with Web server can be reached by a programming device or PC, you must take additional actions to ensure that the safety program is downloaded to the correct F-CPU by restoring it.

Use CPU-specific passwords for the "F-Admin" right on the Web server. For example, select a uniform password with attached IP address (e.g. Password_192.168.0.8) for each F-CPU. *(S065)*

10.3.6 Uploading project data from an F-CPU

Uploading the safety program to a programming device or PC (S7-300, S7-400)

To upload a safety program to a programming device or PC, proceed as for standard blocks.

Note

In principle, it is possible to upload a safety program from the F-CPU to a programming device or PC. Note, however, that any symbols used in the safety program are deleted and cannot be recreated, since no symbol information is saved in the F-CPU. Symbols are available only if you are using an offline project.

A safety program uploaded from the F-CPU to a programming device / PC may not be loaded again into the F-CPU.

Uploading the safety program to a programming device or PC (S7-1200, S7-1500)

The "Load from device" function is not possible for S7-1200/1500 F-CPUs for safety programs. You can download individual F-blocks to a PG-PC. This also applies to standard CPUs with F-I/O in standard mode.

Uploading to a PG/PC (S7-300, S7-400)

You upload a safety program from an F-CPU to a programming device/PC using menu command "Online> Upload from device" or the "Upload from device" button in the toolbar.

You can only upload the hardware configuration if F-capability is not enabled for the F-CPU. You can only upload F-I/O if these are operated in standard mode.

10.4 Program identification

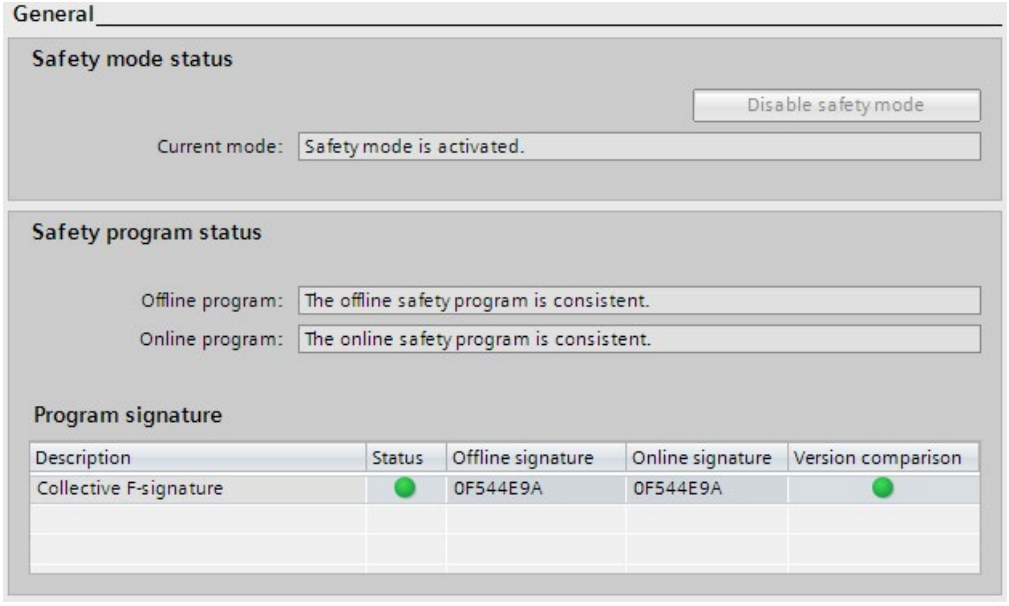
You use the program identification to determine that the correct safety program was downloaded to the F-CPU To do so, you compare the collective F-signatures of the safety program and the assignment of the "F-admin" rights online with the expected value. The expected value can be, for example, the collective F-signature of the safety program offline from the *Safety Administration Editor* or from the safety summary. Check the assignment of the "F-admin" right in the *Safety Administration Editor*.

Use organizational measures to ensure that the safety program is not downloaded by any other TIA Portal (on a separate programming device or PC) while you perform the program identification.

With the *Safety Administration Editor*

For a program identification using the *Safety Administration Editor*, follow these steps:

1. Open the *Safety Administration Editor* of the F-CPU you want to check.
2. Connect online with the F-CPU you want to check.
3. Compare the collective F-signature displayed online with the expected value in the "General" section.
4. Check whether the offline and online program are consistent (Page 321).
5. Check whether the green symbol is displayed in the column "status" and "Version comparison".



6. Check in the "Web server F-admins" section whether only authorized users have the "F-admin" right offline and online.

With HMI

For a program identification using the HMI, follow these steps:

1. Read the collective F-signature of the safety program from the F_PROG_SIG tag of the F-global DB (Page 118) (S7-300, S7-400) or the tag F_SYSINFO.F_PROG_SIG of the F-runtime group information DB (Page 118) (S7-1200, S7-1500).
2. Compare the value of the F_PROG_SIG tag with the expected value.

With the display of an S7-1500 F-CPU

For a program identification using the display of an F-CPU, follow these steps:

1. In the display menu, go to "Overview > Fail-safe".
2. Compare the displayed collective F-signature with the expected value.

With the Web server of an S7-1200/1500 F-CPU

For a program identification using the Web server of an S7-1200/1500 F-CPU, follow these steps:

1. Read the collective F-signature on the homepage of the Web server.
2. Compare the displayed collective F-signature with the expected value.

See also

Safety Administration Editor (Page 68)

10.5 Comparing Safety Programs

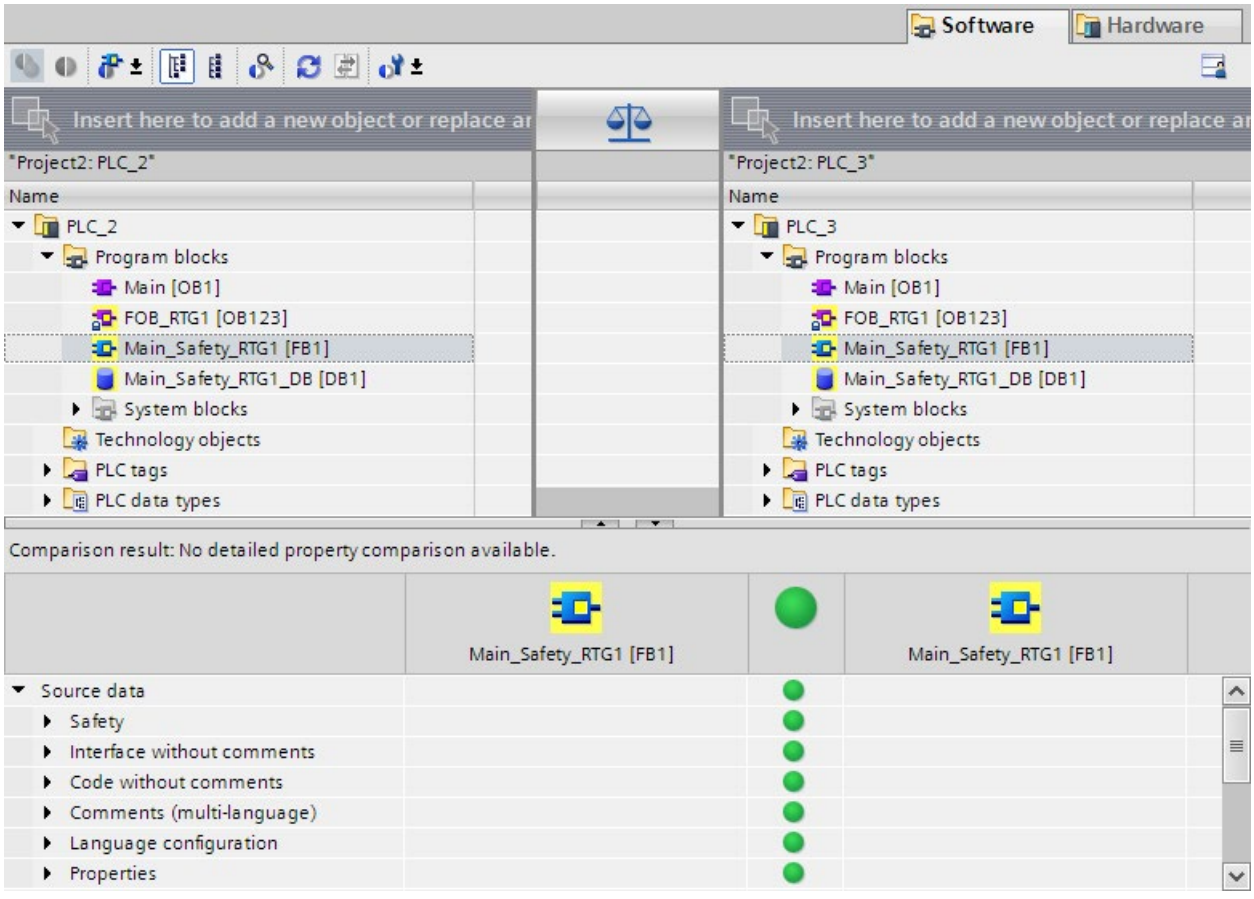
Compare safety programs as in standard

You can use the *comparison editor* in *STEP 7* for offline-online or offline-offline comparison of safety programs. The procedure is the same as for standard user programs. The contents of F-blocks are also compared for the comparison of safety programs. As a result, an offline-offline comparison can also be used for an acceptance of changes (Page 323). You enable this comparison by selecting the "Safety" comparison criterion and disabling all other comparison criteria.

Comparison result for safety programs

The representation of the comparison result corresponds to the representation of *STEP 7*.

If you click the "Program blocks" folder on the left of the comparison editor, you can see the collective F-signature of the safety program displayed under "Comparison result". You also receive information about whether the safety program is consistent.



If you click on an F-block, you can see the respective signatures and interface signatures in addition to the standard information.

Note

If you interrupt the connection to the F-CPU during the online/offline comparison, the comparison result will be incorrect.

Comparison filter options

You can use filters in the *comparison editor* to limit the comparison result to the following block groups:

- Compare only F-blocks
- Compare only F-blocks relevant for certification
- Compare only standard blocks

You also have the *STEP 7* filter options "Show only objects with differences" and "Show identical and different objects".

For comparison of safety programs, F-blocks in the "System blocks" folder are also relevant.

Comparison criteria

Make sure that under only the comparison criterion "Safety" is enabled.

Classification of displayed changes

Regardless of whether you carried out an offline/online or offline/offline-comparison, the following changes could account for the indicated changes to the automatically generated F-blocks:

- Change in the maximum cycle time of F-runtime group and warn cycle time of F-runtime group
- Change in F-parameters of the F-CPU
- changed safety system version or change to the hardware configuration (S7-1200/1500: Displayed as change of the "F_SystemInfo_DB" block).
- (S7-300/400) Change in the F-runtime group communication, for example, change in the number of a DB for F-runtime group communication
- Change in main safety block, F-FB, F-FC, F-DB
- Change of the hardware configuration for the F-I/O addressed in the safety program

It is possible that a block is displayed as changed, but no changes are displayed in the detailed comparison of the block content. This is not a display problem but means that changes of addresses in the tag table, for example, have an effect on this block. Test this block in case of doubt.

Printing result of comparison

The comparison result can be printed via "Project > Print" in the menu bar or the print button in the toolbar. Select "Print objects/area" "All" and "Properties" "All".

Make sure that all pages were printed completely. Incomplete printouts (e.g. due to low on toner) must not be used for the acceptance of changes.

10.6 Printing project data

Printing

You can print all important project data (hardware configuration of the F-CPU and F-I/O, safety program). You obtain a "safety summary" that, alongside the documentation, serves as a basis for testing the correctness of the individual components of the system. Correctness is a prerequisite for system acceptance.

The collective F-signature specifications in the footer of the printout ensure that the printout is explicitly associated with a safety program.

Safety summary

The safety summary provides documentation of the safety-related project data which supports you during acceptance of the system.

Procedure for creating a safety summary

To create a safety summary, follow these steps:

1. In the project tree, select the *Safety Administration Editor* of the F-CPU whose safety summary you want to create.
2. Select "Print" in the shortcut menu or "Project > Print" in the menu bar or the print button in the toolbar.

   In the displayed dialog, you can make layout settings for the printout and specify the scope of the printout (all/subset), among other things.
3. Under "Document information", select one of the ISO formats, e.g. "DocuInfo_ISO_A4_Portait".
4. Select the "All" option, if the F-blocks and F-compliant PLC data types are to be shown in the printout. This is necessary, for example, to document the program code for the acceptance(see Acceptance of system (Page 308)). Select the "Compact" option to exclude the source code from the printout.
5. Click the "Print" button.

As a result, you receive the safety summary for the F-CPU.

Make sure that all pages were printed completely. Incomplete printouts (e.g. due to low on toner) must not be used for the acceptance of changes.

Contents of the summary in overview

The topics that are considered in the summary are summarized in the following:

- General information on program identification, software versions, access protection, settings (from the "Settings" work area of the *Safety Administration Editor*), e.g. safety system version.
- System library elements used in safety program (from the "Instructions" task card) along with their versions
- Information about the F-runtime groups (e.g. cycle time warning limit of the F-runtime group, maximum cycle time of the F-runtime group)
- List of the F-blocks within the "Program blocks" folder (e.g. name, function, associated F-runtime group, signature)
- (S7-1200, S7-1500) List of the know-how protected F-blocks used in the safety program (for example name, signature, used safety system version, used versioned instructions or called F-blocks).
- (S7-1200, S7-1500) List of F-compliant PLC data types (UDT)
- Data from the standard user program that are evaluated in the safety program
- Block parameters of the safety-related CPU-CPU communication
- (S7-300, S7-400) Absolute addresses and names of the F-shared DB tags that can be accessed from the standard user program
- Information on hardware (used F-I/O, CPU version, addresses)
- Information on the printout (print date, number of pages)

Content of the footer of the printouts

On the basis of the footer of the printout, you can find out:

- whether the printout is consistent and whether all pages of the printout belong to the same safety program and the same version (the same collective F-signature in the footer of every page means that the printout belongs to the safety program with this collective F-signature).

The footer is added to the source code of the F-blocks only if the "All" option was selected for the safety summary.

If F-blocks are printed by other means, the footer is omitted, and you can no longer easily identify whether the block printout belongs to the current safety program version.

Printing a migrated project

You can only print a safety summary for a project migrated from *S7 Distributed Safety* V5.4 SP5 if the project was compiled with *STEP 7 Safety Advanced* and the new program structure for safety programs (main safety block) has therefore been applied. Otherwise, the printout is not possible and you will receive a corresponding error message.

We recommend that you print out your project in *S7 Distributed Safety V5.4 SP5* before the migration.

10.7 Testing the safety program

10.7.1 Overview of Testing the Safety Program

Complete function test or test of changes

After creating a safety program, you must carry out a complete function test in accordance with your automation task.

For changes made to a safety program that has already undergone a complete function test, only the changes and that there is no effect on the parts of the safety program that were not changed need be tested.

Monitoring

Read-only test functions (such as monitoring tags of the safety program) are available for safety programs as in the standard.

Modifying

Read and write test functions (such as controlling tags of the safety program) are only available to a limited extent for safety programs and only in disabled safety mode.

Simulation via *S7-PLCSIM*

You can test the safety program using *S7-PLCSIM*. You use *S7-PLCSIM* in the same way as for standard user programs.

You start the simulation with *S7-PLCSIM* using menu item "Online > Simulation > Start".

Rules for testing

- Forcing of F-I/O inputs and F-I/O outputs is not possible.
- Controlling F-I/O outputs in connection with the function “Enabling F-I/O outputs" is not possible.
- Setting breakpoints in the standard user program will cause the following errors in the safety program:
  - Expiration of F-cycle time monitoring
  - Error during communication with the F-I/O
  - Error during safety-related CPU-CPU communication
  - Internal CPU fault

  If you nevertheless want to use breakpoints for testing, you must first disable safety mode (Page 294). This will result in the following errors:
  - Error during communication with the F-I/O
  - Error during safety-related CPU-CPU communication
- Changes in the configuration of F-I/O or safety-related CPU-CPU communication can only be tested after the hardware configuration has been saved and downloaded, and after the safety program has been compiled and downloaded to the F-CPU.

10.7.2 Disabling safety mode

Introduction

The safety program generally runs in the F-CPU in safety mode. This means that all fault control measures are activated. The safety program cannot be modified during operation (in RUN mode) in safety mode. You must disable safety mode of the safety program to, for example, modify tags in the safety program in RUN mode. Safety mode remains disabled until the F-CPU is next switched from STOP to RUN mode.

Rules for disabling safety mode

⚠ WARNING

Because changes to the safety program can be made in RUN mode when safety mode is deactivated, you must take the following into account:

- Disabling safety mode is intended for test purposes, commissioning, etc. Whenever safety mode is disabled, the safety of the system must be ensured by other organizational measures, such as monitored operation, manual safety shutdown, and access restrictions to certain areas.
- Disabling of safety mode must be displayed.

  Use the MODE tag in the F-global DB ("F_GLOBDB".MODE) for S7-300/400 F-CPUs or in the F-runtime group information DB (e.g. RTG1SysInfo.F_SYSINFO.MODE) for S7-1200/1500 F-CPUs, which you can evaluate to read the operating mode (1 = Disabled safety mode). This means not only is the disabled safety mode displayed on the programming device or PC in the dialog box for disabling safety mode, but it can also be indicated by means of an indicator light controlled by the standard user program or a message to an HMI system generated by evaluating the above-mentioned "Disabled safety mode" variable in the F-shared DB.
- It must be possible to verify that safety mode has been disabled. A log is required, if possible by recording and, if applicable. archiving alarms to the operator control and monitoring system or, if need be, through organizational measures. In addition, it is recommended that disabling of safety mode be indicated on the HMI system.
- Safety mode is disabled F-CPU-wide. You must, however, take the following into account for safety-related CPU-CPU communication: If the F-CPU with the SENDDP or SENDS7 instruction is in disabled safety mode, you can no longer assume that the data sent by this F-CPU are generated safely. You must then implement organizational measures such as operation monitoring and manual safety shutdown to ensure safety in those portions of the system that are affected by the sent data. Alternatively, you must output fail-safe values instead of the received data in the F-CPU with the instruction RCVDP or RCVS7 (Page 515) or by evaluating SENDMODE. *(S027)*

Procedure for disabling safety mode

To disable safety mode, follow these steps:

1. Open the *Safety Administration Editor* of the corresponding F-CPU.
2. Open the work area "General (Page 70)" in the area navigation.
3. Check to see whether the safety mode status is displayed as activated.

   If so, continue with the next step; if not, stop the process, because safety mode is already disabled or cannot be disabled.
4. Click the "Disable safety mode" button.
5. Enter the password for the online safety program.

   If you enter the correct password, another prompt will appear, which also contains the collective F-signature in the F-CPU. Check to see whether this is the collective F-signature you expected. If there is a match, acknowledge the dialog.
6. Enter the password for the F-CPU.

   After correctly entering the password for the F-CPU, safety mode is disabled.

   If the password is not valid, safety mode is not deactivated and remains active.

   (S7-300, S7-400) When individual F-blocks are downloaded, the condition "Disable safety mode" is listed automatically in the "Load preview" dialog. For this reason, it is not necessary to explicitly disable safety mode before every F-block download.

Note

If the collective F-signature or the passwords do not agree for the safety program online and offline, this means:

- The offline safety program was modified after the last downloading, or
- An incorrect F-CPU was addressed. Check the latter based on the online collective F-signature.

Enabling safety mode

Note

To enable safety mode, the F-CPU must be switched from STOP to RUN mode.

Switching the F-CPU from STOP to RUN mode always enables safety mode, even if the safety program has been modified or is not consistent. The MODE tag in the F-shared DB for S7-300/400 F-CPUs or F-runtime group information DB is set to "0" for S7-1200/1500 F-CPUs.

If you have changed your safety program, but have not recompiled and downloaded it, the F-CPU can revert to STOP mode.

Evaluating safety mode/disabled safety mode

If you wish to evaluate safety mode/disabled safety mode in the safety program, you can evaluate the "MODE" tag in the F-shared DB for S7-300/400 F-CPUs or F-runtime group information DB for S7-1200/1500 F-CPUs (1 = Disabled safety mode). You use fully qualified access to access this tag (e.g. "F_GLOBDB".MODE or RTG1SysInfo.MODE).

You can use this evaluation, for example, to passivate F-I/O when the safety program is in disabled safety mode. To do so, assign the "MODE" tag in the F-shared DB or F-runtime group information DB to all "PASS_ON" tags in the F-I/O DBs of the F-I/O that you wish to passivate.

⚠ WARNING

When the safety program is in disabled safety mode, the "MODE" tag in the F-shared DB or F-runtime group information DB is also evaluated in disabled safety mode.

Even if the F-I/O are passivated in disabled safety mode as a result of evaluation of the "MODE" tag, system safety must be ensured in disabled safety mode through other organizational measures, such as operation monitoring and manual safety shutdown. *(S028)*

See also

F-shared DB (S7-300, S7-400) (Page 118)

F-runtime group information DB (S7-1200, S7-1500) (Page 118)

10.7.3 Testing the safety program

Introduction

Tags of he safety program can be monitored at any time.

Controlling tags of the safety program is only possible in deactivated safety mode as some fault control measures of the safety program have to be disabled for this.

You can control the following tags of the safety program:

- Inputs and outputs of the F-I/O (channel values and value status (S7-1200, S7-1500))
- Tags in F-global DB (except DB for F-runtime group communication)
- Tags in instance DBs of F-FBs
- Tags in F-I/O DBs (for permitted tags see F-I/O DB (Page 135))

Note

A modify function controlled by the F-system is only possible if the *STEP 7 Safety* optional package is installed. Modification of tags by means of an HMI system as well as modification without an installed *STEP 7 Safety* optional package can cause the F-CPU to go into STOP.

Procedure for monitoring tags of the safety program

Monitor the required tags of the safety program from an open watch table or from the *program editor* (program status).

1. Proceed as in the standard. Additional information can be found in the *STEP 7 help* in “Testing user programs".

Procedure for controlling tags of the safety program

Control the required tags of the safety program from an open watch table:

1. For modifying, deactivate the safety mode (Page 294) in the automatically shown dialog.
2. Terminate existing modify requests after testing is complete before activating safety mode.

Values in F-DBs can only be modified online in the F-CPU. If the value is also to be changed offline, you must do this by editing the start value offline and compiling the safety program.

Proceed as follows to control tags of F-I/O:

1. Create a separate row for each channel value and value status (S7-1200, S7-1500) to be modified. The control value must correspond to the channel value or value status.
2. Set “start of scan cycle" or “end of scan cycle" and "permanent" or “once".

   Regardless of the trigger point setting, requests to modify inputs (PII) of F-I/O always become effective before the main safety block is executed and requests to modify outputs (PIQ) always become effective after execution of the main safety block.
3. (S7-300, S7-400) Create an additional watch table if you want to control more than 5 inputs/outputs.

Note

F-I/O can only be modified in RUN mode of the F-CPU.

You cannot modify a configured F-I/O from which neither a channel value or a value status (S7-1200, S7-1500), nor any tag from the associated F-I/O DB has been used. In your safety program, you should therefore always use at least one tag from the associated F-I/O DB or at least one channel value or value status (S7-1200, S7-1500) of the F-I/O to be modified.

For inputs (PII), modify requests take priority over fail-safe value output, while for outputs (PIQ), fail-safe value output takes priority over modify requests. For outputs (channels) that are not activated in the properties for the F-I/O, modify requests affect the PIQ only, and not the F-I/O.

Note

The following applies for S7-1200/1500 F-CPUs:

To avoid invalid combinations of channel value and status value:

- The value status is set by the F-system automatically to 1 when setting a channel value to a value <> fail-safe value 0
- The fail-safe value 0 is automatically output when setting the value status to 0 for the associated channel value

WARNING

You need to specifically reset constant modify requests in the watch table in disabled safety mode.

Please note that constant modify requests that are not correctly reset can remain active in the background even after a STOP/RUN transition on the F-CPU.

Because the F-CPU is in safety mode again after a STOP/RUN transition, the constant modify requests are no longer effective and are not shown in the watch table.

The requests become active again as soon as you disable safety mode again.

With a memory reset of the F-CPU, you can make sure that no constant modify requests are active in the background on the F-CPU. *(S029)*

Wiring test using watch table

You can carry out a wiring test for an input by changing an input signal and verifying whether or not the new value arrives in the PII.

You can carry out a wiring test for an output by changing the output with the Modify function and verifying whether the required actuator responds.

For the wiring test, note that a safety program must be running on the F-CPU, in which at least one channel value or value status (S7-1200, S7-1500) of the F-I/O to be monitored or modified or one tag from the associated F-I/O DB has been used.

For F-I/O that can also be operated as standard I/O (e.g., S7-300 fail-safe signal modules), you can also carry out the wiring test for outputs using the Modify function in STOP mode by operating the F-I/O as standard I/O rather than in safety mode.

See also

Changing the safety program in RUN mode (S7-300, S7-400) (Page 302)

Downloading project data to an F-CPU (Page 271)

10.7.4 Testing the safety program with S7-PLCSIM

You can test your safety program together with your standard program on a simulated CPU with *S7-PLCSIM* and without the need for hardware.

You use *S7-PLCSIM* for SIMATIC Safety F-systems as you would for S7 standard systems. Note the following special features:

Safety mode/disabled safety mode

We recommend that you test your safety program in safety mode to detect whether the F-CPU goes into STOP as early as in the test phase of your safety program in *S7-PLCSIM* as a result of, for example, that the results of instructions were outside the permitted range for the data type.

The following simulations can be run in *S7-PLCSIM*, just as on an actual F-CPU, in disabled safety mode only.

- Modifying tags in F-DBs and F-I/O DBs.

The F-CPU can go to STOP mode in *S7-PLCSIM* if this is disregarded. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

(S7-1200, S7-1500) To prevent unintentional modification of tags in F-DBs and F-I/O DBs in safety mode, we recommend that you do not select the "Activate/deactivate modification of non-inputs" button in *S7-PLCSIM*

During the simulation with *S7-PLCSIM* , monitoring of the maximum cycle time of the F-runtime group and the cycle time warning limit of the F-runtime group (S7-1200, S7-1500) are disabled.

Input simulation of F-I/O

Modification of inputs (channel values) in *S7-PLCSIM:*

You modify inputs (channel values) of F-I/O as you would inputs (channel values) of standard I/O in *S7-PLCSIM*.

Modification of inputs (value status) in *S7-PLCSIM:*

(S7-1200, S7-1500) By modifying inputs (value status) of F-I/O you can simulate the incoming and outgoing F-I/O/channel faults. Keep in mind the following notes/restrictions:

- To realistically simulate the behavior of the F-I/O, you must note the connection between channel value and value status on the real F-I/O. The combination value status = 0 and channel value **<>** fail-safe value (0) is invalid and can result in the simulation deviating from the behavior of the real F-CPU.
- During the transition from "STOP" to "RUN" of the CPU in *S7-PLCSIM*, all F-I/O inputs (value status) are initialized with 1. This means you can start with the modification of inputs (channel values) without simulation of the inputs (value status).
- The modification of inputs (value status) in *S7-PLCSIM* does not have an effect on the tags QBAD and PASS_OUT in the F-I/O DB. Note that with real F-I/O QBAD and PASS_OUT can be 1 as soon as the value status is 0 for at least one channel of the F-I/O. (see tags of the F-I/O DB: PASS_OUT/QBAD/QBAD_I_xx/QBAD_O_xx and value status (Page 141)).
- For F-I/O configured with "Behavior after channel fault" = "Passivation of the complete F-I/O", use the tag PASS_ON in the F-I/O DB for simulation of the passivation of the complete F-I/O for F-I/O / channel faults. If you only passivate individual inputs (channel value including value status) for the simulation, the behavior of the simulation will deviate from the real F-CPU.
- You can also use the PASS_ON tag in the F-I/O DB for F-I/O without value status to simulate the passivation of the entire F-I/O in case of F-I/O or channel faults.
- You must modify the inputs (channel values) to $7FFF_H$ (for overflow) or 8000_H (for underflow) to simulate an F-I/O/channel fault of the SM 336; AI 6 x 13Bit or the SM 336; F-AI 6 x 0/4...20 mA HART with configuration "Behavior after channel fault" = "Passivate channel".
- For F-I/O which does not support the "RIOforFA-Safety" profile, you must run a user acknowledgment with a positive edge at the ACK_REI tag of the F-I/O DB as with a real F-I/O for reintegration after the value status has changed from 0 to 1 or when the channel value has changed from $7FFF_H$/8000_H to unequal $7FFF_H$/8000_H (see above) when ACK_NEC = 1 of the F-I/O DB. Reintegration takes place automatically in all other cases possibly deviating from the real F-I/O.

Update times

Keep in mind that the status of the inputs (channel values or value status (S7-1200/1500)) which you are monitoring in the SIM table in *S7-PLCSIM* is only identical to the status being processed in the safety program if there is no passivation of the associated F-I/O.

With passivation of the F-I/O, the safety program operates with fail-safe values (channel value and value status (S7-1200/1500) =0).

Instructions for communication between F-CPUs

You cannot simulate communication between F-CPUs with the SENDDP and RCVDP instructions in *S7-PLCSIM*. You can, however, use the SENDDP and RCVDP instructions together with *S7-PLCSIM*.

During simulation in *S7-PLCSIM*, the RCVDP instruction outputs the fail-safe values pending at its inputs SUBBO_xx and SUBI_xx ((S7-1200/1500) or alternatively SUBDI_00). The SENDDP and RCVDP instructions signal this with 1 at output SUBS_ON.

(S7-300, S7-400) You cannot simulate communication between F-CPUs with the SENDS7 and RCVS7 instructions in *S7-PLCSIM*. You can, however, use the SENDS7 and RCVS7 instructions together with *S7-PLCSIM*.

During simulation in *S7-PLCSIM*, the RCVS7 instruction outputs the initial values specified in the communication DB as fail-safe values. The SENDS7 and RCVS7 instructions signal this with 1 at output SUBS_ON.

Inconsistent safety program (S7-1200, S7-1500)

If the CPU goes into STOP in *S7-PLCSIM* with the diagnostic entry "Safety program: inconsistent", the F-CPU is not initialized correctly in *S7-PLCSIM* yet. Perform a memory reset of the F-CPU in *S7-PLCSIM* and download the program once again to the CPU in *S7-PLCSIM*.

10.7.5 Changing the safety program in RUN mode (S7-300, S7-400)

Introduction

Changes to the safety program during operation (in RUN mode) can only be made in disabled safety mode (Page 294). You make changes to F-blocks offline in the *program editor* in the same way as for a standard program. F-blocks cannot be changed online.

Note

If you do **not** want to make changes to the safety program during operation, see Creating F-blocks in FBD/LAD (Page 122).

Procedure for changing the safety program in RUN mode

To change the safety program, follow these steps:

1. Change the main safety block or F-FB and its associated instance DB, F-FC, or F-DB in the *Program editor*.
2. Download the changed F-block(s) to the F-CPU (for procedure, see Downloading project data to an F-CPU (Page 271)). The entire program is then automatically compiled.
3. If safety mode is active, the "Load preview" dialog will prompt you to deactivate it and to enter the password for the safety program.

Note

When downloading in disabled safety mode, you can only download the fail-safe blocks created by you (main safety blocks, F-FB, F-FC, or F-DB), F-application blocks, or standard blocks and their associated instance DBs. If you download automatically added F-blocks (F-SBs or automatically generated F-blocks and associated instance DBs, F-shared DB), the F-CPU can go to STOP mode or safety mode can be activated.

Therefore, always select individual blocks only when downloading in disabled safety mode.

Sequence for downloading changes

Changes in the safety program in RUN mode when safety mode is disabled can, for example, cause the status of an actuator to change as a result of program changes.

After changes, start by downloading the safety program and then the function of the standard user program monitored by the safety program.

Restrictions on safety-related CPU-CPU communication

During operation (in RUN mode), you cannot establish new safety-related CPU-CPU communication by means of new SENDDP/RCVDP or SENDS7/RCVS7 instructions.

To establish new safety-related CPU-CPU communication you must always download the relevant safety program consistently to the F-CPU while in STOP mode after inserting a new SENDDP, SENDS7, RCVDP, or RCVS7 instruction.

Restrictions on F-runtime group communication

You cannot make any changes to the safety-related communication between F-runtime groups in RUN mode. This means that you cannot assign, delete, or change any DBs for F-runtime group communication of an F-runtime group.

Following changes in the F-runtime group communication, you must always download the safety program consistently to the F-CPU while in STOP mode.

Restrictions on F-I/O access

If during operation (in RUN mode), you insert an F-I/O access to an F-I/O of which no single channel value or tag from the associated F-I/O DB has yet been used in the safety program, the F-I/O access only becomes effective when the safety program is downloaded consistently to the F-CPU.

Changing the standard user program

You can download changes in the standard user program when the F-CPU is in RUN mode, regardless of whether safety mode is enabled or disabled.

⚠ WARNING

(S7-300, S7-400) In safety mode, access with the CPU password must not be authorized during changes to the standard user program as this would also allow changes to the safety program. To rule out this possibility, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU. If only one person is authorized to change the standard user program and the safety program, the protection level "Write protection" or "Read/write protection" should be configured so that other persons have only limited access or no access at all to the entire user program (standard and safety programs).*(S001)*

Procedure for applying changes to the safety program

If you download individual F-blocks to the F-CPU during operation (in RUN mode), the F-system blocks (F-SBs) and the automatically generated F-blocks are neither updated nor downloaded, resulting in an inconsistent safety program in the F-CPU. Use the following procedure to apply changes to the safety program:

1. Download the safety program consistently to the F-CPU, and activate safety mode by switching the F-CPU from STOP to RUN mode (for procedure, see Downloading project data to an F-CPU (Page 271)).
2. Follow the steps described in Acceptance of Changes (Page 323).

10.7.6 Changing the standard user program in RUN mode (S7-1200, S7-1500)

Changing the standard user program

You can download changes in the standard user program when the F-CPU is in RUN mode, regardless of whether safety mode is enabled or disabled.

10.7.7 Deleting the safety program

Deleting individual F-blocks

To delete an F-block, follow the same procedure as in *STEP 7*.

Deleting an F-runtime group

See Deleting an F-runtime group (Page 120)

(S7-300, S7-400) Remove all calls that you have used to call the safety program (Main_Safety).

Deleting the entire safety program for S7-300/400 F-CPUs *with* inserted memory card (SIMATIC Micro memory card or flash card)

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Remove all calls that you have used to call the safety program (Main_Safety).
3. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
4. Compile the project data of the F-CPU

   The offline project no longer contains a safety program.
5. To delete a safety program on the Memory Card (SIMATIC Micro Memory Card or Flash Card), insert the Memory Card (SIMATIC Micro Memory Card or Flash Card) in the programming device or PC or in a SIMATIC USB prommer.
6. Select the menu command "Project > SIMATIC Card Reader/USB memory > Show SIMATIC Card Reader/USB memory" in the menu bar.
7. Open the "SIMATIC Card Reader" folder and delete the Memory Card.
8. Insert the Memory Card into the F-CPU.

You can then download the offline standard user program to the F-CPU.

Deleting the entire safety program for S7-400 F-CPUs *without* inserted flash card

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Remove all calls that you have used to call the safety program (Main_Safety).
3. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
4. Compile the project data of the F-CPU

   The offline project no longer contains a safety program.
5. Perform a memory reset on the F-CPU (in the "Online tools" task card of the F-CPU).

You can then download the offline standard user program to the F-CPU.

Delete the entire safety program for SIMATIC S7-1200/1500 F-CPUs

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
3. Compile the project data of the F-CPU

   The offline project no longer contains a safety program.

You can then download the offline standard user program to the F-CPU.

10.8 F-change history

Enable the logging of changes to the safety program by using the option "Enable F-change history" in the *Safety Administration Editor*. The F-change history behaves like the standard change history.

An F-change history is created for each F-CPU in the project navigation under "Common data/logs".

The following is logged in the F-change history:

- Collective F-signature
- User name
- Compile time stamp
- Download of the safety program with time stamp
- Compiled F-blocks with signature and time stamp

The F-change history can contain a maximum of 5000 entries per F-CPU. When the 5000 entries are exceeded, a new F-change history is created using the name pattern "F-change history <CPU name> YYYY-MM-DD hh:mm:ss".

NOTICE
The connection between the F-CPU and the associated F-change history is made through the name of the F-change history. Therefore, do not rename the F-CPU and the F-change history. If you rename the F-CPU or the F-change history, a new F-change history with the current name of the F-CPU is started.

Note

You may not use the F-change history to recognize changes in the safety program/in the configuration of the F-I/Os during the acceptance of changes.

To accept changes, proceed as described under Acceptance of Changes (Page 323).

Note

We recommend activating the F-change history before changing over to productive operation.

System acceptance 11

11.1 Overview of System Acceptance

Introduction

During a system acceptance test, all the standards and guidelines (for example PROFINET Installation Guidelines) relevant to the specific application must be complied with. This also applies to systems that are not "subject to acceptance". For the acceptance, you must consider the requirements in the Certification Report (http://support.automation.siemens.com/WW/view/en/49368678/134200).

As a general rule, the acceptance of an F-System is performed by an independent expert. The independence required of the expert must be defined in the safety plan and depends on the required PL/SIL.

Observe all warnings in this manual.

WARNING

The F-CPU and F-I/O must be configured in the hardware and network editor of the TIA Portal as described in this documentation. F-blocks must be created with the program editor of the TIA Portal as described in this documentation. For system acceptance, you have to use the safety summary created according to this documentation. Any other procedures are not permitted. *(S056)*

Proof of correctness of components

In order for a system acceptance to be granted, you must recognize and document the correctness of the individual components. For documentation of the component properties, you must create a safety summary.

The following characteristics must be covered:

- Correctness of the safety program including hardware configuration (including testing) (Page 309)
- Completeness of the safety summary (Page 310)
- Compliance of the system library elements used in the safety program with Annex 1 of the Report for the TÜV certificate (Page 311)
- Compliance of the know-how protected F-blocks used in the safety program with their safety documentation. (Page 312)
- Completeness and correctness of the hardware configuration (Page 314)
- Correctness of the communication configuration (Page 320)
- Consistency of the online safety program (Page 321)
- Other characteristics (Page 322) such as software version, use of data from the standard user program

After the acceptance, you should archive all relevant documents and also the project data so as to make the accepted project available as a reference for a subsequent acceptance.

Safety summary

The safety summary (Page 291) is the project documentation required for acceptance of the system.

11.2 Correctness of the safety program including hardware configuration (including testing)

Verification/function test

Already during the creation, you will test (Page 293) your safety program and the associated hardware configuration. You must carry out tests with regard to the specification of your safety functions and document them before you seek acceptance for the system.

To allow you to perform a code review of your safety program and document the accepted program code, the source code of all F-blocks is printed as a part of the safety summary (Page 291), provided you have selected the "All" property for the printout.

If you want to carry out a function test after loading, you have to carry out program identification after loading. Additional information is available in "Downloading project data (Page 271)".

The correct function of the safety program must be guaranteed by verification and complete function tests before it may be used productively. You should archive the test reports along with the safety summary and the acceptance documents.

Times, for example monitoring times (Page 530) and delay times, are extremely hard to verify with functional tests (Page 271). You should check these times selectively to determine whether they are dimensioned correctly, for example, on the basis of the safety summary.

Some of these times are itemized specially in the safety summary, for example, the F-monitoring time (for communication between F-CPU and F-I/O) and the monitoring time of the safety-related CPU-CPU communication (TIMEOUT input). For the approximate determination of these monitoring times, the Excel file for response time calculation is available on the Internet (http://support.automation.siemens.com/WW/view/en/49368678/133100). Note that these monitoring times have an impact on the response times of your safety functions.

Consistency of the safety program

Check in the "General information" section of the safety summary to determine whether the safety program was recognized as "consistent".

This is the case for S7-300/400 F-CPUs only if the following signatures are also identical:

- Collective F-signature ("General information" section, "Collective F-signature")
- "Signature of F-blocks with F-attribute" ("General information" section, "Current compilation")

Consistency of the safety program is required for the acceptance. If the signatures are not identical, you should recompile the safety program and regenerate the safety summary.

11.3 Completeness of the safety summary

Introduction

If your safety program status including hardware configuration is ready for acceptance, you must carry out and document additional checks on the basis of the safety summary. The safety summary must be complete and belong to the safety program undergoing acceptance.

Procedure for creation of safety summary

To generate the safety summary, follow the procedure described in Printing project data (Page 291).

In so doing, use the "All" property in order to include the source code of your F-blocks in the printout.

Checking the safety summary for completeness

If you want to use an existing summary, whose completeness is not exactly known, you must check to determine whether the same collective F-signature is contained in the footer on all pages of the printout. This allows you to prove that all printed sheets belong to the same project.

In section "Supplementary information", you can find the number of pages in the safety summary, among other things. With this, you can prove that all pages of the safety summary are printed. Incomplete printouts (e.g. due to low on toner) must not be used for the acceptance of changes.

If you created the safety summary with the "All" option, the source code of all F-blocks will also be printed. The printout of this source code also contains the footer to enable you to easily assign the source code to a particular safety summary.

Association with the safety program

In the "General information" section of the safety summary, check whether the collective F-signature corresponds to the collective F-signature of the safety program to be accepted in the work area of the *Safety Administration Editor* under "General". If they are not the same, then the summary and safety program do not match.

11.4 Compliance of the system library elements used in the safety program with Annex 1 of the Report for the TÜV certificate

Introduction

The *STEP 7 Safety* optional package contains LAD/FBD instructions for programming of your safety program as well as F-system blocks that have been created and tested by SIEMENS and certified by TÜV for creating an executable safety program. In the process, the F-system blocks used are automatically defined by the F-system based on the set safety system version (see section "Settings" area (Page 75)).

To allow you to check whether the used versioned LAD/FBD instructions and F-system blocks correspond to Annex 1 of the Report for the TÜV certificate and to the versions you intend to use, these are listed in the safety summary.

Procedure

To check, download the current Annex 1 of the report for the TÜV certificate "SIMATIC Safety" from the Internet (http://support.automation.siemens.com/WW/view/en/49368678/134200).

Proceed as follows for the check:

WARNING

- (S7-1200, S7-1500) The versions of the versioned LAD/FBD instructions listed in the safety summary in the section "System library elements used in safety program" must correspond to the versions in Annex 1 of the Report for the TÜV Certificate.
- (S7-300, S7-400) The versions, signatures and initial value signatures of the versioned LAD/FBD instructions and F-system blocks listed in the safety summary in the section "System library elements used in safety program" must correspond to the versions, signatures and initial value signatures in Annex 1 of the Report for the TÜV Certificate.
- The versions of the versioned LAD/FBD instructions listed in the safety summary must meet the safety requirements of your application.

  Keep in mind possible differences in functionality of different versions specified in the section for the respective instruction.
- The safety system version listed in the safety summary under "Safety program settings" must match the versions in Annex 1 of the Report for the TÜV Certificate. *(S054)*

In case of discrepancies, recheck whether you have the correct versions.

11.5 Compliance of the know-how protected F-blocks used in the safety program with their safety documentation.

If you use know-how protected F-blocks for the programming of your safety program (e.g. from libraries), the source code for these is not printed in the safety summary.

Therefore, the author of the know-how protected F-block must already carry out acceptance of the F-block and provide the following information:

S7-300/400 F-CPUs

- Signature and initial value signature of the know-how protected F-block
- Versions of all the used versioned LAD/FBD instructions
- Signatures and initial value signatures of all called F-blocks

During a system acceptance test, you have to carry out the following checks using the safety summary:

- The signature and initial value signature of each know-how protected F-block listed in the safety summary in the section "F-blocks in the safety program" must agree with the signature and initial value signature documented by the author.
- The versions of the versioned LAD/FBD instructions listed in the safety summary in the section "System library elements used in safety program" must correspond to the versions of each know-how protected F-block documented by the author or must be functionally identical with these.
- The signatures and initial value signatures of the F-blocks called in each know-how protected F-block listed in the safety summary in the section "F-blocks in the safety program" must correspond to the signatures and initial value signatures (of the called F-blocks) documented by the author.

In case of differences, set the documented (or functionally identical) versions and use the F-blocks with the documented signatures and initial value signatures. If the version conflicts cannot be eliminated due to other dependencies, please contact the author of the know-how protected block in order to obtain a compatible approved version.

S7-1200/1500 F-CPUs

- Signature of the know-how protected F-block
- Safety system version when setting up the know-how protection
- Versions of all the used versioned LAD/FBD instructions
- Signatures of all called F-blocks

During a system acceptance test, you have to carry out the following checks using the safety summary:

- The signature of each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the safety program" must agree with the signature documented by the author.
- The safety system version of each know-how protected F-block listed in the safety summary under "Know-how protected F-blocks in the safety program" must match the versions in Annex 1 of the Report for the TÜV Certificate.
- The versions of the versioned LAD/FBD instructions of each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the safety program" must correspond to the versions documented by the author or must be functionally identical with these.
- The signatures of the F-blocks called in each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the safety program" must correspond to the signatures (of the called F-blocks) documented by the author.

In case of differences, set the documented (or functionally identical) versions and use the F-blocks with the documented signatures. If the version conflicts cannot be eliminated due to other dependencies, please contact the author of the know-how protected block in order to obtain a compatible approved version.

11.6 Completeness and correctness of the hardware configuration

Introduction

The hardware configuration is an essential component of the project to be accepted. With the configuration of the hardware, you have set properties that can influence the safety of signals. You must document these settings with the safety summary to prove that you fulfill the safety requirements for your application.

The section "Hardware configuration of F-I/O" is available in the safety summary for this. This section consists of several tables:

- A table with information about the F-CPU and the ranges of F-destination addresses used and of the Central F-source address of the F-CPU.
- An overview table with the F-I/O used.
- A table for each F-I/O with information about the F-I/O and all parameters of the F-I/O with the configured values.

Check whether only authorized users have the "F-admin" right in the *Safety Administration Editor* or in the standard printout of the project data.

Note

Note that you will find F-I/O that you address via safety-related I-slave-slave communication in the safety summary of the I-slave F-CPU and not in the F-CPU of the assigned DP master.

The safety summary of the F-CPU of the DP master includes a note for this F-I/O in the overview table indicating that the F-I/O is not assigned to this F-CPU.

Note

When using shared devices:

Note that you will find F-I/O that you address in a shared device in the safety summary of the F-CPU of the IO controller to which it is assigned.

The safety summary of the F-CPUs of the other IO controllers between which the shared device is divided, includes a note in the overview table for this F-I/O that it is not assigned to this F-CPU.

Procedure for checking that the hardware configuration is complete

Check whether the safety summary contains the complete configured F-I/O. Also make sure that there is no F-I/O that you have not configured as belonging to this F-CPU.

Procedure for checking the correctness of the hardware configuration using the safety summary

To check the hardware configuration for correctness, proceed as follows:

1. Check in the “F-hardware configuration“ section to verify the uniqueness of the PROFIsafe addresses.

   Please see sections PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 56) or PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 58), Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 65) and Recommendation for PROFIsafe address assignment (Page 53).

   – Check if the "Central F-source address" parameter of the individual F-CPUs differs network-wide. F-CPUs to which solely F-IOs of the PROFIsafe address type 1 are assigned do not have to be considered during the check.

   – For F-I/Os of PROFIsafe address type 1 check whether the F-destination addresses comply with the following warning:

   ⚠ WARNING

   F-I/Os of PROFIsafe address type 1 are uniquely addressed by their F-destination address (e.g. with the switch setting on the address switch).

   The F-destination address (and therefore also the switch setting on the address switch) of the F-I/O must be unique network-wide* and CPU-wide** (system-wide) **for the entire** F-I/O. The F-I/O of PROFIsafe address type 2 must also be considered. *(S051)*

   * A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

   ** "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

– For F-I/Os of PROFIsafe address type 2 check whether the F-destination addresses comply with the following warning:

WARNING

FI/O of PROFIsafe address type 2 is uniquely addressed using a combination of F-source address ("Central F-source address" parameter of the assigned F-CPU) and F-destination address.

The combination of F-source address and F-destination address for each F-I/O must be unique network-wide* and CPU-wide** (system-wide). In addition, the F-destination address may not be occupied by F-I/O of PROFIsafe address type 1.

To ensure that addresses are unique across F-CPUs for supported configurations (Page 54), you need to ensure that the "Central F-source address" parameter of all F-CPUs is unique network-wide*. This is achieved through different settings for the "Central F-source address" parameter of the F-CPUs. *(S052)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

– fail-safe GSD based DP slaves / GSD based I/O devices check whether the PROFIsafe addresses comply with the following warning:

WARNING

Check the documentation for your fail-safe GSD based DP slaves / GSD based I/O devices to find out the valid PROFIsafe address type. If you do not find the necessary information, assume PROFIsafe address type 1. Proceed as described under PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 56) or PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 58).

Set the PROFIsafe source address for fail-safe GSD based DP slaves / fail-safe GSD based I/O devices according to the manufacturer's specifications. If the PROFIsafe source address needs to correspond to the "Central F-source address" parameter of the F-CPU (PROFIsafe address type 2), you will find the latter in the "Properties" tab of the F-CPU. In this case, also check in the safety summary that the value of the F-CPU for the "Central F-source address" parameter matches the value of the PROFIsafe source address of the fail-safe GSD based DP slave / fail-safe GSD based I/O device. *(S053)*

2. Check the safety-related parameters (including F-monitoring time or F_WD_Time) of all configured F-I/O.

   You can find these parameters in the "Hardware configuration of F-I/O" section in the detailed tables for the F-I/O.

   The table consists of two parts:

   – The left part contains the parameters which refer to the F-I/O itself ("Module data").
   – The right part contains the parameters of the individual channels ("Channel parameters")

   These parameters must be set as prescribed by the safety requirements of your application.

   When using fail-safe GSD based DP slaves/GSD based I/O devices, note the relevant documents for the possible additional safety-related (technical) parameters.

   Note

   F-I/O that are to be assigned the same safety-related parameters (except for PROFIsafe addresses) can be copied during configuration. Except for the PROFIsafe addresses, you no longer have to check the safety-related parameters individually. It is sufficient to compare the "Signature of F-parameters (without addresses)" in the "Hardware configuration of the F-I/O" section in the overview table. This also applies to fail-safe GSD based DP slaves/GSD based I/O devices without i-parameters. For GSD based DP slaves / GSD based I/O devices with i-parameters, it may be that "F-parameter signature (w/o addresses)" does not match, even though all safety-related parameters, except for the PROFIsafe addresses, do match. In this case, you need to compare all safety-related parameters.

3. Check whether the article numbers of the F-I/O in the safety summary correspond to the article numbers of the actual F-I/O in the system. If the article numbers do not match, the F-I/O in the system must be spare-part compatible with the F-I/O listed in the safety summary.

4. For non-supported configuration, please see Configurations supported by the SIMATIC Safety F-system (Page 54).

⚠ WARNING

Please note the following with configurations that are not included in supported configurations:

- Make sure that the F-I/O of this configuration appears in the safety summary and that an F-I/O DB has been created for it. Otherwise, you cannot use the F-I/O in this configuration. (Contact Customer Support.)
- For F-I/Os in the PROFINET IO environment**, you must check the PROFIsafe operating mode parameter (F_Par_Version) against the safety summary to make sure that it is correct. V2 mode must be set in the PROFINET IO environment. F-I/O which only support V1 mode may not be used in the PROFINET IO environment.
- You must ensure that PROFIsafe address assignment is unique CPU-wide* and network-wide***:
  - Check the correctness of the PROFIsafe addresses with the help of the safety summary.
  - Use the safety summary to check that the F-source address corresponds to the "Central F-source address" parameter of the F-CPU for F-I/O of PROFIsafe address type 2.
  - For F-I/O of PROFIsafe address type 1 or if you cannot set the F-source address in accordance with the "Central F-source address" parameter of the F-CPU, you will have to ensure the uniqueness of the PROFIsafe address solely by assigning a unique F-destination address.

  You must check the uniqueness of the F-destination address individually for each F-I/O based on the safety summary in a configuration that is not supported.

  (S050)

* "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

** The F-I/O is located in the "PROFINET IO environment" if at least part of safety-related communication with the F-CPU takes place via PROFINET IO. If the F-I/O is connected via I-slave-slave communication, also keep in mind the communication line to the DP master/IO controller.

*** A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

5. Check that only authorized persons have the "F-admin" right.

⚠ WARNING

The "F-admin" authorization for Web server without password protection (user "Everybody" or "Anyone") is only intended for test purposes, maintenance, etc. This means only when the system is not in productive operation. In this case, you must ensure the safety of the system through other organizational measures, for example through protected access to certain areas.

Before you transition into productive operation, you must remove the "F-admin" right for the user "Everybody".

Only authorized personnel may have access to the password of the Web server user with the "F-admin" right. After downloading the hardware configuration, check whether only permitted users of the Web server have the "F-admin" right on the F-CPU. To do so, use the online view of the *Safety Administration Editor* (see also Safety Administration Editor (Page 68)).

Saving the login file and the password of the Web server in the browser is only permitted when use by unauthorized persons is prevented through other organizational measures (e.g. access protection to the PG/PC). *(S064)*

11.7 Correctness of the communication configuration

Introduction

Safety-related communication is based on the mechanisms of the standard communication of *STEP 7*.

To ensure that errors which standard communication does not discover are detected, safety-related communication connections between F-CPUs are secured. Further parameters are required for this, which you have to document and check on acceptance.

For this purpose, the "Block parameters for safety-related CPU-CPU-communication" section is available in the safety summary. In this section, there are up to two tables (for communication via PROFIBUS DP or PROFINET IO and for communication via S7 connections).

Procedure for testing for correctness of the communication configuration

To check the communication configuration for correctness, proceed as follows:

- In the "Safety-related CPU-CPU communication via PROFIBUS DP or PROFINET IO" table, check to determine whether you have assigned a unique DP_DP_ID input network-wide* for all safety-related communication connections (e.g., master-master, master-I-slave and IO controller-IO controller communication).
- In the "Safety-related CPU-CPU communication via S7 connections" table, check to determine whether you have assigned a unique R_ID input network-wide* for all safety-related communication via S7 connections.

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

11.8 Consistency of the online safety program

Once you have checked all properties of the offline safety program you must ensure that the safety program is identical on the F-CPU on which it is supposed to be run.

The signatures must match the signature from the safety summary online and offline. To do so, open the *Safety Administration Editor* and go to online view.

In the "General" area, check the information for

- Online collective signature
- Offline collective signature
- Information on whether safety programs are consistent online and offline.
- Version check view

Use the output information to check which situation you are dealing with and, if necessary, execute the recommended measure:

collective F-signatures online/offline	Consistency online to offline	Statement	Measure
	(n/a)	The safety programs are different.	Download the safety program to the F-CPU.
		The safety programs are identical but different versions of F-blocks are used.	The safety program must be downloaded to the F-CPU for the latest versions to become effective.
		The safety programs are identical.	None

Keep in mind that only a change comparison will provide reliable information as to whether the safety programs are identical. The display of signatures is used for quick identification of changes.

11.9 Other characteristics

Introduction

In addition, you must check a few more characteristics that are also relevant for the acceptance of the project.

Validity check for data transfer from the standard program to the safety program

Check to determine whether a validity check was programmed for all data transferred from the standard user program to the safety program. For this purpose, the "Data from the standard user program" section lists all tags of the standard user program that you are reading in the safety program. Tags of the safety program that you are writing in the safety program are not listed here because a plausibility check is not required for them.

Checking the program version

Check whether the version of *STEP 7 Safety* used to create the summary (in the footer of the printout) is as least as high as the version used to compile the safety program. The latter version can be found in the "General information" section of the safety summary under "Used Versions". Both versions must be listed in Annex 1 of the Report for the TÜV certificate.

Ability to disable safety mode

Make sure that safety mode cannot be disabled. For information about this, refer to section "General information" under "Safety program settings". This setting ensures that the safety mode of the safety program cannot be disabled inadvertently.

Access protection

Check in the "General information" section under "Access protection" to determine whether the setting for access protection is permitted. Note the following warning.

Otherwise, the project must not be accepted, because the safety program in the F-CPU is not protected against unauthorized accesses.

⚠ WARNING

(S7-300, S7-400) In safety mode, access with the CPU password must not be authorized during changes to the standard user program as this would also allow changes to the safety program. To rule out this possibility, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU. If only one person is authorized to change the standard user program and the safety program, the protection level "Write protection" or "Read/write protection" should be configured so that other persons have only limited access or no access at all to the entire user program (standard and safety programs).*(S001)*

WARNING

(S7-1200, S7-1500) In safety mode, the safety program must be password-protected. You therefore need to configure at least the protection level "Full access (no protection)". This protection level only allows full access to the standard user program, not to F-blocks.

If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)". *(S041)*

See also

Data Transfer from Standard User Program to Safety Program (Page 167)

11.10 Acceptance of Changes

Introduction

In general, you can adopt the same approach for the acceptance of changes as the initial acceptance (see Overview of System Acceptance (Page 308)).

You must check the entire safety program including the HW configuration for changes.

WARNING

In case of acceptance of changes, you must check whether the intended changes were made correctly.

You must also check whether unintentional changes may have been made at another location (for example, I/O or instructions that were added).*(S072)*

To avoid the acceptance of the entire system in case of negligible changes, *STEP 7 Safety* helps you to identify those parts of your safety program that have changed.

For an acceptance of changes, it is sufficient to check the following:

- Checking the changed or newly added F-blocks.
- Checking the changed or newly added instructions and F-system blocks.
- Checking the safety-related parameters of the changed or newly added F-I/O.

You then perform a function test of the changed or newly added F-blocks/F-I/O.

Check that the changes have no impact on the unchanged parts of the safety program, in particular for deleted F-blocks or deleted F-I/O.

Note

Acceptance of changes is not possible after CPU migration.

WARNING

When you make changes in which the assignment of input/output addresses and wiring can change, then you must perform a wiring test (Page 297).

Examples for such changes are:

- Adding F-I/O
- Changing the start address of F-I/O
- Changing the slot position of F-I/O
- Changing
  - the rack
  - the slave/device address
  - the PROFIBUS DP/PROFINET IO subnet
  - the IP address
  - the device name

(S071)

Detection of changes in the safety program

To detect changes in the safety program, proceed as follows:

1. Perform an offline-offline comparison between the changed safety program and the accepted safety program (see Comparing Safety Programs (Page 289)). Use filter setting "Compare only F-blocks relevant for certification". This limits the output of the comparison to exactly those F-blocks that must be considered for the acceptance of changes.

   WARNING

   Make sure that the comparison criterion "Safety" is enabled so that the criteria relevant for an acceptance of changes are taken into consideration in the comparison. *(S069)*

   By disabling the remaining comparison criteria, you can deselect those differences that are irrelevant for the acceptance of changes (e.g. time stamp).

   The status of the comparison helps you to identify which F-blocks were changed.

Detection of safety-related changes in the configuration of the F-I/O

There are two possible ways of detecting safety-related changes in the configured F-I/O:

- Comparison in the comparison editor
- Comparison based on two safety summaries

Comparison in the comparison editor

If you have saved the project with the accepted F-CPU, you can also perform an offline-offline comparison of the changed project and the accepted project to detect changes in the configuration of the F-I/O (see Comparing Safety Programs (Page 289)). Both projects must be consistent and compiled.

1. Navigate in the comparison result to the "System blocks > STEP 7 Safety > F-I/O DBs" folder. All data blocks listed in this folder are F-I/O-DBs and are each assigned to an F-I/O.
   - If the F-I/O-DBs in the comparison result are identical, this means that the safety-related configuration of the assigned F-I/O was also not changed. Standard-parameters may have changed.
   - If the F-I/O-DBs in the comparison result are not identical, this means that the safety-related configuration of the assigned F-I/O was also changed.
   - If the F-F-I/O DBs in the comparison result are marked as “not existing”, associated F-I/O may be deleted or the name or start addresses were changed. In this case you can find the assignment of an F-I/O DB to a specific F-I/O in the safety summary under "Hardware configuration of F-I/O".
2. If you have found changed F-I/O, you can check the changed parameters in the safety summary as described below.

Comparison based on two safety summaries

Carry out a comparison based on two safety summaries as follows:

1. In the section "Hardware configuration of the F-I/O" compare the start addresses (I/O addresses), the parameter "Behavior after channel fault" and the slot of the F-I/O.
2. In the overview table of the utilized F-I/O in the "Hardware configuration of F-I/O" section, compare the parameter CRCs of the F-I/O with those in the safety summary of the accepted F-CPU.
   - If the "Parameter signature (without addresses)" is different for an F-I/O, this indicates the existence of a safety-related change of safety-related parameters of the F-I/O. In addition, the PROFIsafe addresses may also be changed.

     In this case, in the “F-I/O hardware configuration“ section check the safety-related parameters of the F-I/O and verify the uniqueness of the PROFIsafe addresses.
   - If the "Parameter signature (w/o addresses) is identical, it is possible that only the PROFIsafe addresses were changed.

     In this case it is sufficient to verify the uniqueness of the PROFIsafe addresses.

Check as described in section “Completeness and correctness of the hardware configuration (Page 314)“.

See also

Accessing tags of the F-I/O DB (Page 144)

Operation and Maintenance 12

12.1 Notes on Safety Mode of the Safety Program

Introduction

Pay attention to the following important notes on safety mode of the safety program.

Use of simulation devices/simulation programs

⚠ WARNING

Use of simulation devices/simulation programs

If you operate simulation devices or simulation programs that generate safety message frames, e.g., based on PROFIsafe, and make them available to the SIMATIC Safety F-system via the bus system (such as PROFIBUS DP or PROFINET IO), you must ensure the safety of the F-system using organizational measures, such as operational monitoring and manual safety shutdown.

If you use the S7-PLCSIM (Page 293) to simulate safety programs, these measures are not necessary because S7-PLCSIM cannot establish an online connection to a real component.

Note, for example, that a protocol analyzer is not permitted to perform any function that reproduces recorded message frame sequences with correct time behavior. *(S030)*

Switching F-CPU to STOP mode

⚠ WARNING

STOP via programming device/PC, mode switch, communication function or "STP" instruction

Initiating STOP by means of programming device/PC operation, mode switch, communication function or "STP" instruction as well as maintaining the STOP state is not safety-oriented. This STOP state can be easily (and unintentionally) be revoked by programming device/PC operation.

When an F-CPU is switched from STOP to RUN mode, the standard user program starts up in the usual way. When the safety program is started up, all F-DBs are initialized with the values from the load memory - as is the case with a cold restart. This means that saved error information is lost. The F-system automatically reintegrates the F-I/O.

If your process does not allow such a startup, you must program a restart/startup protection in the safety program: The output of process data must be blocked until manually enabled. This enable must not occur until it is safe to output process data and faults have been corrected (see Programming startup protection (Page 127)). *(S031)*

CRC error in safety-related communication

Note

CRC error in safety-related communication

If you observe that an F-CPU requests manual acknowledgement of a CRC error more than once within the space of 100 hours, and this occurs repeatedly, check whether the PROFINET or PROFIBUS installation guidelines have been followed.

There is a CRC error if:

- The ACK_REQ tag of the F-I/O DB is set and the DIAG tag of the F-I/O DB (bit 2 or bit 6) indicates CRC errors
  or
- A CRC error is entered in the diagnostic buffer of the F-CPU

In this case, the failure probability values (https://support.industry.siemens.com/cs/ww/en/view/109481784) (PFD_{avg}/PFH) for safety-related communication no longer apply.

Information on installation guidelines for PROFINET and PROFIBUS can be found in:

- PROFIBUS Installation Guidelines (www.profibus.com/PBInstallationGuide)
- PROFIBUS Interconnection Technology (http://www.profibus.com/nc/downloads/downloads/profibus-interconnection-technology/display/)
- PROFINET Installation Guidelines (www.profibus.com/PNInstallationGuide)
- PROFINET Cabling and Interconnection Technology (http://www.profibus.com/nc/downloads/downloads/profinet-cabling-and-interconnection-technology/display/)
- PROFIsafe Environment Requirements (www.profibus.com/PROFIsafeRequirements)

When your review indicates that the configuration guidelines for PROFIBUS and PROFINET have been met, contact Customer Support.

12.2 Replacing Software and Hardware Components

Replacement of software components

When replacing software components on your programming device or PC, e.g. with a new version of *STEP 7*, you must adhere to the information regarding upward and downward compatibility in the documentation and readme files for these products (e.g. *STEP 7 Safety*).

When replacing *STEP 7 Safety*, check whether the version of *STEP 7 Safety* is listed in Annex 1 of the Report for the TÜV certificate.

Replacement of hardware components

Hardware components for SIMATIC Safety (F-CPU, F-I/O, batteries, etc.) are replaced in the same way as in standard automation systems.

Replacement of S7-1500 F software Controllers

⚠ WARNING

After replacing a CPU module (e.g. new PC with data storage medium of old PC) or replacement of the data storage medium (e.g. data storage medium with safety program 1 is replaced with data storage medium with safety program 2), you must use the Panel to check if the correct collective F-signature is displayed or whether a program identification is carried out. *(S066)*

Removing and inserting F-I/O during operation

If removing and inserting is possible for standard I/O during operation, it is also possible for the respective F-I/O. However, be aware that replacing an F-I/O module during operation can cause a communication error in the F-CPU.

You must acknowledge the communication error in your safety program in the ACK_REI tag of the F-I/O DB (Page 135) or, alternatively, by using the "ACK_GL (Page 432)" instruction. Without an acknowledgment, the F-I/O will remain passivated.

CPU firmware update

Check of the CPU operating system for F-approval: When using a new CPU operating system (firmware update), you must check to see if the CPU operating system you are using is approved for use in an F-system.

The minimum CPU operating system versions with guaranteed F-capability are specified in the appendix of the Certificate. This information and any notes on the new CPU operating system must be taken into account.

Firmware update for interface module

When using a new operating system for an interface module, e.g. IM 151-1 HIGH FEATURE ET 200S (firmware update), you must observe the following:

If you have selected the "Activate firmware after update" option for the firmware update (see *Help on STEP 7*, "Online & Diagnostics"), the IM will be automatically reset following a successful download operation and will then run on the new operating system. Note that the firmware update for interface modules during operation generates a communication error in the F-CPU.

You must acknowledge the communication error in your safety program in the ACK_REI tag of the F-I/O DB (Page 135) or, alternatively, by using the "ACK_GL (Page 432)" instruction. Without an acknowledgment, the F-I/O will remain passivated.

Preventive maintenance (proof test)

Proof test for complex electronic components generally means replacement with new, unused components.

PFD_{avg} and PFH values for S7-300/400 F-CPUs and F-I/O

You will find a list of the failure probability values (PFD_{avg}, PFH values) for components that can be used in SIMATIC Safety on the Internet.

PFD_{avg} and PFH values for S7-1200/1500 F-CPUs

Below are the probability of failure values (PFD_{avg}, PFH values) for S7-1200/1500 F-CPUs with a service life of 20 years and an MTTR of 100 hours:

Operation in low demand mode low demand mode **According to IEC 61508:2010:** **PFD_{avg} = Average probability of a dangerous failure on demand**	**Operation in high demand or continuous mode** high demand/continuous mode **According to IEC 61508:2010:** **PFH = Average frequency of a dangerous failure [h^{-1}]**
< 2E-05	< 1E-09

PFD_{avg} and PFH values for safety-related communication

Below you will find the failure probability values (PFD_{avg}, PFH values) for safety-related communication:

Operation in low demand mode low demand mode **According to IEC 61508:2010:** **PFD_{avg} = Average probability of a dangerous failure on demand**	**Operation in high demand or continuous mode** high demand/continuous mode **According to IEC 61508:2010:** **PFH = Average frequency of a dangerous failure [h^{-1}]**
< 1E-05*	< 1E-09*

*** Note on S7-300/400 F-CPUs:**
The PFH value is valid under the assumption that a maximum of 100 F-I/Os are involved in a safety function. If you use more than 100 F-I/Os, you have to also add 4E-12 per F-I/O for the safety function.
The PFD_{avg} value is valid for a service life of 20 years and under the assumption, that a maximum of 25 F-I/Os are involved in a safety function. If more than 25 F-I/OS are used, you need to add 3.5E-7 per F-I/O for this safety function.

12.3 Special features when creating and importing images of an S7-1500 F Software Controller

Creating an image

⚠ WARNING

You must comply with the following points when creating an image with a safety program:

- You must limit access to an S7-1500 F Software Controller through access protection to persons who are authorized to create images.
- Before creating the image, you must use program identification to ensure that the correct safety program is installed on the S7-1500 F Software Controller.
- Images with safety programs must be created on an empty data carrier (deleted or formatted) or an existing image must be explicitly deleted.
- After creating the image, remove the data carrier containing the image.
- Clearly label the data storage medium (e.g. with the collective F-signature). *(S073)*

NOTICE

If the safety program in the image and the old safety program on the S7-1500 F Software Controller are not identical, the imported safety program would not start. In this case, you must download the safety program to the F-CPU once again. For example, with the TIA Portal. Therefore, you should always keep your image backups up-to-date.

Import image

⚠ WARNING

You must comply with the following points when importing an image with a safety program:

- You must limit access to an S7-1500 F Software Controller through access protection to persons who are authorized to import images.
- When importing an image via LAN, remote access or comparable accesses, you have to ensure access protection (e.g. via Windows administrator permission (ADMIN)). Note, however, that only authorized persons are set up as users.
- To ensure that the images are written to the correct S7-1500 F software controller, when importing an image via LAN you must ensure that only one S7-1500 F software controller can be accessed. For example, by removing the physical connections and routing options to other S7-1500 F software controllers.
- You must ensure that the correct safety program is on the image, for example, through unique identification of the data storage medium.
- After importing the image, remove the image and copies thereof.
- After importing the image, you must use program identification to ensure, for example with the Panel, that the correct safety program is installed on the S7-1500 F software controller.*(S074)*

12.4 Guide to diagnostics (S7-300, S7-400)

Introduction

Here you find a compilation of diagnostic capabilities that can be evaluated for your system when an error occurs. Most of the diagnostic capabilities are the same as those in standard automation systems. The sequence of steps represents a recommendation.

Steps for evaluating diagnostic capabilities

The following table shows the steps you take to evaluate diagnostic capabilities.

Step	Procedure	Reference
1	**Evaluate LEDs on the hardware (F-CPU, F-I/O):** • BUSF LED on the F-CPU: Flashes when a communication error occurs on PROFIBUS DP/PROFINET IO; On if a programming error occurs when OB 85 and OB 121 are programmed (e.g. instance DB is not loaded) • STOP LED on the F-CPU: illuminates when the F-CPU is in STOP mode • Fault LEDs on the F-I/O: e.g. SF-LED (group error LED) on if any fault occurs in the individual F-I/O	*Manuals for F-CPU and F-I/O*
2	**Evaluate diagnostic buffer of the modules:** You read the diagnostic buffer of a module (F-CPU, F-I/O, CP) in its online and diagnostic view in the "Diagnostic buffer" group under the "Online & Diagnostics" folder.	*Help on STEP 7 and manuals for the F-CPU and F-I/O*
3	**Evaluate stacks of the F-CPU:** when the F-CPU is in STOP mode, read the following successively: • Block stack: Check whether STOP mode of the F-CPU was triggered by an F-block of the safety program • Interruption stack • Local data stack	*Help on STEP 7*

Step	Procedure	Reference
4	**Evaluate diagnostic tag of the F-I/O DB using testing and commissioning functions, by means of an operator control and monitoring system, or in the standard user program:** Evaluate the DIAG tag in the F-I/O DB	F-I/O access (Page 128)
5	**Evaluate diagnostic outputs of the instance DBs of instructions using testing and commissioning functions, using an operator control and monitoring system, or in the standard user program:** • Evaluate the following for MUTING, EV1oo2DI, TWO_H_EN, MUT_P, ESTOP1, FDBACK, SFDOOR in the assigned instance DB: – Output DIAG • Evaluate the following for SENDDP or RCVDP in the assigned instance DB: – Output RET_DPRD/RET_DPWR – Output DIAG • Evaluate the following for SENDS7 or RCVS7 in the assigned instance DB: – Output STAT_RCV – Output STAT_SND – Output DIAG	Instructions

Tip on RET_DPRD/RET_DPWR

The diagnostic information of the RET_DPRD/RET_DPWR outputs of the SENDDP or RCVDP instructions corresponds to the diagnostic information of the RETVAL return value of the "DPRD_DAT" and "DPWR_DAT" instructions. You can find the description in the help on *STEP 7* for the "DPRD_DAT" and "DPWR_DAT" instructions.

Tip: STAT_RCV and STAT_SND

The diagnostic information of the STAT_RCV output of the SENDS7 or RCVS7 instructions corresponds to the diagnostic information of the STATUS output of the "URCV" instruction. The diagnostic information of the STAT_SND output of the SENDS7 or RCVS7 instructions corresponds to the diagnostic information of the STATUS output of the "USEND" instruction. You can find the description in the help on *STEP 7* for the instruction "UCRV" or "USEND" .

12.5 Guide to diagnostics (S7-1500)

Detailed information on diagnostics for an S7-1500 F-CPU can be found in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

12.6 Guide to diagnostics (S7-1200)

Detailed information on diagnostics for an S7-1200 F-CPU can be found in the S7-1200 Functional Safety manual (http://support.automation.siemens.com/WW/view/en/104547552).

STEP 7 Safety V14 instructions 13

Overview of instructions for the safety program

When programming an F-block, you can find all instructions available for programming an F-block in LAD or FBD with the configured F-CPU in the "Instructions" task card.

In addition to the instructions that are familiar to you from programming a standard block, there are also special safety functions, e.g., for two-hand monitoring, discrepancy analysis, muting, emergency STOP/emergency OFF, safety door monitoring, and feedback monitoring and instructions for safety-related CPU-CPU communication.

Note the following

Note

Preconnection of enable input EN or evaluation of enable output ENO is not possible.

13.1 General

13.1.1 LAD

13.1.1.1 New network (STEP 7 Safety V14)

Requirement

An F-block is open.

Procedure

To insert a new network, follow these steps:

1. Select the network after which you want to insert a new network.
2. Select the "Insert network" command in the shortcut menu.

Note

If you insert an element into the last empty network of the F-block in an LAD program, a new empty network is automatically inserted below it.

Result

A new empty network is inserted into the F-block.

13.1.1.2 Empty box (STEP 7 Safety V14)

Requirement

A network is available.

Procedure

To insert an LAD instruction into a network using an empty box, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Empty box".
3. Use a drag-and-drop operation to move the "Empty box" element to the desired place in the network.
4. Hover the cursor over the yellow triangle in the top right corner of the empty box.

   A drop-down list is displayed.
5. Select the required instruction from the drop-down list.

If the instruction acts as a function block (FB) within the system, the "Call options" dialog opens. In this dialog, you can create an instance data block for the function block, either as a single instance or, if necessary, multi-instance, in which data of the inserted instruction are stored. Once it is created, the new instance data block can be found in the "Program resources" folder in the project tree under "Program blocks > System blocks". If you have selected "multi-instance", you can find it in the block interface in the "Static" section.

Result

The empty box is changed to the appropriate instruction. Placeholders are inserted for the parameters.

13.1.1.3 Open branching (STEP 7 Safety V14)

Description

Use branches to program parallel connections with the Ladder Logic (LAD) programming language. Branches are inserted into the main current path. You can insert several contacts into the branch, thereby creating a parallel connection from series connections. You can program complex ladder diagrams in this way.

Requirement

- A network is available.
- The network contains elements.

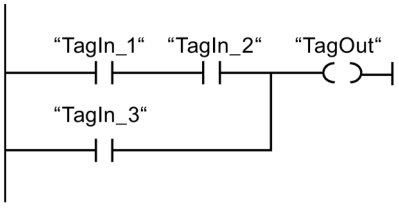
Procedure

To insert a new branch in a network, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Open branch".
3. Use a drag-and-drop operation to move the element to the desired place in the network.
4. If you want to connect the new branch directly to the power rail, drag the element to the power rail.

Example

The following figure provides an example of how to use branches:



13.1.1.4 Close branching (STEP 7 Safety V14)

Description

Branches must be closed again at suitable places. If necessary, branches will be arranged so that they do not cross each other.

Requirement

A branch is available.

Procedure

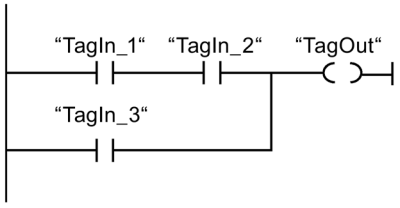
To close an open branch, follow these steps:

1. Select the open branch.
2. Press and hold down the left mouse button.

   A dashed line will appear as soon as the cursor is moved.
3. Drag the dashed line to a suitable place on the network. Permissible connections are indicated by green lines.
4. Release the left mouse button.

Example

The figure below provides an example of how to use branches:



13.1.2 FBD

13.1.2.1 New network (STEP 7 Safety V14)

Requirement

An F-block is open.

Procedure

To insert a new network, follow these steps:

1. Select the network after which you want to insert a new network.
2. Select the "Insert network" command in the shortcut menu.

Note

If you insert an element into the last empty network of the F-block in an FBD program, a new empty network is automatically inserted below it.

Result

A new empty network is inserted into the F-block.

13.1.2.2 Empty box (STEP 7 Safety V14)

Requirement

A network is available.

Procedure

To insert FBD elements into a network using an empty box, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Empty box".
3. Use a drag-and-drop operation to move the "Empty box" element to the desired place in the network.
4. Hover the cursor over the yellow triangle in the top right corner of the empty box.

   A drop-down list is displayed.
5. Select the desired FBD element from the drop-down list.

If the instruction acts as a function block (FB) within the system, the "Call options" dialog opens. In this dialog, you can create an instance data block for the function block, either as a single instance or, if necessary, multi-instance, in which data of the inserted instruction are stored. Once it is created, the new instance data block can be found in the "Program resources" folder in the project tree under "Program blocks > System blocks". If you have selected "multi-instance", you can find it in the block interface in the "Static" section.

Result

The empty box is changed to the appropriate instruction. Placeholders are inserted for the parameters.

13.1.2.3 Open branching (STEP 7 Safety V14)

Description

You use branches, which you insert between the boxes, to program parallel connections with the Function Block Diagram (FBD) programming language You can insert additional boxes in the branch, thereby programming complex function block diagrams.

Requirement

A network is available.

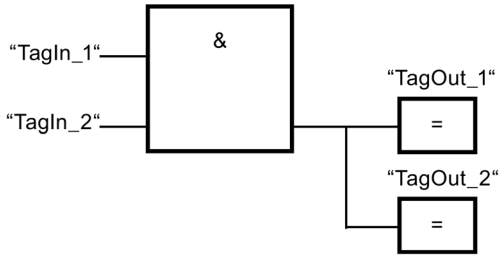
Procedure

To insert a new branch in a network, follow these steps:

1. Open the "Instructions" task card.
2. Navigate in the pane to "Basic instructions > General > Branch".
3. Use a drag-and-drop operation to move the element to the desired place to a connecting line between two boxes.

Example

The following figure provides an example of how to use branches:



13.1.2.4 Insert binary input (STEP 7 Safety V14)

Description

Use the "Insert binary input" instruction to expand the box of one of the following instructions by a binary input:

- "AND logic operation"
- "OR logic operation"
- "EXCLUSIVE OR logic operation"

You can query the signal state of several operands by expanding the instruction box.

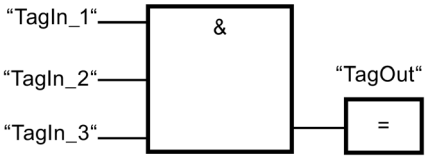
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



The box of instruction "AND logic operation" has been expanded by an additional binary input at which the signal state of operand "TagIn_3" is queried. Output "TagOut" is set when the signal state of operands "TagIn_1", "TagIn_2", and "TagIn_3" is "1".

See also

AND logic operation (STEP 7 Safety V14) (Page 356)

OR logic operation (STEP 7 Safety V14) (Page 357)

X: EXCLUSIVE OR logic operation (STEP 7 Safety V14) (Page 358)

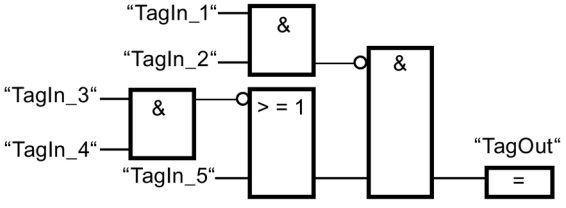
13.1.2.5 Invert RLO (STEP 7 Safety V14)

Description

You can use the "Invert RLO" instruction to invert the result of logic operation (RLO).

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- Input "TagIn_1" or "TagIn_2" has signal state "0".
- Input "TagIn_3" or "TagIn_4" has the signal state "0" or input "TagIn_5" has the signal state "1".

13.2 Bit logic operations

13.2.1 LAD

13.2.1.1 ---| |---: NO contact (STEP 7 Safety V14)

Description

The activation of the normally open contact depends on the signal state of the associated operand. If the operand has signal state "1," the normally open contact is closed. Power flows from the left power rail through the normally open contact into the right power rail and the signal state at the output of the instruction is set to "1".

If the operand has signal state "0," the normally open contact is not activated. The power flow to the right power rail is interrupted and the signal state at the output of the instruction is reset to "0".

Two or more normally open contacts are linked bit-by-bit by AND when connected in series. With a series connection, power flows when all contacts are closed.

The normally open contacts are linked by OR when connected in parallel. With a parallel connection, power flows when one of the contacts is closed.

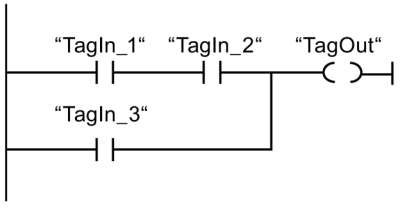
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	Operand whose signal state is queried.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "1".

13.2.1.2 ---| / |---: NC contact (STEP 7 Safety V14)

Description

The activation of the normally closed contact depends on the signal state of the associated operand. If the operand has signal state "1", the normally closed contact is opened and the signal state at the output of the instruction is reset to "0".

If the operand has signal state "0", the normally closed contact is not activated and the signal state at the output of the instruction is set to "1".

Two or more normally closed contacts are linked bit-by-bit by AND when connected in series. With a series connection, power flows when all contacts are closed.

The normally closed contacts are linked by OR when connected in parallel. With a parallel connection, power flows when one of the contacts is closed.

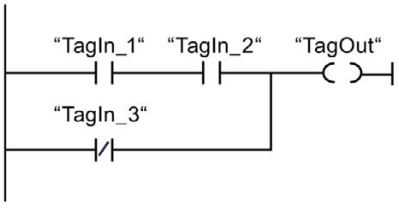
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	Operand whose signal state is queried.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "0".

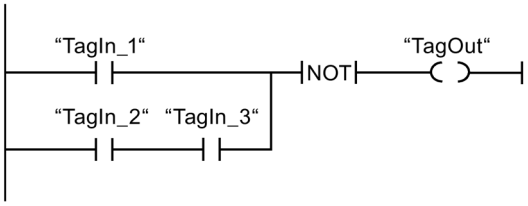
13.2.1.3 --|NOT|--: Invert RLO (STEP 7 Safety V14)

Description

You can use the "Invert RLO" instruction to invert the signal state of the result of logic operation (RLO). When the signal state is "1" at the input of the instruction, the output of the instruction has the signal state "0". When the signal state is "0" at the input of the instruction, the output has the signal state "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operands "TagIn_2" and "TagIn_3" have signal state "1".

13.2.1.4 ---( )---: Assignment (STEP 7 Safety V14)

Description

You can use the "Assignment" instruction to set the bit of a specified operand. When the result of logic operation (RLO) at the input of the coil is "1," the specified operand is set to signal state "1". When the signal state is "0" at the input of the coil, the bit of the specified operand is reset to "0".

The instruction does not influence the RLO. The RLO at the input of the coil is sent immediately to the output.

The "Assignment" instruction can be placed at any position in the network.

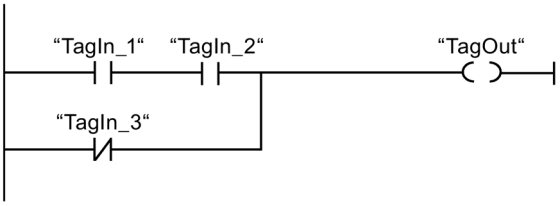
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand to which the RLO is assigned.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "0".

13.2.1.5 ---(R)---: Reset output (STEP 7 Safety V14)

Description

You can use the "Reset output" instruction to reset the signal state of a specified operand to "0".

If power flows to the coil (RLO is "1"), the specified operand is set to "0". If the result of logic operation at the input of the coil is "0" (no signal flow to the coil), the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the input of the coil is sent directly to the output of the coil.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

Note

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

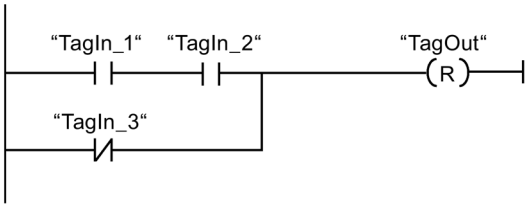
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is reset when RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.2.1.6 ---(S)---: Set output (STEP 7 Safety V14)

Description

You can use the "Set output" instruction to set the signal state of a specified operand to "1".

If power flows to the coil (RLO is "1"), the specified operand is set to "1". If the result of logic operation at the input of the coil is "0" (no signal flow to the coil), the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the input of the coil is sent directly to the output of the coil.

Note

The instruction is not executed if it is applied to an output of an F-I/O that is passivated (e.g., during startup of the F-system). Therefore, it is preferable to access outputs of the F-I/O using only the "Assignment" instruction.

An F-I/O output is passivated if QBAD or QBAD_O_xx = 1 or value status = 0 is set in the corresponding F-I/O DB.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

Note

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

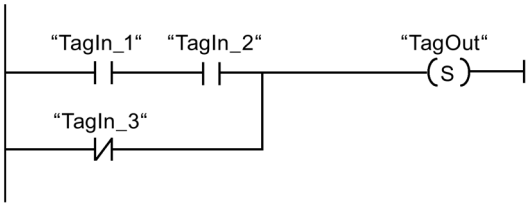
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is set when RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.2.1.7 SR: Set/reset flip-flop (STEP 7 Safety V14)

Description

You can use the "Set/reset flip-flop" instruction to set or reset the bit of the specified operand based on the signal state of inputs S and R1. If the signal state at input S is "1" and the signal state at input R1 is "0", the specified operand is set to "1". If the signal state at input S is "0" and the signal state at input R1 is "1", the specified operand is reset to "0".

Input R1 takes priority over input S. If the signal state is "1" at the two inputs S and R1, the signal state of the specified operand is reset to "0".

The instruction is not executed if the signal state at the two inputs S and R1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

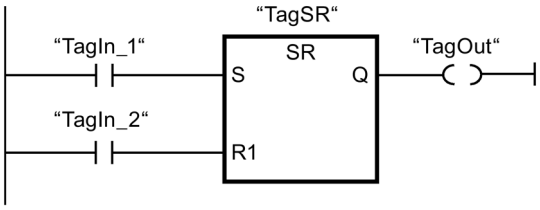
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
S	Input	BOOL	Enable set
R1	Input	BOOL	Enable reset
<Operand>	Output	BOOL	Operand that is set or reset.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands "TagSR" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands "TagSR" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Both operands "TagIn_1" and "TagIn_2" have signal state "1".

13.2.1.8 RS: Reset/set flip-flop (STEP 7 Safety V14)

Description

You can use the "Reset/set flip-flop" instruction to reset or set the bit of the specified operand based on the signal state of inputs R and S1. When the signal state is "1" at input R and "0" at input S1, the specified operand is reset to "0". When the signal state is "0" at input R and "1" at input S1, the specified operand is set to "1".

Input S1 takes priority over input R. If the signal state is "1" at the two inputs R and S1, the signal state of the specified operand is set to "1".

The instruction is not executed if the signal state at the two inputs R and S1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

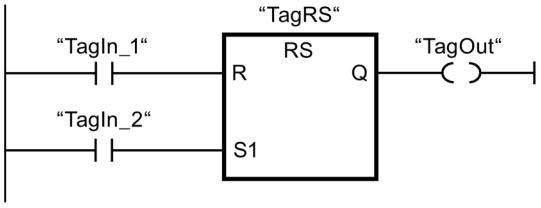
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
R	Input	BOOL	Enable reset
S1	Input	BOOL	Enable set
<Operand>	Output	BOOL	Operand that is reset or set.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands "TagRS" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands "TagRS" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Operands "TagIn_1" and "TagIn_2" have signal state "1".

13.2.1.9 --|P|--: Scan operand for positive signal edge (STEP 7 Safety V14)

Description

You can use the "Scan operand for positive signal edge" instruction to determine if there is a change from "0" to "1" in the signal state of a specified operand (<Operand1>). The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation so that the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

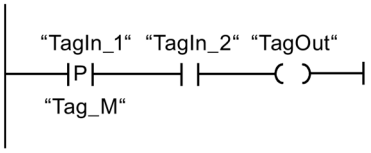
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when the following conditions are fulfilled:

- There is a rising edge at input "TagIn_1". The signal state of the previous query is saved at edge memory bit "Tag_M".
- The signal state of operand "TagIn_2" is "1".

13.2.1.10 --|N|--: Scan operand for negative signal edge (STEP 7 Safety V14)

Description

You can use the "Scan operand for negative signal edge" instruction to determine if there is a change form "1" to "0" in the signal state of a specified operand. The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation so that the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

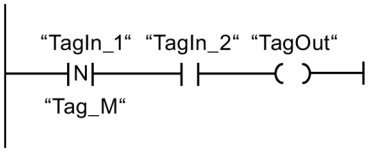
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when the following conditions are fulfilled:

- There is a falling edge at operand "TagIn_1". The signal state of the previous query is saved at edge memory bit "Tag_M".
- The signal state of operand "TagIn_2" is "1".

13.2.1.11 P_TRIG: Scan RLO for positive signal edge (STEP 7 Safety V14)

Description

You can use the "Scan RLO for positive signal edge" instruction to query a change in the signal state of the result of logic operation from "0" to "1". The instruction compares the current signal state of the result of logic operation (RLO) with the signal state of the previous query, which is saved in the edge bit memory (<Operand>). If the instruction detects a change in the RLO from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation so that the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

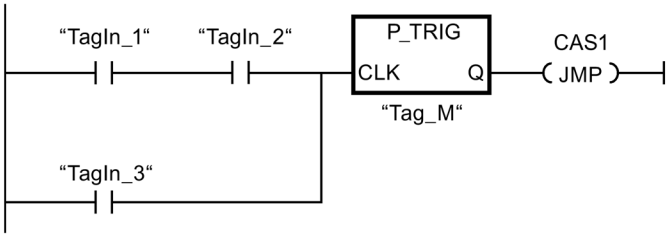
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO from the previous bit logic operation is saved in edge memory bit "Tag_M". If a change in the RLO signal state from "0" to "1" is detected, the program jumps to jump label CAS1.

13.2.1.12 N_TRIG: Scan RLO for negative signal edge (STEP 7 Safety V14)

Description

You can use the "Scan RLO for negative signal edge" instruction to query a change in the signal state of the result of logic operation from "1" to "0". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation so that the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

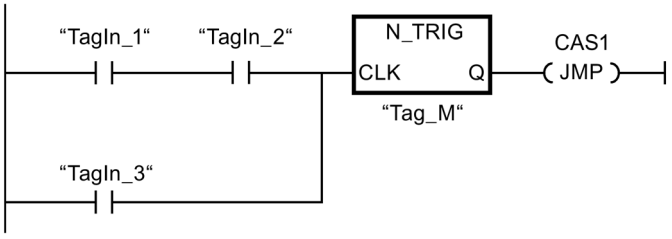
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO of the previous bit logic operation is saved in edge bit memory "Tag_M". If a change in the RLO signal state from "1" to "0" is detected, the program jumps to jump label CAS1.

13.2.2 FBD

13.2.2.1 AND logic operation (STEP 7 Safety V14)

Description

You can use the "AND logic operation" instruction to query the signal states of two or more specified operands and evaluate them according to the AND truth table.

If the signal state of all the operands is "1", then the conditions are fulfilled and the instruction returns the result "1". If the signal state of one of the operands is "0", then the conditions are not fulfilled and the instruction generates the result "0".

If the "AND logic operation" instruction is the first instruction in a logic string, it saves the result of its signal state query in the RLO bit.

Each "AND logic operation" instruction that is not the first instruction in the logic string logically combines the result of its signal state query with the value saved in the RLO bit. This logical combination is performed according to the AND truth table.

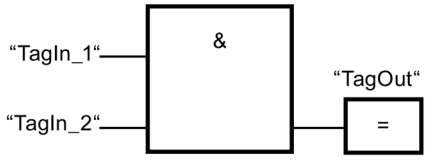
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the signal state of operands "TagIn_1" and "TagIn_2" is "1".

AND truth table

The following table shows the results when linking two operands by an AND logic operation:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	1	1
0	1	0
1	0	0
0	0	0

See also

Insert binary input (STEP 7 Safety V14) (Page 340)

13.2.2.2 OR logic operation (STEP 7 Safety V14)

Description

You can use the "OR logic operation" instruction to get the signal states of two or more specified operands and evaluate them according to the OR truth table.

If the signal state of at least one of the operands is "1", then the conditions are fulfilled and the instruction returns the result "1". If the signal state of all of the operands is "0", then the conditions are not fulfilled and the instruction generates the result "0".

If the "OR logic operation" instruction is the first instruction in a logic string, it saves the result of its signal state query in the RLO bit.

Each "OR logic operation" instruction that is not the first instruction in the logic string, logically combines the result of its signal state query with the value saved in the RLO bit. This logical combination is performed according to the OR truth table.

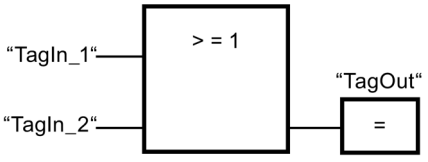
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the signal state of operand "TagIn_1" or "TagIn_2" is "1".

OR truth table

The following table shows the results when linking two operands by an OR logic operation:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	0	1
0	1	1
1	1	1
0	0	0

See also

Insert binary input (STEP 7 Safety V14) (Page 340)

13.2.2.3 X: EXCLUSIVE OR logic operation (STEP 7 Safety V14)

Description

You can use the "EXCLUSIVE OR logic operation" instruction to get the result of a signal state query according to the the EXCLUSIVE OR truth table.

With an "EXCLUSIVE OR logic operation" instruction, the signal state is "1" when the signal state of one of the two specified operands is "1". When more than two operands are queried, the overall result of logic operation is "1" if an odd-numbered quantity of queried operands returns the result "1".

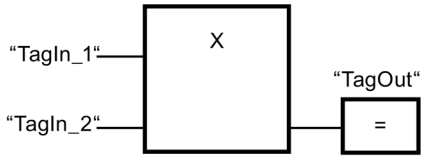
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the signal state of one of the two operands "TagIn_1" and "TagIn_2" is "1". When both operands have signal state "1" or "0" then output "TagOut" is reset.

EXCLUSIVE OR truth table

The following table shows the results when two operands are linked by an EXCLUSIVE OR:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	0	1
0	1	1
1	1	0
0	0	0

The following table shows the results when three operands are linked by an EXCLUSIVE OR:

Signal state of the first operand	Signal state of the second operand	Signal state of the third operand	Result of logic operation
1	0	0	1
0	1	1	0
0	1	0	1
1	0	1	0
0	0	1	1
1	1	0	0
1	1	1	1
0	0	0	0

See also

Insert binary input (STEP 7 Safety V14) (Page 340)

13.2.2.4 =: Assignment (STEP 7 Safety V14)

Description

You can use the "Assignment" instruction to set the bit of a specified operand. If the result of logic operation (RLO) at the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is set to signal state "1". If the signal state at the box input is "0", the bit of the specified operand is reset to "0".

The instruction does not influence the RLO. The RLO at the box input is assigned directly to the operand located above the Assign box.

The "Assignment" instruction can be placed at any position in the logic operation sequence.

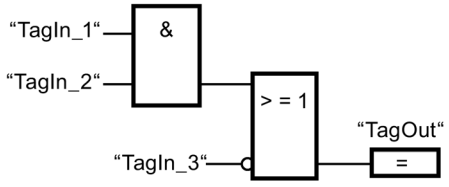
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand to which the RLO is assigned.

Example

The following example shows how the instruction works:



Operand "TagOut" at the output of the "Assignment" instruction is set when one of the following conditions is fulfilled:

- Inputs "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at input "TagIn_3" is "0".

13.2.2.5 R: Reset output (STEP 7 Safety V14)

Description

You can use the "Reset output" instruction to reset the signal state of a specified operand to "0".

If the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is reset to "0". If there is a result of logic operation of "0" at the box input, the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the box input is transferred directly to the box output.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

Note

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

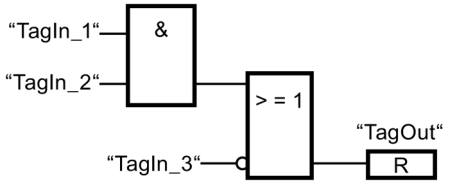
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is reset with RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.2.2.6 S: Set output (STEP 7 Safety V14)

Description

You can use the "Set output" instruction to set the signal state of a specified operand to "1".

If the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is set to "1". If there is a result of logic operation of "0" at the box input, the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the box input is transferred directly to the box output.

Note

The instruction is not executed if it is applied to an output of an F-I/O that is passivated (e.g., during startup of the F-system). Therefore, it is preferable to access outputs of the F-I/O using only the "Assignment" instruction.

An F-I/O output is passivated if QBAD or QBAD_O_xx = 1 or value status = 0 is set in the corresponding F-I/O DB.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

Note

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

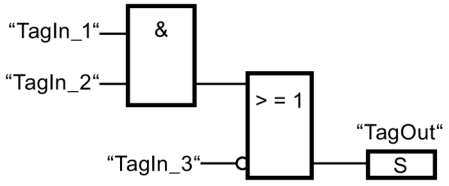
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is set with RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.2.2.7 SR: Set/reset flip-flop (STEP 7 Safety V14)

Description

You can use the "Set/reset flip-flop" instruction to set or reset the bit of the specified operand based on the signal state of inputs S and R1. If the signal state at input S is "1" and the signal state at input R1 is "0", the specified operand is set to "1". If the signal state at input S is "0" and the signal state at input R1 is "1", the specified operand is reset to "0".

Input R1 takes priority over input S. If the signal state is "1" at the two inputs S and R1, the signal state of the specified operand is reset to "0".

The instruction is not executed if the signal state at the two inputs S and R1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the edge bit memory of the instruction, the local data bit used must be initialized beforehand.

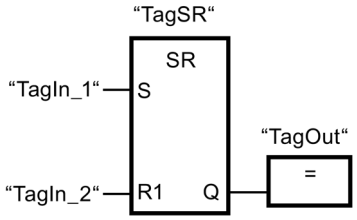
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
S	Input	BOOL	Enable set
R1	Input	BOOL	Enable reset
<Operand>	Output	BOOL	Operand that is set or reset.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands "TagSR" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands "TagSR" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Both operands "TagIn_1" and "TagIn_2" have signal state "1".

13.2.2.8 RS: Reset/set flip-flop (STEP 7 Safety V14)

Description

You can use the "Reset/set flip-flop" instruction to reset or set the bit of the specified operand based on the signal state of inputs R and S1. When the signal state is "1" at input R and "0" at input S1, the specified operand is reset to "0". When the signal state is "0" at input R and "1" at input S1, the specified operand is set to "1".

Input S1 takes priority over input R. If the signal state is "1" at the two inputs R and S1, the signal state of the specified operand is set to "1".

The instruction is not executed if the signal state at the two inputs R and S1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

Note

If you want to use a formal parameter of an F-FB/F-FC for the operands of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the edge bit memory of the instruction, the local data bit used must be initialized beforehand.

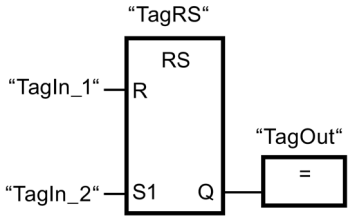
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
R	Input	BOOL	Enable reset
S1	Input	BOOL	Enable set
<Operand>	Output	BOOL	Operand that is reset or set.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands "TagRS" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands "TagRS" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Operands "TagIn_1" and "TagIn_2" have signal state "1".

13.2.2.9 P: Scan operand for positive signal edge (STEP 7 Safety V14)

Description

You can use the "Scan operand for positive signal edge" instruction to determine if there is a change from "0" to "1" in the signal state of a specified operand (<Operand1>). The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

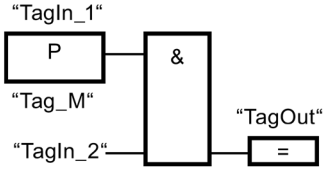
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



"TagOut" is set when the following conditions are fulfilled:

- There is a rising edge at input "TagIn_1".
- The signal state of operand "TagIn_2" is "1".

13.2.2.10 N: Scan operand for negative signal edge (STEP 7 Safety V14)

Description

You can use the "Scan operand for negative signal edge" instruction to determine if there is a change form "1" to "0" in the signal state of a specified operand. The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

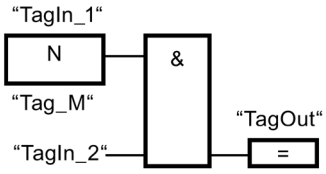
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- There is a falling edge at input "TagIn_1".
- The signal state of operand "TagIn_2" is "1".

13.2.2.11 P_TRIG: Scan RLO for positive signal edge (STEP 7 Safety V14)

Description

You can use the "Scan RLO for positive signal edge" instruction to query a change in the signal state of the result of logic operation from "0" to "1". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

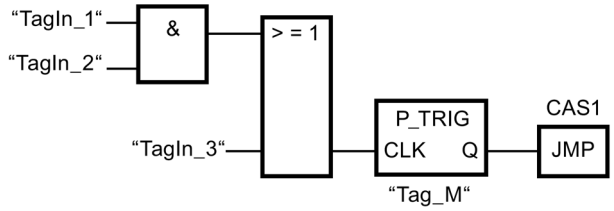
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO from the previous bit logic operation is saved in edge memory bit "Tag_M". If a change in the RLO signal state from "0" to "1" is detected, the program jumps to jump label CAS1.

13.2.2.12 N_TRIG: Scan RLO for negative signal edge (STEP 7 Safety V14)

Description

You can use the "Scan RLO for negative signal edge" instruction to query a change in the signal state of the result of logic operation from "1" to "0". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Note

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

Note

If you want to use a formal parameter of an F-FB/F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an input/output parameter.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

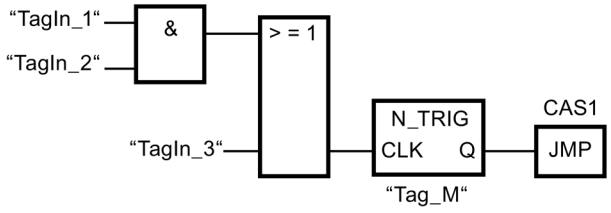
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO of the previous bit logic operation is saved in edge bit memory "Tag_M". If a change in the RLO signal state from "1" to "0" is detected, the program jumps to jump label CAS1.

13.3 Safety functions

13.3.1 ESTOP1: Emergency STOP/OFF up to stop category 1 (STEP 7 Safety V14)

Description

This instruction implements an emergency STOP/emergency OFF shutdown with acknowledgment for Stop Categories 0 and 1.

Enable signal Q is reset to 0, as soon as input E_STOP takes a signal state of 0 (Stop category 0). Enable signal Q_DELAY is reset to 0 after the time delay set at input TIME_DEL (Stop Category 1).

Enable signal Q is reset to 1 not before input E_STOP takes a signal state of 1 and an acknowledgment occurs. The acknowledgment for the enable takes place according to the parameter assignment at input ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK for acknowledging the enable.

Output ACK_REQ is used to signal that a user acknowledgment is required at input ACK for the acknowledgment. The instruction sets output ACK_REQ to 1, as soon as input E_STOP = 1.

Following an acknowledgment, the instruction resets ACK_REQ to 0.

Every call of the "Emergency STOP/Emergency OFF up to Stop Category 1" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ESTOP1_DB_1) or a multi-instance (e.g., ESTOP1_Instance_1) for the "Emergency STOP/Emergency OFF up to Stop Category 1" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of 0 unless an automatic restart of the affected process is otherwise excluded. *(S033)*

WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Note: In case of two channels according to category 3,4 of ISO 13849-1:2015 or EN ISO 13849-1:2015, the discrepancy monitoring of the two NC contacts of the EMERGENCY STOP/EMERGENCY OFF must already take place in the F-I/O. The F-I/O has to be configured accordingly (sensor evaluation: two-channel, equivalent), and the result of the evaluation interconnected with the E_STOP input. In order to keep the discrepancy time from influencing the response time, you must assign "Supply value 0" for the behavior of discrepancy during configuration.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
E_STOP	Input	BOOL	EMERGENCY STOP/EMERGENCY OFF
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	1=Acknowledgment
TIME_DEL	Input	TIME	Time delay
Q	Output	BOOL	1=Enable
Q_DELAY	Output	BOOL	Enable is OFF delayed
ACK_REQ	Output	BOOL	1=Acknowledgment necessary
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	Version 1.0 requires that the F_TOF block with the number FB 186 is available in the project tree in the "Program blocks/System blocks/STEP 7 Safety" folder. When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction. You will then avoid number conflicts.
1.1	x	—	-—	These versions are functionally identical to version V1.0, but do not require the F_TOF block to have a particular number.
1.2	x	—	o	
1.3	x	o	o	
1.4	x	o	o	
1.5	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Startup characteristics

After an F-system startup, when ACK_NEC = 1, you must acknowledge the instruction using a rising edge at input ACK.

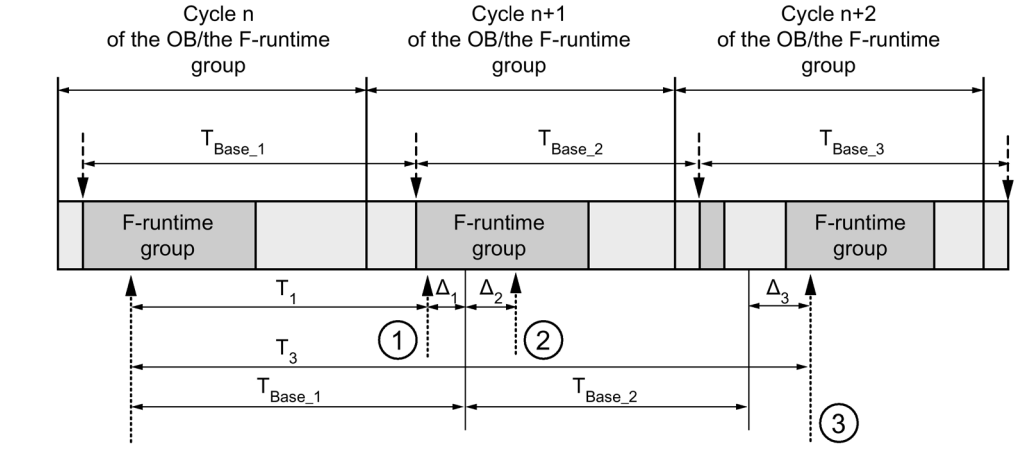
Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 1 to 5 are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Incorrect TIM_DEL setting	Time delay setting < 0	Set time delay > 0
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Acknowledgment not possible because emergency STOP/emergency OFF is still active	Emergency STOP/Emergency OFF pushbutton is locked	Release Emergency STOP/Emergency OFF pushbutton
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of emergency STOP/emergency OFF pushbutton	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
		Emergency STOP/Emergency OFF pushbutton is defective	Check emergency STOP/emergency OFF pushbutton
		Wiring fault	Check wiring of the emergency STOP/emergency OFF pushbutton
Bit 5	If enable is missing: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time of the time base used in the instruction:



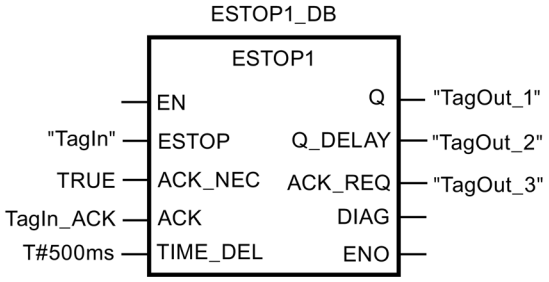
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

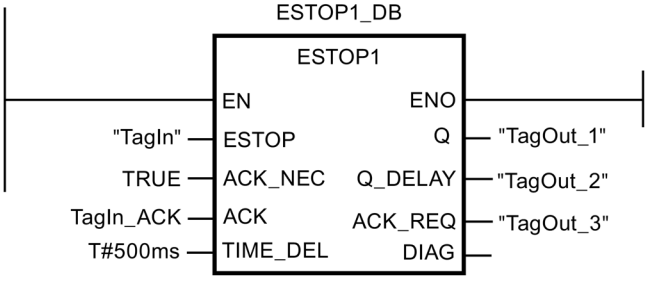
② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:





13.3.2 TWO_HAND: Two-hand monitoring (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Description

This instruction implements two-hand monitoring.

Note

This instruction is only available for S7-300 and S7-400 F-CPUs. For S7-1200/1500 F-CPUs, you use the instruction "Two-hand monitoring with enable". The application "Two-hand monitoring with enable" replaces the instruction "Two-hand monitoring" with compatible functions.

If pushbuttons IN1 and IN2 are activated within the permitted discrepancy time DISCTIME ≤ 500 ms (IN1/IN2 = 1) (synchronous activation), output signal Q is set to 1. If the time difference between activation of pushbutton IN1 and pushbutton IN2 is greater than DISCTIME, then the pushbuttons must be released and reactivated.

Q is reset to 0 as soon as one of the pushbuttons is released (IN1/IN2 = 0). Enable signal Q can be reset to 1 only if the other pushbutton has been released, and if both pushbuttons are then reactivated within the discrepancy time. Enable signal Q can never be set to 1 if the discrepancy time is set to values less than 0 or greater than 500 ms.

Every call of the "Two-hand monitoring" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., TWO_HAND_DB_1) or a multi-instance (e.g., TWO_HAND_Instance_1) for the "Two-hand monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

The instruction supports the requirements in accordance with EN 574:1996 + A1:2008.

Note: Only one signal per pushbutton can be evaluated in the instruction. Discrepancy monitoring of the NC and NO contacts of pushbuttons IN1 and IN2 is performed directly during suitable configuration (sensor evaluation: 1oo2 evaluation, non-equivalent) directly through the F-I/O with inputs. The normally open contact must be wired in such a way that it supplies the useful signal (see manual for the F-I/O you are using). In order to keep the discrepancy time from influencing the response time, you must assign "Supply value 0" for the behavior of discrepancy during configuration. If a discrepancy is detected, a fail-safe value of 0 is entered in the process image of the inputs (PII) for the pushbutton and QBAD or QBAD_I_xx = 1 is set in the relevant F-I/O DB. (See also F-I/O access (Page 128))

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

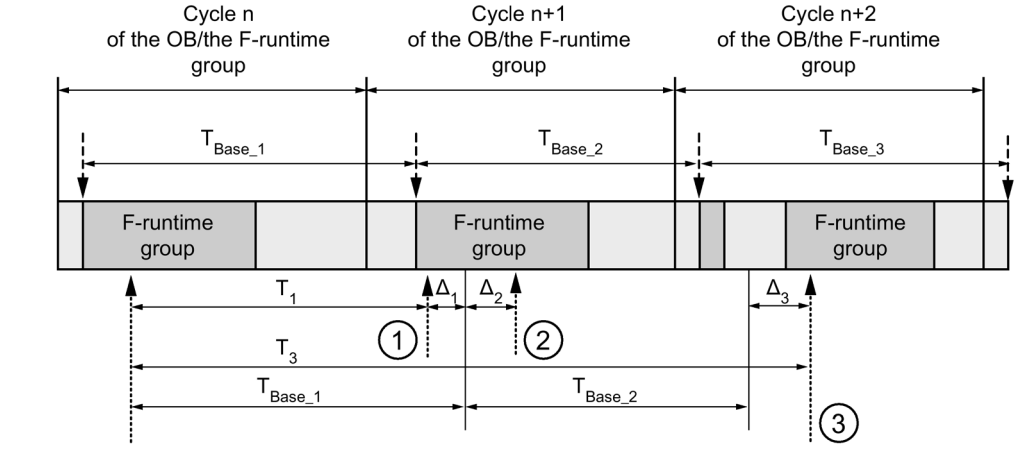
You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Pushbutton 1
IN2	Input	BOOL	Pushbutton 2
DISCTIME	Input	TIME	Discrepancy time (0 to 500 ms)
Q	Output	BOOL	1=Enable

Timing imprecision resulting from the update time of the time base used in the instruction:



⇢ = Time base update

⇢ = Call time of an instruction with time processing

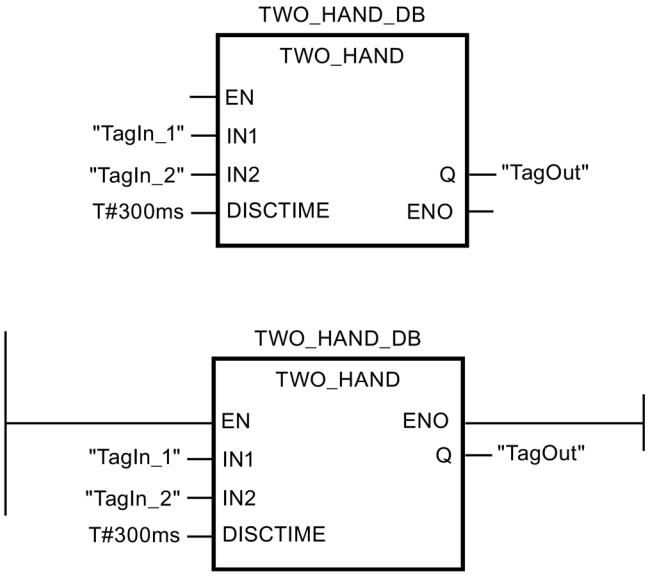
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:



13.3.3 TWO_H_EN: Two-hand monitoring with enable (STEP 7 Safety V14)

Description

This instruction implements two-hand monitoring with enable.

If pushbuttons IN1 and IN2 are activated within the permitted discrepancy time DISCTIME ≤ 500 ms (IN1/IN2 = 1) (synchronous activation), output signal Q is set to 1 when existing ENABLE = 1. If the time difference between activation of pushbutton IN1 and pushbutton IN2 is greater than DISCTIME, then the pushbuttons must be released and reactivated.

Q is reset to 0 as soon as one of the pushbuttons is released (IN1/IN 2 = 0) or ENABLE = 0. Enable signal Q can be reset to 1 only if the other pushbutton has been released, and if both pushbuttons are then reactivated within the discrepancy time when existing ENABLE = 1.

Every call of the "Two-hand monitoring with enable" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., TWO_H_EN_DB_1) or a multi-instance (e.g., TWO_H_EN_Instance_1) for the "Two-hand monitoring with enable" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

The instruction supports the requirements in accordance with EN 574:1996 + A1:2008.

Note: Only one signal per pushbutton can be evaluated in the instruction. Discrepancy monitoring of the NC and NO contacts of pushbuttons IN1 and IN2 is performed directly during suitable configuration (sensor evaluation: 1oo2 evaluation, non-equivalent) directly through the F-I/O with inputs. The normally open contact must be wired in such a way that it supplies the useful signal (see manual for the F-I/O you are using). In order to keep the discrepancy time from influencing the response time, during the configuration of discrepancy behavior, you must configure "Supply value 0".

If a discrepancy is detected, a fail-safe value of 0 is entered in the process image input (PII) for the pushbutton and QBAD or QBAD_I_xx = 1 or value status = 0 is set in the corresponding F-I/O DB.

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Pushbutton 1
IN2	Input	BOOL	Pushbutton 2
ENABLE	Input	BOOL	Enable input
DISCTIME	Input	TIME	Discrepancy time (0 to 500 ms)
Q	Output	BOOL	1=Enable
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

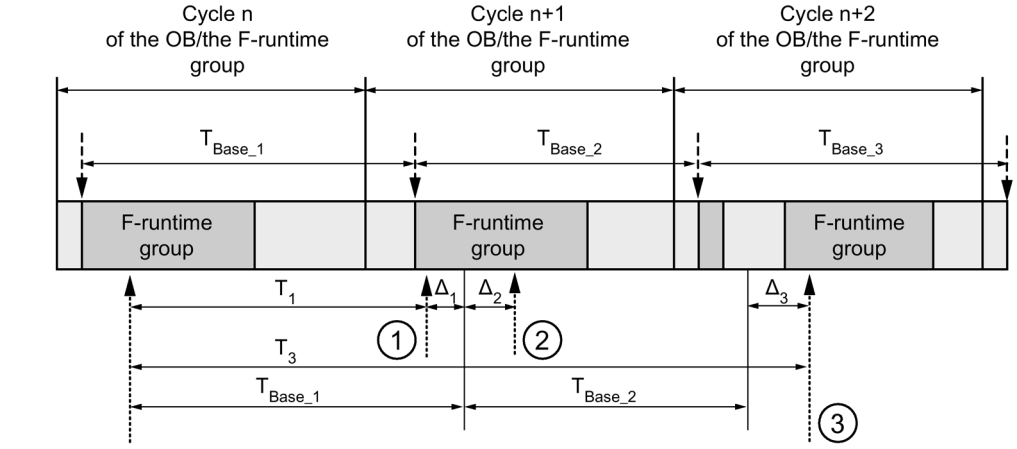
Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0 to 5 are saved until the cause of the error has been eliminated.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Incorrect discrepancy time DISCTIME setting	Discrepancy time setting is <0 or > 500 ms	Set discrepancy time in range of 0 to 500 ms
Bit 1	Discrepancy time elapsed	Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Pushbuttons were not activated within the discrepancy time	Release pushbuttons and activate them within the discrepancy time
		Wiring fault	Check wiring of pushbuttons
		Pushbuttons defective	Check pushbuttons
		Pushbuttons are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Incorrect activation sequence	One pushbutton was not released	Release pushbuttons and activate them within the discrepancy time
		Pushbuttons defective	Check pushbuttons
Bit 5	ENABLE does not exist	ENABLE = 0	Set ENABLE = 1, release pushbutton and activate it within the discrepancy time
Bit 6	Reserved	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time of the time base used in the instruction:



----► = Time base update

·····► = Call time of an instruction with time processing

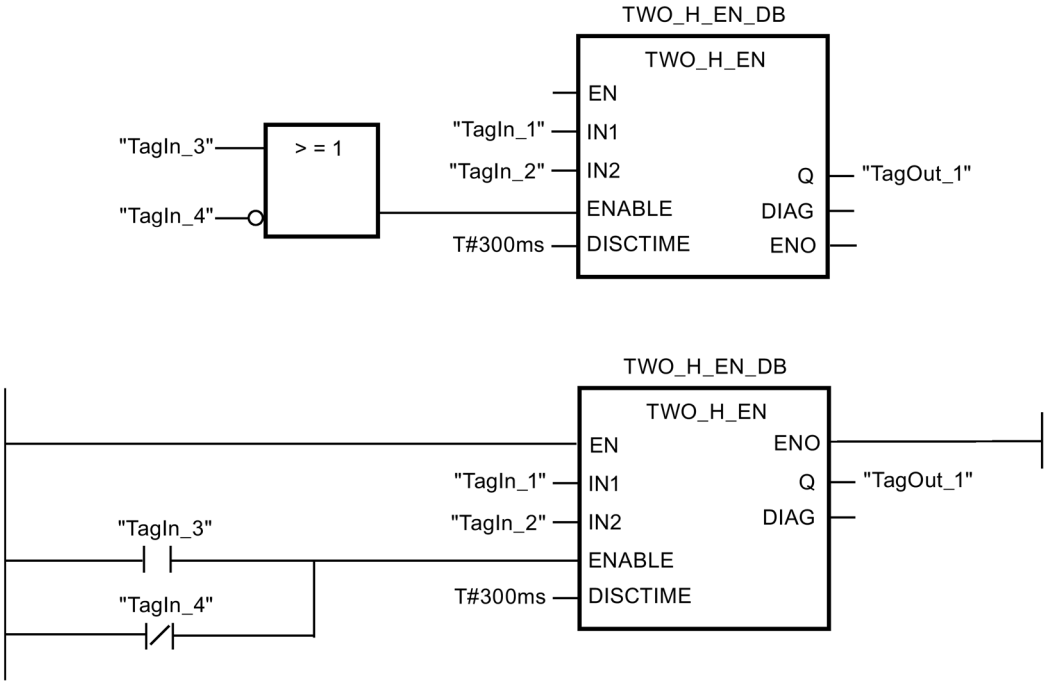
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:



13.3.4 MUTING: Muting (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Description

This instruction performs parallel muting with two or four muting sensors.

Note

This instruction is only available for S7-300 and S7-400 F-CPUs. For S7-1200/1500 F-CPUs, you use the instruction "Parallel muting (Page 399)". The instruction "Parallel muting" replaces the instruction "Muting" with compatible functions.

Muting is a defined suppression of the protective function of light curtains. Light curtain muting can be used to introduce goods or objects into the danger area monitored by the light curtain without causing the machine to stop.

To utilize the muting function, at least two independently wired muting sensors must be present. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger area while the light curtain is muted.

Every call of the "Muting" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., MUTING_DB_1) or a multi-instance (e.g., MUTING_Instance_1) for the "Muting" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

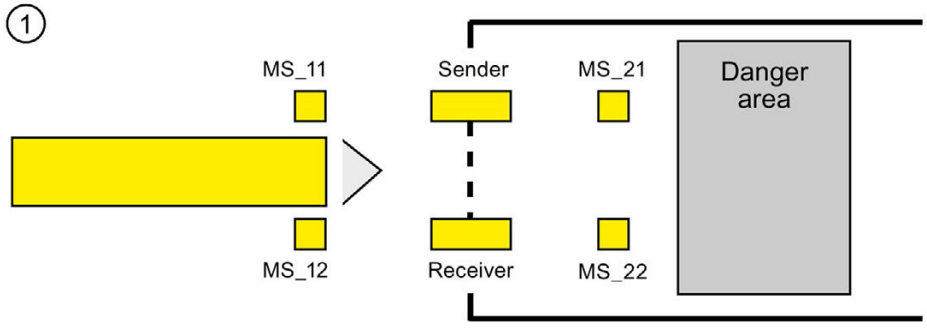
You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
MS_11	Input	BOOL	Muting sensor 1 of sensor pair 1
MS_12	Input	BOOL	Muting sensor 2 of sensor pair 1
MS_21	Input	BOOL	Muting sensor 1 of sensor pair 2
MS_22	Input	BOOL	Muting sensor 2 of sensor pair 2
STOP	Input	BOOL	1=Conveyor system stopped
FREE	Input	BOOL	1=Light curtain uninterrupted
QBAD_MUT	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal of the muting lamp channel
DISCTIM1	Input	TIME	Discrepancy time of sensor pair 1 (0 to 3 s)
DISCTIM2	Input	TIME	Discrepancy time of sensor pair 2 (0 to 3 s)
TIME_MAX	Input	TIME	Maximum muting time (0 to 10 min)
ACK	Input	BOOL	Acknowledgment of restart inhibit
Q	Output	BOOL	1= Enable, not off
MUTING	Output	BOOL	Display of muting is active
ACK_REQ	Output	BOOL	Acknowledgment necessary
FAULT	Output	BOOL	Group error
DIAG	Output	BYTE	Non-fail safe service information

Schematic sequence of error-free muting procedure with 4 muting sensors (MS_11, MS_12, MS_21, MS_22)



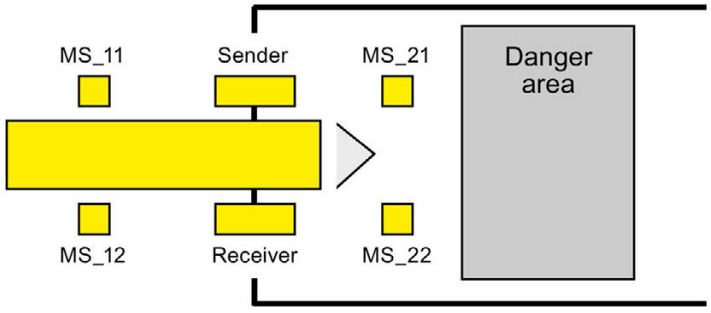
- If both muting sensors MS_11 and MS_12 are activated by the product within DISCTIM1 (apply signal state = 1), the instruction starts the MUTING function. Enable signal Q remains 1, even when input FREE = 0 (light curtain interrupted by product). The MUTING output for setting the muting lamp switches to 1.

Note

The muting lamp can be monitored using the QBAD_MUT input. To do this, you must wire the muting lamp to an output with wire break monitoring of an F-I/O and supply the QBAD_MUT input with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal of the associated channel. If QBAD_MUT = 1, muting is terminated by the instruction. If monitoring of the muting lamp is not necessary, you do not have to supply input QBAD_MUT.

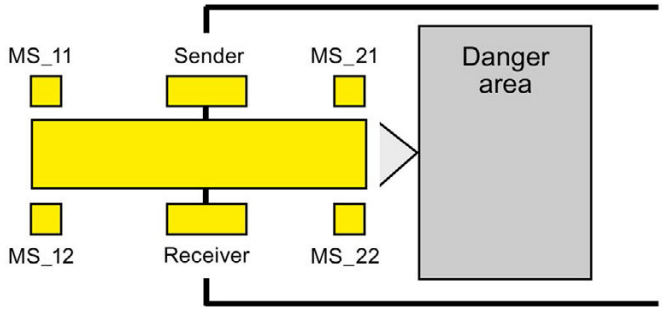
F-I/O that can promptly detect a wire break after activation of the muting operation must be used (*see manual for specific F-I/O*).

②



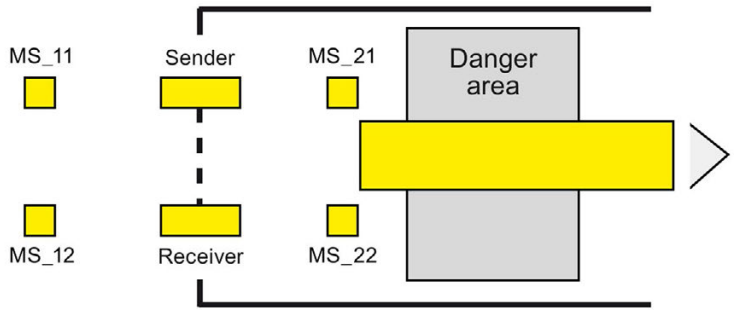
- As long as both muting sensors MS_11 and MS_12 continue to be activated, the MUTING function of the instruction causes Q to remain 1 and MUTING to remain 1 (so that the product can pass through the light curtain without causing the machine to stop).

③



- The two muting sensors MS_21 and MS_22 must be activated (within DISCTIM2) before muting sensors MS_11 and MS_12 are switched to inactive (apply signal state 0). In this way, the instruction retains the MUTING function. (Q = 1, MUTING = 1).

④

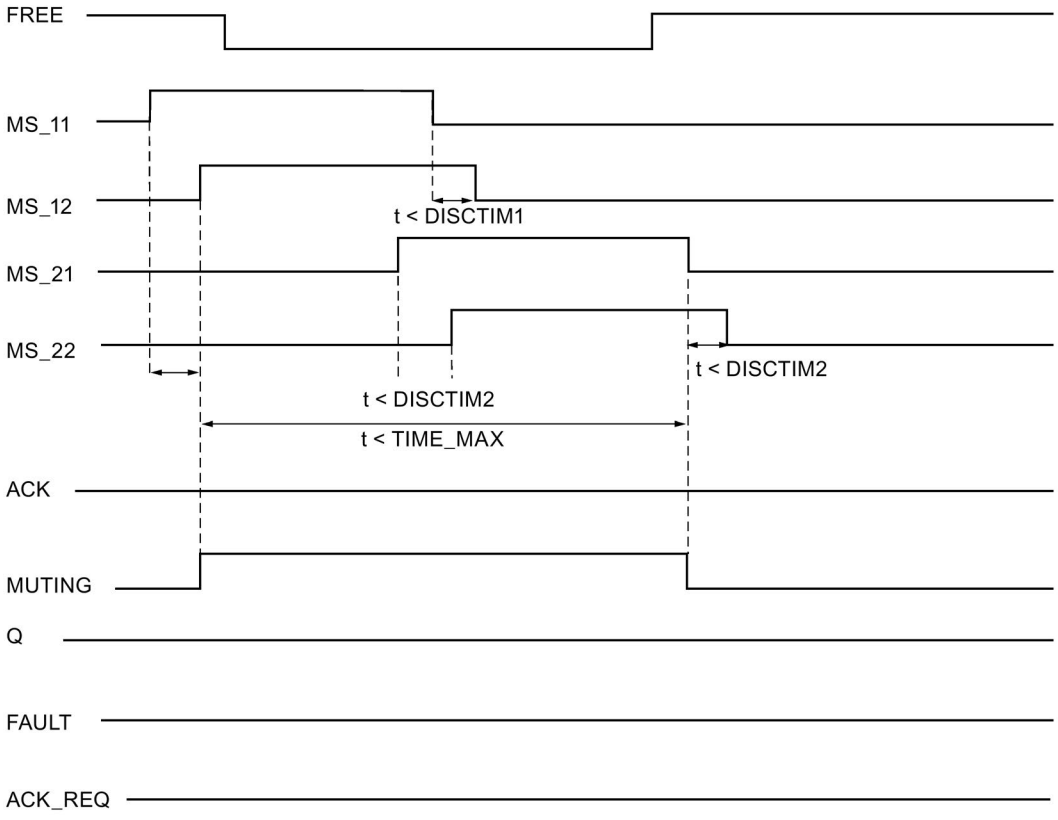


- Only if one of the two muting sensors MS_21 and MS_22 is switched to inactive (product enables sensors) is the MUTING function terminated (Q = 1, MUTING = 0). The maximum activation time for the MUTING function is the time set at input TIME_MAX.

Note

The MUTING function is also started if the product passes the light curtain in the reverse direction and the muting sensors are thus activated by the product in reverse order.

Timing diagrams for error-free muting procedure with 4 muting sensors

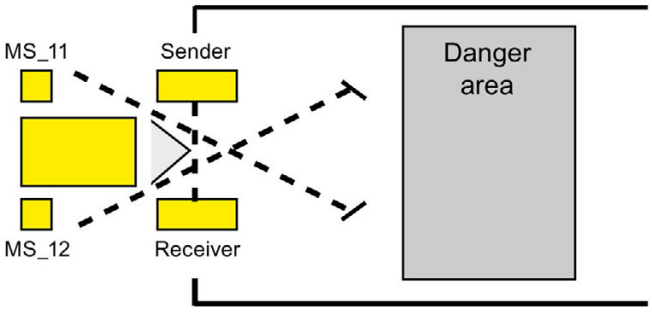


Schematic sequence of muting procedure with reflection light barriers

If reflection light barriers are used as muting sensors, they are generally arranged diagonally.

In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only MS_11 and MS_12 are interconnected.

The sequence is similar to that of the muting procedure with 4 muting sensors. Step 3 is omitted. In step 4, replace MS_21 and MS_22 with MS_11 and MS_12, respectively.



Restart inhibit upon interruption of light curtain (if MUTING is not active), when errors occur, and during F-system startup

Enable signal Q cannot be set to 1 or becomes 0, if:

- Light curtain is interrupted (e.g., by a person or material transport) while the MUTING function is not active
- The muting lamp monitoring function responds at input QBAD_MUT
- Sensor pair 1 (MS_11 and MS_12) or sensor pair 2 (MS_21 and MS_22) is not activated or deactivated during discrepancy time DISCTIM1 or DISCTIM2, respectively
- The MUTING function is active longer than the maximum muting time TIME_MAX
- Discrepancy times DISCTIM1 and DISCTIM2 have been set to values < 0 or > 3 s
- Maximum muting time TIME_MAX has been set to a value< 0 or > 10 min

In the identified cases, output FAULT (group error) is set to 1 (restart inhibit). If the MUTING function is started, it will be terminated and the Muting output becomes 0.

WARNING

When a valid combination of muting sensors is immediately detected at startup of the F-system (for example, because the muting sensors are interconnected to inputs of a standard I/O that immediately provide process values during the F-system startup), the MUTING function is immediately started and the MUTING output and enable signal Q are set to 1. The FAULT output (group error) is not set to 1 (no restart inhibit!). *(S035)*

Acknowledgment of restart inhibit

Enable signal Q becomes 1 again, when:

- The light curtain is no longer interrupted
- If present, errors are eliminated (see output DIAG)

  and

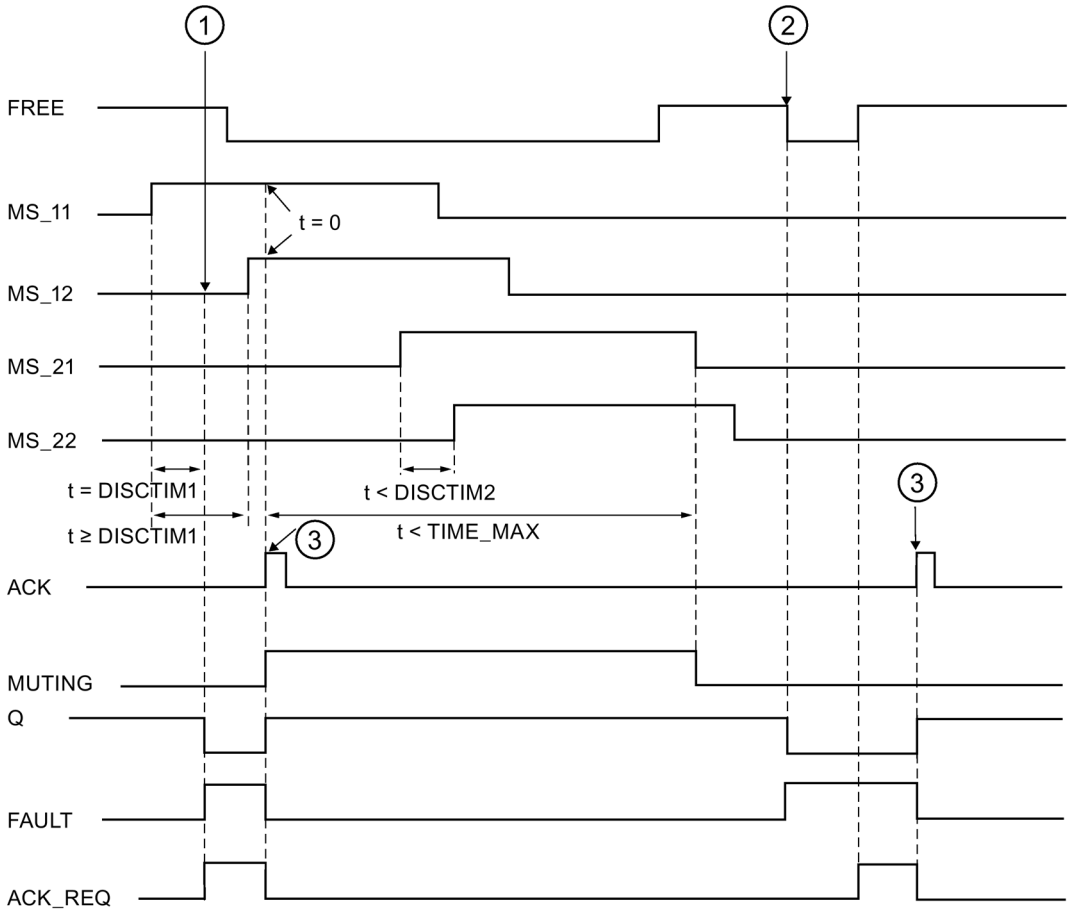
- A user acknowledgment with positive edge occurs at input ACK (see also Implementation of user acknowledgment (Page 156)).

The FAULT output is set to 0. Output ACK_REQ = 1 signals that user acknowledgment at input ACK is required to eliminate the restart inhibit. The instruction sets ACK-REQ = 1 as soon as the light curtain is no longer interrupted or errors have been eliminated. Once acknowledgment has occurred, the instruction resets ACK_REQ to 0.

Note

Following discrepancy errors and once the maximum muting time has been exceeded, ACK_REQ is immediately set to 1. As soon as a user acknowledgment has taken place at input ACK, discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

Timing diagrams for discrepancy errors at sensor pair 1 or interruption of the light curtain (if MUTING is not active)



① Sensor pair 1 (MS_11 and MS_12) is not activated within discrepancy time DISCTIM1.

② The light curtain is interrupted even though the MUTING function is not active.

③ Acknowledgment

Behavior with stopped conveyor equipment

If, while the conveyor equipment has stopped, the monitoring for one of the following reasons is to be deactivated:

- To comply with discrepancy time DISCTIM1 or DISCTIM2
- To comply with maximum muting time TIME_MAX

you must supply input STOP with a "1" signal for as long as the conveyor equipment is stopped. As soon as the conveyor equipment is running again (STOP = 0), discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

⚠ WARNING

When STOP = 1, the discrepancy monitoring is shut down. During this time, if inputs MSx1/MSx2 of a sensor pair both take a signal state of 1 due to an undetected error, e.g., because both muting sensors fail to 1, the error is not detected and the MUTING function can be started unintentionally. *(S036)*

Output DIAG

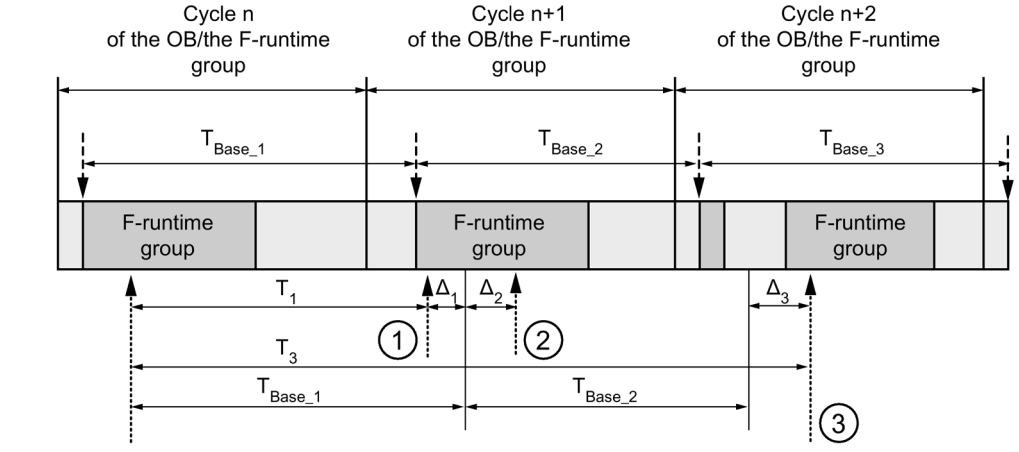
The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time DISCTIM 1 setting for sensor pair 1	Malfunction in production sequence	Malfunction in production sequence eliminated
		Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 3 s	Set discrepancy time in range between 0 s and 3 s
Bit 1	Discrepancy error or incorrect discrepancy time DISCTIM 2 setting for sensor pair 2	Same as Bit 0	Same as Bit 0
Bit 2	Maximum muting time exceeded or incorrect muting time TIME_MAX setting	Malfunction in production sequence	Malfunction in production sequence eliminated
		Maximum muting time setting is too low	If necessary, set a higher maximum muting time
		Muting time setting is < 0 s or > 10 min	Set muting time in range from 0 s to 10 min

Bit no.	Assignment	Possible error causes	Remedies
Bit 3	Light curtain interrupted and muting not active	Light curtain is defective	Check light curtain
		Wiring fault	Check wiring of light curtain (FREE input)
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of light curtain (FREE input)	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
		See other DIAG bits	
Bit 4	Muting lamp is defective or cannot be set	Muting lamp is defective	Replace muting lamp
		Wiring fault	Check wiring of muting lamp
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of muting lamp	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
Bit 5	Reserved	—	—
Bit 6	Reserved	—	—
Bit 7	Reserved	—	—

Timing imprecision resulting from the update time of the time base used in the instruction:



⇢ = Time base update

⇢ = Call time of an instruction with time processing

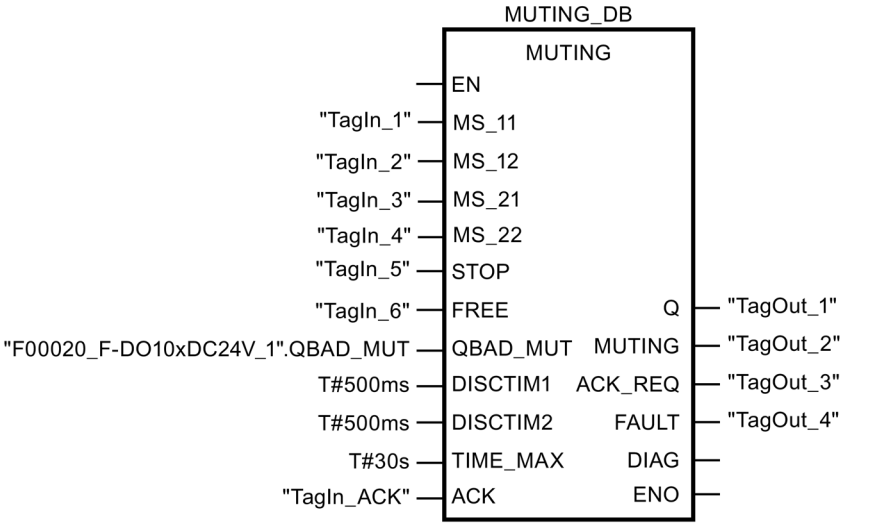
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

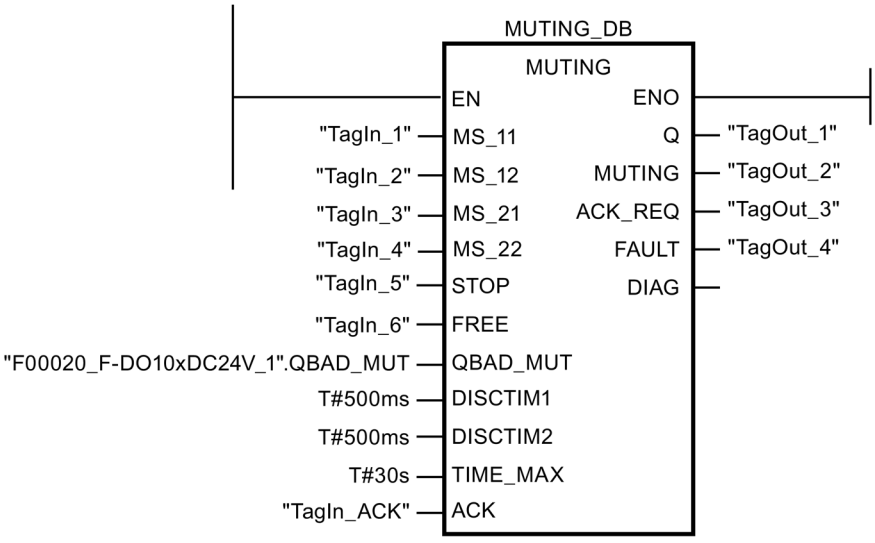
② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:





13.3.5 MUT_P: Parallel muting (STEP 7 Safety V14)

Description

This instruction performs parallel muting with two or four muting sensors.

Muting is a defined suppression of the protective function of light curtains. Light curtain muting can be used to introduce goods or objects into the danger area monitored by the light curtain without causing the machine to stop.

To utilize the muting function, at least two independently wired muting sensors must be present. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger area while the light curtain is muted.

Every call of the "Parallel muting" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., MUT_P_DB_1) or a multi-instance (e.g., MUT_P_Instance_1) for the "Parallel muting" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
MS_11	Input	BOOL	Muting sensor 11
MS_12	Input	BOOL	Muting sensor 12
MS_21	Input	BOOL	Muting sensor 21
MS_22	Input	BOOL	Muting sensor 22
STOP	Input	BOOL	1=Conveyor system stopped
FREE	Input	BOOL	1=Light curtain uninterrupted
ENABLE	Input	BOOL	1=Enable MUTING
QBAD_MUT	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the muting lamp channel
ACK	Input	BOOL	Acknowledgment of restart inhibit
DISCTIM1	Input	TIME	Discrepancy time of sensor pair 1 (0 to 3 s)
DISCTIM2	Input	TIME	Discrepancy time of sensor pair 2 (0 to 3 s)
TIME_MAX	Input	TIME	Maximum muting time (0 to 10 min)
Q	Output	BOOL	1= Enable, not off
MUTING	Output	BOOL	Display of muting is active
ACK_REQ	Output	BOOL	Acknowledgment necessary
FAULT	Output	BOOL	Group error
DIAG	Output	WORD	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x*	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x*	—	—	These versions have identical functions to version V1.0. The output DIAG can now be correctly interconnected with the operand of data type WORD.
1.2	x*	—	o	
1.3	x*	o	o	
1.4	x	x	x	

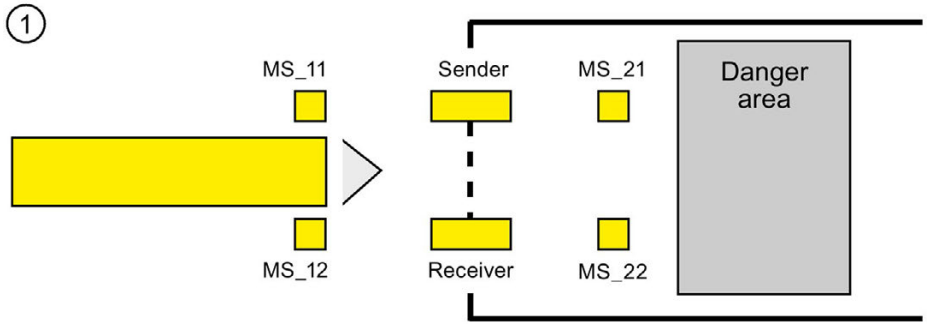
o This version is no longer supported.

* S7-300/400: When a restart inhibit (output FAULT = 1) and ENABLE = 1 is present, output ACK_REQ is set to 1 even if not at least one muting sensor is activated. Use the DIAG bits 5 and 6 for additional information.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Schematic sequence of error-free muting procedure with 4 muting sensors (MS_11, MS_12, MS_21, MS_22)

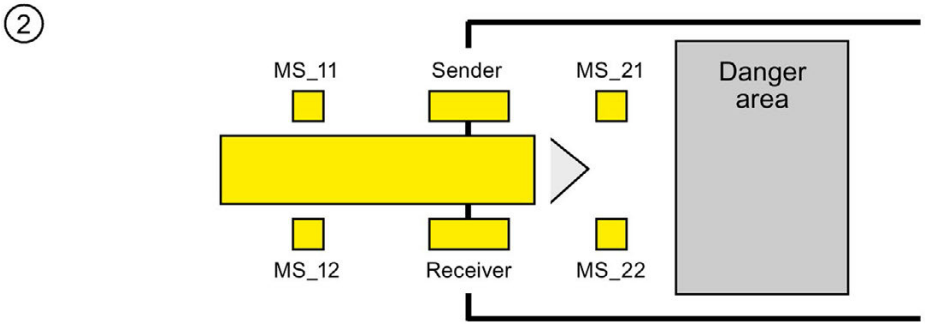


- If muting sensors MS_11 and MS_12 are both activated by the product within DISCTIM1 (apply signal state = 1) and MUTING is enabled by setting the ENABLE input to 1, the instruction starts the MUTING function. Enable signal Q remains 1, even when input FREE = 0 (light curtain interrupted by product). The MUTING output for setting the muting lamp switches to 1.

  Note

  The muting lamp can be monitored using the QBAD_MUT input. To do this, you must wire the muting lamp to an output with wire break monitoring of an F-I/O and supply the QBAD_MUT input with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal / with inverted value statues of the associated channel. If QBAD_MUT = 1, muting is terminated by the instruction. If monitoring of the muting lamp is not necessary, you do not have to supply input QBAD_MUT.

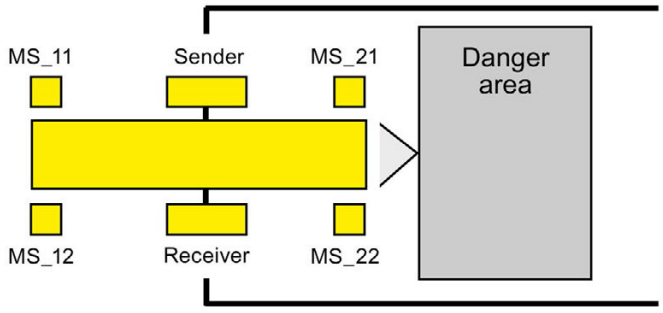
  F-I/O that can promptly detect a wire break after activation of the muting operation must be used (*see manual for specific F-I/O*).



- As long as both muting sensors MS_11 and MS_12 continue to be activated, the MUTING function of the instruction causes Q to remain 1 and MUTING to remain 1 (so that the product can pass through the light curtain without causing the machine to stop). Each of

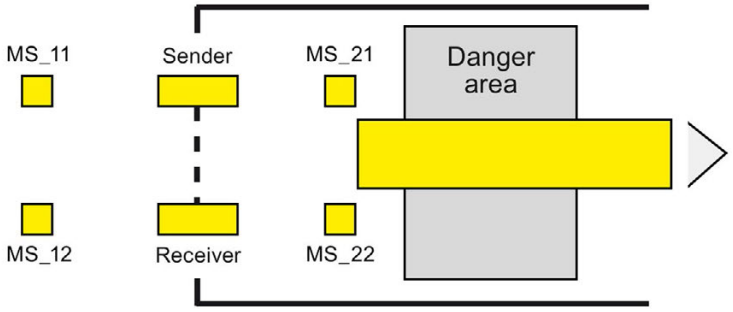
the two muting sensors MS_11 and MS_12 may be switched to inactive (t < DISCTIM1) for a short time (apply signal state 0).

③



- Muting sensors MS_21 and MS_22 must both be activated (within DISCTIM2) before muting sensors MS_11 and MS_12 are switched to inactive (apply signal state 0). In this way, the instruction retains the MUTING function. (Q = 1, MUTING = 1).

④

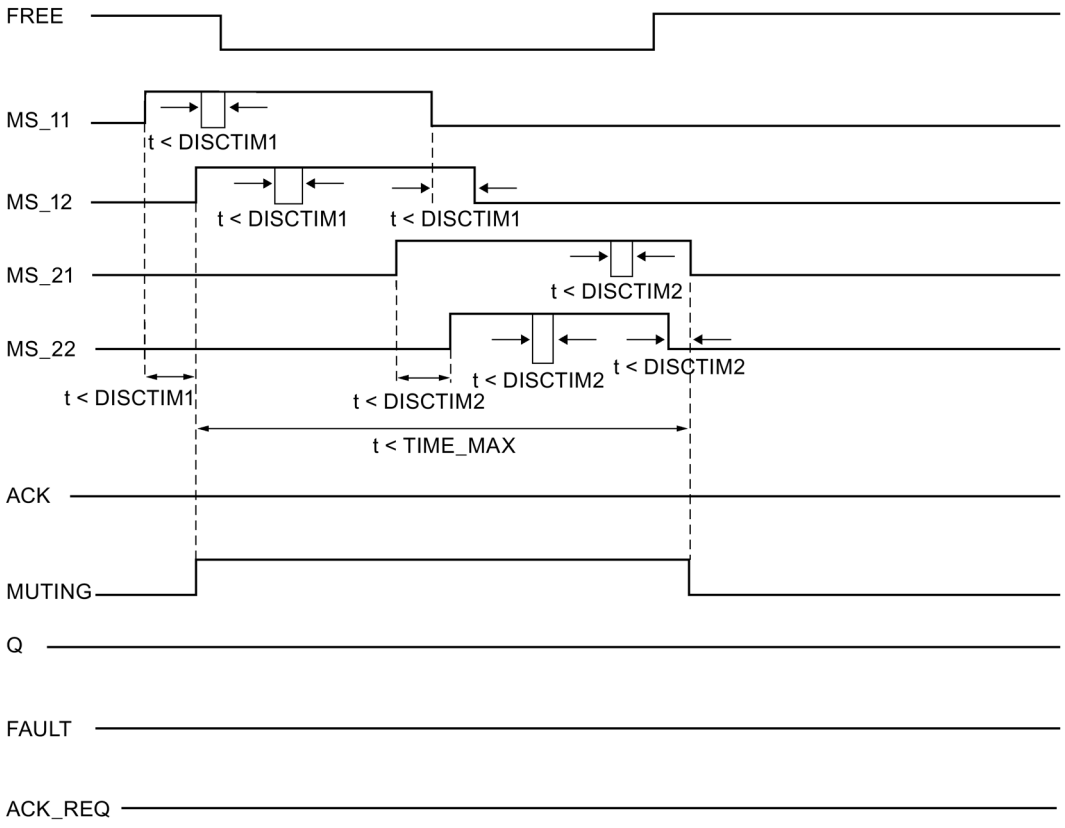


Only if muting sensors MS_21 and MS_22 are both switched to inactive (product enables sensors) is the MUTING function terminated (Q = 1, MUTING = 0). The maximum activation time for the MUTING function is the time set at input TIME_MAX.

Note

The MUTING function is also started if the product passes the light curtain in the reverse direction and the muting sensors are thus activated by the product in reverse order.

Timing diagrams for error-free muting procedure with 4 muting sensors

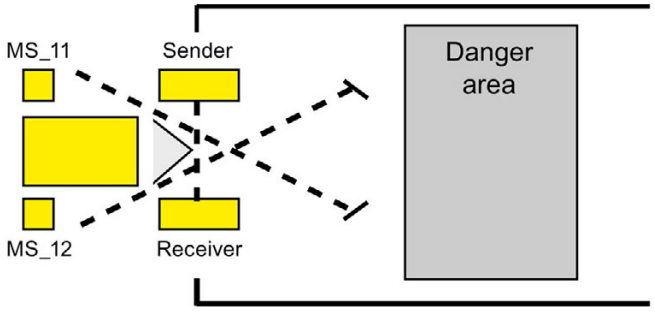


Schematic sequence of muting procedure with reflection light barriers

If reflection light barriers are used as muting sensors, they are generally arranged diagonally.

In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only MS_11 and MS_12 are interconnected.

The sequence is similar to that of the muting procedure with 4 muting sensors. Step 3 is omitted. In step 4, replace MS_21 and MS_22 with MS_11 and MS_12, respectively.



Restart inhibit upon interruption of light curtain (MUTING is not active), as well as when errors occur and during F-system startup

Enable signal Q cannot be set to 1 or becomes 0, if:

- Light curtain is interrupted (e.g., by a person or material transport) while the MUTING function is not active
- Light curtain is (being) interrupted and the muting lamp monitoring at input QBAD_MUT is set to 1
- Light curtain is (being) interrupted and the MUTING function is not enabled by setting input ENABLE to 1
- Sensor pair 1 (MS_11 and MS_12) or sensor pair 2 (MS_21 and MS_22) is not activated or deactivated during discrepancy time DISCTIM1 or DISCTIM2, respectively
- The MUTING function is active longer than the maximum muting time TIME_MAX
- Discrepancy times DISCTIM1 and DISCTIM2 have been set to values < 0 or > 3 s
- Maximum muting time TIME_MAX has been set to a value< 0 or > 10 min
- The F-system starts up (regardless of whether or not the light curtain is interrupted, because the F-I/O is passivated after F-system startup and, thus, the FREE input is initially supplied with 0)

In the identified cases, output FAULT (group error) is set to 1 (restart inhibit). If the MUTING function is started, it will be terminated and the Muting output becomes 0.

User acknowledgment of restart inhibit (no muting sensor is activated or ENABLE = 0)

Enable signal Q becomes 1 again, when:

- The light curtain is no longer interrupted
- If present, errors are eliminated (see output DIAG)

  and

- A user acknowledgment with positive edge occurs at input ACK (see also Implementation of user acknowledgment (Page 156)).

The FAULT output is set to 0. Output ACK_REQ = 1 (and DIAG bit 6) signals that user acknowledgment at input ACK is required to eliminate the restart inhibit. The instruction sets ACK_REQ = 1 as soon as the light curtain is no longer interrupted or the errors have been eliminated. Once acknowledgment has occurred, the instruction resets ACK_REQ to 0.

User Acknowledgment of restart inhibit (at least one muting sensor is activated and ENABLE = 1)

Enable signal Q becomes 1 again, when:

- If present, errors are eliminated (see output DIAG)
- FREE occurs until a valid combination of muting sensors is detected

The FAULT output is set to 0. The MUTING function is restarted, if necessary, and the MUTING output becomes 1 if a valid combination of muting sensors is detected. When ENABLE = 1, output ACK_REQ = 1 (and DIAG bit 5) signals that FREE is necessary for error elimination and for removal of the restart inhibit.*After successful FREE, ACK_REQ is reset to 0 by the instruction.

Note

Once the maximum muting time is exceeded, TIME_MAX is reset as soon as the MUTING function is restarted.

FREE function

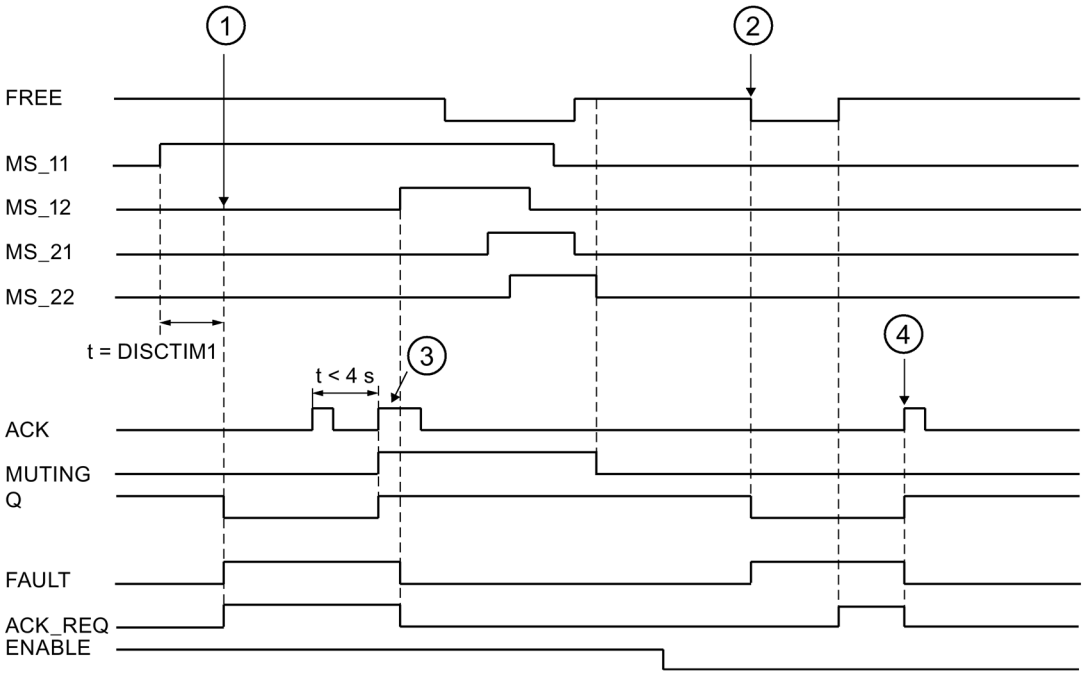
If an error cannot be corrected immediately, the FREE function can be used to free the muting range. Enable signal Q and output MUTING =1 temporarily. The FREE function can be used if:

- ENABLE = 1
- At least one muting sensor is activated
- A user acknowledgment with rising edge at input ACK occurs twice within 4 s, and the second user acknowledgment at input ACK remains at a signal state of 1 (acknowledgment button remains activated)

⚠ WARNING

When using the FREE function, the action must be observed. A dangerous situation must be able to be interrupted at any time by releasing the acknowledgment button. The acknowledgment button must be mounted in such a way the entire danger area can be observed. *(S037)*

Timing diagrams for discrepancy errors at sensor pair 1 or interruption of the light curtain (MUTING is not active)



① Sensor pair 1 (MS_11 and MS_22) is not activated within discrepancy time DISCTIM1.

② The light curtain is interrupted even though there is no enable (ENABLE=0)

③ FREE function

④ Acknowledgment

Behavior with stopped conveyor equipment

If, while the conveyor equipment has stopped, the monitoring for one of the following reasons is to be deactivated:

- To comply with discrepancy time DISCTIM1 or DISCTIM2
- To comply with maximum muting time TIME_MAX

You must supply input STOP with a "1" signal for as long as the conveyor equipment is stopped. As soon as the conveyor equipment is running again (STOP = 0), discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

⚠ WARNING

When STOP = 1 or ENABLE = 0, discrepancy monitoring is shut down. During this time, if inputs MSx1/MSx2 of a sensor pair both take a signal state of 1 due to an undetected error, e.g., because both muting sensors fail to 1, the fault is not detected and the MUTING function can be started unintentionally (when ENABLE =1). *(S038)*

Output DIAG

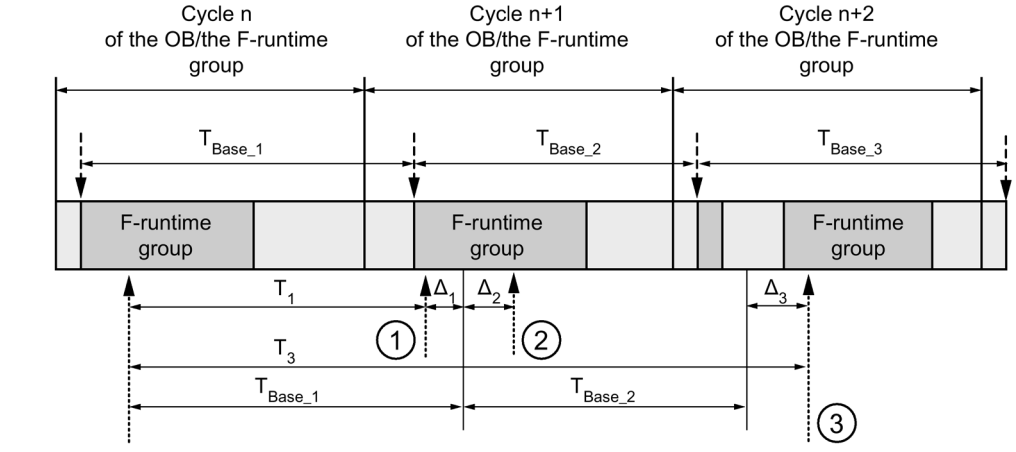
The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0 to 6 are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time DISCTIM 1 setting for sensor pair 1	Malfunction in production sequence	Malfunction in production sequence eliminated
		Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 3 s	Set discrepancy time in range between 0 s and 3 s
Bit 1	Discrepancy error or incorrect discrepancy time DISCTIM 2 setting for sensor pair 2	Same as Bit 0	Same as Bit 0
Bit 2	Maximum muting time exceeded or incorrect muting time TIME_MAX setting	Malfunction in production sequence	Malfunction in production sequence eliminated
		Maximum muting time setting is too low	If necessary, set a higher maximum muting time
		Muting time setting is < 0 s or > 10 min	Set muting time in range from 0 s to 10 min
Bit 3	Light curtain interrupted and muting not active	ENABLE = 0	Set ENABLE = 1
		Light curtain is defective	Check light curtain
		Wiring fault	Check wiring of light curtain (FREE input)
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of light curtain (FREE input)	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
		Startup of F-system	For FREE, see DIAG Bit 5
		See other DIAG bits	
Bit 4	Muting lamp is defective or cannot be set	Muting lamp is defective	Replace muting lamp
		Wiring fault	Check wiring of muting lamp
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of muting lamp	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)

Bit no.	Assignment	Possible error causes	Remedies
Bit 5	FREE is necessary	See other DIAG bits	Two rising edges at ACK within 4 s, and activate acknowledgment button until ACK_REQ = 0
Bit 6	Acknowledgment necessary	—	—
Bit 7	State of output Q	—	—
Bit 8	State of output MUTING	—	—
Bit 9	FREE active	—	—
Bit 10	Reserved	—	—
...			
Bit 15	Reserved	—	—

Timing imprecision resulting from the update time of the time base used in the instruction:



----► = Time base update

·····► = Call time of an instruction with time processing

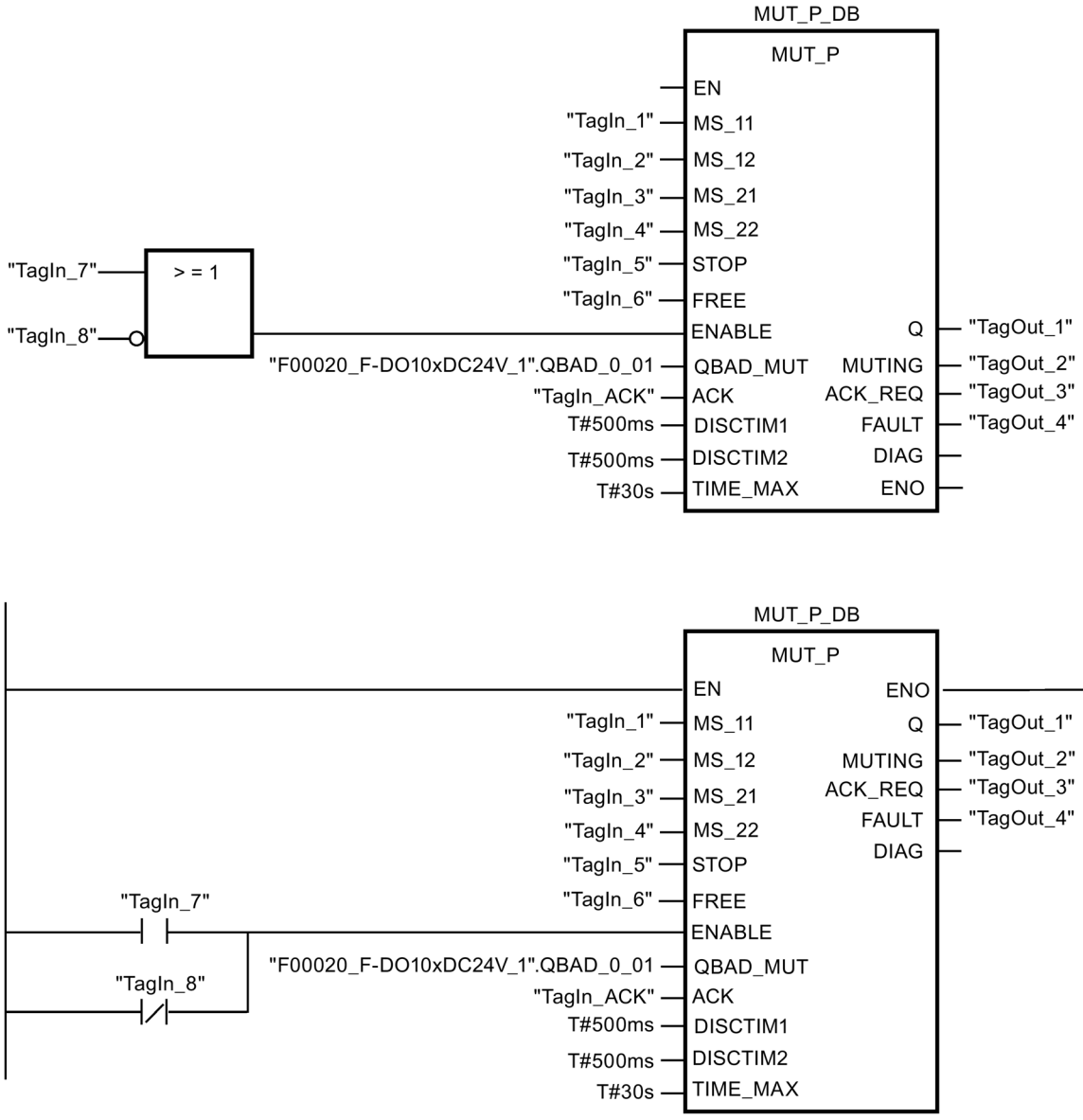
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:



13.3.6 EV1oo2DI: 1oo2 evaluation with discrepancy analysis (STEP 7 Safety V14)

Description

This instruction implements a 1oo2 evaluation of two single-channel sensors combined with a discrepancy analysis.

Output Q is set to 1, if the signal states of inputs IN1 and IN2 both equal 1 and no discrepancy error DISC_FLT is stored. if the signal state of one or both inputs is 0, output Q is set to 0.

As soon as the signal states of inputs IN1 and IN2 are different, the discrepancy time DISCTIME is started. If the signal states of the two inputs are still different once the discrepancy time expires, a discrepancy error is detected and DISC_FLT is set to 1 (restart inhibit).

If the discrepancy between inputs IN1 and IN2 is no longer detected, the discrepancy error is acknowledged according to the parameter assignment of ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK to acknowledge the discrepancy error.

The output ACK_REQ = 1 signals that a user acknowledgment at input ACK is necessary to acknowledge the discrepancy error (cancel the restart inhibit). The instruction sets ACK_REQ = 1 as soon as discrepancy is no longer detected. After acknowledgment or if, prior to acknowledgment, there is once again a discrepancy between inputs IN1 and IN2, the instruction resets ACK_REQ to 0.

Output Q can never be set to 1 if the discrepancy time setting is < 0 or > 60 s. In this case, output DISC_FLT is also set to 1 (restart inhibit). The call interval of the safety program (e.g., OB 35) must be less than the discrepancy time setting.

Every call of the "1oo2 evaluation with discrepancy analysis" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., EV1oo2DI_DB_1) or a multi-instance (e.g., EV1oo2DI_Instance_1) for the "1oo2 evaluation with discrepancy analysis" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of 0 unless an automatic restart of the affected process is otherwise excluded. *(S033)*

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Sensor 1
IN2	Input	BOOL	Sensor 2
DISCTIME	Input	TIME	Discrepancy time (0 to 60 s)
ACK_NEC	Input	BOOL	1 = acknowledgment necessary for discrepancy error
ACK	Input	BOOL	Acknowledgment of discrepancy error
Q	Output	BOOL	Output
ACK_REQ	Output	BOOL	1 = acknowledgment required
DISC_FLT	Output	BOOL	1 = discrepancy error
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

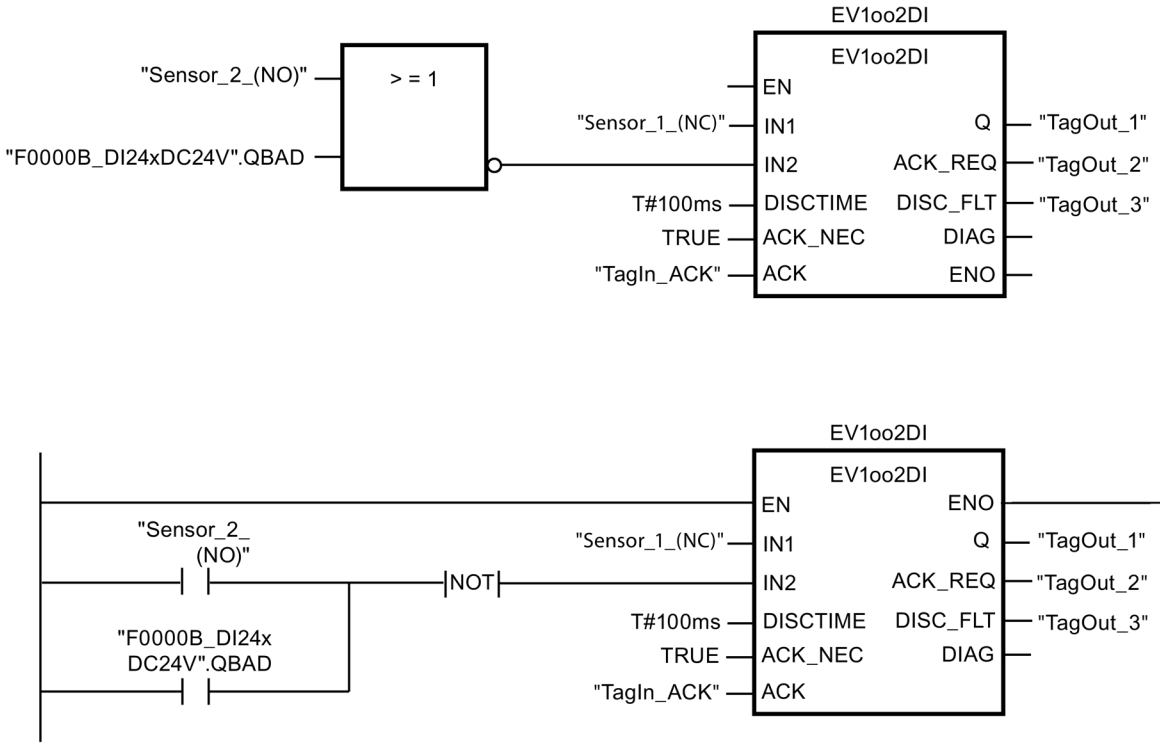
For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Activating inputs IN1 and IN2

Inputs IN1 and IN2 must both be activated in such a way that their safe state is 0.

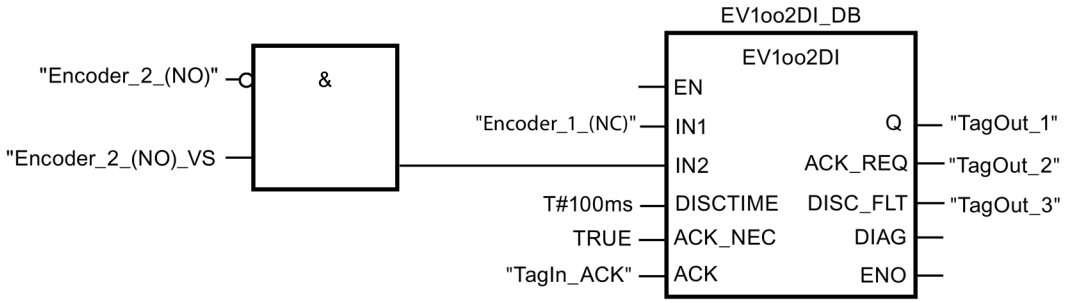
Example with QBAD or QBAD_I_xx signal

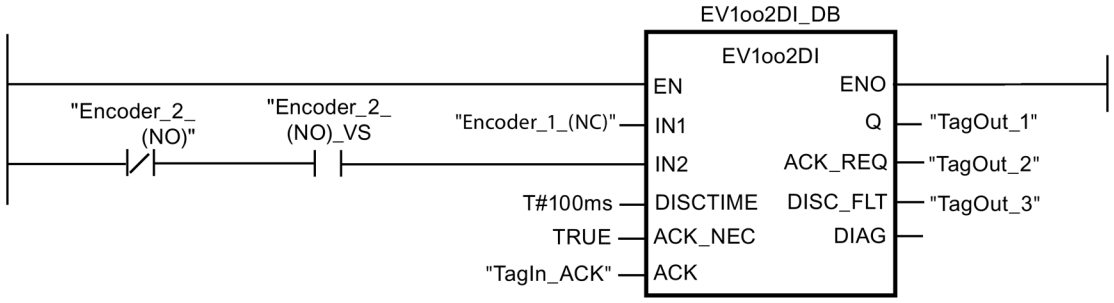
For non-equivalent signals you need to OR the input (IN1 and IN2) with which you assign the encoder signal to the safe state 1, with the QBAD signal of the associated F-I/O or the QBAD_I_xx signal of the associated channel (with S7-300/400 F-CPUs) and negate the result. Signal state 0 is then at input IN1 or IN2 when fail-safe values are output.



Example with value status

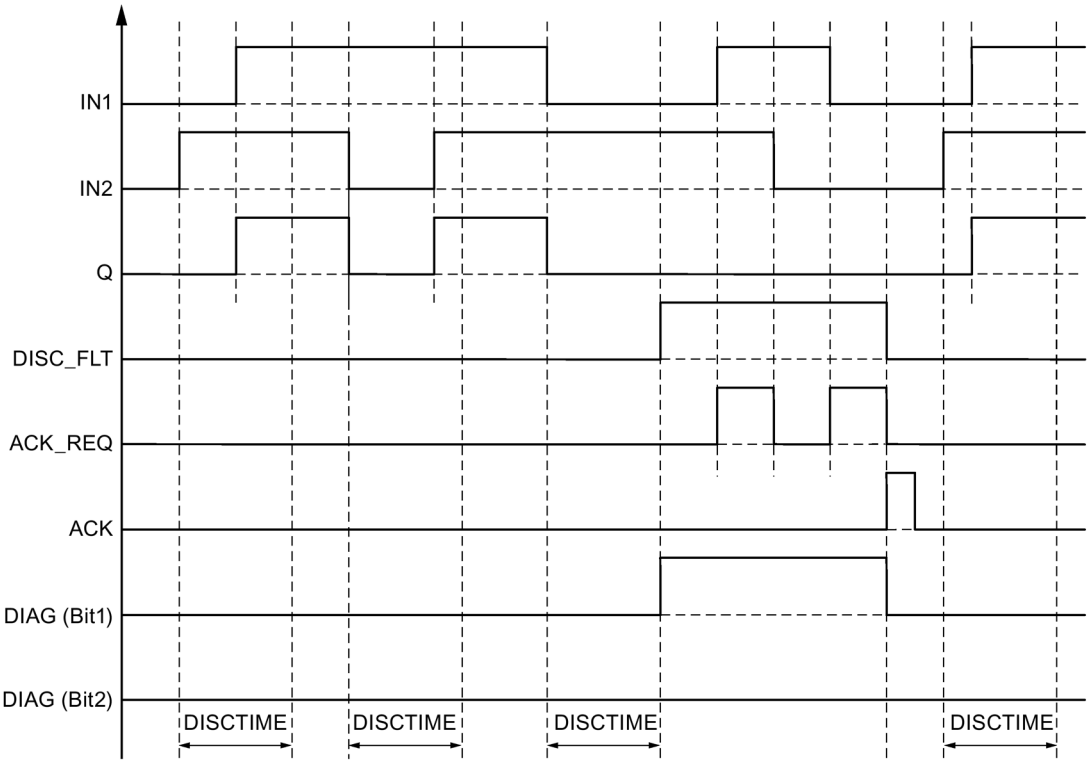
For nonequivalent signals, you have to negate the input (IN1 or IN2) with which you have assigned the encoder signal to a safe state of 1 and AND it with the value status of the associated channel. Signal state 0 is then at input IN1 or IN2 when fail-safe values are output.





Timing diagrams EV1oo2DI

If ACK_NEC = 1:



Startup characteristics

Note

If the sensors at inputs IN1 and IN2 are assigned to different F-I/O, it is possible that the fail-safe values are output for different lengths of time following startup of the F-system due to different startup characteristics of the F-I/O. If the signal states of inputs IN1 and IN2 remain different after the discrepancy time DISCTIME has expired, a discrepancy error is detected after the F-system starts up.

If ACK_NEC = 1 you must acknowledge the discrepancy error with a rising edge at input ACK.

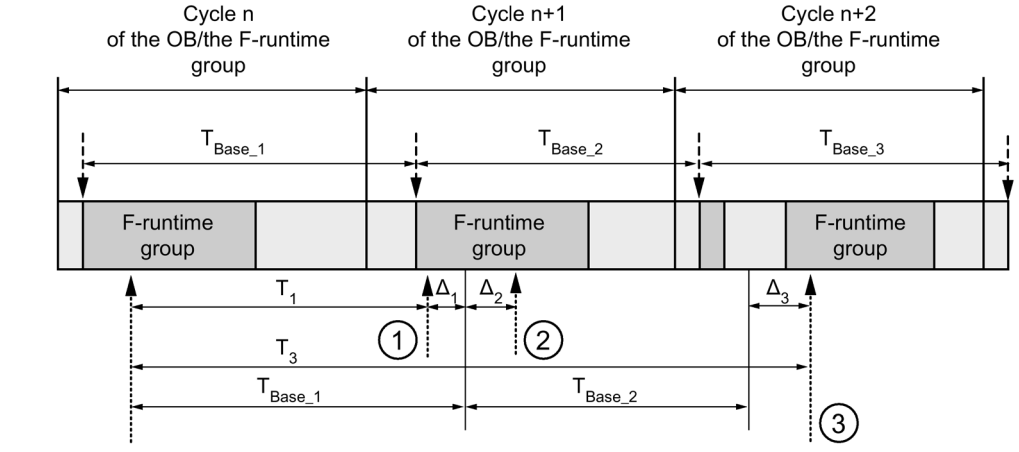
Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time setting (= status of DISC_FLT)	Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 60 s	Set discrepancy time in range between 0 s and 60 s
Bit 1	For discrepancy errors: last signal state change was at input IN1	—	—
Bit 2	For discrepancy errors: last signal state change was at input IN2	—	—
Bit 3	Reserved	—	—
Bit 4	Reserved	—	—
Bit 5	For discrepancy errors: input ACK has a permanent signal state of 1	Acknowledgment button defective	Replace acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment necessary	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time of the time base used in the instruction:



⇢ = Time base update

⇢ = Call time of an instruction with time processing

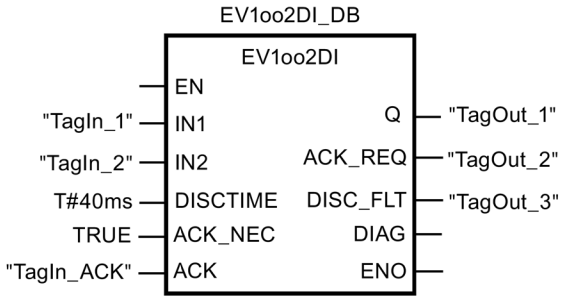
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

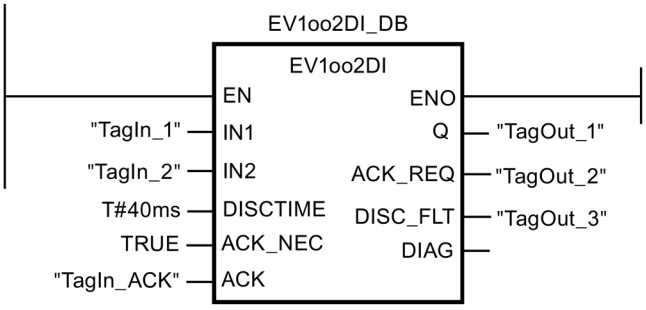
② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:





13.3.7 FDBACK: Feedback monitoring (STEP 7 Safety V14)

Description

This instruction implements feedback monitoring.

The signal state of output Q is checked to see whether it corresponds to the inverse signal state of the feedback input FEEDBACK.

Output Q is set to 1 as soon as input ON = 1. Requirement for this is that the feedback input FEEDBACK = 1 and no feedback error is saved.

Output Q is reset to 0, as soon as input ON = 0 or if a feedback error is detected.

A feedback error ERROR = 1 is detected if the inverse signal state of the feedback input FEEDBACK (to input Q) does not follow the signal state of output Q within the maximum tolerable feedback time. The feedback error is saved.

If a discrepancy is detected between the feedback input FEEDBACK and the output Q after a feedback error, the feedback error is acknowledged in accordance with the parameter assignment of ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must acknowledge the feedback error with a rising edge at input ACK.

The ACK_REQ = 1 output then signals that a user acknowledgment is necessary at input ACK to acknowledge the feedback error. Following an acknowledgment, the instruction resets ACK_REQ to 0.

To avoid a feedback errors from being detected and acknowledgment from being required when the F-I/O controlled by the Q output are passivated, you need to supply input QBAD_FIO with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal / inverted value status of the associated channel.

Every call of the "Feedback monitoring" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., FDBACK_DB_1) or a multi-instance (e.g., FDBACK_Instance_1) for the "Feedback monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING
The ACK_NEC tag must not be assigned a value of 0 unless an automatic restart of the affected process is otherwise excluded. *(S033)*

WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision *(S034)*.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ON	Input	BOOL	1= Enable output
FEEDBACK	Input	BOOL	Feedback input
QBAD_FIO	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the Q output
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	Acknowledgment
FDB_TIME	Input	TIME	Feedback time
Q	Output	BOOL	Output
ERROR	Output	BOOL	Feedback error
ACK_REQ	Output	BOOL	Acknowledgment request
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

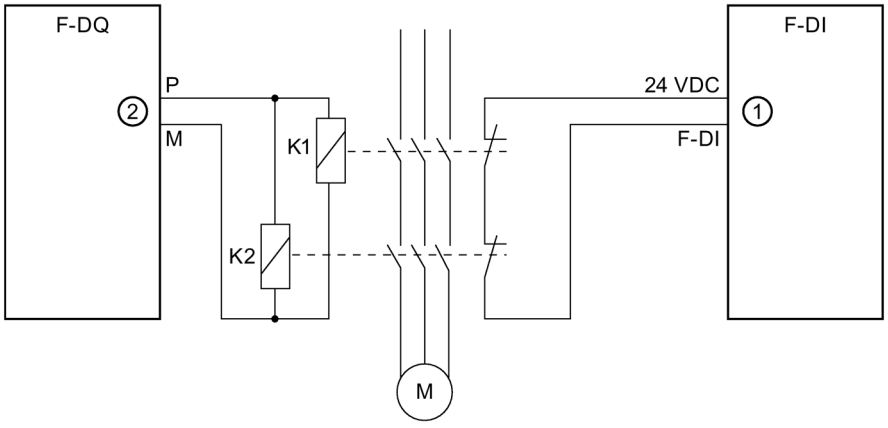
Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	Version 1.0 requires that the F_TOF block with the number FB 186 is available in the project tree in the "Program blocks/System blocks/STEP 7 Safety" folder. When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction. You will then avoid number conflicts.
1.1	x	—	—	These versions are functionally identical to version V1.0, but do not require the F_TOF block to have a particular number.
1.2	x	—	o	
1.3	x	o	o	
1.4	x	o	o	
1.5	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Interconnection example



① Sent to the FEEDBACK input of the instruction
② from output Q of the instruction

Startup characteristics

After an F-system startup, the instruction does not have be acknowledged when no errors are present.

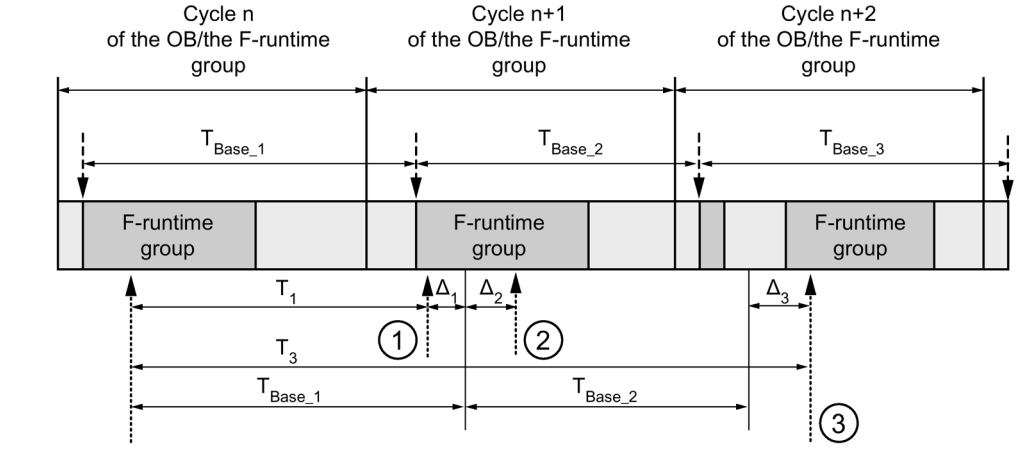
Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0, 2, and 5 are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Feedback error or incorrect feedback time setting (= state of ERROR)	Feedback time setting < 0	Set feedback time > 0
		Feedback time setting is too low	If necessary, set a higher feedback time
		Wiring fault	Check wiring of actuator and feedback contact
		Actuator or feedback contact is defective	Check actuator and feedback contact
		I/O fault or channel fault of feedback input	Check I/O
Bit 1	Passivation of F-I/O/channel controlled by output Q (= state of QBAD_FIO)	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
Bit 2	After feedback error: feedback input has permanent signal state of 0	F-I/O fault or channel fault of feedback input	Check I/O
		Feedback contact is defective	Check feedback contact
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of feedback input	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)
Bit 3	Reserved	—	—
Bit 4	Reserved	—	—
Bit 5	For feedback error: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time of the time base used in the instruction:



⇢ = Time base update

⇢ = Call time of an instruction with time processing

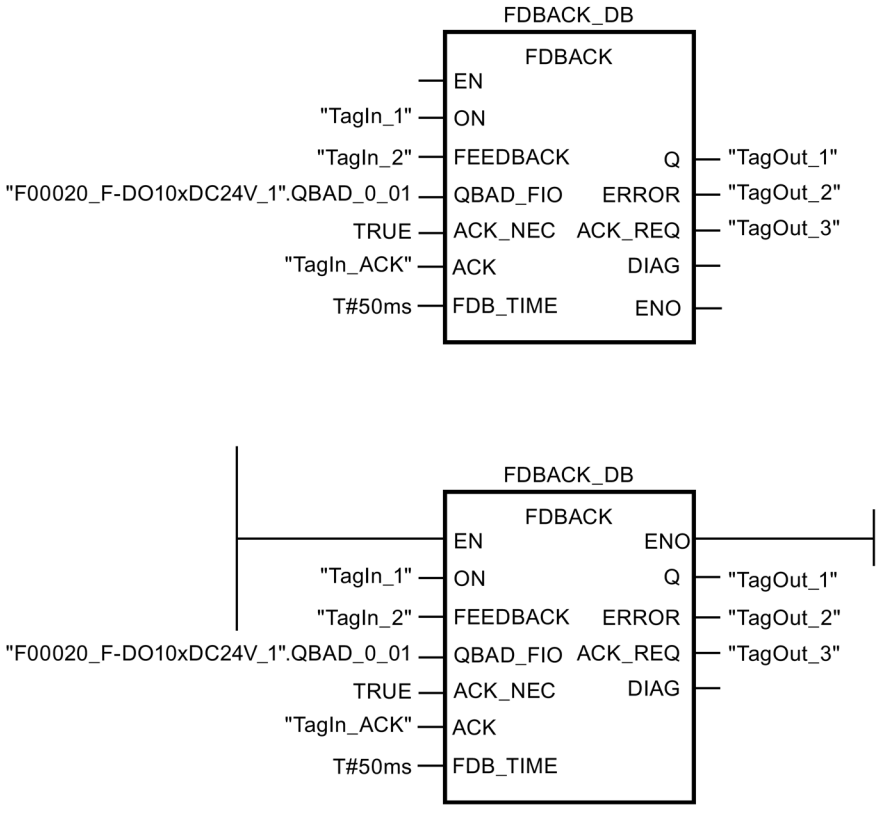
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

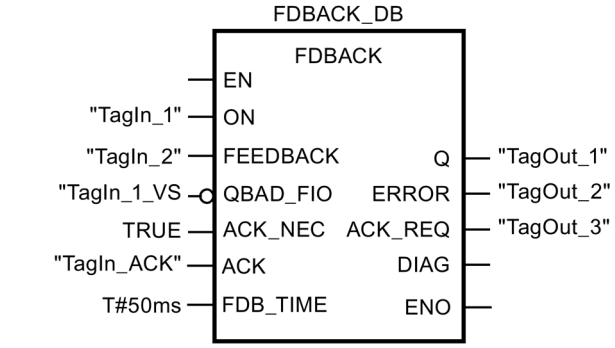
③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

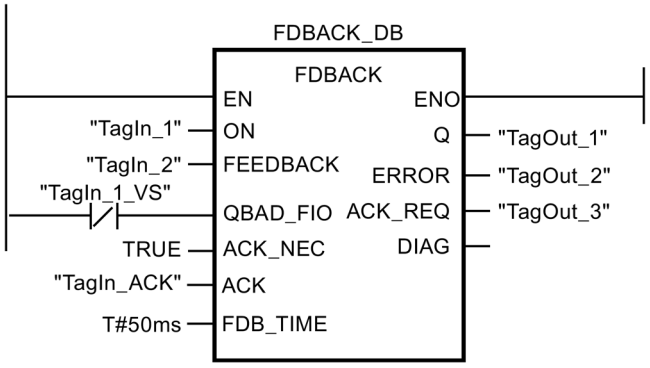
Example

The following example shows how the instruction for S7-300/400 F-CPUs works:



The following example shows how the instruction for S7-1200/1500 F-CPUs works:





13.3.8 SFDOOR: Safety door monitoring (STEP 7 Safety V14)

Description

This instruction implements safety door monitoring.

Enable signal Q is reset to 0 as soon as one of the inputs IN1 or IN2 take a signal state of 0 (safety door is opened). The enable signal can be reset to 1, only if:

- Inputs IN1 and IN2 both take a signal state of 0 prior to opening the door (safety door has been completely opened)
- Inputs IN1 and IN2 then both take a signal state of 1 (safety door is closed)
- An acknowledgment occurs

The acknowledgment for the enable takes place according to the parameter assignment at input ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK for acknowledging the enable.

Output ACK_REQ = 1 is used to signal that a user acknowledgment is required at input ACK for the acknowledgment. The instruction sets ACK_REQ = 1 as soon as the door is closed. Following an acknowledgment, the instruction resets ACK_REQ to 0.

In order for the instruction to recognize whether inputs IN1 and IN2 are 0 merely due to passivation of the associated F-I/O, you need to supply inputs QBAD_IN1 or QBAD_IN2 with the QBAD signal of the associated F-I/O or QBAD_I_xx signal / inverted value status of the associated channel. Among other things, this will prevent you from having to open the safety door completely prior to an acknowledgment in the event the F-I/O are passivated.

Every call of the "Safety door monitoring" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., SFDOOR_DB_1) or a multi-instance (e.g., SFDOOR_Instance_1) for the "Safety door monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

WARNING
The ACK_NEC tag must not be assigned a value of 0 unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Input 1
IN2	Input	BOOL	Input 2
QBAD_IN1	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the channel of input IN1
QBAD_IN2	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the channel of input IN2
OPEN_NEC	Input	BOOL	1= Open necessary at startup
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	Acknowledgment
Q	Output	BOOL	1= Enable, safety door closed
ACK_REQ	Output	BOOL	Acknowledgment request
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	x	x	

o This version is no longer supported.

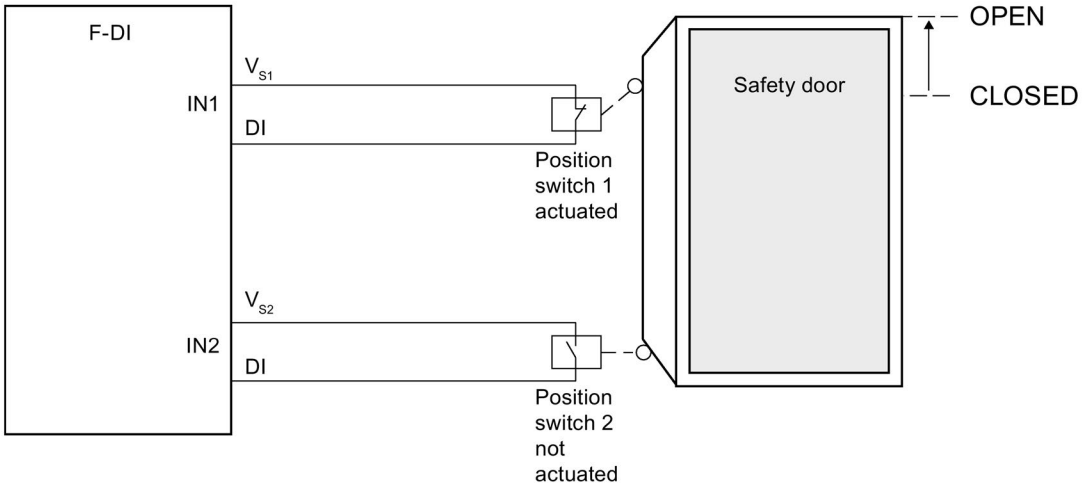
When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

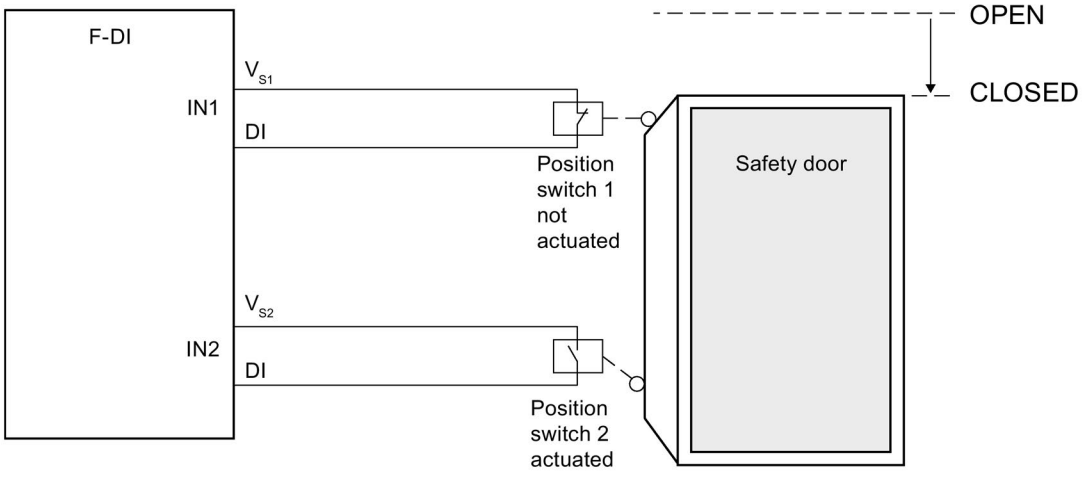
Interconnection example

You must interconnect the NC contact of position switch 1 of the safety door at input IN1 and the NO contact of position switch 2 at input IN2. Position switch 1 must be mounted in such a way that it is positively operated when the safety door is open. Position switch 2 must be mounted in such a way that it is operated when the safety door is closed.

Safety door open:



Safety door closed:



Startup characteristics

After an F-system startup, enable signal Q is reset to 0. The acknowledgment for the enable takes place according to the parameter assignment at inputs OPEN_NEC and ACK_NEC:

- When OPEN_NEC = 0, an automatic acknowledgment occurs **independently** of ACK_NEC, as soon as the two inputs IN1 and IN2 take signal state 1 for the first time following reintegration of the associated F-I/O (safety door is closed).
- When OPEN_NEC = 1 **or** if at least one of the IN1 and IN2 inputs still has a signal state of 0 after reintegration of the associated F-I/O, an automatic acknowledgment occurs **according** to ACK_NEC or you have to use a rising edge at input ACK for the enable. Prior to acknowledgment, inputs IN1 and IN2 both have to take a signal state of 0 (safety door has been completely opened) followed by a signal state of 1 (safety door is closed).

⚠ WARNING

The OPEN_NEC tag must not be assigned a value of 0 unless an automatic restart of the affected process is otherwise excluded. *(S039)*

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program.

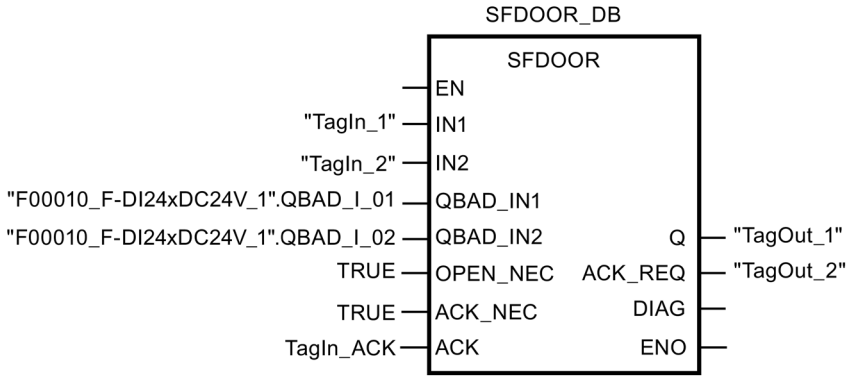
Structure of DIAG

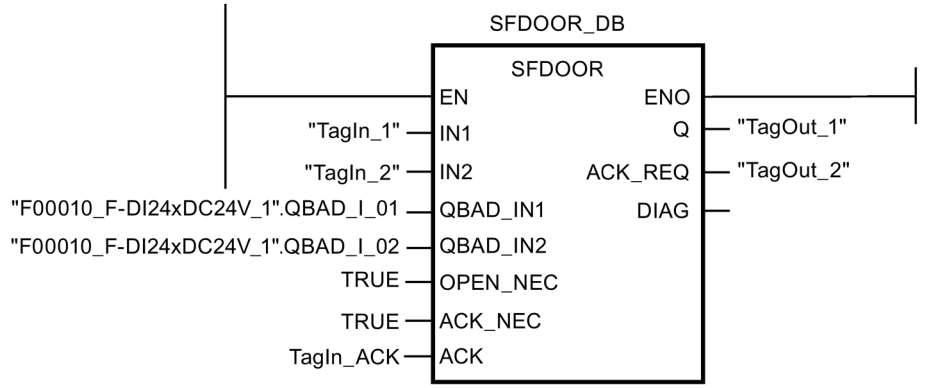
Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Signal state 0 is missing at both IN1 and IN2 inputs	Safety door was not completely opened when OPEN_NEC = 1 after F-system startup	Open safety door completely
		Open safety door was not completely opened	Open safety door completely
		Wiring fault	Check wiring of position switch
		Position switch is defective	Check position switch
		Position switch is incorrectly adjusted	Adjust position switch properly
Bit 2	Signal state 1 is missing at both IN1 and IN2 inputs	Safety door was not closed	Close safety door
		Wiring fault	Check wiring of position switch
		Position switch is defective	Check position switch
		Position switch is incorrectly adjusted	Adjust position switch properly
Bit 3	QBAD_IN1 and/or QBAD_IN2 = 1	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O or channel of IN1 and/or IN2	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 143)

Bit no.	Assignment	Possible error causes	Remedies
Bit 4	Reserved	—	—
Bit 5	If enable is missing: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

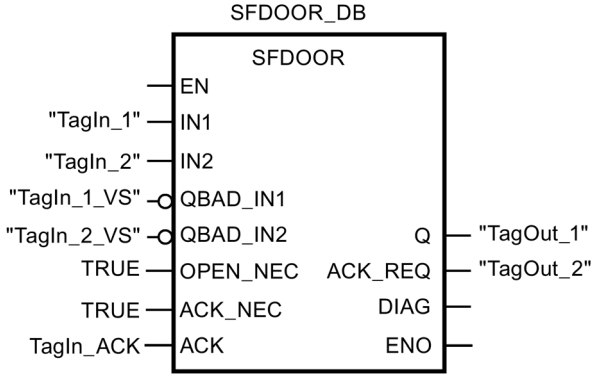
Example

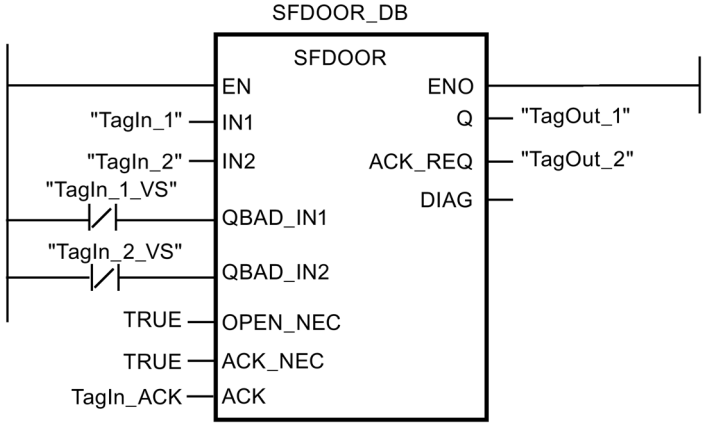
The following example shows how the instruction for S7-300/400 F-CPUs works:





The following example shows how the instruction for S7-1200/1500 F-CPUs works:





13.3.9 ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V14)

Description

This instruction creates an acknowledgment for the simultaneous reintegration of all F-I/O or channels of the F-I/O of an F-runtime group after communication errors, F-I/O errors, or channel faults.

A user acknowledgment (Page 156) with a positive edge at input ACK_GLOB is required for reintegration. The acknowledgment occurs analogously to the user acknowledgment via the ACK_REI tag of the F-I/O DB (Page 138), but it acts simultaneously on all F-I/O of the F-runtime group in which the instruction is called.

If you use the instruction ACK_GL, you do not have to provide a user acknowledgment for each F-I/O of the F-runtime group via the ACK_REI tag of the F-I/O DB.

Every call of the "Global acknowledgment of all F-I/O of a runtime group" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_GL_DB_1) or a multi-instance (e.g., ACK_GL_Instance_1) for the "Global acknowledgment of all F-I/O of a runtime group" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

An acknowledgment via the ACK_GL instruction is only possible if the tag ACK_REI of the F-I/O DB = 0. Accordingly, an acknowledgment via the tag ACK_REI of the F-I/O DB is only possible if the input ACK_GLOB of the instruction = 0.

The instruction is only allowed to be called once per F-runtime group.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ACK_GLOB	Input	BOOL	1=acknowledgment for reintegration

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	x	x	

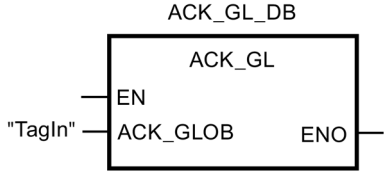
o This version is no longer supported.

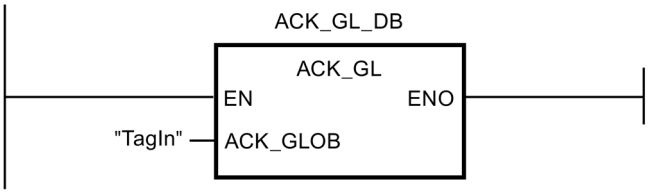
When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:





13.4 Timer operations

13.4.1 TP: Generate pulse (STEP 7 Safety V14)

Description

You can use the "Generate pulse" instruction to set output Q for a programmed period. The instruction is started if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. The programmed period PT starts running when the instruction starts. Output Q is set for period PT, regardless of the subsequent sequence of the input signal. Also the detection of a new positive signal edge does not influence the signal state at output Q as long as period PT runs.

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. If period PT is reached and the signal state at input IN is "0", output ET is reset.

Every call of the "Generate pulse" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate pulse" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction").
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

The operating system resets the instances of the "Generate pulse" instruction on a startup of the F-system.

Note

The functionality of this instruction differs from the corresponding standard TP instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the outputs Q and ET are reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the pulse, a new rising signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of pulse; must be positive.
Q	Output	BOOL	Pulse output
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	o	o	
1.4	x	x	x	

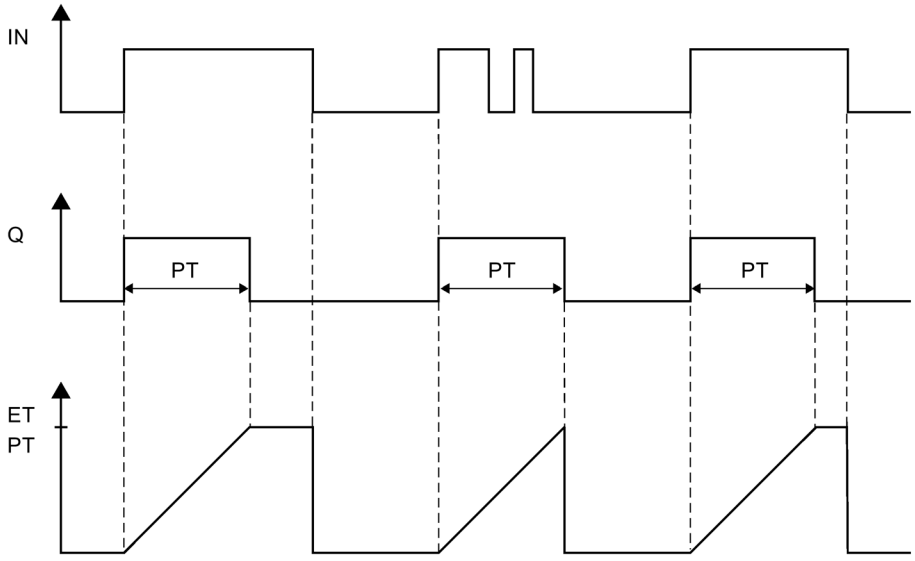
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

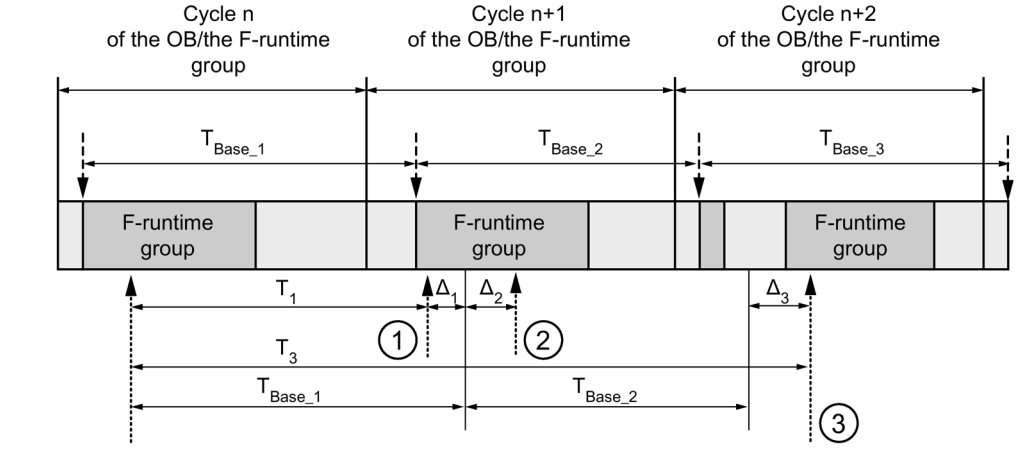
For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate pulse":



Timing imprecision resulting from the update time of the time base used in the instruction:



⇢ = Time base update

⇢ = Call time of an instruction with time processing

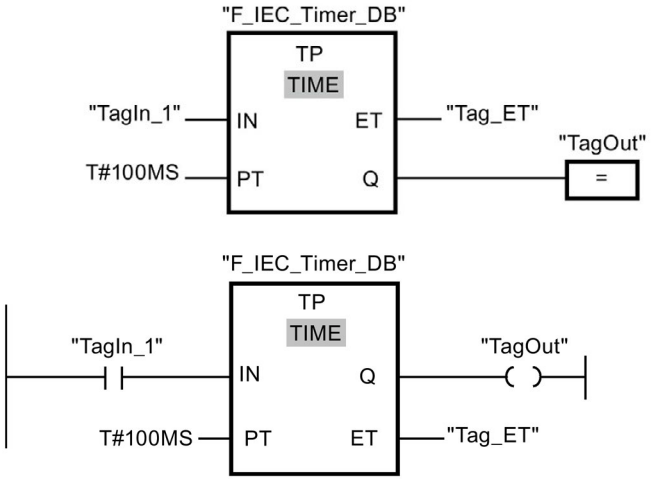
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:



If the signal state of operand "TagIn_1" changes from "0" to "1", the "Generate pulse" instruction is started and the period assigned at input PT (100 ms) runs, regardless of the further course of operand "TagIn_1".

Operand "TagOut" at output Q has signal state "1" as long as the period is running. Operand "Tag_ET" contains the current time value.

13.4.2 TON: Generate on-delay (STEP 7 Safety V14)

Description

You use the "Generate on-delay" instruction to delay the setting of output Q by the assigned period PT. The instruction is started if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. The programmed period PT starts running when the instruction starts. When period PT has expired, output Q is set to signal state "1". Output Q remains set as long as the start input is set to "1". When the signal state at the start input changes from "1" to "0", output Q is reset. The time function is restarted when a new positive signal edge is detected at the start input.

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. Output ET is reset, as soon as the signal state at input IN changes to "0".

Every call of the "Generate on-delay" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate on-delay" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

The operating system resets the instances of the "Generate on-delay" instruction on a startup of the F-system.

Note

The functionality of this instruction differs from the corresponding standard TON instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the output ET is reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the on-delay, a new rising signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of on-delay; must be positive.
Q	Output	BOOL	Output that is set after expiration of time PT.
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	o	o	
1.4	x	x	x	

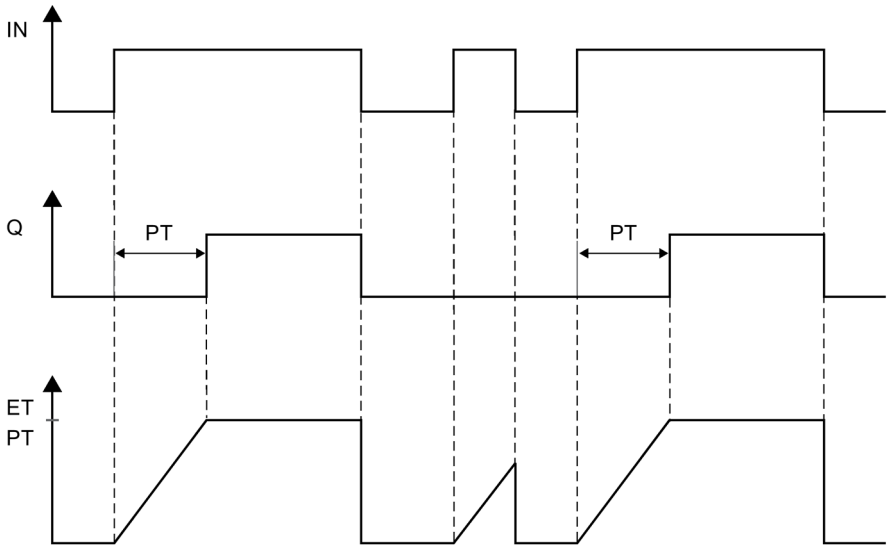
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

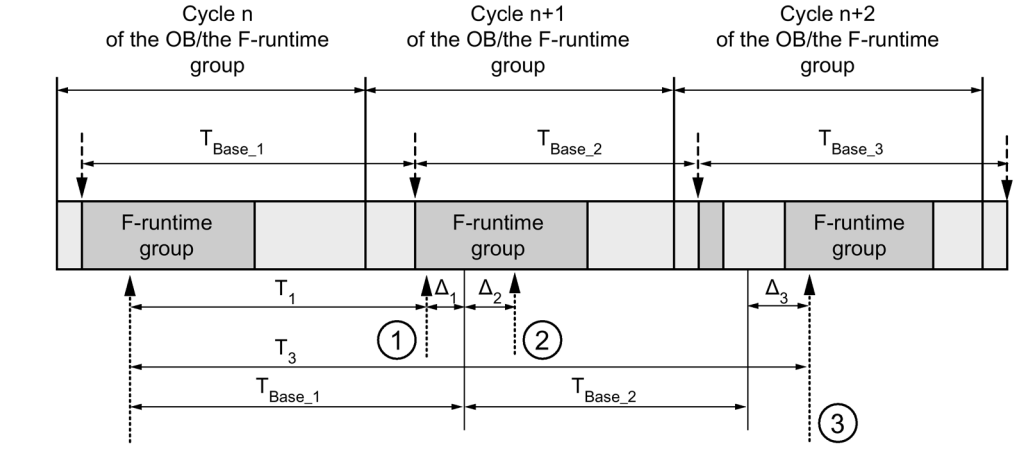
For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate on-delay":



Timing imprecision resulting from the update time of the time base used in the instruction:



----► = Time base update

·····► = Call time of an instruction with time processing

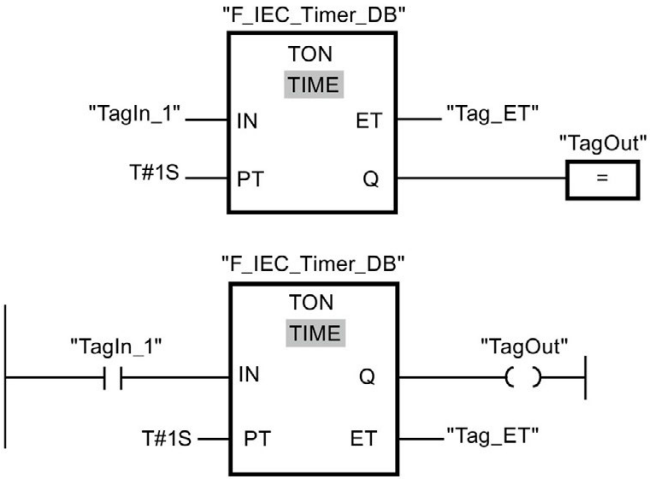
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:



When the signal state of operand "TagIn_1" changes from "0" to "1", the "Generate on-delay" instruction is started and the period assigned at input PT (1 s) runs.

Operand "TagOut" at output Q feeds signal state "1" when the period has elapsed and remains set as long as operand "TagIn_1" still feeds signal state "1". Operand "Tag_ET" contains the current time value.

13.4.3 TOF: Generate off-delay (STEP 7 Safety V14)

Description

You use the "Generate off-delay" instruction to delay the resetting of output Q by the assigned period PT. Output Q is set if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. When the signal state at input IN changes back to "0", the programmed period PT starts. Output Q remains set as long as period PT runs. After period PT expires, output Q is reset. If the signal state at input IN changes to "1" before period PT has expired, then the time is reset. The signal state at output Q remains at "1".

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. After time PT has elapsed, output ET remains at its current value until input IN changes back to "1". If input IN changes to "1" before time PT has expired, the output ET is reset to value T#0.

Every call of the "Generate off-delay" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is in inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate off-delay" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

The operating system resets the instances of the "Generate off-delay" instruction on a startup of the F-system.

Note

The functionality of this instruction differs from the corresponding standard TOF instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the outputs Q and ET are reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the off-delay, another falling signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of off delay; must be positive.
Q	Output	BOOL	Output that is reset after expiration of time PT.
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	o	o	
1.4	x	x	x	

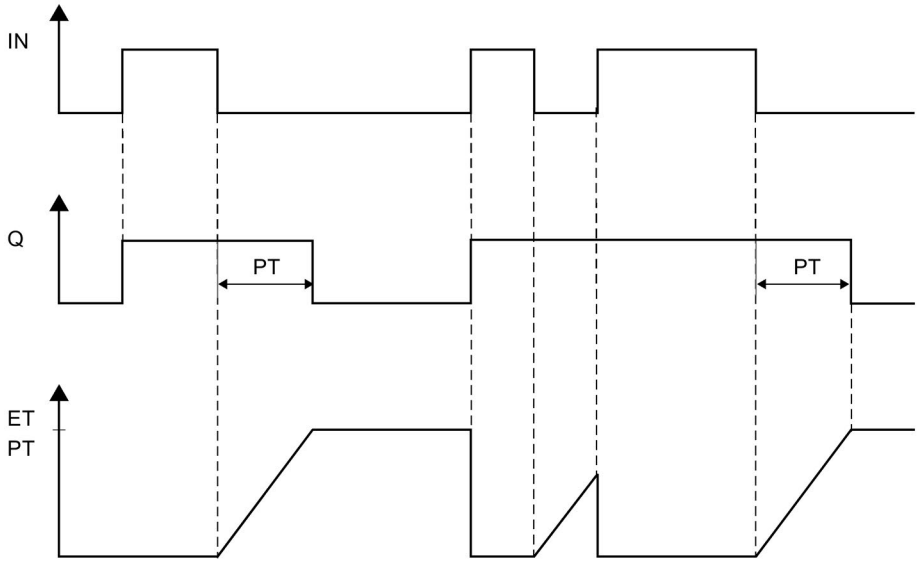
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

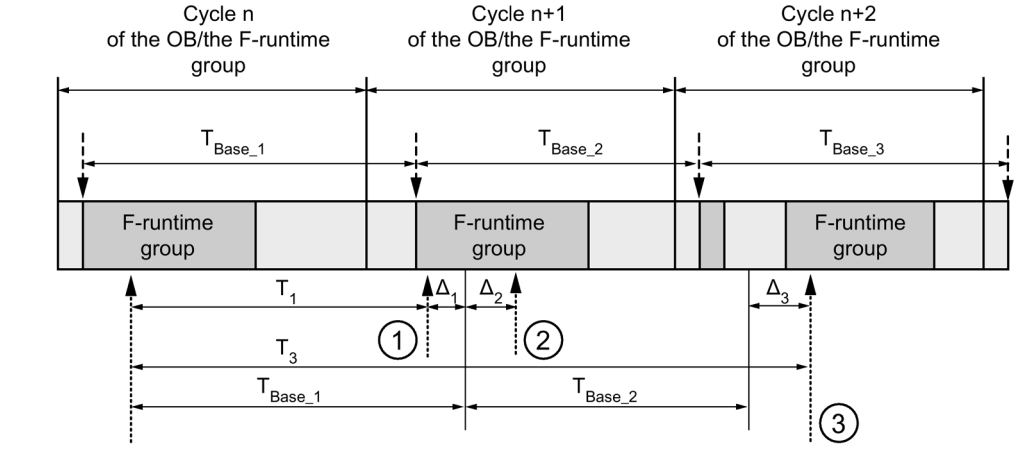
For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate off-delay":



Timing imprecision resulting from the update time of the time base used in the instruction:



⇢ = Time base update

⇢ = Call time of an instruction with time processing

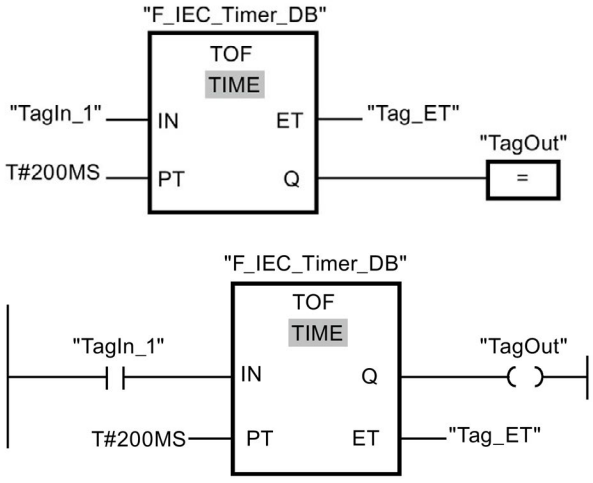
① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

The following example shows how the instruction works:



If the signal state of operand "TagIn_1" changes from "0" to "1", the signal state of operand"TagOut" at output Q is set to "1".

If the signal state of operand "TagIn_1" changes back to "0", the period assigned at input PT (200 ms) runs.

The "TagOut" operand at output Q is set back to "0" when the period expires. Operand "Tag_ET" contains the current time value.

13.5 Counter operations

13.5.1 CTU: Count up (STEP 7 Safety V14)

Description

You can use the "Count up" instruction to increment the value at output CV. When the signal state at input CU changes from "0" to "1" (positive signal edge), the instruction is executed and the current count value at output CV is increased by one. The count value is increased on each detection of a positive signal edge until it reaches the high limit of the data type specified at output CV. When the high limit is reached, the signal state at input CU no longer affects the instruction.

The counter status can be queried at output Q. The signal state at output Q is determined by parameter PV. When the current count value is greater than or equal to the value of parameter PV, output Q is set to signal state "1". In all other cases, the signal state at output Q is "0".

The value at output CV is reset to zero when the signal state at input R changes to "1". As long as signal state "1" exists at input R, the signal state at input CU has no effect on the instruction.

Every call of the "Count up" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count up" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count up" instruction on a startup of the F-system.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CU	Input	BOOL	Counter input
R	Input	BOOL	Reset input
PV	Input	INT	Value for which output Q is set
Q	Output	BOOL	Counter status
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	x	x	

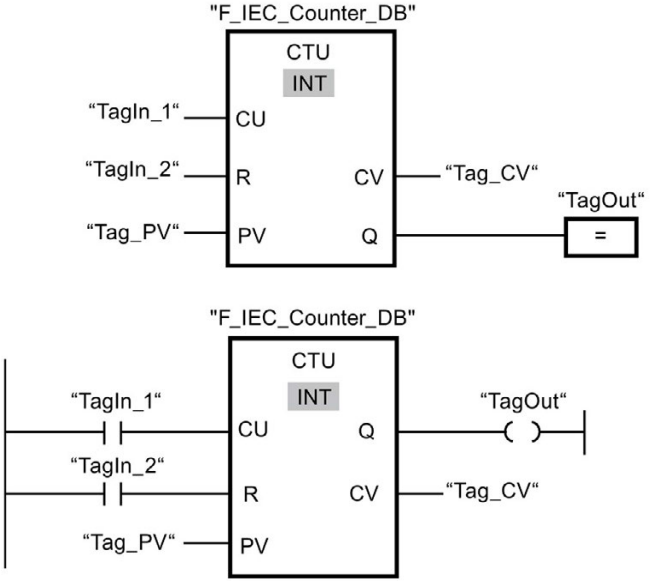
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



When the signal state of the "TagIn_1" operand changes from "0" to "1", the "Count up" instruction is executed and the current count value of the "Tag_CV" operand is increased by one. The count value is increased on every additional positive signal edge until the high limit of the specified data type (32767) is reached.

The value at parameter PV is taken as the limit for the determination of output "TagOut". Output "TagOut" delivers the signal state "1" as long as the current count value is greater than or equal to the value of operand "Tag_PV". In all other cases, output TagOut has signal state "0".

13.5.2 CTD: Count down (STEP 7 Safety V14)

Description

You can use the "Count down" instruction to decrement the value at output CV. When the signal state at input CD changes from "0" to "1" (positive signal edge), the instruction is executed and the current count value at output CV is decreased by one. The count value is decreased on each detection of a positive signal edge until it reaches the low limit of the specified data type. When the low limit is reached, the signal state at input CD no longer affects the instruction.

The counter status can be queried at output Q. When the current count value is less than or equal to zero, output Q is set to signal state "1". In all other cases, the signal state at output Q is "0".

The value at output CV is set to the value of parameter "PV" when the signal state at input LD changes to "1". As long as signal state "1" exists at input LD, the signal state at input CD has no effect on the instruction.

Every call of the "Count down" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count down" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count down" instruction on a startup of the F-system.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CD	Input	BOOL	Counter input
LD	Input	BOOL	Load input
PV	Input	INT	Value at the output CV when LD = 1 is set
Q	Output	BOOL	Counter status
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	x	x	

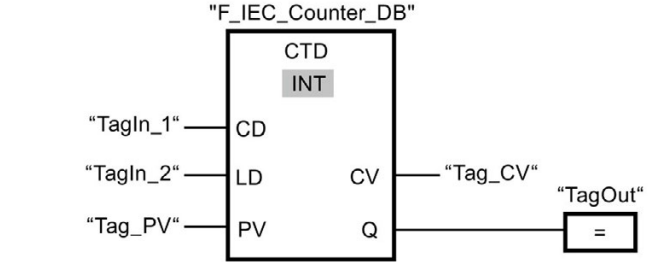
o This version is no longer supported.

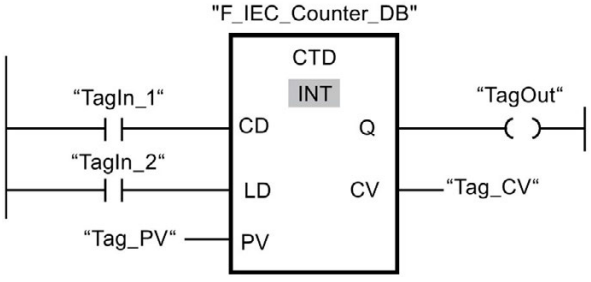
When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:





If the signal state of the "TagIn_1" operand changes from "0" to "1", the "Count down" instruction is executed and the current count value at output "Tag_CV" is decreased by one. The count value is decreased on each additional positive signal edge until the low limit of the specified data type (-32768) is reached.

Output "TagOut" delivers the signal state "1" as long as the current count value is less than or equal to zero. In all other cases, output TagOut has signal state "0".

13.5.3 CTUD: Count up and down (STEP 7 Safety V14)

Description

You can use the "Count up and down" instruction to increment and decrement the count value at output CV. If the signal state at input CU changes from "0" to "1" (positive signal edge), the current count value at output CV is increased by one. If the signal state at input CD changes from "0" to "1" (positive signal edge), the count value at output CV is decreased by one. If a positive signal edge is present at inputs CU and CD in one program cycle, the current count value at output CV remains unchanged.

The count value can be increased until it reaches the high limit of the data type specified at output CV. When the high limit is reached, the count value is no longer incremented on a positive signal edge. When the low limit of the specified data type is reached, the count value is no longer decreased.

When the signal state at input LD changes to "1", the count value at output CV is set to the value of parameter PV. As long as signal state "1" exists at input LD, the signal state at inputs CU and CD has no effect on the instruction.

The count value is set to zero, when the signal state at input R changes to "1". As long as signal state "1" exists at input R, the signal state at inputs CU, CD, and LD has no effect on the "Count up and down" instruction.

The status of the up counter can be queried at output QU. When the current count value is greater than or equal to the value of parameter PV, output QU delivers signal state "1". In all other cases, the signal state at output QU is "0".

The status of the down counter can be queried at output QD. When the current count value is lesser than or equal to zero, output QD delivers signal state "1". In all other cases, the signal state at output QD is "0".

Every call of the "Count up and down" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count up and down" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count up and down" instruction when the F-system is started up.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CU	Input	BOOL	Count up input
CD	Input	BOOL	Count down input
R	Input	BOOL	Reset input
LD	Input	BOOL	Load input
PV	Input	INT	Value set at the output QU/ at which the output CV is set at LD = 1.
QU	Output	BOOL	Status of up counter
QD	Output	BOOL	Status of down counter
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	o	o	
1.3	x	x	x	

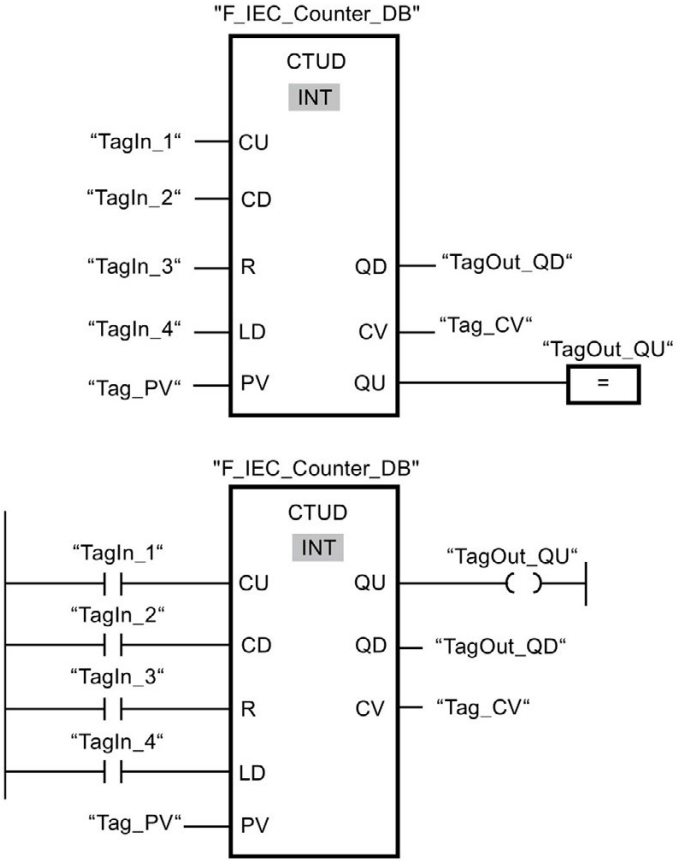
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



When the signal state at input "TagIn_1" or at input "TagIn_2" changes from "0" to "1" (positive signal edge), the "Count up and down" instruction is executed. When a positive signal edge is present at input "TagIn_1", the current count value of the "Tag_CV" operand is increased by one. When a positive signal edge is present at input "TagIn_2", the current count value at output "Tag_CV" is decreased by one. The count value is increased on each positive signal edge at input CU until it reaches the high limit of 32767. The count value is decreased on each positive signal edge at input CD until it reaches the low limit of -32768.

Output "TagOut_QU" delivers the signal state "1" as long as the current count value is greater than or equal to the value at input "Tag_PV". In all other cases, output TagOut_QU has signal state "0".

Output "TagOut_QD" delivers the signal state "1" as long as the current count value is less than or equal to zero. In all other cases, output TagOut_QD has signal state "0".

13.6 Comparator operations

13.6.1 CMP ==: Equal (STEP 7 Safety V14)

Description

You can use the "Equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is equal to the second comparison value (IN2 or <Operand2>).

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

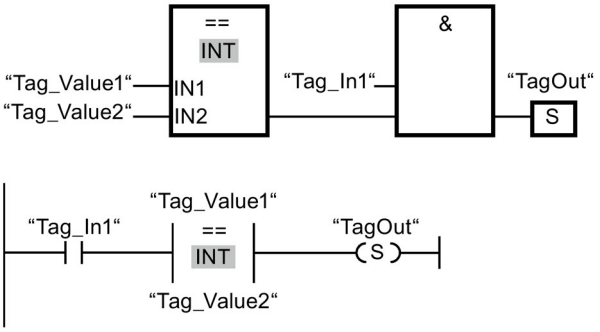
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME, WORD, (S7-300/400) DWORD	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME, WORD, (S7-300/400) DWORD	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" = "Tag_Value2").

13.6.2 CMP <>: Not equal (STEP 7 Safety V14)

Description

You can use the "Not equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is not equal to the second comparison value (IN2 or <Operand2>).

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

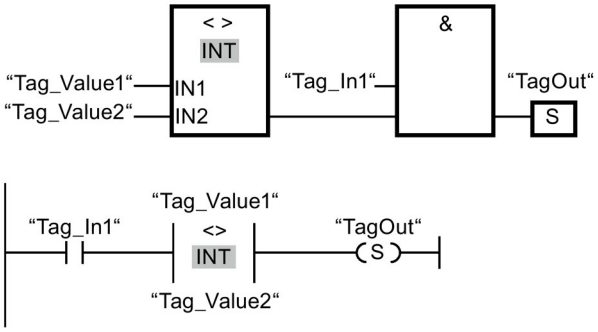
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME, WORD, (S7-300/400) DWORD	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME, WORD, (S7-300/400) DWORD	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" <> "Tag_Value2").

13.6.3 CMP >=: Greater or equal (STEP 7 Safety V14)

Description

You can use the "Greater or equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is greater than or equal to the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

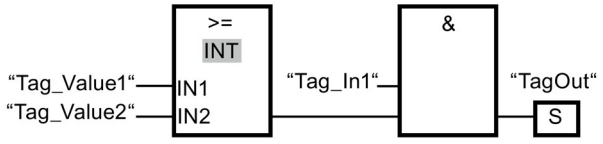
The following table shows the parameters of the instruction:

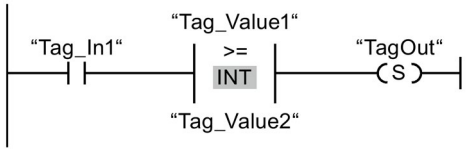
Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:





Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" >= "Tag_Value2").

13.6.4 CMP <=: Less or equal (STEP 7 Safety V14)

Description

You can use the "Less or equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is less than or equal to the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

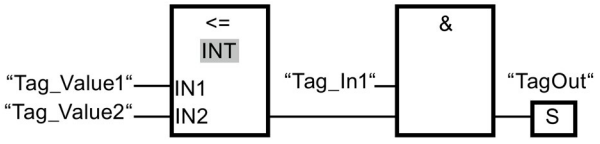
The following table shows the parameters of the instruction:

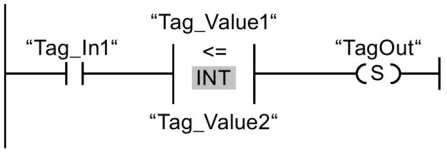
Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:





Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" <= "Tag_Value2").

13.6.5 CMP >: Greater than (STEP 7 Safety V14)

Description

You can use the "Greater than" instruction to determine if the first comparison value (IN1 or <Operand1>) is greater than the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

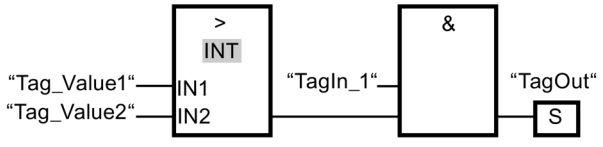
The following table shows the parameters of the instruction:

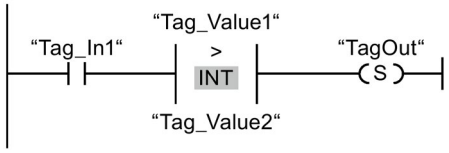
Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:





Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" > "Tag_Value2").

13.6.6 CMP <: Less than (STEP 7 Safety V14)

Description

You can use the "Less than" instruction to determine if the first comparison value (IN1 or <Operand1>) is less than the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

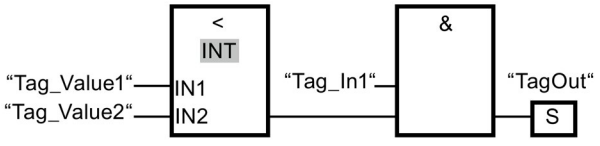
The following table shows the parameters of the instruction:

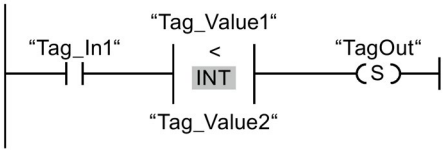
Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:





Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" < "Tag_Value2").

13.7 Math functions

13.7.1 ADD: Add (STEP 7 Safety V14)

Description

You can use the "Add" instruction to add the value at input IN1 and the value at input IN2 and query the sum at the OUT output (OUT = IN1 + IN2).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

If the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.

Parameters

The following table shows the parameters of the instruction:

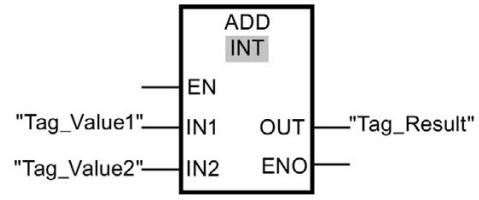
Parameter	Declaration	Data type	Description
IN1	Input	INT, DINT	First addend
IN2	Input	INT, DINT	Second addend
OUT	Output	INT, DINT	Total

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

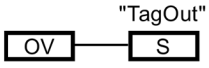
Example

The following example shows how the instruction works:

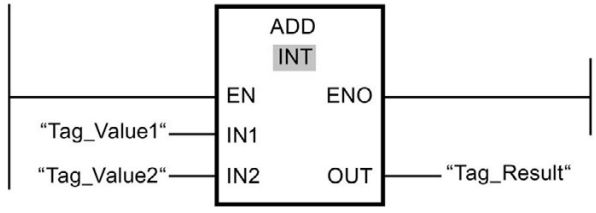
Network 1:



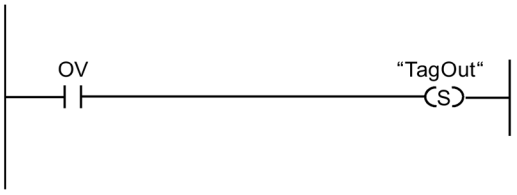
Network 2: (S7-300, S7-400)



Network 1:



Network 2: (S7-300, S7-400)



The "Add" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the "Tag_Result" operand.

(S7-300, S7-400) If an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 511)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 512)

13.7.2 SUB: Subtract (STEP 7 Safety V14)

Description

You can use the "Subtract" instruction to subtract the value at input IN2 from the value at input IN1 and query the difference at the OUT output (OUT = IN1 – IN2).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

If the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.

Parameters

The following table shows the parameters of the instruction:

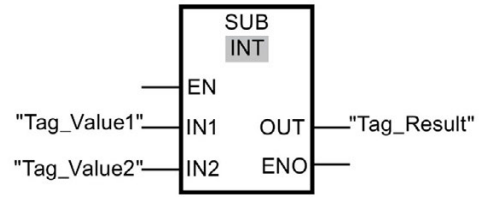
Parameter	Declaration	Data type	Description
IN1	Input	INT, DINT	Minuend
IN2	Input	INT, DINT	Subtrahend
OUT	Output	INT, DINT	Difference

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

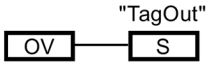
Example

The following example shows how the instruction works:

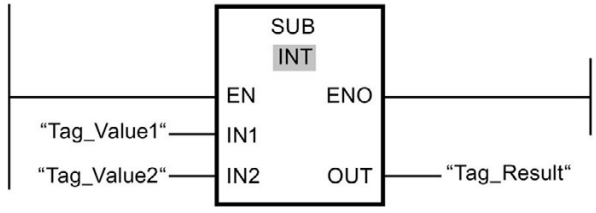
Network 1:



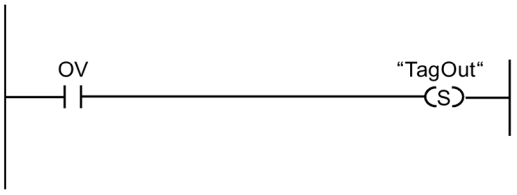
Network 2: (S7-300, S7-400)



Network 1:



Network 2: (S7-300, S7-400)



The "Subtract" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value2" operand is subtracted from the value of the "Tag_Value1" operand. The result of the addition is stored in the "Tag_Result" operand.

(S7-300, S7-400) If an overflow occurs during execution of the "Subtract" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 511)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 512)

13.7.3 MUL: Multiply (STEP 7 Safety V14)

Description

You can use the "Multiply" instruction to multiply the value at input IN1 by the value at input IN2 and query the product at output OUT (OUT = IN1 × IN2).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

If the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.

Parameters

The following table shows the parameters of the instruction:

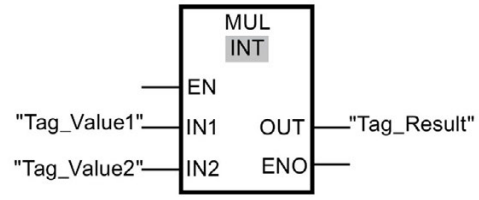
Parameter	Declaration	Data type	Description
IN1	Input	INT, DINT	Multiplier
IN2	Input	INT, DINT	Multiplicand
OUT	Output	INT, DINT	Product

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

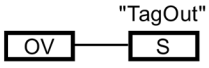
Example

The following example shows how the instruction works:

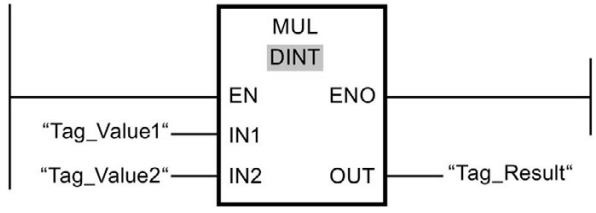
Network 1:



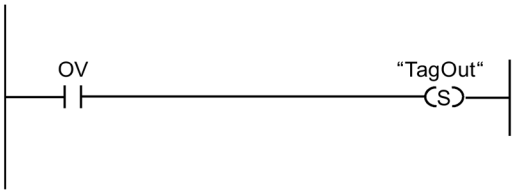
Network 2: (S7-300, S7-400)



Network 1:



Network 2: (S7-300, S7-400)



The "Multiply" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is multiplied by the value of the "Tag_Value2" operand. The result of the multiplication is stored in the "Tag_Result" operand.

(S7-300, S7-400) If an overflow occurs during execution of the "Multiply" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 511)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 512)

13.7.4 DIV: Divide (STEP 7 Safety V14)

Description

You can use the "Divide" instruction to divide the value at input IN1 by the value at input IN2 and query the quotient at the OUT output (OUT = IN1 / IN2).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

If the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.

Note

S7-300/400:

If the divisor (input IN2) of a DIV instruction = 0, the quotient of the division (result of division at output OUT) = 0. The result reacts like the corresponding instruction in a standard block. The F-CPU does *not* go to STOP mode.

S7-1200/1500:

If the divisor (input IN2) of a DIV instruction = 0, the F-CPU goes to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU. We recommend that you rule out a divisor (input IN2) = 0 when creating the program.

Parameters

The following table shows the parameters of the instruction:

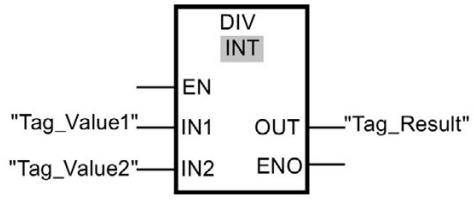
Parameter	Declaration	Data type	Description
IN1	Input	INT, DINT	Dividend
IN2	Input	INT, DINT	Divisor
OUT	Output	INT, DINT	Quotient

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

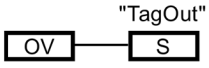
Example

The following example shows how the instruction works:

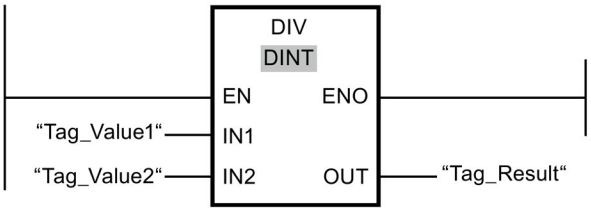
Network 1:



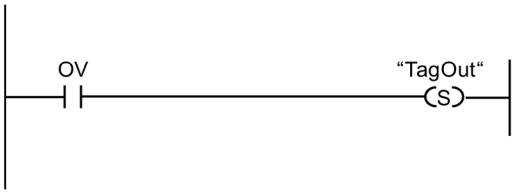
Network 2: (S7-300, S7-400)



Network 1:



Network 2: (S7-300, S7-400)



The "Divide" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is divided by the value of the "Tag_Value2" operand. The result of the division is stored in the "Tag_Result" operand.

(S7-300, S7-400) If an overflow occurs during execution of the "Divide" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 511)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 512)

13.7.5 NEG: Create twos complement (STEP 7 Safety V14)

Description

You can use the "Create twos complement" instruction to change the sign of the value at input IN input and query the result at output OUT. If there is a positive value at input IN, for example, the negative equivalent of this value is sent to output OUT.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

If the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.

Parameters

The following table shows the parameters of the instruction:

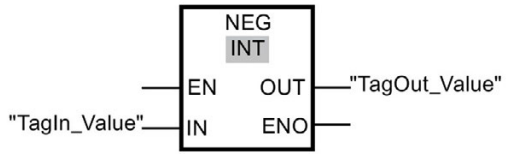
Parameter	Declaration	Data type	Description
IN	Input	INT, DINT	Input value
OUT	Output	INT, DINT	Twos complement of the input value

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

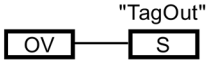
Example

The following example shows how the instruction works:

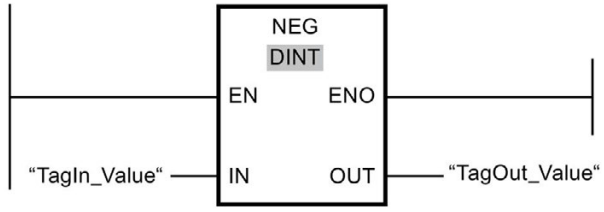
Network 1:



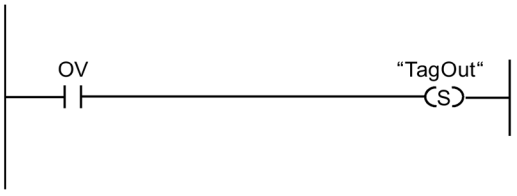
Network 2: (S7-300, S7-400)



Network 1:



Network 2: (S7-300, S7-400)



The "Create twos complement" instruction is always executed (regardless of the signal state at enable input EN).

The sign of the "TagIn_Value" operand is changed and the result is stored in the "TagOut_Value" operand.

(S7-300, S7-400) If an overflow occurs during execution of the "Create twos complement" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 511)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400) (Page 512)

13.8 Move operations

13.8.1 MOVE: Move value (STEP 7 Safety V14)

Description

You can use the "Move value" instruction to transfer the content of the operand at input IN to the operand at output OUT1.

Only operands with identical operand width and identical data structure can be specified for input IN and output OUT1.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

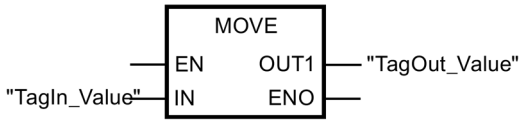
Parameters

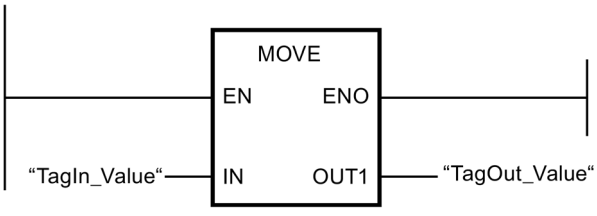
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT, DINT, WORD, (S7-300/400) DWORD, TIME, F-compliant PLC data type (UDT)	Source value
OUT1	Output	INT, DINT, WORD, (S7-300/400) DWORD, TIME, F-compliant PLC data type (UDT)	Destination address

Example

The following example shows how the instruction works:





The instruction is always executed regardless of the signal state at enable input "EN". The instruction copies the content of operand "TagIn_Value" to operand "TagOut_Value".

13.8.2 WR_FDB: Write value indirectly to an F-DB (STEP 7 Safety V14) (S7-300, S7-400)

Description

This instruction writes the value specified in input IN to the tag addressed by INI_ADDR and OFFSET in an F-DB.

The address of the tags addressed using INI_ADDR and OFFSET must be within the address range defined by addresses INI_ADDR and END_ADDR.

If the F-CPU has gone to STOP mode with diagnostics event ID 75E2, check to determine if this condition is satisfied.

The start address of the area in an F-DB to which the value at input IN is to be written is transferred using input INI_ADDR. The associated offset in this area is transferred using input OFFSET.

The addresses transferred in input INI_ADDR or END_ADDR must point to a tag of the selected data type in an F-DB. Only tags of the selected data type are permitted between the INI_ADDR and END_ADDR addresses. The INI_ADDR address must be smaller than the END_ADDR address.

As shown in the following example, the INI_ADDR and END_ADDR addresses must be transferred fully-qualified as "DBx".DBWy or in the corresponding symbolic representation. Transfers in other forms are not permitted.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT, DINT	Value to be written to the F-DB
INI_ADDR	Input	POINTER	Start address of the area in an F-DB
END_ADDR	Input	POINTER	End address of the area in an F-DB
OFFSET	Input	INT	Offset

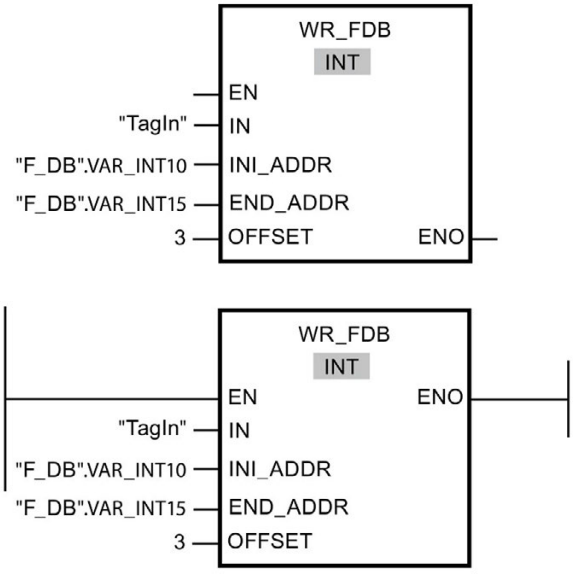
You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Examples of parameter assignment of INI_ADDR, END_ADDR, and OFFS

Name	Data type	Initial value	Comment
Static			
VAR_BOOL10	BOOL	false	
VAR_BOOL11	BOOL	false	
VAR_BOOL12	BOOL	false	
VAR_BOOL13	BOOL	false	
VAR_TIME10	TIME	T#0MS	
VAR_TIME11	TIME	T#0MS	
VAR_INT10	INT	0	<- INI_ADDR = "F-DB".VAR_INT10 Example 1
VAR_INT11	INT	0	
VAR_INT12	INT	0	
VAR_INT13	INT	0	<- OFFSET = 3
VAR_INT14	INT	0	
VAR_INT15	INT	0	<- END_ADDR = "F-DB".VAR_INT15
VAR_BOOL20	BOOL	false	
VAR_BOOL21	BOOL	false	
VAR_BOOL22	BOOL	false	
VAR_BOOL23	BOOL	false	
VAR_INT20	INT	0	<- INI_ADDR = "F-DB".VAR_INT20 Example 2
VAR_INT21	INT	0	
VAR_INT22	INT	0	
VAR_INT23	INT	0	<- END_ADDR = "F-DB".VAR_INT23
VAR_INT30	INT	0	<- INI_ADDR = "F-DB".VAR_INT30 Example 3
VAR_INT31	INT	0	<- OFFSET = 1
VAR_INT32	INT	0	
VAR_INT33	INT	0	
VAR_INT34	INT	0	<- END_ADDR = "F-DB".VAR_INT34
VAR_TIME20	TIME	T#0MS	
VAR_DINT10	DINT	0	<- INI_ADDR = "F-DB".VAR_DINT10 Example 4
VAR_DINT11	DINT	0	
VAR_DINT12	DINT	0	<- OFFSET = 2
VAR_DINT13	DINT	0	<- END_ADDR = "F-DB".VAR_DINT13

Example

The following example shows how the instruction works:



13.8.3 RD_FDB: Read value indirectly from an F-DB (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Description

This instruction reads the tag addressed via INI_ADDR and OFFSET in an F-DB and provides it at output OUT.

The address of the tags addressed using INI_ADDR and OFFSET must be within the address range defined by addresses INI_ADDR and END_ADDR.

If the F-CPU has gone to STOP mode with diagnostics event ID 75E2, check to determine if this condition is satisfied.

The start address of the area in an F-DB from which the tag is to be read is transferred using input INI_ADDR. The associated offset in this area is transferred using input OFFSET.

The addresses transferred in input INI_ADDR or END_ADDR must point to a tag of the selected data type in an F-DB. Only tags of the selected data type are permitted between the INI_ADDR and END_ADDR addresses. The INI_ADDR address must be smaller than the END_ADDR address.

The INI_ADDR and END_ADDR addresses must be transferred fully-qualified as "DBx".DBWy or in the corresponding symbolic representation. Transfers in other forms are not permitted. Examples of parameter assignment of INI_ADDR, END_ADDR, and OFFSET are contained in WR_FDB: Write value indirectly to an F-DB (STEP 7 Safety V14) (S7-300, S7-400) (Page 474).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

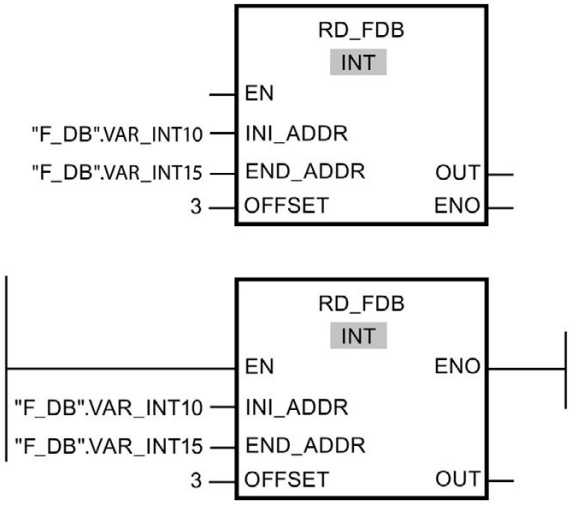
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
INI_ADDR	Input	POINTER	Start address of the area in an F-DB
END_ADDR	Input	POINTER	End address of the area in an F-DB
OFFSET	Input	INT	Offset
OUT	Output	INT, DINT	Value to be read from the F-DB

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



13.9 Conversion operations

13.9.1 CONVERT: Convert value (STEP 7 Safety V14)

Description

The "Convert value" instruction reads the content of parameter IN and converts it according to the data types selected in the instruction box. The converted value is output at output OUT.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

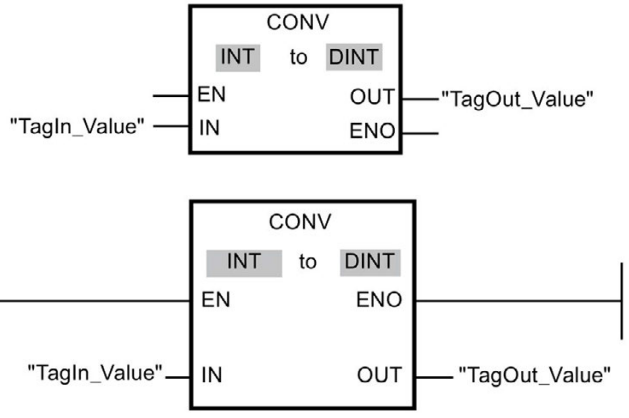
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT	Value to be converted.
OUT	Output	DINT	Result of the conversion

Example

The following example shows how the instruction works:



The instruction is always executed regardless of the signal state at enable input "EN". The content of the operand "TagIn_Value" is read and converted to an integer (32 bit). The result is stored in operand "TagOut_Value".

13.9.2 BO_W: Convert 16 data elements of data type BOOL to a data element of data type WORD (STEP 7 Safety V14)

Description

This instruction converts the 16 values of data type BOOL at inputs IN0 to IN15 to a value of data type WORD, which is made available at output OUT. The conversion takes place as follows: The i-th bit of the WORD value is set to 0 (or 1), if the value at input INi = 0 (or 1).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN0	Input	BOOL	Bit 0 of WORD value
IN1	Input	BOOL	Bit 1 of WORD value
...			...
IN15	Input	BOOL	Bit 15 of WORD value
OUT	Output	WORD	WORD value consisting of IN0 to IN15

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	o	—	o	These versions have identical functions to version V1.0.
1.2	x	—	o	
1.3	x	o	o	
1.4	x	x	x	
2.0	x	x[1]	x[2]	

o This version is no longer supported.

[1] supported for Firmware version V4.2 or higher

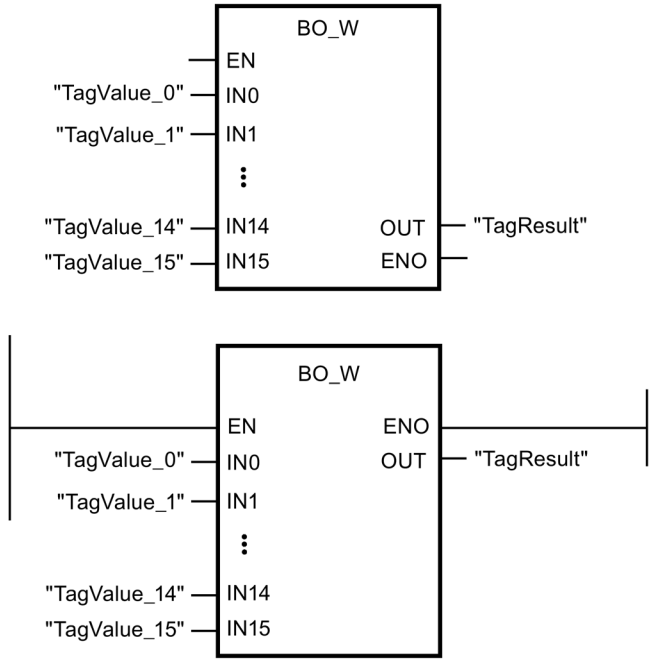
[2] supported for Firmware version V2.0 or higher

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN0	TagValue_0	FALSE
IN1	TagValue_1	FALSE
...		...
IN13	TagValue_13	FALSE
IN14	TagValue_14	TRUE
IN15	TagValue_15	TRUE
OUT	TagResult	W#16#C000

The values of operands "TagValue_0" to " TagValue_15" are combined to form data type WORD and assigned to operand "TagResult".

13.9.3 W_BO: Convert a data element of data type WORD to 16 data elements of data type BOOL (STEP 7 Safety V14)

Description

This instruction converts the value of data type WORD at input IN to 16 values of data type BOOL, which are provided at outputs OUT0 to OUT15. The conversion takes place as follows: Output OUTi is set to 0 (or 1), if the i-th bit of the WORD value is 0 (or 1).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	WORD value
OUT0	Output	BOOL	Bit 0 of WORD value
OUT1	Output	BOOL	Bit 1 of WORD value
...			...
OUT15	Output	BOOL	Bit 15 of WORD value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	o	—	o	These versions have identical functions to version V1.0.
1.2	x	—	o	
1.3	x	o	o	
1.4	x	x	x	
2.0	x	x[1]	x[2]	

o This version is no longer supported.

1 supported for Firmware version V4.2 or higher

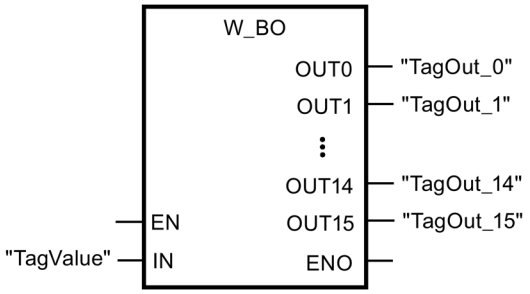
2 supported for Firmware version V2.0 or higher

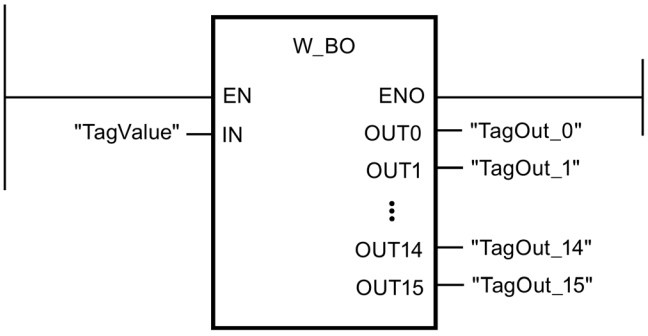
When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:





The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	TagValue	W#16#C000
OUT0	TagOUT_0	FALSE
OUT1	TagOUT_1	FALSE
...		...
OUT13	TagOUT_13	FALSE
OUT14	TagOUT_14	TRUE
OUT15	TagOUT_15	TRUE

The value of operand "TagValue" of data type WORD is converted to the 16 values "TagOUT_0" to "TagOUT_15" of data type BOOL.

13.9.4 SCALE: Scale values (STEP 7 Safety Advanced V14)

Description

This instruction scales the value at input IN in physical units between the low limit value at input LO_LIM and the high limit value at input HI_LIM. It is assumed that the value at input IN is between 0 and 27648. The scaling result is provided at output OUT.

The instruction uses the following equation:

OUT = [IN × (HI_LIM – LO_LIM)] / 27648 + LO_LIM

As long as the value at input IN is greater than 27648, output OUT is linked to HI_LIM and OUT_HI is set to 1.

As long as the value at input IN is less than 0, output OUT is linked to LO_LIM and OUT_LO is set to 1.

For inverse scaling, you must assign LO_LIM > HI_LIM. With inverse scaling, the output value at output OUT decreases while the input value at input IN increases.

Every call of the "Scale values" instruction must be assigned a data area in which the instruction data are stored. In addition, when the instruction is inserted in the program, the "Call options" dialog is automatically opened, where you can create a data block (single instance) (e.g., SCALE_DB_1) or a multi-instance (e.g., SCALE_Instance_1) for the "Scale values" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT	Input value to be scaled in physical units
HI_LIM	Input	INT	High limit value of value range of OUT
LO_LIM	Input	INT	Low limit value of value range of OUT
OUT	Output	INT	Result of scaling
OUT_HI	Output	BOOL	1 = Input value > 27648: OUT = HI_LIM
OUT_LO	Output	BOOL	1 = Input value < 0: OUT = LO_LIM

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions have identical functions to version V1.0.
1.2	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Behavior in the event of overflow or underflow of analog values and fail-safe value output

Note

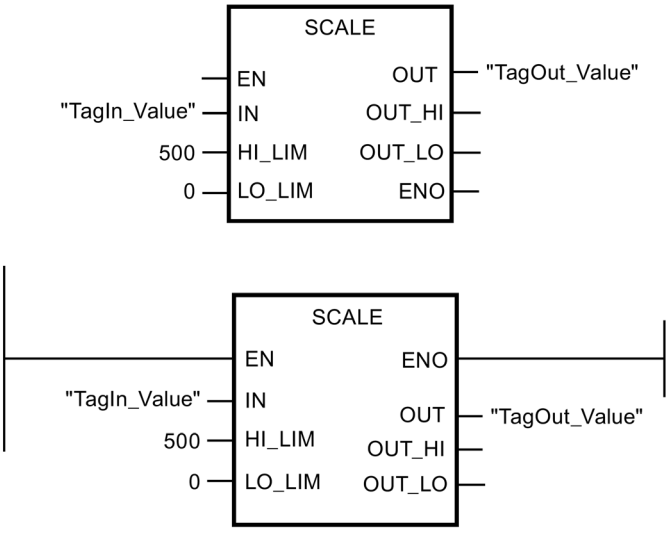
If inputs from the PII of an SM 336; AI 6 x 13Bit or SM 336; F-AI 6 x 0/4 ... 20 mA HART are used as input values, note that the F-system detects an overflow or underflow of a channel of this F-SM as an F-I/O fault or channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

If other fail-safe values should be output in this case, you need to evaluate the QBAD signal of the associated F-I/O or QBAD_I_xx signal / value status of the corresponding channel.

If the value in the PII of the F-SM is within the overrange or underrange, but is > 27648 or < 0, you can likewise branch to the output of an individual fail-safe value by evaluating outputs OUT_HI and OUT_LO, respectively.

Example

The following example shows how the instruction works:



When operand "TagIn_Value" = 20000, the result is "TagOut_Value" 361.

13.10 Program control operations

13.10.1 JMP: Jump if RLO = 1 (STEP 7 Safety V14)

Description

You can use the "Jump if RLO = 1" instruction to interrupt the linear execution of the program and resume it in another network. The destination network must be identified by a jump label (Page 490) (LABEL). The description of the jump label is specified in the placeholder above the instruction.

The specified jump label must be in the same block in which the instruction is executed. The name you specify can only occur once in the block.

If the result of logic operation (RLO) at the input of the instruction is "1" or the input is not connected, the jump to the network identified by the jump label is executed. The jump direction can be towards higher or lower network numbers.

If the result of logic operation (RLO) at the input of the instruction is "0", the program continues executing in the next network.

Note

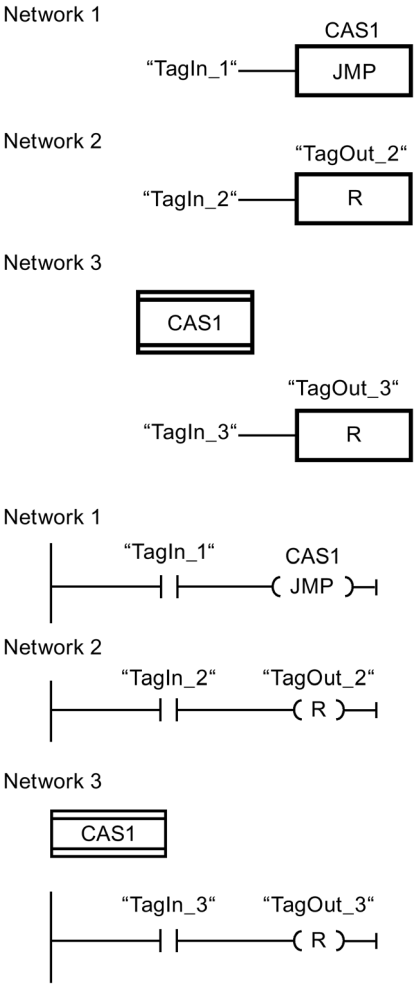
(S7-1200, S7-1500)
If the jump destination (jump label) for an instruction "JMP" or "JMPN" is above the associated instruction "JMP" or "JMPN" (backwards jump), you cannot insert any other instructions for program control (JMP, JMPN, RET, jump label) between them.
Exception: You can insert an instruction "JMP" or "JMPN" between them if you also insert the associated jump destination in between as well as below the associated instruction "JMP" or "JMPN" (forward jump).
Non-compliance can lead to compilation errors or to the F-CPU going to STOP.

Note

You are not permitted to insert any SENDDP or SENDS7 instructions between an instruction JMP or JMPN and the associated jump destination (jump label).

Example

The following example shows how the instruction works:



When operand "TagIn_1" has signal state "1", the "Jump if RLO = 1" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

13.10.2 JMPN: Jump if RLO = 0 (STEP 7 Safety V14)

Description

You can use the "Jump if RLO = 0" instruction to interrupt the linear execution of the program and resume it in another network, when the result of logic operation at the input of the instruction is "0". The destination network must be identified by a jump label (Page 490) (LABEL). The description of the jump label is specified in the placeholder above the instruction.

The specified jump label must be in the same block in which the instruction is executed. The name you specify can only occur once in the block.

If the result of logic operation (RLO) at the input of the instruction is "0", the jump to the network identified by the jump label is executed. The jump direction can be towards higher or lower network numbers.

If the result of logic operation (RLO) at the input of the instruction is "1", the program continues executing in the next network.

Note

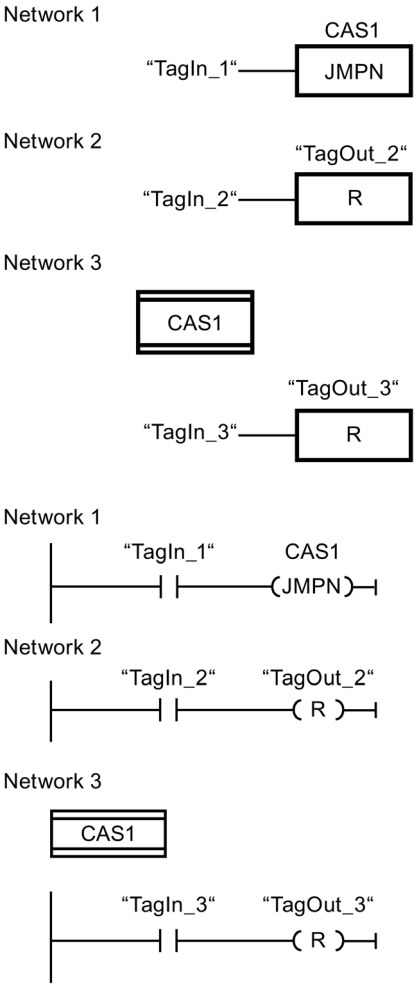
(S7-1200, S7-1500)
If the jump destination (jump label) for an instruction "JMP" or "JMPN" is above the associated instruction "JMP" or "JMPN" (backwards jump), you cannot insert any other instructions for program control (JMP, JMPN, RET, jump label) between them.
Exception: You can insert an instruction "JMP" or "JMPN" between them if you also insert the associated jump destination in between as well as below the associated instruction "JMP" or "JMPN" (forward jump).
Non-compliance can lead to compilation errors or to the F-CPU going to STOP.

Note

You are not permitted to insert any SENDDP or SENDS7 instructions between an instruction JMP or JMPN and the associated jump destination (jump label).

Example

The following example shows how the instruction works:



When operand "TagIn_1" has signal state "0", the "Jump if RLO = 0" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

13.10.3 LABEL: Jump label (STEP 7 Safety V14)

Description

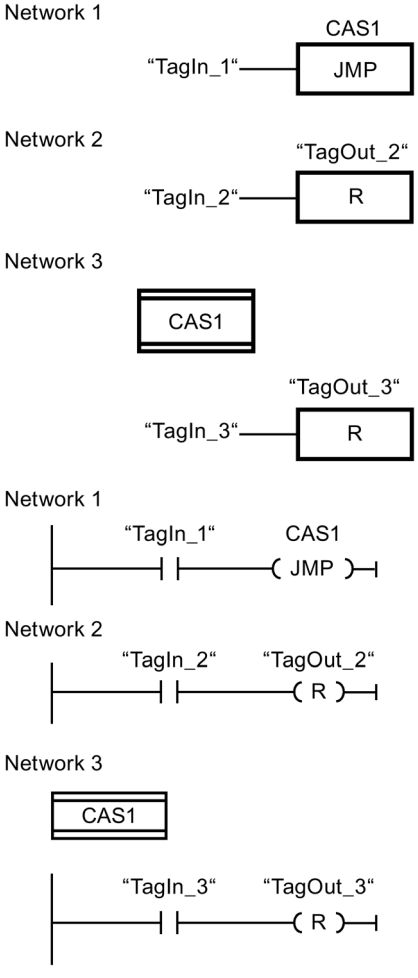
You can use a jump label to specify a destination network, in which the program execution should resume after a jump.

The jump label and the instruction in which the jump label is specified must be located in the same block. The name of a jump label can only be assigned once in a block.

Only one jump label can be placed in a network. To each jump label can be jumped from several locations.

Example

The following example shows how the instruction works:



When operand "TagIn_1" has signal state "1", the "Jump if RLO = 1" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

See also

JMP: Jump if RLO = 1 (STEP 7 Safety V14) (Page 486)

JMPN: Jump if RLO = 0 (STEP 7 Safety V14) (Page 488)

RET: Return (STEP 7 Safety V14) (Page 491)

13.10.4 RET: Return (STEP 7 Safety V14)

Description

You can use the "Return" instruction to stop the processing of a block.

If the result of logic operation (RLO) at the input of the "Return" instruction is "1" or the box input of the S7-1200/1500 F-CPUs is not connected in FBD, program execution is terminated in the currently called block and continued in the calling block (for example, in the main safety block) after the call function. If the RLO at the input of the "Return" instruction is "0", the instruction is not executed. Program execution continues in the next network of the called block.

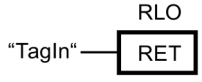
Influencing the status of the call function (ENO) is irrelevant, because the enable output "ENO" cannot be connected.

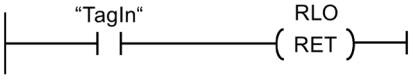
Note

You cannot program a RET instruction before a main safety block call.

Example

The following example shows how the instruction works:





When the "TagIn" operand delivers signal state "1", the "Return" instruction is executed. Program execution is terminated in the called block and continues in the calling block.

See also

JMP: Jump if RLO = 1 (STEP 7 Safety V14) (Page 486)

JMPN: Jump if RLO = 0 (STEP 7 Safety V14) (Page 488)

LABEL: Jump label (STEP 7 Safety V14) (Page 490)

13.10.5 OPN: Open global data block (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Description

You can use the "Open global data block" instruction to open a data block. The number of the data block is transferred to the DB register. Subsequent DB commands access the relevant blocks depending on the register contents.

Note

Note when using the "Open global data block" instruction that the content of the DB register can be changed after calls of F-FB/F-FC and "fully qualified DB accesses", such that there is no guarantee that the last data block you opened with "Open global data block" is still open.

You should therefore use the following method for addressing data to avoid errors when accessing data of the DB register:

- Use symbolic addressing.
- Use only fully qualified DB accesses.

If you still want to use the "Open global data block" operation, you must ensure that the DB register is restored by repeating the "Open global data block" instruction following calls of F-FB/F-FC and "fully qualified DB accesses." Otherwise, a malfunction could result.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Data block>	Input	BLOCK_DB	Data block that is opened

"Fully qualified DB access"

The initial access to data of a data block in an F-FB/F-FC must always be a "fully qualified DB access," or it must be preceded by the "Open global data block" instruction. This also applies to the initial access to data of a data block after a jump label.

An example of "fully qualified DB access" and "non-fully qualified DB access" is provided in Restrictions in the programming languages FBD/LAD (Page 97).

Access to instance DBs

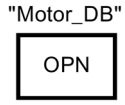
You can also access instance DBs of F-FBs with fully qualified access, e.g., for transfer of block parameters. It is not possible to access static local data in single/multi-instances of other F-FBs.

Note that accessing instance DBs of F-FBs that are not called in the safety program can cause the F-CPU to go to STOP mode.

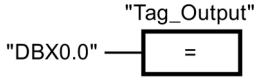
Example

The following example shows how the instruction works:

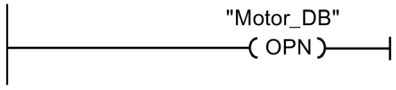
Network 1:



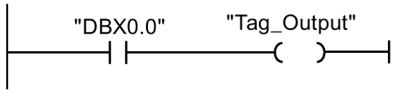
Network 2:



Network 1:



Network 2:



The "Motor_DB" data block is called in network 1. The number of the data block is transferred to the DB register. The "DBX0.0" operand is queried in network 2. The signal state of the "DBX0.0" operand is assigned to the "Tag_Output" operand.

13.11 Word logic operations

13.11.1 AND: AND logic operation (STEP 7 Safety V14)

Description

You can use the "AND logic operation" instruction to combine the value at input IN1 to the value at input IN2 bit-by-bit by AND logic and query the result at output OUT.

When the instruction is executed, bit 0 of the value at input IN1 and bit 0 of the value at input IN2 are ANDed. The result is stored in bit 0 of output OUT. The same logic operation is executed for all other bits of the specified values.

The result bit has signal state "1" only when both of the bits in the logic operation also have signal state "1". If one of the two bits of the logic operation has signal state "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

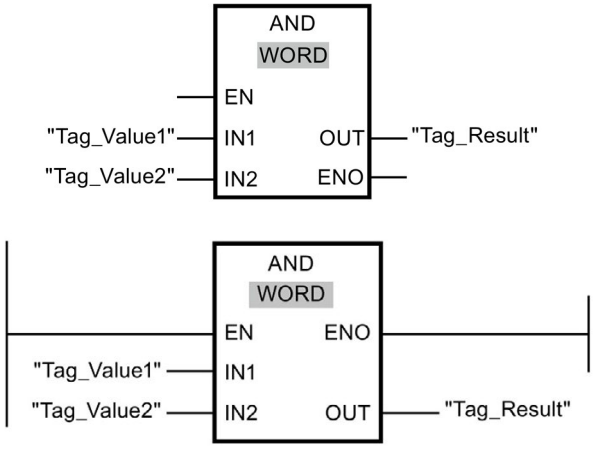
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:



IN1	"Tag_Value1" = 01010101 01010101
IN2	"Tag_Value2" = 00000000 00001111
OUT	"Tag_Result" = 00000000 00000101

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are ANDed. The result is mapped bit-by-bit and output in the "Tag_Result" operand.

13.11.2 OR: OR logic operation (STEP 7 Safety V14)

Description

You can use the "OR logic operation" instruction to connect the value at input IN1 input to the value at input IN2 bit-by-bit by OR logic and query the result at output OR.

When the instruction is executed, bit 0 of the value at input IN1 and bit 0 of the value at input IN2 are ORed. The result is stored in bit 0 of output OUT. The same logic operation is executed for all bits of the specified tags.

The result bit has signal state "1" when at least one of the two bits in the logic operation has signal state "1". If both of the bits of the logic operation have signal state "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

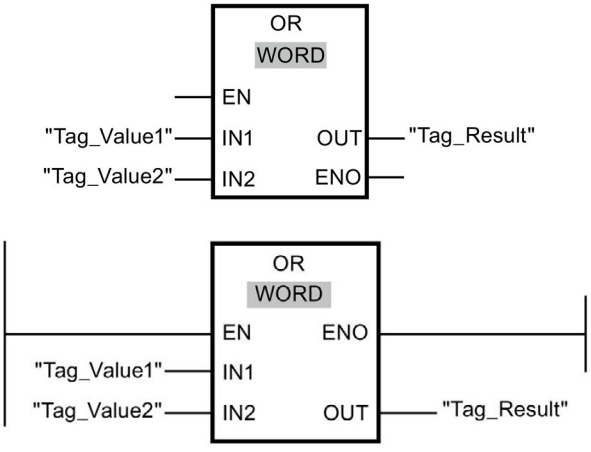
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:



IN1	"Tag_Value1" = 01010101 01010101
IN2	"Tag_Value2" = 00000000 00001111
OUT	"Tag_Result" = 01010101 01011111

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are ORed. The result is mapped bit-by-bit and output in the "Tag_Result" operand.

13.11.3 XOR: EXCLUSIVE OR logic operation (STEP 7 Safety V14)

Description

You can use the "EXCLUSIVE OR logic operation" instruction to combine the value at input IN1 and the value at input IN2 bit-by-bit by EXCLUSIVE OR logic and query the result at output OUT.

When the instruction is executed, bit 0 of the value at input IN1 input and bit 0 of the value at input IN2 are logically combined by EXCLUSIVE OR. The result is stored in bit 0 of output OUT. The same logic operation is executed for all other bits of the specified value.

The result bit has signal state "1" when one of the two bits in the logic operation has signal state "1". If both of the bits of the logic operation have signal state "1" or "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

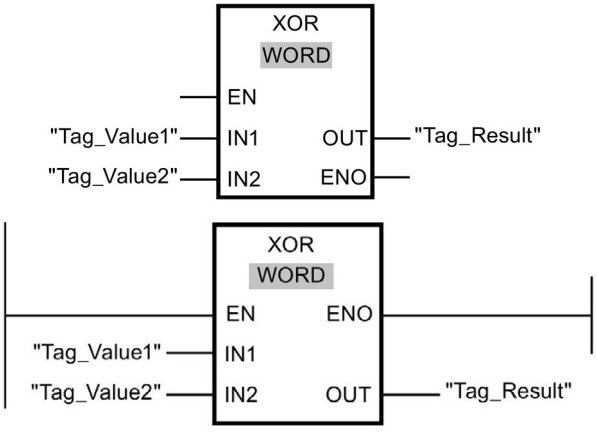
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:



IN1	"Tag_Value1" = 01010101 01010101
IN2	"Tag_Value2" = 00000000 00001111
OUT	"Tag_Result" = 01010101 01011010

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are logically combined by EXCLUSIVE OR. The result is mapped bit-by-bit and output in the "Tag_Result" operand.

13.12 Shift and rotate

13.12.1 SHR: Shift right (STEP 7 Safety V14)

Description

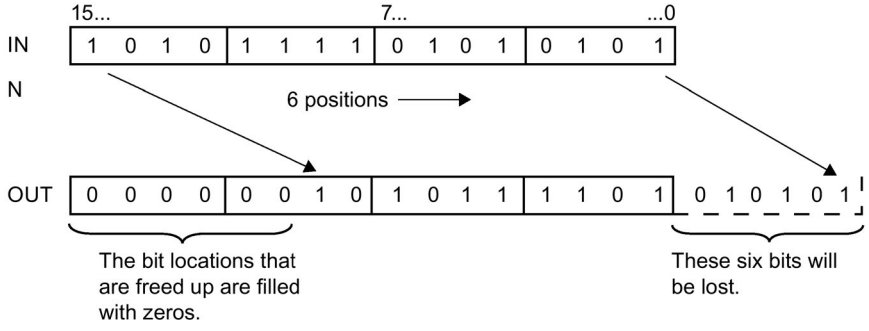
Use the "Shift right" instruction to shift the content of the operand at input IN bit-by-bit to the right and query the result at output OUT. Use input N to specify the number of bit positions by which the specified value is to be moved.

If the value at input N is "0", the value at input IN is copied to the operand at output OUT.

If the value at input N is greater than the number of available bit positions, the operand value at input IN is shifted to the right by the available number of bit positions.

The bit locations that are freed up in the left area of the operand during the shift operation are filled with zeros.

The following figure shows how the content of an operand of data type WORD is moved by 6 bit positions to the right:



Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

S7-300/400:

Only the low-byte is evaluated from input N.

S7-1200/1500:

If the value at input N < 0, the output OUT is set to 0.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	Value that is shifted
N	Input	INT	Number of bit positions by which the value is shifted
OUT	Output	WORD	Result of the instruction

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	o	—	o	These versions have identical functions to version V1.0.
1.2	x	—	o	
1.3	x	o	o	
1.4	x	x	x	
2.0	x	x[1]	x[2]	

o This version is no longer supported.

[1] supported for Firmware version V4.2 or higher

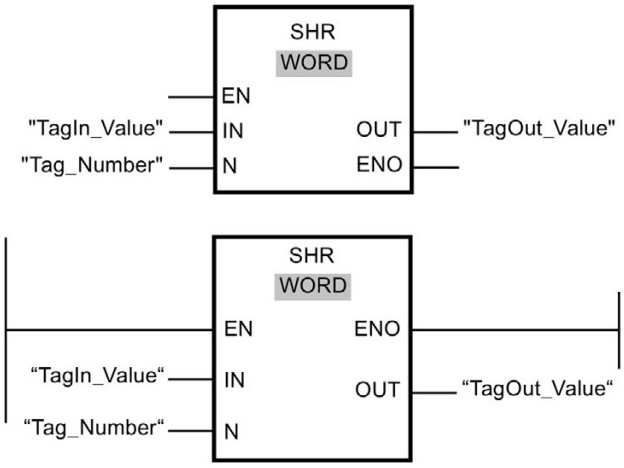
[2] supported for Firmware version V2.0 or higher

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	TagIn_Value	0011 1111 1010 1111
N	Tag_Number	3
OUT	TagOut_Value	0000 0111 1111 0101

The instruction is always executed regardless of the signal state at enable input "EN". The content of the operand "TagIn_Value" is moved three bit positions to the right. The result is output at output "TagOut_Value".

13.12.2 SHL: Shift left (STEP 7 Safety V14)

Description

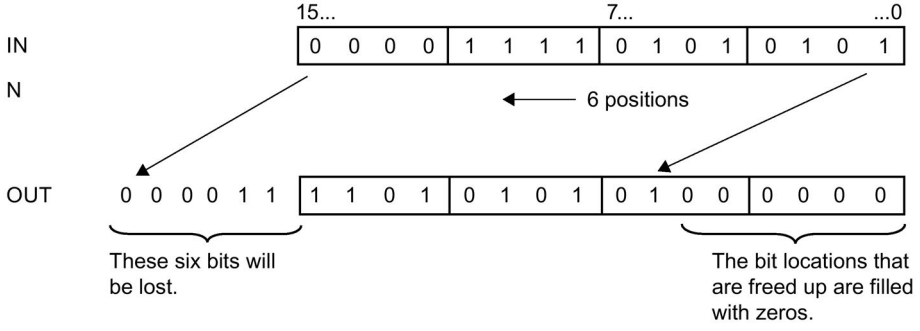
Use the "Shift left" instruction to shift the content of the operand at input IN bit-by-bit to the left and query the result at output OUT. Use input N to specify the number of bit positions by which the specified value is to be moved.

If the value at input N is "0", the value at input IN is copied to the operand at output OUT.

If the value at input N is greater than the number of available bit positions, the operand value at input IN is shifted to the left by the available number of bit positions.

The bit positions that are freed up in the right area of the operand during the shift operation are filled with zeros.

The following figure shows how the content of an operand of data type WORD is moved by 6 bit positions to the left:



Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note

S7-300/400:

Only the low-byte is evaluated from input N.

S7-1200/1500:

If the value at input N < 0, the output OUT is set to 0.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	Value that is shifted
N	Input	INT	Number of bit positions by which the value is shifted
OUT	Output	WORD	Result of the instruction

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	o	—	o	These versions have identical functions to version V1.0.
1.2	x	—	o	
1.3	x	o	o	
1.4	x	x	x	
2.0	x	x[1]	x[2]	

o This version is no longer supported.

1 supported for Firmware version V4.2 or higher

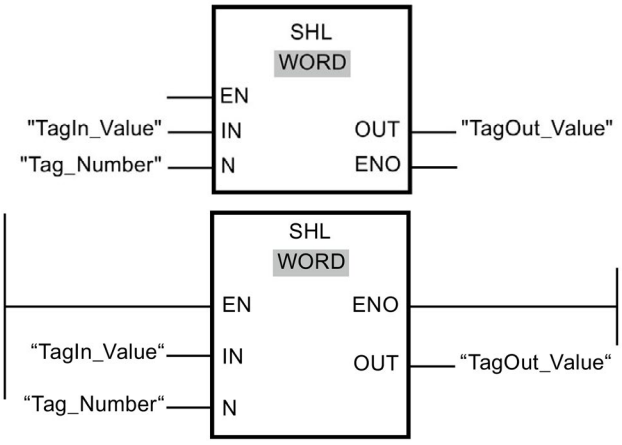
2 supported for Firmware version V2.0 or higher

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	TagIn_Value	0011 1111 1010 1111
N	Tag_Number	4
OUT	TagOut_Value	1111 1010 1111 0000

The instruction is always executed regardless of the signal state at enable input "EN". The content of the operand "TagIn_Value" is moved four bit positions to the left. The result is output at output "TagOut_Value".

13.13 Operating

13.13.1 ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V14)

Description (S7-300, S7-400)

This instruction enables fail-safe acknowledgment from an HMI system. It allows, for example, reintegration of F-I/O to be controlled from the HMI system. Acknowledgment takes place in two steps:

- Input/output parameter IN changes to a value of 6 for exactly one cycle.
- Input/output parameter IN changes to a value of 9 within a minute for exactly one cycle

Once the in/out parameter IN has changed to a value of 6, the instruction evaluates whether this parameter has changed to a value of 9 after 1 second, at the earliest, or one minute, at the latest. Output OUT (output for acknowledgment) is then set to 1 for one cycle.

If an invalid value is input or if in/out parameter IN has not changed to the value 9 within one minute or the change occurred before one second has elapsed, then in/out parameter IN is reset to 0, and both steps listed above must be repeated.

During the time in which in/out parameter IN must change from 6 to the value 9, output Q is set to 1. Otherwise, Q has a value of 0.

Every call of the "Fail-safe acknowledgment" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_OP_DB_1) or a multi-instance (e.g., ACK_OP_Instance_1) for the "Fail-safe acknowledgment" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Note

A separate data area must be used for each call of ACK_OP. Each call can be processed only once in an F-runtime group cycle.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example by automatically storing them along with the time conditions in a program and using a function key to trigger them.
Having two separate acknowledgment steps also prevents erroneous triggering of an acknowledgment by your non-fail-safe HMI system. *(S013)*

⚠ WARNING

If you have HMI systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

- To do this, store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your HMI system, set up a field from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:

  in your HMI system, set up a field to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored name.*(S014)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

Note

You can read out output Q by means of operator control and monitoring systems or, if applicable, evaluate it in your standard user program.

You can provide the in/out parameter IN with a separate memory word or DBW of a DB of the standard user program supply for each instance of the ACK_OP instruction.

Note

The configuration of your operator control and monitoring system does not have any effect on the collective F-signature.

Changes to the configuration of your operator control and monitoring system therefore do not result in a changed collective F-signature.

⚠ WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Description (S7-1200, S7-1500)

This instruction enables fail-safe acknowledgment from an HMI system. It allows, for example, reintegration of F-I/O to be controlled from the HMI system. Acknowledgment takes place in two steps:

- Input/output parameter IN changes to a value of 6 for exactly one cycle.
- Input/output parameter IN changes to the value at the ACK_ID input within a minute for exactly one cycle

Once the in/out parameter IN has changed to a value of 6, the instruction evaluates whether this parameter has changed to a value at the ACK_ID input after 1 second, at the earliest, or one minute, at the latest. Output OUT (output for acknowledgment) is then set to 1 for one cycle.

If an invalid value is input or if in/out parameter IN has not changed to the value at the ACK_ID input within one minute or the change occurred before one second has elapsed, then in/out parameter IN is reset to 0, and both steps listed above must be repeated.

During the time in which in/out parameter IN must change from 6 to the value at the ACK_ID input, output Q is set to 1. Otherwise, Q has a value of 0.

Every call of the "Fail-safe acknowledgment" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_OP_DB_1) or a multi-instance (e.g., ACK_OP_Instance_1) for the "Fail-safe acknowledgment" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Note

A separate data area must be used for each call of ACK_OP. Each call can be processed only once in an F-runtime group cycle.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example by automatically storing them along with the time conditions in a program and using a function key to trigger them.
Having two separate acknowledgment steps also prevents erroneous triggering of an acknowledgment by your non-fail-safe HMI system. *(S013)*

⚠ WARNING

If you have HMI systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

Alternative 1:

- The value for each identifier of the acknowledgment (ACK_ID input; data type: INT) can be freely selected in the range from 9 to 30000, but must be unique network-wide* for all instances of the ACK_OP instruction.
  You must supply the ACK_ID input with constant values when calling the instruction. Direct read or write access in the associated instance DB is not permitted in the safety program!

Alternative 2:

- To do this, store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your HMI system, set up a field from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:

  in your HMI system, set up a field to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S047)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

Note

You can read out output Q by means of operator control and monitoring systems or, if applicable, evaluate it in your standard user program.

You need to provide the in/out parameter IN with a separate memory word or DBW of a DB of the standard user program for each instance of the ACK_OP instruction.

Note

The supply of the IN input/output of the ACK_OP instruction as well as the configuration of your operator control and monitoring system do not have any effect on the collective F-signature or of the signature of the block that calls the ACK_OP instruction.

Changes to the supply of the IN input/output or to the configuration of your operator control and monitoring system therefore do not result in a changed collective F-signature/signature of the calling block.

WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- Known timing imprecision (based on standard systems) resulting from cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value

You must choose the interval between two call times of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Parameters (S7-300, S7-400)

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	InOut	INT	Input variable from HMI system
OUT	Output	BOOL	Output for acknowledgment
Q	Output	BOOL	Time status

Parameters (S7-1200, S7-1500)

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ACK_ID	Input	INT	Identifier of the acknowledgment (9 to 30000)
IN	InOut	INT	Input variable from HMI system
OUT	Output	BOOL	Output for acknowledgment
Q	Output	BOOL	Time status

Instruction versions

A number of versions are available for this instruction:

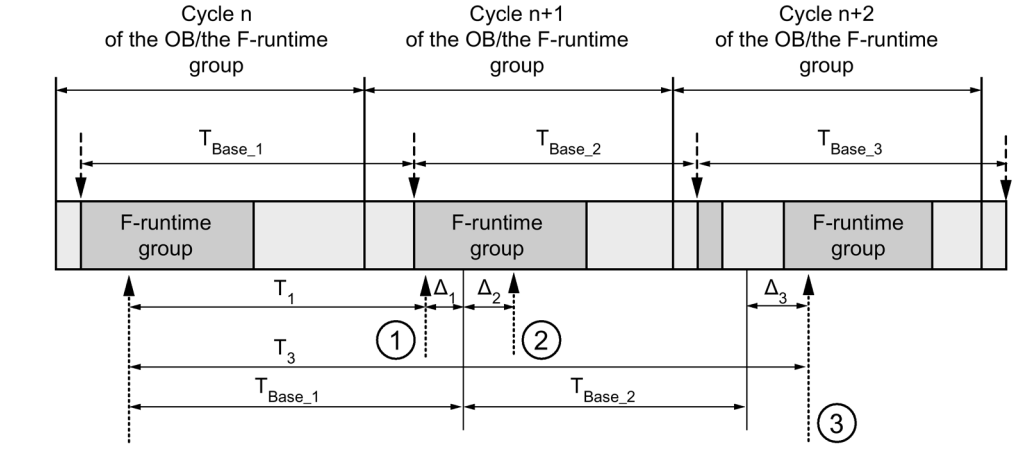
Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	x	—	o	These versions are identical in function to version V1.0 for S7-300/400 F-CPUs. The input ACK_ID must also be taken into consideration for S7-1200/1500 F-CPUs.
1.2	x	o	o	
1.3	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Timing imprecision resulting from the update time of the time base used in the instruction:



----► = Time base update

·····► = Call time of an instruction with time processing

① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

Example

An example how the instruction is used is available under Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 156).

See also

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 162)

13.14 Additional instructions

13.14.1 LAD

13.14.1.1 ---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Description

You can use the "Get status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed.

The "Get status bit OV" instruction functions like a normally open contact. If the query is fulfilled, the instruction has signal state "1". If the query is not fulfilled, the instruction has signal state "0".

The "Get status bit OV" evaluation must be inserted in the network that follows the instruction that influences the OV. This network must not contain any jump labels.

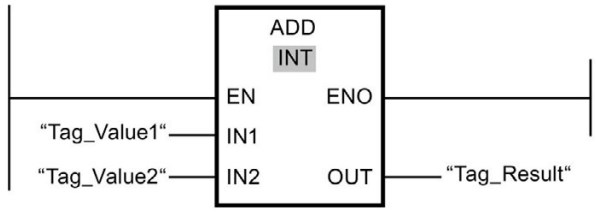
Note

The execution time of the OV-affecting instruction is extended when the "Get status bit OV " instruction is used (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).

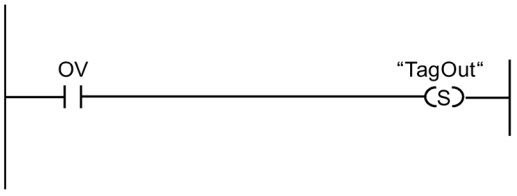
Example

The following example shows how the instruction works:

Network 1:



Network 2:



The "Add" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the "Tag_Result" operand.

If an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.14.1.2 ---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Description

You can use the "Get negated status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed. This instruction is only available in LAD.

The "Get negated status bit OV" instruction functions like a normally closed contact. If the query is satisfied, the instruction has signal state "0". If the query is not satisfied, the instruction has signal state "1".

The "Get negated status bit OV" evaluation must be inserted in the network following the instruction that influences the OV. This network must not contain any jump labels.

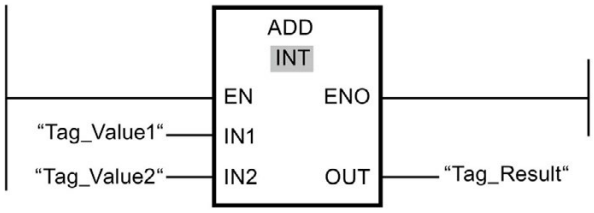
Note

The execution time of the OV-affecting instruction is extended when the "Get negated status bit OV " instruction is used (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).

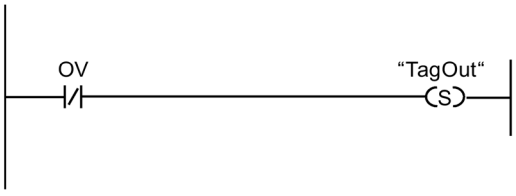
Example

The following example shows how the instruction works:

Network 1:



Network 2:



The "Add" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the "Tag_Result" operand.

If an overflow does *not* occur during execution of the "Add" instruction, the status bit OV is reset to "0". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.14.2 FBD

13.14.2.1 OV: Get negated status bit OV (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Description

You can use the "Get status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed.

The "Get status bit OV" evaluation must be inserted in the network that follows the instruction that influences the OV. This network must not contain any jump labels.

If the query is fulfilled, the instruction has signal state "1". If the query is not fulfilled, the instruction has signal state "0".

You can program a query of status bit OV for "0" with the "Invert RLO" instruction.

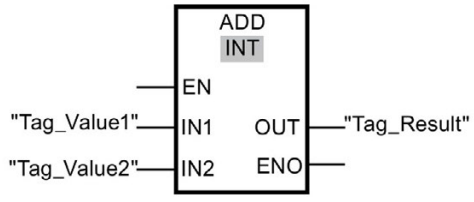
Note

The execution time of the OV-affecting instruction is extended when the "Get status bit OV " instruction is used (see also Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100)).

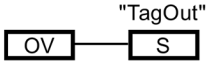
Example

The following example shows how the instruction works:

Network 1:



Network 2:



The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the "Tag_Result" operand.

If an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.15 Communication

13.15.1 PROFIBUS/PROFINET

13.15.1.1 SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V14)

Introduction

You use the SENDDP and RCVDP instructions for fail-safe sending and receiving of data using:

- Safety-related master-master communication
- Safety-related master-master communication for S7 Distributed Safety
- Safety-related master-I-slave communication
- Safety-related I-slave-I-slave communication
- Safety-related IO controller-IO controller communication
- Safety-related IO controller-IO controller communication for S7 Distributed Safety
- Safety-related IO controller-I-device communication
- Safety-related IO controller-I-slave communication

Description

The SENDDP instruction sends 16 data elements of data type BOOL and 2 data elements of data type INT or one data element of the data type DINT (S7-1200, S7-1500) in a fail-safe manner to another F-CPU via PROFIBUS DP/PROFINET IO. The data can be received there by the related RCVDP instruction.

Every call of this instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., RCVDP_DB_1) for these instructions. Once it is created, the new data block can be found in the "STEP 7 Safety" folder in the project tree under "Program blocks > System blocks". For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

With the SENDDP instruction, the data to be sent (for example, outputs of other F-blocks/instructions) are available at input SD_BO_xx or SD_I_xx or SD_DI_00 as alternative.

With the RCVDP instruction, the data received are available at outputs RD_BO_xx and RD_I_xx or RD_DI_00 as alternative for additional processing by other F-blocks/instructions.

(S7-1200, S7-1500) At the DINTMODE input of the SENDDP instruction you specify if the data at the inputs SD_I_00 and SD_I_01 or the data at the input SD_DI_00 is sent.

The operating mode of the F-CPU with the SENDDP instruction is provided at output SENDMODE. If the F-CPU with the SENDDP instruction is in disabled safety mode, output SENDMODE = 1.

Communication between F-CPUs takes place in the background by means of a special safety protocol. You must define the communication relationship between a SENDDP instruction in one F-CPU and a RCVDP instruction in the other F-CPU by specifying an address relationship at the DP_DP_ID inputs of the SENDDP and RCVDP instructions. Associated SENDDP and RCVDP instructions are assigned the same value for DP_DP_ID.

⚠ WARNING

The value for each address association (input DP_DP_ID; data type: INT) is user-defined; however, it must be unique from all other safety-related communication connections network-wide* and CPU-wide. The uniqueness must be checked in the safety summary during acceptance of the safety program. You can find additional information in Correctness of the communication configuration (Page 320).

You must supply inputs DP_DP_ID and LADDR with constant values when calling the instruction. Direct read or write access to the associated instance DB to DP_DP_ID and LADDR is not permitted in the safety program. *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

Note

Within a safety program, you must assign a different start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) for every call of the SENDDP and RCVDP instructions at input LADDR.

A separate instance DB must be used for each call of the SENDDP and RCVDP instructions. You must not declare and call these instructions as multi-instances.

The input and outputs of the RCVDP instruction cannot be initialized with temporary or static local data of the main safety block.

The inputs of the RCVDP instruction cannot be initialized with outputs (using fully qualified DB accesses) of a RCVDP or RCVS7 instruction called in an upstream network.

The RD_D_00 output must not be evaluated for DINTMODE = 0; the RD_I_xx outputs of the RCVDP instruction must not be evaluated for DINTMODE = 1.

(S7-1200, S7-1500) The outputs of the SENDDP and RCVDP instructions must not be supplied with tags from the standard user program. Exception: RET_DPRD, RET_DPWR and DIAG outputs.

You cannot use an actual parameter for an output of an RCVDP instruction, if it is already being used for an input of the same or another RCVDP or RCVS7 instruction.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You are not permitted to insert any SENDDP instructions between an instruction JMP or JMPN and the associated jump destination (jump label).

You cannot insert a RET instruction prior to a SENDDP instruction.

SENDDP parameter

The following table shows the parameters of the SENDDP instruction:

Parameter	Declaration	Data type	Description
SD_BO_00	Input	BOOL	Send data BOOL 00
...			...
SD_BO_15	Input	BOOL	Send data BOOL 15
SD_I_00	Input	INT	Send data INT 00
SD_I_01	Input	INT	Send data INT 01
SD_DI_00	Input	DINT	(S7-1200, S7-1500) (hidden) Send data DINT 00
DINTMODE	Input	DINT	(S7-1200, S7-1500) (hidden) 0=SD_I_00 u. SD_I_01 are sent 1=SD_DI_00 is sent
DP_DP_ID	Input	INT	Network-wide unique value for the address relationship between a SENDDP and RCVDP instruction
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 530))
LADDR	Input	INT (S7-300, S7-400) HW_SUBMODULE (S7-1200, S7-1500)	The start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) of the address area/transfer area: • Of DP/DP coupler for safety-related master-master communication • For safety-related master-I-slave communication • For safety-related I-slave-I-slave communication • Of PN/PN coupler for safety-related IO controller-IO controller communication • For safety-related IO controller-I-device communication • For safety-related IO controller-I-slave communication
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=RCVDP outputs fail-safe values
RET_DPRD	Output	WORD	Non-fail-safe error code RET_VAL of the DPRD_DAT instruction (for a description of error codes, refer to the online help for the DPRD_DAT instruction ("Extended instructions > Distributed I/O > Other".))
RET_DPWR	Output	WORD	Non-fail-safe error code RET_VAL of the DPWR_DAT instruction (for a description of error codes, refer to the online help for the DPWR_DAT instruction ("Extended instructions > Distributed I/O > Other".))
DIAG	Output	BYTE	Non-fail safe service information

RCVDP parameter:

The following table shows the parameters of the RCVDP instruction:

Parameter	Declaration	Data type	Description
ACK_REI	Input	BOOL	1=Acknowledgment for reintegration of send data following communication error
SUBBO_00	Input	BOOL	Fail-safe value for receive data BOOL 00
...			...
SUBBO_15	Input	BOOL	Fail-safe value for receive data BOOL 15
SUBI_00	Input	INT	Fail-safe value for receive data INT 00
SUBI_01	Input	INT	Fail-safe value for receive data INT 01
SUBDI_00	Input	DINT	(S7-1200, S7-1500) (hidden) Fail-safe value for receive data DINT 00
DP_DP_ID	Input	INT	Network-wide unique value for the address relationship between a SENDDP and RCVDP instruction
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 530))
LADDR	Input	INT (S7-300, S7-400) HW_SUBMODULE (S7-1200, S7-1500)	The start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) of the address area/transfer area: • Of DP/DP coupler for safety-related master-master communication • For safety-related master-I-slave communication • For safety-related I-slave-I-slave communication • Of PN/PN coupler for safety-related IO controller-IO controller communication • For safety-related IO controller-I-device communication • For safety-related IO controller-I-slave communication
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Fail-safe values are output
ACK_REQ	Output	BOOL	1=Acknowledgment for reintegration of send data required
SENDMODE	Output	BOOL	1=F-CPU with SENDDP instruction in disabled safety mode
RD_BO_00	Output	BOOL	Receive data BOOL 00
...			...
RD_BO_15	Output	BOOL	Receive data BOOL 15
RD_I_00	Output	INT	Receive data INT 00
RD_I_01	Output	INT	Receive data INT 01
RD_DI_00	Output	DINT	(S7-1200, S7-1500) (hidden) Receive data DINT 00
RET_DPRD	Output	WORD	Non-fail-safe error code RET_VAL of the DPRD_DAT instruction (for a description of error codes, refer to the online help for the DPRD_DAT instruction ("Extended instructions > Distributed I/O > Other".))

Parameter	Declaration	Data type	Description
RET_DPWR	Output	WORD	Non-fail-safe error code RET_VAL of the DPWR_DAT instruction (for a description of error codes, refer to the online help for the DPWR_DAT instruction ("Extended instructions > Distributed I/O > Other".))
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for these instructions:

Version	S7-300/400	S7-1200	S7-1500	Function
1.0	x	—	—	When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.0 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.1	o	—	o	These versions have identical functions to version V1.0.
1.2	x	—	o	
1.4	x	—	x	
1.3	x	—	o	S7-300/400: These versions have identical functions to version V1.0. S7-1200/1500: Instead of 2 data of data type INT, one data of data type DINT can be sent/received as alternative. Otherwise identical function as version V1.0.
1.5	x	x	x	
2.0	x	x[1]	x[2]	

o This version is no longer supported.

[1] supported for Firmware version V4.2 or higher

[2] supported for Firmware version V2.0 or higher

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Placement

The RCVDP instruction must be inserted at the start of the main safety block and the SENDDP instruction at the end.

Startup characteristics

After the sending and receiving F-systems are started up, communication must be established between the connection partners for the fist time (SENDDP and RCVDP instructions). During this time, the receiver (RCVDP instruction) outputs the fail-safe values present at its inputs SUBBO_xx and SUBI_xx or alternatively SUBDI_00.

The SENDDP and RCVDP instructions signal this with 1 at output SUBS_ON. The SENDMODE output has default setting "0" and is not updated as long as output SUBS_ON = 1.

Behavior in the event of communication errors

If a communication error occurs, for example, due to a signature error (CRC) or when monitoring time TIMEOUT expires, outputs ERROR and SUBS_ON = 1 are set. The receiver (RCVDP instruction) then outputs the fail-safe values assigned at its SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs. Output SENDMODE is not updated while output SUBS_ON = 1.

The send data of the SENDDP instruction present at inputs SD_BO_xx and SD_I_xx, SD_DI_00 as alternative, are only output again when communication errors are no longer detected (ACK_REQ = 1) and you acknowledge (Page 156) the RCVDP instruction with a positive edge at input ACK_REI.

⚠ WARNING

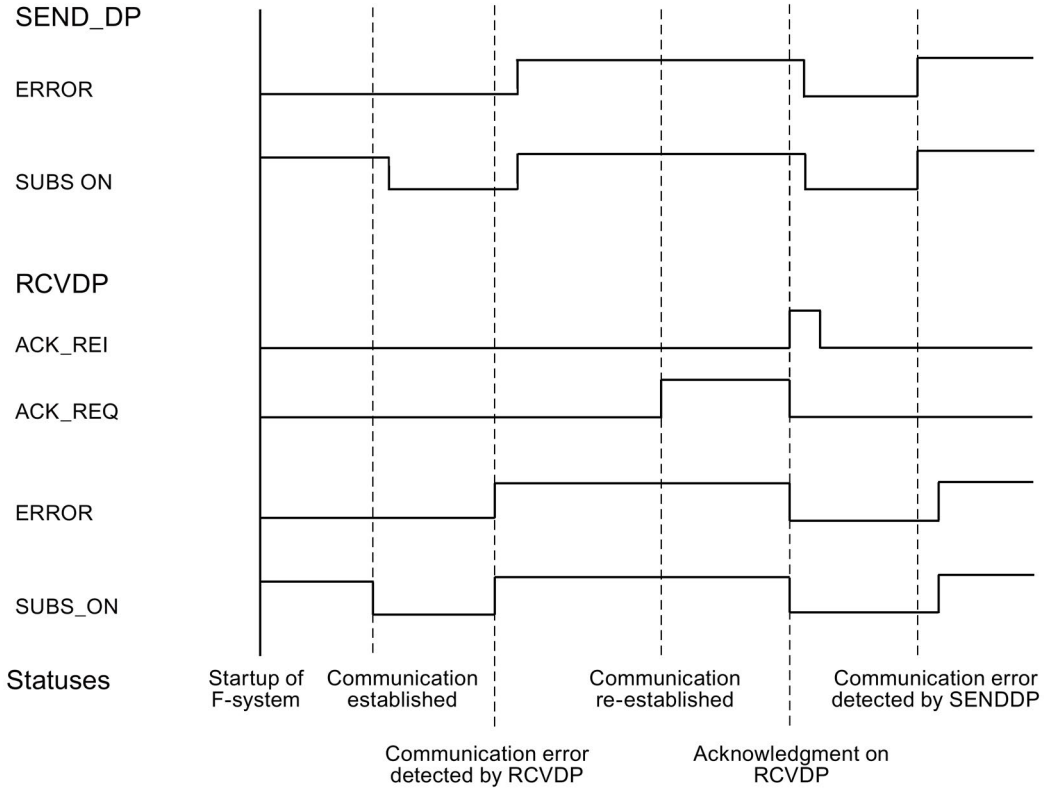
For the user acknowledgment, you must interconnect input ACK_REI with a signal generated by the operator input.

An interconnection with an automatically generated signal is not permitted. *(S040)*

Note that output ERROR (1=communication error) for a communication error will not be set unless communication between the connection partners (SENDDP and RCVDP instructions) has been previously established. If communication cannot be established after startup of the sending and receiving F-Systems, check the configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDDP and the RCVDP instructions, and the bus connection. You also obtain information on possible error causes by evaluating outputs RET_DPRD and RETDP_WR.

In general, always evaluate RET_DPRD and RETDP_WR, since it is possible that only one of the two outputs will contain error information.

Timing diagrams SENDDP/RCVDP



Output DIAG

In addition, non-fail-safe information about the type of communication errors that occurred is provided at output DIAG of the SENDDP and RCVDP instructions for service purposes.

You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until you acknowledge the errors at input ACK_REI of the RCVDP instruction.

Structure of DIAG of the SENDDP/RCVDP instruction

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Timeout of SENDDP/RCVDP detected	Interference in bus connection to partner F-CPU.	Check bus connection and ensure that no external fault sources are present.
		Monitoring time setting for F-CPU and partner F-CPU is too low.	Check assigned monitoring time TIMEOUT for SENDDP and RCVDP of both F-CPUs. If possible, set a higher value. Recompile safety program
		DP/DP coupler or PN/PN coupler configuration is invalid.	Check DP/DP coupler or PN/PN coupler configuration
		Internal fault of DP/DP coupler or PN/PN coupler	Replace DP/DP coupler or PN/PN coupler
		CP in STOP mode, or internal fault in CP	Switch CP to RUN mode, check diagnostic buffer of CP, and replace CP, if necessary
		F-CPU/partner F-CPU in STOP mode, or internal fault in F-CPU/partner F-CPU	Switch F-CPUs to RUN mode, check diagnostic buffer of F-CPUs, and replace F-CPUs, if necessary
Bit 5	Sequence number error of SENDDP/RCVDP detected	See description for bit 4	See description for bit 4
Bit 6	CRC-error of SENDDP/RCVDP detected	See description for bit 4	See description for bit 4
Bit 7	Reserved	—	—

See also

Configuring and programming communication (S7-300, S7-400) (Page 170)

Safety-related IO controller-IO controller communication (Page 173)

Safety-related master-master communication (Page 182)

Safety-related IO controller-I-device communication (Page 191)

Safety-related master-I-slave communication (Page 197)

Safety-related IO controller-I-slave communication (Page 215)

Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication) (Page 223)

Communication with S7 Distributed Safety via DP/DP coupler (master-master communication) (Page 224)

13.15.2 S7 communication

13.15.2.1 SENDS7 and RCVS7: Communication via S7 connections (STEP 7 Safety Advanced V14) (S7-300, S7-400)

Introduction

You use the SENDS7 and RCVS7 instructions for fail-safe sending and receiving of data using S7 connections.

Note

In *STEP 7 Safety Advanced*, S7 connections are generally permitted over Industrial Ethernet only.

Safety-related communication via S7 connections is possible from and to F-CPUs with PROFINET interface or S7-400 F-CPUs with PROFINET-capable CPs. See also Safety-related communication via S7 connections (Page 215).

Description

The SENDS7 instruction sends the send data contained in an F-communication DB to the F-communication DB of the associated RCVS7 instruction of another F-CPU in a fail-safe manner using an S7 connection.

Every call of this instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., SENDS7_DB_1) or a multi-instance (e.g., SENDS7_Instance_1) for this instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Information on the F-communication DB is contained in "Programming safety-related communication via S7 connections (Page 218)".

An F-communication DB is an F-DB for safety-related CPU-CPU communication with special properties. You must specify the numbers of the F-communication DBs at inputs SEND_DB and RCV_DB of instructions SENDS7 and RCVS7.

The operating mode of the F-CPU with the SENDS7 instruction is provided at output SENDMODE of the RCVS7 instruction. If the F-CPU with the SENDS7 instruction is in disabled safety mode, then output SENDMODE = 1.

To reduce the bus load, you can temporarily shut down communication between the F-CPUs at input EN_SEND of the SENDS7 instruction. To do so, supply input EN_SEND with "0" (default = "1"). In this case, send data are no longer sent to the F-communication DB of the associated RCVS7 instruction, and the receiver provides fail-safe values for this period of time (initial values in its F-communication DB). If communication was already established between the partners, a communication error is detected.

You must specify the local ID - from the perspective of the F-CPU - of the S7 connection (from the connection table in the network view) at input ID of the SENDS7 instruction (see also Configuring (Page 39)).

Communication between F-CPUs takes place in the background by means of a special safety protocol. You must define a communication relationship between an SENDS7 instruction in one F-CPU and a communication relationship between an RCVS7 instruction and the other F-CPU by assigning an odd number at input R_ID (of the SENDS7 and RCVS7 instructions). Associated SENDS7 and RCVS7 instructions receive the same value for R_ID.

⚠ WARNING

The value for each address association (R_ID input; data type: DWORD) is user-defined; however, it must be odd for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.

You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to the associated instance DB is not permitted in the safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

Note

A separate instance DB must be used for each call of the SENDS7 and RCVS7 instructions within a safety program. You must not declare and call these instructions as multi-instances.

The input and outputs of the RCVS7 instruction cannot be initialized with temporary or static local data of the main safety block.

The inputs of the RCVS7 instruction cannot be initialized with outputs (using fully qualified DB accesses) of a RCVS7 or RCVDP instruction called in an upstream network.

You cannot use an actual parameter for an output of an RCVS7 instruction, if it is already being used for an input of the same or another RCVS7 or RCVDP instruction. The F-CPU can go to STOP if this is not observed. A diagnostics event is entered in the diagnostics buffer of the F-CPU.

Note

You must not program any SENDS7 instruction between a JMP or JMPN instruction and the associated destination network of the JMP or JMPN instruction.

You cannot program a RET instruction prior to a SENDS7 instruction.

SENDS7 parameter

The following table shows the parameters of the SENDS7 instruction:

Parameter	Declaration	Data type	Description
SEND_DB	Input	BLOCK_DB	Number of F-communication DB
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 530))
EN_SEND	Input	BOOL	1= Send enable
ID	Input	WORD	Local ID of the S7 connection
R_ID	Input	DWORD	Network-wide unique value for an address relationship between a SENDS7 instruction and a RCVS7 instruction
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Receiving block outputs fail-safe values
STAT_RCV	Output	WORD	Non-fail-safe status parameter STATUS of the URCV instruction (You can find a description of error codes in the online help for the URCV instruction ("Communication > S7 Communication"))
STAT_SND	Output	WORD	Non-fail-safe status parameter STATUS of the USEND instruction (You can find a description of error codes in the online help for the USEND instruction ("Communication > S7 Communication"))
DIAG	Output	BYTE	Non-fail safe service information

RCVS7 parameter

The following table shows the parameters of the RCVS7 instruction.

Parameter	Declaration	Data type	Description
ACK_REI	Input	BOOL	Acknowledgment for reintegration of send data after communication error
RCV_DB	Input	BLOCK_DB	Number of F-communication DB
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 530))
ID	Input	WORD	Local ID of the S7 connection
R_ID	Input	DWORD	Network-wide unique value for an address relationship between a SENDS7 instruction and a RCVS7 instruction
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Fail-safe values are output
ACK_REQ	Output	BOOL	1=Acknowledgment for reintegration of send data required

Parameter	Declaration	Data type	Description
SENDMODE	Output	BOOL	1=F-CPU with the SENDS7 instruction in disabled safety mode
STAT_RCV	Output	WORD	Non-fail-safe status parameter STATUS of the URCV instruction (You can find a description of error codes in the online help for the URCV instruction ("Communication > S7 Communication"))
STAT_SND	Output	WORD	Non-fail-safe status parameter STATUS of the USEND instruction (You can find a description of error codes in the online help for the USEND instruction ("Communication > S7 Communication"))
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for these instructions:

Version	S7-300/400	S7-1500	Function
1.0	x	—	
1.1	x	—	This version has identical functions to version V1.0. It also supports later versions of internally called instructions. When projects that were created with *S7 Distributed Safety V5.4 SP5* are migrated, version 1.1 of the instruction is used automatically. If you want to compile a migrated safety program with *STEP 7 Safety Advanced* for the first time, we recommend that you first update to the latest available version of the instruction.
1.2	x	—	This version has identical functions to version V1.0/1.1. It also supports later versions of internally called instructions.

When a new F-CPU is created with *STEP 7 Safety Advanced*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Startup characteristics

After the sending and receiving F-systems are started up, communication must be established between the connection partners for the fist time (SENDS7 and RCVS7 instructions). The receiver (RCVS7 instruction) provides fail-safe values for this time period (initial values in its F-communication DB).

The SENDS7 and RCVS7 instructions signal this with 1 at output SUBS_ON. The SENDMODE output (RCVS7 instruction) has default setting "0" and is not updated as long as output SUBS_ON = 1.

Behavior in the event of communication errors

If a communication error occurs, for example, due to a signature error (CRC) or when monitoring time TIMEOUT expires, outputs ERROR and SUBS_ON = 1 are set. The receiver (RCVS7 instruction) then provides fail-safe values (initial values in its F-communication DB). Output SENDMODE is not updated while output SUBS_ON = 1.

The send data present in the F-communication DB (SENDS7 instruction) are not output before the communication error is no longer detected (ACK_REQ = 1) and you acknowledge (Page 156) with a positive edge at input ACK_REI of the RCVS7 instruction.

⚠ WARNING

For the user acknowledgment, you must interconnect input ACK_REI with a signal generated by the operator input.

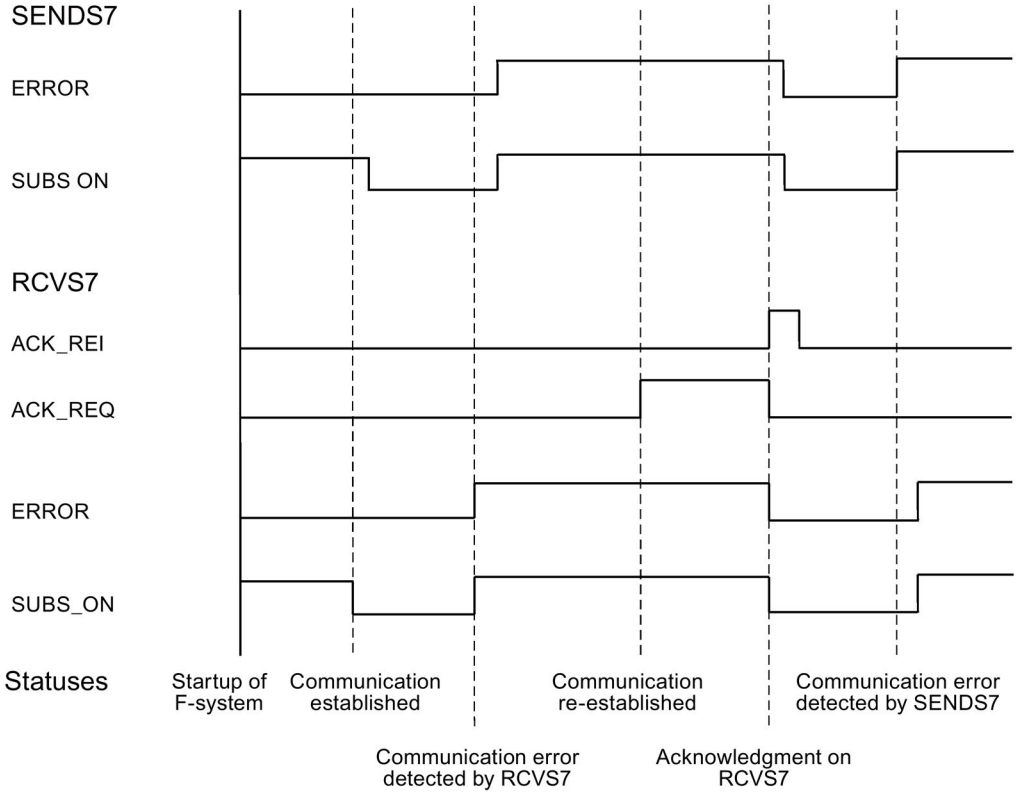
An interconnection with an automatically generated signal is not permitted. *(S040)*

Note that output ERROR (1=communication error) will be set for the first time on a communication error if communication has already been established between the connection partners (SENDS7 and RCVS7 instructions). If communication cannot be established after startup of the sending and receiving F-Systems, check the configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDS7 and the RCVS7 instructions, and the bus connection. You can also receive information on possible error causes by evaluating the STAT_RCV and STAT_SND outputs.

In general, always evaluate STAT_RCV and STAT_SND, since it is possible that only one of the two outputs will contain error information.

If one of the DIAG bits is set at output DIAG, also check whether the length and structure of the associated F-communication DB on both the sending and receiving ends match.

Timing diagrams SENDS7 and RCVS7



Output DIAG

Non-fail-safe information on the type of communication errors that have occurred is made available at output DIAG for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until you acknowledge them at input ACK_REI of the associated RCVS7 instruction.

Structure of DIAG

Bit no.	Assignment of SENDS7 and RCVS7	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Timeout detected by SENDS7 and RCVS7	Fault in bus connection to partner F-CPU	Check bus connection and ensure that no external fault sources are present.
		Monitoring time setting for F-CPU and partner F-CPU is too low	Check assigned monitoring time TIMEOUT for SENDS7 and RCVS7 of both F-CPUs. If possible, set a higher value. Recompile safety program
		CPs in STOP mode, or internal fault in CPs	• Switch CPs to RUN mode • Check diagnostic buffer of CPs • Replace CPs, if necessary
		F-CPU/partner F-CPU in STOP mode, or internal fault in F-CPU/partner F-CPU	• Switch F-CPUs to RUN mode • Check diagnostic buffer of F-CPUs • Replace F-CPUs, if necessary
		Communication was shut down with EN_SEND = 0.	Enable communication again at the associated SENDS7 with EN_SEND = 1
		S7 connection has changed, the IP address of the CP has changed, for example	Recompile the safety programs and download them to the F-CPUs
Bit 5	Sequence number error detected by SENDS7 and RCVS7	See description for bit 4	See description for bit 4
Bit 6	CRC-error detected by SENDS7 and RCVS7	See description for bit 4	See description for bit 4
Bit 7	RCVS7: Communication cannot be established	Configuration of the safety-related CPU-CPU communication is incorrect, parameter assignment of the SENDS7 and RCVS7 instructions is incorrect See also description for Bit 4	Check configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDS7 and the RCVS7 instructions is incorrect See also description for Bit 4
	SENDS7: Reserved	—	—

Monitoring and response times

A

Introduction

In the following, you will learn:

- Which F-specific monitoring times you must configure
- Which rules must be followed when specifying monitoring times
- Where you enter the F-specific monitoring times
- Which rules must be followed with regard to the maximum response time of a safety function

Support for calculations

An Excel file is available on the Internet (http://support.automation.siemens.com/WW/view/en/49368678/133100) to assist you in calculating approximately the runtimes of the F-runtime groups, the minimum F-specific monitoring times, and the maximum response times of your F-System.

Additional information

The monitoring and response times for the standard part are calculated in SIMATIC Safety in exactly the same way as for standard S7-300, S7-400, S7-1200 and S7-1500 automation systems and are not addressed here. For a description of this calculation, refer to the *hardware manuals for the CPUs*.

A.1 Configuring monitoring times

Monitoring times to be configured

You must configure the following monitoring times:

Monitoring...	Setting...	Parameters	See
F-cycle time or cycle time warning limit of the F-runtime groups that contain the safety program	in *Safety Administration Editor*: • Dialog for definition of an F-runtime group	Maximum cycle time of the F-runtime group	• Procedure for defining an F-runtime group (S7-300, S7-400) (Page 110) • Procedure for defining an F-runtime group (S7-1200, S7-1500) (Page 112)
of the safety-related communication between F-CPU and F-I/O via PROFIsafe (PROFIsafe monitoring time)	In the *hardware and network editor*: • Centrally when configuring the F-CPU; properties of the F-CPU; or • when configuring the F-I/O; properties of the F-I/O	F-monitoring time F_WD_TIME	• Configuring an F-CPU (Page 44) • Configuring F-I/O (Page 49) • Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 65)
of the safety-related CPU-CPU communication	At the TIMEOUT input of the instructions: • SENDDP; RCVDP; SENDS7; RCVS7	TIMEOUT	• Communication (Page 515)

You do not have to configure the monitoring time for safety-related communication between F-runtime groups.

Rules for configuring monitoring times

When configuring monitoring times, you must take into account the availability as well as the safety of the F-system as follows:

- Availability: To ensure that the time monitoring is not triggered when there is no error, the monitoring times selected must be sufficiently long.
- Safety: To ensure that the process safety time is not exceeded for the process, the monitoring times selected must be sufficiently short.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired at the sender end and transferred to the receiver if the signal level is pending for at least as long as the assigned F-monitoring time. *(S018)*

General procedure for configuring monitoring times

Use the following procedure for configuring monitoring times:

1. Configure the standard system.

   Refer to the applicable *hardware manuals* and *Help on STEP 7* for the necessary information.

2. Configure the specific monitoring times of the F-System with respect to availability. You use the Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100) to calculate the approximate minimum monitoring time.

3. Use the Excel file for response time calculation to calculate the maximum response time and then verify that the process safety time of the process is not exceeded. If necessary, you must reduce the specific monitoring times of the F-System.

A.1.1 Minimum monitoring time for the F-runtime group cycle time

Parameter "Maximum cycle time of the F-runtime group"

You configure the monitoring time for the F-runtime group cycle time in the *Safety Administration Editor* in the work area for definition of the F-runtime group (Page 109).

The specified maximum cycle time of the F-runtime group must be high enough to prevent F-runtime group cycle time monitoring from being triggered when there are no pending faults and causing the F-CPU to go to STOP. For S7-1200/1500 F-CPUs, you can use the "F-runtime group cycle time warning limit (Page 112)" and the TCYC_CURR (Page 118) and TCYC_LONG (Page 118) tags for dimensioning.

Use the Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100) to determine the minimum monitoring time for the F-runtime group cycle time. Note also the comments in the Excel file.

A.1.2 Minimum monitoring time for safety-related communication between F-CPU and F-I/O

Parameter "F-monitoring time"

You have two options for configuring the monitoring time of safety-related communication between the F-CPU and F-I/O:

- Centrally in the *hardware and network editor* during parameter assignment of the F-CPU (Page 44); in the properties of the F-CPU, or
- During parameter assignment of the F-I/O (Page 49) in the *hardware and network editor*; in the properties of the F-I/O

"F-monitoring time" = PROFIsafe monitoring time T_{PSTO}

The specified PROFIsafe monitoring time T_{PSTO} must be high enough to prevent tripping the F-cycle time monitoring when no faults are present.

Use the Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100) available for SIMATIC Safety to calculate the minimum monitoring time for safety-related communication between the F-CPU and F-I/O.

Note also the comments in the Excel file.

Check to determine whether configured PROFIsafe monitoring time is too short

Note

During commissioning of the F-system, you can perform a check while safety mode is active to determine whether the configured PROFIsafe monitoring time is too short.

This check of the PROFIsafe monitoring time is useful if you want to ensure that the configured monitoring time exceeds the minimum monitoring time by a sufficient amount. In this way, you can avoid the possible occurrence of sporadic monitoring time errors.

Procedure:

1. Insert an F-I/O (one that will not be needed later for system operation).
2. Assign a shorter monitoring time for this F-I/O than for the F-I/O of the system.
3. If the additional F-I/O fails and the "Monitoring time for safety message frame exceeded" diagnostic is signaled, you have fallen below the minimum possible PROFIsafe monitoring time.
4. Increase the monitoring time for the added F-I/O just to the point where it no longer fails. This monitoring time corresponds approximately to the minimum possible monitoring time.

Conditions:

The F-I/O to be inserted additionally and the F-I/O whose PROFIsafe monitoring time is to be checked must have the following properties in common:

- They must be inserted in the same rack
- They must be nodes in the same subnet

Tip:

It may be useful to leave the additional F-I/O in place for systems that will be modified or expanded during operation after commissioning. This F-I/O will then provide an early warning in the event of changes in the time behavior, enabling you to avoid a process shutdown triggered by the F-I/O in the process.

A.1.3 Minimum monitoring time of safety-related CPU-CPU communication

TIMEOUT input at SENDDP and RCVDP or SENDS7 and RCVS7

The time monitoring is performed in the SENDDP and RCVDP (Page 515) or SENDS7 and RCVS7 (Page 523) instructions of the communication partner. You must assign the time monitoring with identical monitoring time for both instructions at the TIMEOUT input.

The specified monitoring time TIMEOUT must be high enough to prevent tripping the monitoring when no faults are present.

Use the Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100) available for SIMATIC Safety to determine the minimum value for TIMEOUT.

Note also the comments in the Excel file.

A.1.4 Monitoring time for safety-related communication between F-runtime groups (S7-300, S7-400)

The monitoring time for safety-related communication between F-runtime groups is determined automatically from the values for the "Maximum cycle time of F-runtime group" (work area for Definition of the F-runtime group (Page 109) in the *Safety Administration Editor*).

Monitoring time = (maximum cycle time of the 1st F-runtime group) + (maximum cycle time of the 2nd F-runtime group)

A.2 Response Times of Safety Functions

Definition of response time

The response time is the time from detection of an input signal until the linked output signal changes.

Fluctuation range

The actual response time lies between a minimum response time and maximum response time. You must always take the maximum response time into account in your system configuration.

Rules for maximum response time of a safety function

The maximum response time of a safety function must be less than the process safety time of the process.

Definition of process safety time of a process

The process safety time of a process is the time interval within which the process can be left on its own without causing injury to operating personnel or damage to the environment.

Within the process safety time, any type of F-system process control is tolerated. That is, during this time, the F-system can control its process incorrectly or it can even execute no control at all. The process safety time of a process depends on the process type and must be determined on a case-by-case basis.

Procedure for response time calculation

The Excel file for response time calculation (http://support.automation.siemens.com/WW/view/en/49368678/133100) is available for calculating the maximum response time of a safety function.

Use the Excel file to calculate the approximate maximum response time of the safety function and then check that the process safety time of the process is not exceeded.

If necessary, you must reduce the specific monitoring times of the F-system (see Minimum monitoring time for safety-related communication between F-CPU and F-I/O (Page 533)).

Checklist

B

Life cycle of fail-safe automation systems

The following table contains a checklist summarizing all activities in the life cycle of a fail-safe SIMATIC Safety system, including requirements and rules that must be observed for each activity.

Checklist

Legend:

- Stand-alone section references refer to this documentation.
- *"F-SMs Manual"* refers to the Automation System S7-300, ET 200M Distributed I/O System, Fail-Safe Signal Modules (http://support.automation.siemens.com/WW/view/en/19026151) manual.
- *"F-Modules Manual"* refers to the ET 200S Distributed I/O System, Fail-Safe Modules (http://support.automation.siemens.com/WW/view/en/27235629) manual.
- *"ET 200eco Manual"* refers to the ET 200eco Distributed I/O Station, Fail-Safe I/O Module (http://support.automation.siemens.com/WW/view/en/19033850) manual.
- *"ET 200pro Manual"* refers to the ET 200pro Distributed I/O System, Fail-Safe I/O Module (http://support.automation.siemens.com/WW/view/en/22098524) manual.
- *"ET 200iSP Manual"* refers to the ET 200iSP Distributed I/O Device, Fail-Safe Modules (http://support.automation.siemens.com/WW/view/en/47357221) manual.
- *"ET 200SP Manual*" refers to the ET 200SP System (http://support.automation.siemens.com/WW/view/en/58649293) manual
- *"ET 200MP Manual*" refers to the S7-1500/ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59191792) manual
- *"ET 200SP Modules Manual"* refers to the device manuals for F-Modules of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/ps/14059/man)

Phase	Note the following	Reference	Check
Planning			
Requirement: "Safety requirements specification" available for the intended application	Process-dependent	—	
Specification of system architecture	Process-dependent	—	
Assignment of functions and subfunctions to system components	Process-dependent	under Product Overview (Page 21)	
Selection of sensors and actuators	Requirements for actuators	*F-SMs Manual*, section 6.5; *F-Modules Manual*, section 4.5; *ET 200eco Manual*, section 5.5 *ET 200pro Manual*, section 4.4 *ET 200S Manual*, section 4.5 *ET 200SP manual*, section 5.2.2 *ET 200MP manual*, section 5.2.2	
Specification of required safety properties for individual components	IEC 61508:2010	—	
Configuration			
Installing the optional package	Requirements for installation	under Installing/uninstalling the STEP 7 Safety Basic V14 optional package (Page 27) orInstalling/uninstalling the STEP 7 Safety Advanced V14 optional package (Page 28)	
Selection of S7 components	Descriptions of configuration	under Product Overview (Page 21); *F-SMs Manual*, section 3; *F-Modules Manual*, section 3; *ET 200eco Manual*, section 3 *ET 200pro Manual*, section 2 *ET 200iSP Manual*, section 3 *ET 200SP Modules Manual*, section 3 *ET 200MP Modules Manual*, section 3	
Configuration of hardware	• Description of F-systems • Verification of utilized hardware components based on Annex 1 of Report in the Certificate	under Configuring (Page 39); Annex 1 of Report on the Certificate	

Phase	Note the following	Reference	Check
Configuration of F-CPU	• Protection level, "Write protection for F-blocks" (S7-300, S7-400) • Protection level, at least "Full access" (S7-1200, S7-1500) • Password • F-capability enabled • Definition/setting of F-specific parameters • Cycle time for the F-runtime group in which the safety program is to be executed, defined in accordance with the requirements and safety regulations - same as with standard system	under Configuring an F-CPU (Page 44); *Standard S7-300;* *Standard S7-400;* *S7-1200 standard;* *S7-1500 standard;* under Monitoring and response times (Page 530)	
Configuration of F-I/O	• Settings for safety mode • Setting of passivation type • Configuring monitoring times • Defining sensor evaluation • Defining diagnostic behavior • Special F-parameters • Assigning names • Unique PROFIsafe address	under Configuring F-I/O (Page 49) orPeculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 65) under Monitoring and response times (Page 530); *F-SMs Manual*, sections 3, 9, 10; *F-Modules Manual*, sections 2.4, 7; *ET 200eco Manual*, sections 3, 8; *ET 200pro Manual,* Sections 2.4, 8; *ET 200iSP Manual,* Sections 2.4, 7, 8 *ET 200SP Modules Manual*, section 4 *ET 200MP Modules Manual*, section 4	
Programming			
Defining program design and structure	• Follow warnings and notes on programming	under Overview of Programming (Page 90), Program structure of the safety program (S7-300, S7-400) (Page 91), Program structure of the safety program (S7-1200, S7-1500) (Page 93); Programming startup protection (Page 127);	

Phase	Note the following	Reference	Check
Creating the F-runtime groups	• Assignment of F-FB or F-FC as main safety block to the calling block (S7-300, S7-400) or F-OB (S7-1200, S7-1500) • Setting maximum cycle time for the F-runtime group in accordance with requirements (dependent on process and safety regulations) • Creating DB for F-runtime group communication • (S7-300, S7-400) Call of main safety blocks directly in OBs (e.g. OB 35), FBs, or FCs • (S7-1200, S7-1500) Call of the main safety block from the F-OB	under Defining F-Runtime Groups (Page 109) under Monitoring and response times (Page 530)	
Creating/inserting the F-blocks	• Generating, editing, and saving F-FBs, F-FCs, and F-DBs in accordance with the requirements of the program structure • Description: – F-I/O access – Passivation and reintegration of F-I/O – Inserting F-blocks from global libraries – Safety-related CPU-CPU communication – Communication with the standard user program	under Creating F-blocks in FBD / LAD (Page 122) under Addressing F-I/O (Page 128) under Implementation of user acknowledgment (Page 156) under Reuse of F-blocks (Page 125) under Configuring and programming communication (S7-300, S7-400) (Page 170) and Configuring and programming communication (S7-1200, S7-1500) (Page 229) under Data exchange between standard user program and safety program (Page 165)	
Compiling the safety program	—	under Compiling the safety program (Page 269)	
Implementing safety program call (S7-300, S7-400)	Check whether the main safety block is called directly in OBs (e.g., OB 35), FBs, or FCs.	under Defining F-Runtime Groups (Page 109)	
Installation			
Hardware configuration	Description of • Installation • Wiring	under Overview of Configuration (Page 39); Particularities for configuring the F-System (Page 42); *F-SMs Manual*, sections 5, 6; *F-Modules Manual*, sections 3, 4; *ET 200eco Manual*, sections 3, 4; *ET 200pro Manual,* Sections 2, 3; *ET 200iSP Manual,* sections 3 and 4; *ET 200SP Manual*, sections 4 and 5 *ET 200MP Manual*, sections 4 and 5	

Phase	Note the following	Reference	Check
Commissioning, Testing			
Switching on	Description of commissioning – same as in standard	Standard S7-300; S7-400 standard; S7-1200 standard; S7-1500 standard; Standard-S7-1500 Software Controller; WinAC RTX F	
Downloading safety program and standard user program	Description • Downloading • Program identification • Comparing safety programs	under Downloading project data to an F-CPU (Page 271) under Comparing Safety Programs (Page 289)	
Testing the safety program	• Description of disabling of safety mode • Procedures for changing safety program data	under Downloading project data (Page 271); Testing the safety program (Page 297); Disabling safety mode (Page 294)	
Changing the safety program	Description • Disabling safety mode • Changing the safety program	under Changing the safety program in RUN mode (S7-300, S7-400) (Page 302); Disabling safety mode (Page 294); Deleting the safety program (Page 305);	
Testing the safety-related parameters	Description of configuration	under Printing project data (Page 291); *F-SMs Manual*, sections 4, 9, 10; *F-Modules Manual*, sections 2.4, 7; *ET 200eco Manual*, sections 3, 8; *ET 200pro Manual,* Sections 2.4, 8; *ET 200iSP Manual,* Sections 2.4, 7, 8 *ET 200SP Modules Manual*, section 4 *ET 200MP Modules Manual*, section 4	
System acceptance			
Acceptance	• Description and notes on acceptance • Printouts	under System acceptance (Page 308)	
Operation, maintenance			
General operation	Notes on operation	under Notes on Safety Mode of the Safety Program (Page 326)	
Access protection	—	under Access protection (Page 80)	
Diagnostics	Responses to faults and events	under Guide to diagnostics (S7-300, S7-400) (Page 332); Guide to diagnostics (S7-1200) (Page 334); Guide to diagnostics (S7-1500) (Page 334);	

Phase	Note the following	Reference	Check
Replacement of software and hardware components	Description • Module replacement • Update of operating systems of F-CPU – same as in standard • Update of SW components Notes • Operating system update of IMs	under Replacing Software and Hardware Components (Page 328); Addressing F-I/O (Page 128); Help on *STEP 7*	
Uninstallation, disassembly	• Notes for uninstalling software components • Notes for disassembling modules	under Installing/uninstalling the STEP 7 Safety Advanced V14 optional package (Page 28); Installing/uninstalling the STEP 7 Safety Basic V14 optional package (Page 27); Replacing Software and Hardware Components (Page 328);	

Glossary

Access protection

→ Fail-safe systems must be protected against dangerous, unauthorized access. Access protection for F-systems is implemented by assigning two passwords (one for the → F-CPU, and one for the → safety program).

Automatically generated F-blocks

→ F-blocks that are automatically generated and, if necessary, called when the → safety program is compiled, in order to generate an executable safety program from the safety program programmed by the user.

Category

Category in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

With SIMATIC Safety, use in → safety mode up to category 4 is possible.

Channel fault

Channel-specific fault, such as a wire break or short circuit.

Collective F-signatures

The collective F-signatures uniquely identify a particular state of the → safety program and the safety-related parameters of the F-CPU and F-I/O. They are important for the on-site acceptance of the safety program, e.g., by → experts.

CPU-wide

In the context of F-I/Os, "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

In the context of safety-related CPU-CPU communication, "CPU-wide" encompasses all the safety-related communication connections that are configured in an F-CPU.

CRC

Cyclic Redundancy Check → CRC signature

CRC signature

The validity of the process data in the → safety message frame, the correctness of the assigned address relationships, and the safety-related parameters are validated by means of a CRC signature contained in the safety message frame.

DB for F-runtime group communication

-> F-DB for safety-related communication between F-runtime groups of a safety program.

Depassivation

→ Reintegration

Disabled safety mode

Temporary deactivation of → safety mode for test purposes, commissioning, etc.

The following actions are possible only in disabled safety mode:

- Downloading changes of the → safety program to the -> F-CPU during ongoing operation (in RUN mode)
- Test functions such as "Modify" or other write access to data of the → safety program (with limitations)

Whenever safety mode is deactivated, the safety of the system must be ensured by other organizational measures, such as operation monitoring and manual safety shutdown.

Discrepancy analysis

Discrepancy analysis for equivalence or non-equivalence is used for fail-safe inputs to detect errors caused by the time characteristic of two signals with the same functionality. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same level). On expiration of an assignable period (→ discrepancy time), a check is made to determine whether the difference in levels (for non-equivalence testing, the same level) has disappeared after an assignable time period, the so-called discrepancy time. If not, there is a discrepancy error. The discrepancy analysis is performed between the two input signals of the 1oo2 evaluation of the sensors (→ sensor evaluation) in the fail-safe input.

Discrepancy time

Assignable time for the → discrepancy analysis. If the discrepancy time is set too high, the fault detection time and → fault reaction time are prolonged unnecessarily. If the discrepancy time is set too low, availability is decreased unnecessarily because a discrepancy error is detected when, in reality, no error exists.

DP/DP coupler

Device for coupling two PROFIBUS DP subnets required for master-master communication between → safety programs in different → F-CPUs in SIMATIC Safety and S7 Distributed Safety.

Expert

The acceptance of a system, i.e., the safety-related acceptance test of the system, is usually carried out by an independent expert (for example, from TÜV).

Fail-safe GSD based DP slaves

Fail-safe GSD based DP slaves are standard slaves that are operated on PROFIBUS with the DP protocol. They must operate in accordance with IEC 61784-1:2010 (Fieldbus profiles) and the PROFIsafe bus profile. A GSD file is used for their configuration.

Fail-safe GSD based I/O devices

Fail-safe GSD based I/O devices are standard devices that are operated on PROFINET with the I/O protocol. They must operate in accordance with IEC 61784-1:2010 (Fieldbus profiles) and the PROFIsafe bus profile in V2-MODE. A GSD file is used for their configuration.

Fail-safe I/O modules

ET 200eco modules that can be used for safety-related operation (-> safety mode). These modules are equipped with integrated → safety functions. They operate in accordance with IEC 61784-1:2010 (Fieldbus profiles) and the PROFIsafe bus profile.

Fail-safe modules

Fail-safe modules ET 200SP, ET 200S, ET 200pro, ET 200iSP that can be used in the ET 200SP, ET 200S, ET 200pro or ET 200iSP distributed I/O systems.

Fail-safe modules S7-1500/ET 200MP, which can be used centrally in an S7-1500 or in a distributed I/O ET 200MP system.

Fail-safe module S7-1200 which can be used centrally in an S7-1200 system.

These modules are equipped with integrated safety functions (→ Safety mode) for fail-safe operation (→ Fail-safe operation). They operate in accordance with the → PROFIsafe bus profile.

Fail-safe systems

Fail-safe systems (F-systems) are systems that remain in a safe state or immediately switch to another safe state as soon as particular failures occur.

Fault reaction function

→ User safety function

Fault reaction time

The maximum fault reaction time for an F-system specifies the time between the occurrence of any error and a safe reaction at all affected fail-safe outputs.

F-blocks

The following fail-safe blocks are designated as F-blocks:

- those created by the user in LAD or FBD
- those created by the user as → F-DBs
- those selected by the user from a global library
- those added automatically in the → safety program (→ F-SBs, → automatically generated F-blocks, → F-shared DB, → F-I/O DBs; instance DBs of F-FBs)

All F-blocks are shown in yellow in the project tree.

F-CALL

"F-call blocks" for the → safety program in *S7 Distributed Safety*.

F-communication DBs

Fail-safe data blocks for the safety-related CPU-CPU communication via S7 connections.

F-compliant PLC data type (UDT)

An F-compliant PLC data type (UDT) is a PLC data type (UDT) in which you can use all data types that can be used in safety programs.

F-CPU

An F-CPU is a central processing unit with fail-safe capability that is approved for use in SIMATIC Safety and in which a → safety program can run in addition to the → standard user program.

F-DBs

Optional fail-safe data blocks that can be read-/write-accessed from anywhere within the safety program (exception: DBs for F-runtime group communication).

F-destination address

→ PROFIsafe address

F-FBs

Fail-safe function blocks (with instance DBs), in which the user programs the → safety program in FBD or LAD.

F-FCs

Fail-safe FCs, in which the user programs the → safety program in → FBD or → LAD.

F-I/O

Collective name for fail-safe inputs and outputs available in *SIMATIC S7* for integration in SIMATIC Safety, among others. The following are available:

- → ET 200eco fail-safe I/O module
- → S7-300 fail-safe signal modules
- → Fail-safe modules for S7-1200
- → Fail-safe modules for ET 200MP
- → Fail-safe modules for ET 200SP
- → Fail-safe modules for ET 200S
- → Fail-safe modules for ET 200pro
- → Fail-safe modules for ET 200iSP
- → Fail-safe GSD based DP slaves
- → Fail-safe GSD based I/O devices

F-I/O DB

Fail-safe data block for F-CPUs to an → F-I/O in *STEP 7 Safety*. An F-I/O DB is automatically created for each F-I/O when the F-I/O is configured in the *hardware and network editor*. The F-I/O DB contains tags that the user can or must evaluate or write in the safety program as follows:

- For reintegration of the F-I/O after communication errors
- For reintegration of F-I/O after F-I/O or channel faults
- If the F-I/O must be passivated as a result of particular states of the safety program (for example, group passivation)
- For reassignment of parameters for fail-safe GSD based DP slaves/GSD based I/O devices or enabling HART communication for the F-I/O with the corresponding functionality
- In order to evaluate whether fail-safe values or process data are output

F-I/O faults

Module-related F-I/O fault, such as a communication error or parameter assignment error

F-I/Os of PROFIsafe address type 1

F-I/Os which ensure the uniqueness of the PROFIsafe address solely with the F-destination address, for example, ET 200S F-modules. The PROFIsafe address is usually assigned by DIP switches.

F-I/Os of PROFIsafe address type 2

F-I/Os which can ensure the uniqueness of the PROFIsafe address with a combination of F-source address and F-destination address, for example, S7-1500/ET 200MP F-modules. The PROFIsafe address is usually assigned with *STEP 7 Safety*.

F-modules

→ Fail-safe modules

F-OB

The F-OB calls the main safety block of an F-runtime group in S7-1200/1500 F-CPUs.

F-runtime group

The → safety program consists of one or two F-runtime groups. An F-runtime group is a logical construct of several associated → F-blocks. It is generated internally by the F-system. An F-runtime group consists of the following F-blocks:

→ Main safety block, F-OB (S7-1200, S7-1500), if applicable → F-FBs/ → F-FCs, if applicable → F-DBs, → F-I/O DBs, F-blocks of global libraries, instance DBs, → F-SBs, and → automatically generated F-blocks.

F-runtime group information DB

The F-runtime group information DB provides key information on the corresponding → F-runtime group and on the → safety program as a whole.

F-shared DB

(S7-300, S7-400) Fail-safe data block that contains all of the shared data of the → safety program and additional information needed by the F-system. The F-shared DB is automatically inserted and expanded when the hardware configuration is compiled. Using its name F_GLOBDB, the user can evaluate certain data of the → safety program.

F-SMs

→ S7-300 fail-safe signal modules

F-source address

→ PROFIsafe address

F-system blocks

Fail-safe system blocks that are automatically inserted and called when the → safety program is compiled in order to generate an executable safety program from the user's safety program.

F-systems

→ Fail-safe systems

I-device

The functionality of the "I-device" (intelligent I/O-device) of a CPU allows data exchange with an I/O-controller and thus, its use as an intelligent preprocessor of sub-processes, for example. In this case, the I-device is connected as an I/O-device to a "parent" I/O-controller.

IE/PB link

Device for coupling PROFINET IO and PROFIBUS DP-systems required, among other things, for IO-controller-I-slave communication between -> safety programs in different → F-CPUs in SIMATIC Safety.

i-parameter

Individual parameters of → fail-safe GSD based DP slaves and → fail-safe GSD based I/O devices

I-slave

The functionality of the "I-slave" (intelligent DP slave) of a CPU allows data exchange with a DP master and, thus, its use as an intelligent preprocessor of sub-processes, for example. In this case, the I-slave is connected as a DP slave to a "parent" DP master.

Main safety block

"Introductory F-block" for fail-safe programming of the → safety program in *STEP 7 Safety*. The main safety block is an → F-FB or → F-FC that the user assigns to the calling F-OB (S7-1200, S7-1500) or block (OB, FC, FB) (S7-300, S7-400) of an → F-runtime group.

The main safety block contains the safety program and any calls of other → F-FBs/F-FCs for program structuring.

Network-wide

A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/32 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

Passivation

When passivation occurs in an → F-I/O with inputs, the → F-system provides the safety program with fail-safe values (0) instead of the process data pending at the fail-safe inputs in the PII.

When passivation occurs in an F-I/O with outputs, the F-system transfers fail-safe values (0) to the fail-safe outputs instead of the output values in the PIQ provided by the safety program.

PL

Performance Level (PL) in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

With SIMATIC Safety, use up to Performance Level (PL) e is possible in → safety mode.

PN/PN coupler

Device for coupling two PROFINET IO systems required for IO controller-IO controller communication between → safety programs in different → F-CPUs in SIMATIC Safety and S7 Distributed Safety.

PROFIsafe

Safety-related bus profile of PROFIBUS DP and PROFINET IO for communication between the → safety program and the → F-I/O in an → F-system. See IEC 61784-3-3:2010 or PROFIsafe – Profile for Safety Technology on PROFIBUS DP and PROFINET IO; Order No: 3.192 (V2.6.1).

PROFIsafe address

The PROFIsafe address (code name according to IEC 61784-3-3:2010) is used for protection of standard addressing mechanisms, such as IP addresses. The PROFIsafe address consists of an F-source address and an F-destination address. Each → F-I/O therefore has two address parts, an F-source address and an F-destination address.

The F-source address is automatically assigned and is displayed for fail-safe DP standard slaves/GSD-based I/O devices and ET 200SP, ET 200MP and S7-1200 fail-safe modules. The F-source address for F-modules ET 200S, ET 200eco, ET 200pro, ET 200iSP and F-SMs S7-300 is always 1. For F-modules ET 200SP/ET 200MP, the F-source address corresponds to the "Central F-source address" parameter of the assigned F-CPU.

You need to configure the F-destination address in the *hardware and network editor*. You assign the F-destination address for the ET 200S, ET 200eco, ET 200pro, ET 200iSP and F-SMs S7-300 F-modules with a switch. For ET 200SP F-modules and ET 200MP F-modules, assign the PROFIsafe address in the *hardware and network editor*. For S7-1200 F-modules, the F-destination address is automatically assigned by the F-system.

Program signature

→ collective F-signature

Project data

The project data includes the hardware configuration and the → user program.

Reintegration

The switchover from fail-safe values (0) to process data (reintegration of an → F-I/O) takes place automatically or following user acknowledgment in the F-I/O DB. The reintegration method depends on the following:

- The reason for → passivation of the F-I/O/channels of the F-I/O
- The parameter assignment in the → F-I/O DB or in the configuration itself (for example, ET 200MP fail-safe modules on an S7-1500 F-CPU and S7-1200 fail-safe modules on an S7-1200 F-CPU)

Following reintegration for an → F-I/O module with inputs, the process data pending at the inputs in the PII are provided again for the safety program. For an F-I/O with outputs, the F-system again transfers the output values provided in the PIQ in the safety program to the fail-safe outputs.

RIOforFA Safety

Remote IO for Factory Automation with PROFIsafe; profile for F-I/O

S7-300 fail-safe signal modules

Fail-safe signal modules of the S7-300 module series that can be used for safety-related operation (→ Safety mode) as centralized modules in an S7-300 or as distributed modules in the ET 200M distributed I/O system. The fail-safe signal modules are equipped with integrated → safety functions. They operate in accordance with the → PROFIsafe bus profile.

S7-PLCSIM

The *S7-PLCSIM* application enables you to execute and test your program on a simulated automation system on your programming device or PC. Because the simulation takes place completely in your programming device or PC, you do not need any hardware (CPU, I/O).

Safe state

The basic principle of the safety concept in → fail-safe systems is the existence of a safe state for all process variables. For digital → F-I/O that conform to IEC 61508:2010, this is always the value "0".

Safety Administration Editor

The *Safety Administration Editor* provides support for the main tasks of your safety program.

Safety function

Mechanism integrated in the → F-CPU and → F-I/O that allows them to be used in -> fail-safe systems.

According to IEC 61508:2010, a function that is implemented by a safety device in order to maintain the system in the safe state or bring the system to a safe state in the event of a specific fault. (fault reaction function -> user safety function)

Safety message frame

In → safety mode, data are transferred in a safety message frame between the → F-CPU and → F-I/O, or between the F-CPUs in safety-related CPU-CPU communication.

Safety mode

1. Operating mode of → F-I/O in which → safety-related communication can take place using → safety message frames.
2. Operating mode of the safety program. In safety mode of the safety program, all safety mechanisms for error detection and fault reaction are enabled. In safety mode, the safety program cannot be modified during operation. Safety mode can be disabled by the user (→ disabled safety mode).

Safety program

Safety-related user program

Safety protocol

→ Safety message frame

Safety summary

The safety summary provides documentation of the safety-related project data which supports you during acceptance of the system.

Safety-related communication

Safety-related communication is used to exchange fail-safe data.

Safety-related project data

The safety-related project data includes the hardware configuration of the F-CPUs and the → F-I/O and the → safety program.

Sensor evaluation

There are two types of sensor evaluation:

- 1oo1 evaluation – sensor signal is read once
- 1oo2 evaluation - sensor signal is read twice by the same → F-I/O and compared internally

Shared device

The "Shared Device" functionality enables distribution of the submodules of an IO-device between different IO-controllers.

Signature

→ collective F-signatures

SIL

Safety integrity level SIL in accordance with IEC 61508:2010. The higher the Safety Integrity Level, the more rigid the measures for prevention of systematic faults and for management of systematic faults and random hardware failures.

With SIMATIC Safety, up to Safety Integrity Level SIL3 is possible in safety mode.

Standard communication

Communication used to exchange non-safety-related data

Standard mode

Operating mode of → F-I/O in which → safety-related communication between the F-CPU and the F-I/O by means of → safety message frames is not possible; only → standard communication is possible in this operating mode.

Standard user program

Non-safety-related user program

Startup of F-system

In the STOP/RUN transition of an → F-CPU, the → standard user program starts up in the normal way. When the → safety program is started up, all F-DBs are initialized with the values from the load memory - as is the case with a cold restart. This means that saved error information is lost.

The → F-system performs an automation → reintegration of the → F-I/O.

User program

The user program comprises the → standard user program and the → safety program.

User safety function

The → safety function for the process can be provided through a user safety function or a fault reaction function. The user only has to program the user safety function. In the event of an error, if the → F-system can no longer execute its actual user safety function, it executes the fault reaction function: for example, the associated outputs are disabled, and the → F-CPU switches to STOP mode, if necessary.

Value status

The value status is additional binary information for a channel value. The value status is entered in the process image input and provides information on the validity of the channel value.

1: A valid process data is output for the channel value.

0: A fail-safe value is output for the channel value.

Versioned instruction

Instruction for which a version is displayed in the "Version" column of the "Instructions" task card:

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